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Distribution of the large blue butterflies *Phengaris* (Lepidoptera: Lycaenidae) in the Koroška Region, northern Slovenia

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ABSTRACT

Large blues are among the most threatened species of butterflies in Europe, known for their unique brood-parasitic life cycles, which include a specific host plant and a host ant. All four species found in Europe (*Phengaris arion*, *Phengaris alcon*, *Phengaris teleius* and *Phengaris nausithous*) have been recorded in the Koroška Region. However, only a handful of localities had previously been reported for these species in the region. Furthermore, with rapid decline of their habitats in the last decades, many of the historical localities may now be unsuitable. In this article, a revision of the previously known localities of all four *Phengaris* species found in Koroška region was made, with a report on new findings of *P. alcon*, *P. nausithous* and *P. arion*, as well as a confirmation of *P. teleius* and *P. nausithous* from one of the known localities. The reported findings are especially relevant from the conservation standpoint for the species in Slovenia, as they are isolated from their respective known ranges.

IZVLEČEK

Metulji iz rodu mravljiščarjev *Phengaris* (Lepidoptera: Lycaenidae) na Slovenskem Koroškem

Vrste iz rodu mravljiščarjev (*Phengaris*) so ene izmed najbolj ogroženih metuljev v Evropi, med drugim tudi zaradi njihovega parazitskega življenjskega cikla, ki vključuje tako specifično gostiteljsko rastlino kot gostiteljske mravlje. Vse štiri vrste mravljiščarjev, ki jih najdemo v Evropi (*Phengaris arion*, *Phengaris alcon*, *Phengaris teleius* in *Phengaris nausithous*), živijo tudi na slovenskem Koroškem. Do sedaj je bilo na tem območju znanih zgolj nekaj lokacij za te vrste. Zaradi pospešene izgube habitatov v zadnjih desetletjih so nekatere poznane lokacije postale neprimerne za njihovo preživetje. V tem članku tako podajamo pregled vseh historičnih podatkov štirih vrst mravljiščarjev v Koroški regiji, poročamo o novo odkritih lokacijah za vrste *P. alcon*, *P. nausithous* in *P. arion* ter potrjujemo ponovne najdbe vrst *P. nausithous* in *P. teleius* na eni izmed že znanih lokacij. Obstoječe populacije so izrednega pomena za ohranitev omenjenih vrst v Sloveniji, saj so izolirane od drugih območij razširjenosti v državi.

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INTRODUCTION

Large blues, the genus *Phengaris* (previously *Maculinea*) is a genus of Palearctic butterflies known for its complex brood-parasitic lifestyle, which includes a specific larval host plant in the first, as well as a specific larval host ant from the genus *Myrmica* in the second part of larval development. Both larval hosts can differ depending on the species of the butterfly and region (Arnaldo et al. 2013; Tartally et al. 2019). Four *Phengaris* species have been found in Europe, including Slovenia, specifically *Phengaris teleius* (Bergsträsser, 1779), *Phengaris nausithous* (Bergsträsser, 1779), *Phengaris alcon* (Dennis & Shiffermüller, 1775) and *Phengaris arion* (Linnaeus, 1758) (Verovnik et al. 2012; Arnaldo et al. 2013). All four species are included in the Rules on the listing of endangered plant and animal species in the Red List (Ur. l. RS 2002) and the Decree on protected species of wild fauna (Ur. l. RS 2004), while all species except *P. alcon* are also included in the Annexes of the Habitat Directive (OJ EC 1992). *P. teleius* and *P. nausithous* are found on humid extensive grasslands, depending on the *Sanguisorba officinalis* L. as their larval host plants. On the other hand, *P. arion* is restricted to dry extensive grasslands with *Thymus* sp. and *Origanum vulgare* L. as the main host plants, whereas *P. alcon* can be found in humid, as well as dry extensive grasslands. On the first, caterpillars predominantly feed on *Gentiana pneumonanthe* L., while on dry extensive grasslands they predominantly use *Gentiana cruciata* L., among other species (Rebeušek 2006; Verovnik et al. 2012; Arnaldo et al. 2013). In Slovenia, all the afore-mentioned species are still present at several localities, but declining trend is evident (Verovnik et al. 2012; Zakšek et al. 2022).

P. nausithous and *P. teleius* are restricted to the humid lowlands, mostly in the north-eastern part of Slovenia, and can be found only at altitudes below 500 m and 1,000 m, respectively (Verovnik et al. 2012; Čelik 2013). While *P. nausithous* is restricted to the north east of the country, *P. teleius* reaches central, south west and north-western parts of the country (Verovnik et al. 2012). However, in the northwest (Bača Valley) the species was last observed in 2008/2009, and was not recorded on its three previously known localities during recent surveys (Zakšek et al. 2022; Šturm pers. obs.). Both species are included in the Rules on the listing of endangered plant and animal species in the Red List (Ur. l. RS 2002) and the Decree on protected species of wild fauna (Ur. l. RS 2004), with both of them also included in the national monitoring scheme (Verovnik et al. 2009, 2011). While both species are relatively widespread in north east Slovenia in the Goričko Region, they are very rare in the Koroška Region. *P. nausithous* was previously known from only two localities, found besides the railway track between the Holmec border crossing and Dolga Brda, both being relatively near to one another. Consequently, both localities probably belonged to the same population (Verovnik et al. 2012; CKFF 2024). *P. teleius* was also known from the same two localities, as well as from the Mislinja Valley near Pameče and Šentjanž pri Dravogradu (Verovnik et al. 2012; CKFF 2024). Both species were also reported from Austrian Carinthia near the border with Slovenia (Rakosy 2001; OÖ Landes-Kultur GmbH 2025; Verovnik pers. obs.).

P. alcon is a species that can utilise both dry and thermophilous, as well as humid and marshy extensive grasslands. It is also one the most widespread of the four species in the country, being found up to an altitude of 1,500 m (Verovnik et al. 2012). It is the most widespread on the southern ridge of the Trnovski gozd Plateau and southern parts of central Slovenia (Verovnik et al. 2012). It is included in the Rules on the listing of endangered plant and animal species in the Red List (Ur. l. RS 2002) and the Decree on protected species of wild fauna (Ur. l. RS 2004). Unlike the other three species of this genus, however, no monitoring scheme exist, as the butterfly is not included in the Annexes of the Habitat Directive like the previous three species (OJ EC 1992). In the Koroška Region, the species is relatively rare, previously known from only four localities. The first one is in Dolga Brda, in close proximity to *P. nausithous* and *P. teleius* localities. The other three are from Suhodolnica marshland near Plešivški mlin, the Črni potok Valley near Kotlje, and the Topla Valley below Mt. Peca (Verovnik et al. 2012; CKFF 2024).

P. arion is the largest *Phengaris* species in Slovenia and is found in dry, extensive and thermophilic grasslands throughout most of the country, up to an altitude of 1,900 m (Verovnik et al. 2012). Its largest populations are located in Haloze, northwest of Pohorje Mts., Zasavje, and in Polhograjsko and Škofjeloško Hills (Verovnik et al. 2012; Šturm et al. 2024). It is included in the Rules on the listing of endangered plant and animal species in the Red List (Ur. l. RS 2002) and Decree on protected species of wild fauna (Ur. l. RS 2004). A monitoring scheme was also established (Verovnik et al. 2009, 2011). It is mostly found in relatively low densities of adults, and has been recorded from 25 localities in the Koroška Region, mostly in its eastern part: in the mountains northwest and north of Dravograd, north of Muta, and from north-western part of the Pohorje Mts. (Verovnik et al. 2011, 2012, 2015; Kadiš 2016; Švara & Verovnik 2018; CKFF 2024). Several of these 25 localities are close to one another, so the number of local populations is very likely much lower. The species was also reported from Austrian Carinthia near the border with Slovenia (Hassler & Tschinder 1998).

All in all, until now Large blues have been found in no more than 33 localities in the Koroška Region, as localities of certain species overlapped (*P. teleius* and *P. nausithous*). Among the species, *P. arion* has been found in most localities (25), while the other three species have been observed in only in a total of eight localities.

MATERIAL AND METHODS

GEOGRAPHICAL DESCRIPTION OF THE STUDIED REGION

Slovenska Koroška is one of the smallest regions of Slovenia, situated along the border with Austria in the north and north-eastern part of the country. Historically, it was a part of much bigger region of Carinthia in the former Austro-Hungarian empire. Today, only a small fragment of the region is located inside the borders of the Republic of Slovenia. However, the recent (statistical) region of Koroška in Slovenia encompasses

greater territory than the historical region and now includes 12 municipalities: Črna na Koroškem, Dravograd, Mežica, Mislinja, Muta, Podvelka, Prevalje, Radlje ob Dravi, Ravne na Koroškem, Ribnica na Pohorju, Slovenj Gradec and Vuzenica (Geršič et al. 2021). For the purposes of this article, the term »Koroška Region« refers to the entire Slovenian (statistical) region of Koroška (including all 12 aforementioned municipalities above), and not only to its historical parts in Slovenia.

According to Ogrin (1996), the eastern part of Koroška has a temperate continental climate typical of central Slovenia, while the western part (near the highest peaks in the region) has a lower alpine climate typical of northern Slovenia. The precipitation regime is characteristic for the mild continental climate with approximately 1,100-1,700 mm of annual rainfall, with the average for the 1961-2017 period being 1,271.7 mm (Praprotnik 2021). According to Wraber (1969), the entire surveyed area falls into the alpine phytogeographical region. The tallest mountain peak, Mt. Peca, with its tallest peak Kordeževa glava at an altitude of 2,125 m, is located along the Austrian border in the western part of the region, where all the high mountains in this region are located (Geršič et al. 2021). This part is also densely interspersed with steep valleys, hills and lower mountains, while in the east, wider river valleys and hills, including the western part of Pohorje Mts., and Kozjak Mts. prevail (Perko et al. 2020).

The area boasts extremely diverse habitats. The higher altitudes, above the 1,600 m, are dominated by lower alpine meadows, rocky outcrops and pine forests, the latter being also predominant in the steep alpine valleys where small streams, grassland, marshes and bogs are present. In the eastern part, between the altitudes of 600-1,600 m, dry extensive grasslands, pastures and mixed/pine forests on the silicate bedrock cover the hills, while at the altitudes below 600 m the wider river valleys are mostly covered by intensive grasslands, fields, orchards and settlements. Due to the urbanisation and agriculture, most bogs and marshes have been lost, while the remaining ones have been reduced to small fragments in different states of overgrowing (Perko et al. 2020; Geršič et al. 2021; Šturm & Verovnik pers. obs.). Another reason for the high diversity of the habitats, especially the flora, is also the incredibly rich geological structure of the region. While the western parts, particularly around the mountain peaks, mostly consist of dolomite and limestone, the biggest part of the region, especially the entire east, consists of silicate sandstone and conglomerate in the valleys, and metamorphic and igneous rocks in the hills (Perko et al. 2020).

FIELD WORK

The surveys of the area took place from 2021 to 2024 in the western part of Koroška Region, with the majority of study completed in the summer of 2023 during the Raziskovalni tabor študentov biologije (RTŠB). Additionally, two separate observations from two localities near Helenski potok, made in 2018 and 2019, were also included. During the surveys, each locality was thoroughly checked and all butterflies belonging to the *Phengaris* genus were recorded. We only provide the records for the localities where at least a single Large blue was found (Fig. 1, Tab. 1), although many more were surveyed. Among the reported localities, several were later denoted as micro-locali-

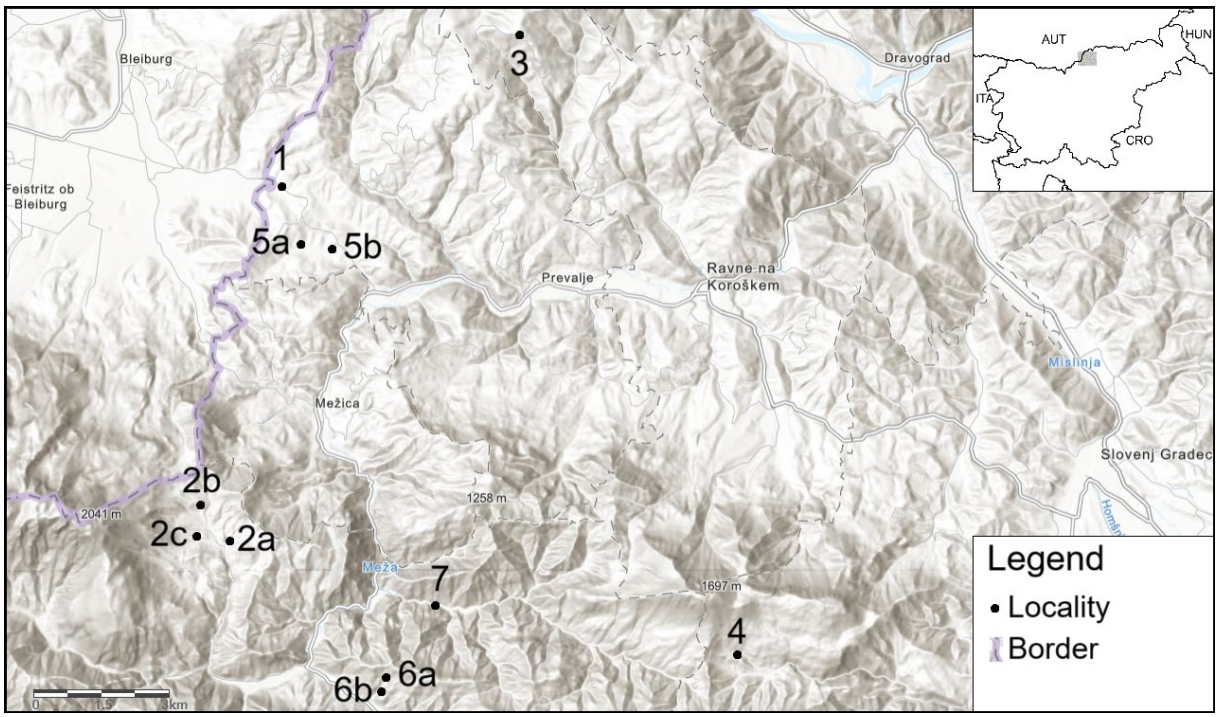

Figure 1. Map of the western part of Koroška Region with surveyed localities between 2018 and 2024. Numbers refer to localities given in Tab. 1. The position of the surveyed area within the country is shown in the upper right corner of the figure. The basic map layout was taken from https://www.arcgis.com (accessed on 20. 12. 2024).

Slika 1. Zemljevid zahodnega dela Koroške, ki vključuje pregledane lokacije med letom 2018 in 2024. Številke lokacij so enake kot v Tab. 1. Pozicija pregledanega območja znotraj države je prikazana v zgornjem desnem kotu slike. Osnovni zemljevid je bil vzet iz https://www.arcgis.com (dostopano dne 20. 12. 2024).

Table 1. List of surveyed localities in the Koroška Region where at least one *Phengaris* species was (re)discovered, including their description, habitat type, coordinates, altitude and the sampling dates. The coordinates are given in WGS-84 decimal degrees, latitude (Lat.), followed by longitude (Long.).

Tabela 1. Seznam lokacij znotraj Koroške, kjer je bila (ponovno) odkrita vsaj ena vrsta iz rodu *Phengaris*, skupaj z opisom lokacij, tipom habitata, koordinatami, nadmorskimi višinami in datumi vzorčenj. Koordinate so podane v WGS-84 decimalnih stopnjah kot zemljepisna širina (Lat.) in zemljepisna dolžina (Long.).

No.	Location description	Habitat type	Coordinates (Lat., Long.)	Altitude [m]	Date sampled
1*	Grasslands around the railway track at Holmec border crossing; N of Mežica	Dry and humid extensive and intensive grasslands, bushes, forest edge	46.56593, 14.84258	500-520	20. 7. 2022; 28. 7. and 16. 8. 2024 (V); 16. 7. 2023 (Š, Z)
2a	Meadow near the spring of Helenski potok in Podpeca; NW of Črna na Koroškem	Humid extensive grasslands, marshes, forest edge	46.49598, 14.82712	900	16. 7. 2023 (Š, Z)
2b	Meadow near the spring of the Helenski potok in Podpeca, near Najbrž farm; NW of Črna na Koroškem	Humid extensive grasslands, forest edge	46.50193, 14.81735	960	27. 6. 2018 and 21. 7. 2019 (L)
2c	Meadow near the spring of Helenski potok in Podpeca, near Terče farm; NW of Črna na Koroškem	Humid extensive grasslands, forest edge	46.49698, 14.81704	960	21. 7. 2019 (L)
3	Steep pastures W of the St. Urh church at Strojna; N of Prevalje	Pastures, extensive dry grasslands, bushes	46.59593, 14.91301	1,000	16. 7. 2023 (Š, Z)
4	Pastures SE of Mt. Uršlja gora near Plešivec farm; E of Črna na Koroškem	Pastures, semi-intensive grasslands, forest edge	46.47306, 14.97405	950-970	18. 7. 2023 (Š)
5a	Grasslands beneath Podlap farm, W of Lokovica; N of Mežica	Intensive and semi-intensive humid grassland, stream, trees	46.55407, 14.84781	480-500	19. 7. 2023 (Š); 28. 7. and 16. 8. 2024 (V)
5b	Grassland in the NW part of Lokovica settlement; N of Mežica	Intensive and semi-intensive humid grassland	46.55323, 14.85768	480-500	19. 7. 2023 (Š); 28. 7. and 16. 8. 2024 (V)
6a	Pastures above Matvoz farm at Javorje; E of Črna na Koroškem	Pastures, dry extensive grasslands, forest edge	46.46728, 14.87113	740-780	20. 7. 2023 (Š)
6b	Pastures above Javorje; SE of Črna na Koroškem	Pastures, humid and dry extensive grasslands, forest edge	46.46495, 14.86925	660-700	20. 7. 2023 (Š)
7	Jazbinski potok Valley, opposite abandoned quarry at Žerjav; NE of Črna na Koroškem	Mowed lawn near a house, forest edge, gardens, bushes	46.48285, 14.88663	510-520	20. 7. 2023 (Š)

* – previously known locality; the surveyors: L – Jernej Lavbič; Š – Luka Šturm; V – Rudi Verovnik; Z – Jure Zaman

ties, since the distances between the observed adults were too great to be attributed to a single locality, but too short not to be considered part of a potentially connected population. The surveying was performed using a butterfly net and identification was done in the field. Butterflies were identified using the standard butterfly guide (Tolman & Lewington 2008), while localities were selected based on past surveys (Švara & Verovnik 2018; Zakšek et al. 2022), knowledge of the region and the inspection of satellite photos/maps. All surveys were performed during appropriate weather conditions (sunny, relatively light wind/windless, temperatures above 15 °C) between 9:00 and 18:00.

RESULTS AND DISCUSSION

During the surveys, 10 new localities were discovered where at least a single *Phengaris* species or butterfly eggs were observed. Additionally, presence of *P. teleius* and *P. nausithous* was confirmed in a previously known locality near Holmec border crossing after almost 30 and 15 years, respectively. The locality was consequently included in the results of this survey (Tab. 1). Seven out of 10 newly discovered localities were subsequently denoted as microlocalities and grouped together in three larger localities/areas (Tab. 1).

Table 2. Distribution of *Phengaris* species found in the Koroška Region, with the numbering of localities as in Tab. 1.

Tabela 2. Razširjenost vrst iz rodu *Phengaris*, najdenih na Koroškem, z oštevilčenjem lokacij kot v Tab. 1.

Species	No. of locality (with years, when necessary)
Phengaris alcon	2a, 2b (2018; 2019 - eggs only), 2c (eggs only)
Phengaris arion	3, 4, 6a, 6b, 7
Phengaris nausithous	1 (2022), 5a, 5b
Phengaris teleius	1 (2023)

Phengaris nausithous (BERGSTRÄSSER, 1779)

P. nausithous was known only from two localities near the Holmec border crossing, which coincide with *P. teleius* finds (Verovnik et al. 2012; CKFF 2024). Like *P. teleius*, *P. nausithous* was never again observed from the locality near Dolga Brda but was recorded at the locality near the Holmec railway station in 2008, when five imagines were observed during the surveys for establishment of the species monitoring scheme (Fig. 2) (Verovnik et al. 2009). In the next 14 years, however, the butterfly seemingly disappeared from the area with no further observations despite deliberate search. Thus, the species was considered extinct in the region (Rebeušek 2006; Verovnik et al. 2012; Zakšek et al. 2020). In 2022, a male specimen was found a few hundred metres from the railway station to the SE (locality 1; Tab. 2) near a small railway tunnel (Zakšek et al. 2022). However, it was not found again in 2023 nor 2024, suggesting the find was a stray individual from an unknown location. It could have come from the two new localities discovered in 2023 (localities 5a and 5b; Tab. 2), both in the southern part of Lokovica settlement, and only a kilometre away from the 2022 observation location. The most intriguing new locality of the two, where *S. officinalis* was relatively sparse but still found over a larger area, is just south below the Podlap farm in the southwest of Lokovica (locality 5a; Tab. 2, Fig. 3). Here, only a single specimen was recorded in 2023, while the species was not observed again in 2024. At the second locality in the settlement itself (locality 5b; Tab. 2), only a few clumps of *S. officinalis* were present alongside a 150 m long ditch in otherwise intensive grassland. At this locality, three imagines were found and at least one of them was a female (observed lying eggs on one of the *S. officinalis* plants). During 2024 survey, the entire area was mowed in the end of July, so no adults were observed. The proximity of all four known localities indicates fragmentation of a potentially single large habitat and population of the species at the Holmec area. These fragments most likely do not provide sufficient habitat for species long term survival, therefore active management and expansion of the suitable habitat is urgently needed. Anyhow, as the species was lastly observed from the Austrian side of the border in 2014 near Bleiburg (Verovnik pers. obs.), despite its wider historical presence in these parts (Rakosy 2001; OÖ Landes-Kultur GmbH 2025), while also being scarcely reported from the Koroška Region in the last decades (Zakšek et al. 2022; CKFF 2024), it is possible that the butterflies observed in 2023 were the last specimens of this humid grassland specialist from this part of Slovenia.

Figure 2. Two imagines of *Phengaris nausithous* on a *Sanguisorba officinalis* plant found near Holmec border crossing (locality 1; Tab. 2) in 2008 (photo: Rudi Verovnik).

Slika 2. Dva osebka vrste *Phengaris nausithous* na rastlini *Sanguisorba officinalis*, najdena v bližini mejnega prehoda Holmec (lokacija 1; Tab. 2) v letu 2008 (foto: Rudi Verovnik).

Figure 3. Eastern part of the locality below the Podlap farm near Lokovica (locality 5a; Tab. 2), showing the highest density of *Sanguisorba officinalis* host plants. Taken on 19. 7. 2023 (photo: Luka Šturm).

Slika 3. Vzhodni del lokacije pod kmetijo Podlap pri Lokovici (lokacija 5a; Tab. 2) z največjo gostoto gostiteljske rastline *Sanguisorba officinalis*. Slikano 19. 7. 2023 (foto: Luka Šturm).

Phengaris teleius (BERGSTRÄSSER, 1779)

P. teleius was known only from four historical localities (Verovnik et al. 2012; CKFF 2024). Two of those are from the 1980's, both located south east of Dravograd. One is located near Otiški vrh and the second near the Jesenk farm, below Jesenkov vrh peak (Verovnik et al. 2012; CKFF 2024). However, the butterfly has not been reported on neither locality ever since. Due to the small population sizes during their discovery, as well as intensification of grasslands, both populations are now presumed extinct, despite *S. officinalis* still being present in the wider area (Jogan et al. 2001; Zakšek et al. 2022; ARSO 2025). The two more recent localities also lie close to one another and are located near the Holmec border crossing. One was discovered besides the Holmec railway station, where the butterfly was observed in 1994, and the other a few kilometres to the southeast in a small flat depression near Dolga Brda

settlement, from where the butterfly was reported in 2000 (Verovnik et al. 2012; CKFF 2024). The butterfly was not confirmed again on neither of these localities, despite extensive search between 2016 and 2022 (Švara & Verovnik 2018; Zakšek et al. 2022; Verovnik pers. obs.). Due to the intensification of the grasslands, as well as partial overgrowing of the former habitats (with *S. officinalis* becoming scarcer in the area), the butterfly was considered extinct in Koroška Region as a whole (Rebeušek 2006; Zakšek et al. 2022). However, it was finally rediscovered in 2023, only 200 m southeast of Holmec railway station besides the railway tracks (locality 1; Tab. 2). Unfortunately, only a single female was observed with one of its wings already severely damaged, but as it was still able to fly, it was released at the point of capture. After a thorough check of all the nearby grasslands, it was established that *S. officinalis* was present besides the railway track in a few-hundred-metres-long strip from the railway station to the small railway tunnel in the southeast, confirming the reports from 2022 (Zakšek et al. 2022). *S. officinalis* was once common on nearby grasslands, but none were observed during the 2024 surveys (Verovnik pers. obs.), therefore it is questionable if the number of remaining host plants in the narrow strip is sufficient to support a small local population without regular influx from potential populations on the Austrian side. The situation there is currently unknown as no specimen has been reported in the last 20 years (OÖ Landes-Kultur GmbH 2025; Verovnik pers. obs.); the last time the species was observed near the Slovenian border was at the beginning of the century (Rakosy 2001). Therefore, it is possible that this was the last specimen of this humid grassland specialist observed from this part of Slovenia.

Phengaris alcon (DENNIS & SHIFFERMÜLLER, 1775)

P. alcon has been known from only four localities in the entire region, despite populating the most diverse habitats of all *Phengaris* species (dry and humid grasslands) (Verovnik et al. 2012; CKFF 2024). It was first recorded in 1994 in a depression near Dolga Brda settlement, 1.5 km from the Holmec border crossing, where humid grasslands were abounded with *G. pneumonanthe* (Verovnik et al. 2012; CKFF 2024; Verovnik pers. obs.). During subsequent visits in this century, the meadows at both sites were intensified and no host plants were present (Verovnik pers. obs.) The species was also found in a small valley besides the Črni potok near Kotlje in 1995, where the host plant *G. pneumonanthe* was limited to a single meadow. Although the meadow retained its humid character the host plant disappeared soon after the discovery of *P. alcon*. In the third location, the marshlands at the Suhodolnica source near Plešivški mlin, northwest of Zgorni Razbor settlement, only a single specimen was observed in 1998 with most of the marshland already heavily overgrown and no host plants recorded (Verovnik pers. obs.). Lastly, in the Topla Valley, the species was recorded in 2005 in a small fragment of blanket bog (Verovnik et al. 2012; CKFF 2024). The locality has not been revisited since 2005 to confirm the record. In recent years, three new localities were discovered around the source of the Helenski potok, where the butterfly or its eggs on *G. cruciata* were found between 2018 and 2023 (localities 2a, 2b and 2c; Tab. 2). Given the close proximity of the three locations, they likely belong to a single population. However, unlike elsewhere in Slovenia, where many individuals are usually observed during the population peak (Zakšek et al. 2022; Šturm et al. 2024), only one imago was found at locality 2c and eggs only at locality 2b in 2018 (Fig. 4). In 2019, no butterflies were observed at any of these localities, but eggs were again found (with locality 2b containing higher number of *G. cruciata* plants and consequently more eggs) (Lavbič pers. comm.). Similarly, only one imago was found in 2023 at locality 2a, while no eggs or host plants were observed in the area. Localities 2b and 2c were not surveyed that year. Due to patchy information and without a more focused survey, the size and strength of the population is hard to evaluate. However, *G. cruciata* plants are still relatively numerous in the area, providing ample suitable habitat for the species. The network of humid meadows and small bogs in the area is well preserved as well, and also hosts the last remaining strong population of *Euphydryas aurinia* (Rottemburg, 1775) in the Koroška Region (Zakšek et al. 2021). Until mapping of *P. alcon* host plants distribution and egg counts are performed over the wider area in Podpeca, it is difficult to assess the potential of a long-term survival of this last population in the Koroška Region. It must be noted, that there are several historical records for both host plants scattered across this region (Jogan et al. 2001), indicating that wider search could potentially lead to discovery of new *P. alcon* populations. With the current rate of disappearance of the habitats for both gentians this is a rather slim chance, although *G. cruciata* might still be present in dry calcareous grasslands in the western part of the region.

Figure 4. The eggs of *Phengaris alcon* found on *Gentiana cruciata*, the larval host plant in Podpeca (locality 2b; Tab. 2), taken on 21. 7. 2019 (photo: Jernej Lavbič).

Slika 4. Jajčeca vrste *Phengaris alcon*, najdena na *Gentiana cruciata*, hranilni rastlini gosenic te vrste, slikano v Podpeci (lokacija 2b; Tab. 2), 21. 7. 2019 (foto: Jernej Lavbič).

Phengaris arion (LINNAEUS, 1758)

P. arion is the only species of the genus that is relatively widespread and has a firm foothold in the region. The species was known from 25 localities in the Koroška Region as of 2022, while five new localities were discovered in 2023 (localities 3, 4, 6a, 6b and 7; Tab. 2), as reported here. The previously known localities are mostly concentrated in the mountainous parts around Dravograd in the northwest (Strojna) and north and northeast (Mt. Košenjak and Kozjak Mts.), from where 12 localities are known. From Pohorje (northwest, central and northcentral parts) 10 more localities were reported. There are also very old records for Mt. Peca near the mountain chalet, the Mežica ski slopes above the town and Breznica peak northwest of Prevalje (Verovnik et al. 2012; CKFF 2024). At 12 of those localities the butterfly was observed at least once in the last 10 years and thus they could still be occupied by the species (Verovnik et al. 2011, 2015; Švara & Verovnik 2018; Zakšek et al. 2017, 2019, 2021, 2023; CKFF 2024). Seven of those localities, all found in the central and northcentral parts of Pohorje Mts., within the Podvelka, Ribnica na Pohorju and Radlje ob Dravi municipalities, are also regularly monitored as they are included in the official monitoring scheme (Verovnik et al. 2011, 2015; Zakšek et al. 2017, 2019, 2021, 2023). In 2023, five new localities were discovered in the region (localities 3, 4, 6a, 6b and 7; Tab. 2): i) three near Črna na Koroškem, where two are located a few hundred meters southeast of Matvoz peak and one east of Žerjav in the valley of the Jazbinski potok; ii) one below Mt. Uršlja gora, a few hundred metres from the source of the Suhodolnica stream where *P. alcon* was found in 1998; iii) one in Strojna, near St. Urh's church, 500 m south of the locality where *P. arion* was observed in 2016 (Švara & Verovnik 2018). However, the butterfly was not observed in the grasslands of the Mežica ski slopes in 2023, from where it was reported in the 80's (Verovnik 2000; CKFF 2024; Šturm pers. obs.). The species is thus still present on at least 17 localities in the Koroška Region and there are three main reasons why it remains relatively widespread in the region: i) numerous suitable habitats, especially well preserved dry extensive thermophilous grasslands and pastures found on south-facing slopes; ii) wide distribution of various species of *Myrmica* ants (Bračko 2023); iii) wide distribution of the main host plants, *O. vulgare* and *Thymus* sp. in the region. While *O. vulgare* is common or at least present in most parts of the Koroška Region, it is especially abundant in the entire northern part, all the way from east to west, as well as at the foothills of Mt. Uršlja gora (Jogan et al. 2001). Similarly, plants from the genus *Thymus* are present almost in the entire region (Jogan et al. 2001), as also confirmed during the 2023 surveys (Šturm pers. obs.). Consequently, *P. arion* is probably even more widespread in the Koroška Region than currently known, as many new localities are likely to be discovered. This is additionally supported by low detectability of the species due to low density of adults (Zakšek et al. 2022, 2023; Šturm et al. 2024). We can conclude that *P. arion* is possibly the only species of the genus *Phengaris* in the Koroška Region with likely stable populations. In the case of reinvigoration of grazing and mowing of steep slopes, additional suitable habitats for the species might appear, as observed at the localities 6a and 6b near Črna na Koroškem (Tab. 2).

CONCLUDING REMARKS

The Koroška Region remains one of the few places in Slovenia where all four *Phengaris* species can still be found, despite *P. nausithous* and *P. teleius* being considered extinct until 2022 and 2023, respectively (Rebeušek 2006; Zakšek et al. 2020, 2021). However, of all four *Phengaris* species, only *P. arion* remains well established in the region, as the butterfly was confirmed on at least 17 localities in the last decade. It is also the only species in Koroška for which the habitats (dry extensive grasslands) are not as drastically threatened as for the other three species. The humid extensive grasslands and marshes have almost completely disappeared with only small fragments of suitable habitat present at former localities. Therefore, all other species face extinction in near future, as they are all limited to only one confirmed population each. Both *P. teleius* and *P. nausithous* were not seen in 2024 and their habitat continues to deteriorate (Verovnik pers. obs.), while *P. alcon* is still holding somehow larger area, but low densities indicate that the remaining habitat is suboptimal. Further surveys are needed to establish the extent of the distribution of both the host plant and the butterfly to better understand the causes for the low abundance of the latter, and to propose protection measures suitable for the species. In case of *P. nausithous* and *P. teleius,* such measures are already well known but should be implemented as soon as possible at all remaining locations around the Holmec border crossing. This is the only way to prevent their extinction.

POVZETEK

V članku predstavljamo pregled vseh poznanih lokacij štirih vrst metuljev iz družine mravljiščarjev (*Phengaris* sp.) v Koroški statistični regiji, dodajamo nove lokacije za vrste *P. alcon*, *P. nausithous* in *P. arion* ter potrjujemo ponovni najdbi vrst *P. nausithous* in *P. teleius* na eni izmed že poznanih lokacij. Terensko delo smo opravljali v letih med 2021 in 2024, med rezultate pa smo dodali še dve prej neobjavljeni lokaciji za vrsto *P. alcon*, ki sta bili najdeni in pregledani v letih 2018 in 2019. Posamezne lokacije vzorčenja smo izbrali na podlagi ohranjenosti habitatov, dostopnosti in predhodnih raziskav (Verovnik et al. 2012; Švara & Verovnik 2018; Zakšek et al. 2022, 2023).

Med popisi smo pregledali večji del zahodnega dela Koroške regije, kjer smo našli 10 novih lokacij z vsaj eno vrsto metulja iz rodu mravljiščarjev na vsaki lokaciji. Obenem smo na nahajališču pri mejnem prehodu Holmec potrdili vrsti *P. nausithous* in *P. teleius*, ki smo ju tam potrdili prvič po skoraj 15 oz. 30 letih. Po pregledu prejšnjega in trenutnega stanja ugotavljamo, da so vrste *P. teleius*, *P. nausithous* in *P. alcon* v Koroški regiji močno ogrožene (Rebeušek 2006; Verovnik et al. 2012; Zakšek et al. 2022, 2023; CKFF 2024), vrsti *P. teleius* in *P. nausithous* pa sta nekaj časa na tem območju že veljali za izumrli (Rebeušek 2006; Zakšek et al. 2022). Vse tri vrste so bile v Koroški regiji sicer izredno redke že prej, namreč vrsti *P. teleius* in *P. alcon* sta bili predhodno poznani iz štirih, *P. nausithous* pa iz samo dveh lokacij (Verovnik et al. 2012; CKFF 2024). Trenutno so za vrsti *P. nausithous* in *P. alcon* poznane po tri lokacije (Tab. 2), a v primeru obeh vrst vse lokacije verjetno pripadajo zgolj eni populaciji (mikrolokacije). Medtem ko je habitat celotnega pojavljanja *P. alcon* relativno dobro ohranjen, pa je habitat na lokaciji, kjer živi *P. nausithous*, v zelo slabem stanju. V še bolj kritičnem stanju kot omenjeni vrsti je vrsta *P. teleius*, ki je bila najdena prvič po skoraj 30 letih v obliki ene same obletane samice. Posledično dvomimo, da se populacija te vrste v Koroški regiji sploh še pojavlja. Obstaja namreč možnost, da je metulj priletel iz kakšne izmed lokacij iz sosednje Avstrije, kljub temu, da vrsta v zadnjih letih od tam ni bila poročana (Rakosy 2001; OÖ Landes-Kultur GmbH 2025; Verovnik osebno). Glede na trenutno stanje vrst *P. teleius*, *P. nausithous* in *P. alcon* lahko vse tri štejemo kot izredno redke v Koroški regiji. V primeru nadaljnje degradacije habitatov na območju bi lahko vse tri vrste v nekaj letih/desetletjih iz regije tudi popolnoma izginile. Na večini prej poznanih lokacij so vrste namreč že neobstoječe, izginile pa so tudi njihove hranilne rastline. Edina vrsta iz rodu mravljiščarjev, ki je v regiji še v dokaj dobrem stanju, tako ostaja *P. arion*, za katero je bilo iz Koroške regije do leta 2022 poznanih kar 25 lokacij (Verovnik et al. 2012; Švara & Verovnik 2018; CKFF 2024). Na 12 lokacijah je bila vrsta potrjena tudi v zadnjem desetletju (Švara & Verovnik 2018; Zakšek et al. 2017, 2019, 2021, 2023; CKFF 2024). V letu 2023 smo na preiskovanem območju našli še pet novih lokacij z omenjeno vrsto, a tudi številne druge morebitne lokacije z ustreznim habitatom. Glede na to, da se vrsta običajno pojavlja v nizkih gostotah, predvsem v primerjavi z drugimi vrstami iz tega rodu (Zakšek et al. 2022, 2023; Šturm et al. 2024), je bila verjetno na mnogih lokacijah, kljub vzorčenju, spregledana. Z ozirom na razmeroma dobro ohranjenost njenih habitatov v Koroški regiji ter na relativno zadovoljive rezultate monitoringa te vrste na sedmih lokacijah v centralnem in severno-centralnem delu Pohorja v zadnjih letih (Zakšek et al. 2017, 2019, 2021, 2023) vrsta v tej regiji ostaja relativno stabilna. Če se bo ustavilo tudi izginjanje suhih ekstenzivnih travišč v Koroški regiji, bi vrsta lahko svoj areal v naslednjih desetletjih celo razširila.

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First data from the new amphibian road-kill hotspot at Vinogradniška pot in Razvanje (NE Slovenia)

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ABSTRACT

There are more than 1500 road segments, where large amphibian mortalities are recorded in Slovenia. One of such road-kill hotspots is Vinogradniška pot at Razvanje (NE Slovenia), where censuses of migrating amphibians were carried out in spring of 2019, 2020, 2021 and 2024 alongside actions to prevent road death that have been taking place since 2018, albeit irregularly. Here, the first data from those censuses are presented. Four amphibian species were recorded migrating over the road, specifically common toad (*Bufo bufo*), common frog (*Rana temporaria*), agile frog (*R. dalmatina*) and Italian crested newt (*Triturus carnifex*). The most numerous was B. bufo, of which 500–1000 individuals migrated over the road annually and represented about 99% of individuals of all recorded amphibian species. Male B. bufo outnumbered females by 4–12:1 and species mortality was fairly low (between 5 and 12%), but was deliberately artificially reduced. Amphibian activity was lower later in the evening and had a significant moderate positive correlation with the air temperature. The data presented indicate the importance of amphibian spring migration monitoring also over low-traffic roads, which are rarely the focus of similar studies.

KEY WORDS:
amphibian spring migration, road-kill hotspot, Razvanje, *Bufo bufo*

KLJUČNE BESEDE:
spomladanska selitev dvoživk, črna točka, Razvanje, *Bufo bufo*

IZVLEČEK

Prvi podatki s črne točke na Vinogradniški poti v Razvanju (SV Slovenija)

V Sloveniji je trenutno registriranih več kot 1500 odsekov, kjer prihaja do množičnih povozov dvoživk. Ena izmed takšnih črnih točk je cesta na Vinogradniški poti v Razvanju (SV Slovenija), kjer smo popise selečih se dvoživk opravljali v letih 2019, 2020, 2021 in 2024 v sklopu akcije prenašanja dvoživk čez cesto, ki v naši lastni režiji poteka od leta 2018, a ne redno. Tukaj predstavljamo prve podatke iz popisnih let. Na lokaciji smo zabeležili štiri vrste selečih se dvoživk, in sicer navadno krastačo (*Bufo bufo*), sekuljo (*Rana temporaria*), rosnico (*R. dalmatina*) in velikega pupka (*Triturus carnifex*). Najštevilčnejša je bila navadna krastača, s 500–1000 selečimi se osebki na leto z okoli 99 % osebkov vseh zabeleženih vrst dvoživk. Samci so v populaciji prevladovali nad samicami v razmerju 4–12:1, smrtnost pa je bila relativno nizka (med 5 in 12 %), a se je v sklopu akcije ta namerno zmanjšala. Aktivnost dvoživk je skozi večer upadla in je korelirala zmerno pozitivno, a statistično značilno s temperaturo zraka. Podatki prikazujejo pomen monitoringov spomladanskih selitev dvoživk tudi čez manj prometne ceste, ki so redko vključene v podobne raziskave.

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INTRODUCTION

Construction of transport infrastructure represents one of the most notable environmental alterations by humans. As a result of our modern lifestyle, which requires ever better and more sophisticated traffic connections, the problem is also increasing with time (Podloucky 1989; Vos & Chardon 1994), which has a large impact on the ecosystems in the aspect of habitat degradation and fragmentation (Trombulak & Frissell 2000). Among all terrestrial vertebrates, populations of amphibians and reptiles were found to suffer the highest impact by transport infrastructure, due to roadkill and habitat fragmentation (Rytwinski & Fahring 2012). Roads can affect amphibians on three different levels, specifically at the level of an individual, level of a population and the level of connectivity between populations (Vos & Chardon 1994). In Slovenia, as many as 1500 road-kill hotspots, where large numbers of amphibians are being run-over annually, have been identified so far (Strašek 2012). Roads in Slovenia pose the greatest threat to the populations of the common toad (*Bufo bufo*) and common frog (*Rana temporaria*), which belong into the group of so-called »explosive breeders«, where almost all sexually mature individuals migrate to their spawning site simultaneously (Poboljšaj et al. 2018).

In order to protect the migrating amphibians from being run-over, an action of transporting amphibians over the road has been conducted along Vinogradniška pot at Razvanje near Maribor (NE Slovenia) since 2018, however, systematic data on migrating amphibians were only gathered in 2019, 2020, 2021 and 2024. Here, we would like to present the data gathered during those years, since, to our knowledge, this road-kill hotspot has not been registered yet.

MATERIAL AND METHODS

Amphibians were surveyed during spring migration rescue activity along the road Vinogradniška pot at Razvanje, about 2 km southwest of Maribor (NE Slovenia). The surveyed path consisted of an 800 m long road segment in all years and an additional 600 m long segment since 2020 (Fig. 1). The latter ran parallel to the first one and was added mainly to reduce amphibian mortality along that road. Coordinates of the amphibian spawning site are: 46°31'02.8"N, 15°37'45.9"E. The road is asphalted, 3 m wide and located in an urbanised area. The pond in which amphibians spawn is surrounded by vineyards, intensively farmed meadows and mixed forests. Meadows east of the pond are ploughed in certain years for the purpose of maize production.

Amphibian surveys were conducted in 2019, 2020, 2021 and 2024. The annual fieldwork started when the first amphibians were spotted on the road and ended when no more amphibians were found for at least three consecutive evenings. During that time, surveys were conducted every evening, except for three in 2019 and two in 2024. Hence, the annual surveys lasted approximately as long as the spring migration itself. Their starting and ending dates are presented in Tab. 1 and

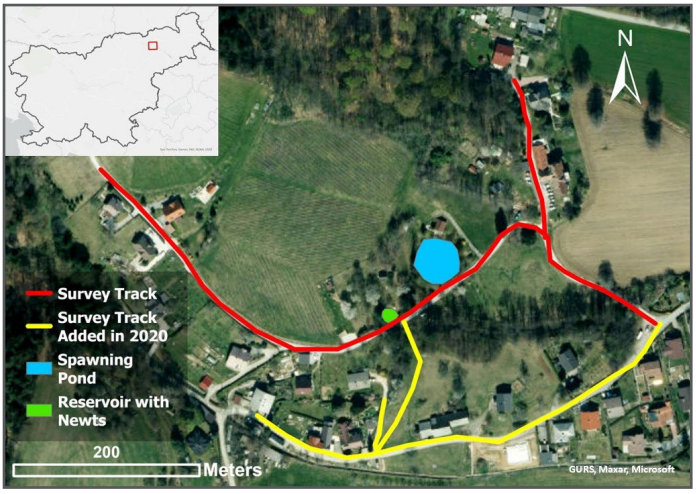

Figure 1. Survey track with the pond that serves as the spawning site for Anurans. Italian crested newts (*Triturus carnifex*) spawn in a smaller water reservoir southwest of the pond.
Slika 1. Popisna pot z ribnikom kot mrestiščem za žabe in krastače. Veliki pupki (*Triturus carnifex*) mrestijo v manjšem vodnem zajetju jugozahodno od ribnika.

individual survey dates are listed in the supplementary material (Tab. S1). Evening fieldwork began at 7:30 pm (8:30 pm when daylight savings changed) and ended after the entire survey path was walked twice. The minimum amount of time spent in the field was set at one hour, but the survey time varied depending on the number of migrating individuals and could last up to 2.5 h. In 2019, the time of the beginning was not consistent and the path was only walked once. In 2020, a third walk was sometimes carried out, however, the data from that one were not used in any analysis except in comparison between the number of individuals found during different walks.

Table 1. Beginning and ending dates of amphibian surveys during the amphibian spring migration over the road at Razvanje (NE Slovenia), according to a specific study year.
Tabela 1. Začetni in končni datum popisov dvoživk med spomladansko selitvijo čez cesto v Razvanju (SV Slovenija), glede na popisno leto.

Study Year	Beginning Date	Ending Date
2019	5. 3.	30. 3.
2020	1. 3.	1. 4.
2021	12. 3.	5. 4.
2024	25. 2.	14. 3.

Every evening, the exact time of the start and end of the survey were noted, together with the weather conditions and air temperature. The latter was measured on site, using a stationary wet-bulb thermometer, positioned at approximately 1 m above ground. Amphibians were searched for using a headlamp, over the whole width of the road, as well as within about 1 m distance from each side of the road. Detected individuals were carried to the spawning pond and counted separately by sex and species and ran-over individuals were also counted separately by sex and species, according to Veenvliet & Veenvliet (2003). Due to their known aggressive mating behaviour, male *B. bufo* were transported in a separate bucket from females and amplexi, and other species in a separate bucket from *B. bufo* to prevent them from being harmed by toxins produced by the toads (Kowalski et al. 2018; Bolčina et al. 2021). No pro-

tective fence for amphibians was used during any of the study years.

Shapiro-Wilk test showed that the distribution of the number of found living individuals during every successive evening walk deviated significantly from normality for the first walk ($W = 0.692$, $p < 0.001$), the second walk ($W = 0.634$, $p < 0.001$) and for the third walk ($W = 0.667$, $p < 0.001$). Hence a non-parametric Kruskal-Wallis test with a post-hoc Dunn's test was used to find out whether the difference in the number of found living individuals between every successive evening walk was statistically significant. Spearman's correlation coefficient was calculated between the average evening air temperature and the number of all living individuals of amphibians observed in a single evening. Only alive individuals were used in the analysis, since the dead ones could have been run-over the night before. Spearman's correlation was chosen, since the data on the number individuals was again not following the normal distribution according to the Shapiro-Wilk test ($W = 0.710$, $p < 0.001$). Using the same data set, a linear regression analysis was conducted between the number of all living individuals of amphibians observed in a single evening and the evening air temperature. In order to obtain the proportion of variance explained, the value of R2 was calculated.

RESULTS AND DISCUSSION

During the census years, four amphibian species were found migrating over the road, specifically the common toad (*Bufo bufo*), common frog (*Rana temporaria*), agile frog (*R. dalmatina*) and Italian crested newt (*Triturus carnifex*) (Tab. 2). *B. bufo* greatly outnumbered the other three species and represented around 99% of individuals of all species of migrating amphibians. Including past observations, there have been five findings of migrating *T. carnifex*, specifically a living female and a dead male in 2018, a dead female in 2020 and two living males in 2021. *T. carnifex* were deliberately searched for in the pond where Anurans spawn, using a single Ortmann's funnel trap, baited with beef (Drechsler & Bock 2010). The trap was moved around the pond during the last week of July in 2020, so as to remain at a single location for one day and one night. Despite the effort newts were never found, until a smaller water reservoir with lush vegetation was discovered west of the pond. Since most individual newts were also found migrating along that path, it is assumed that they spawn in that particular reservoir, rather than in the larger pond (Fig. 1). The reservoir also went dry in the summer of 2024. One of the reasons why newts were not found by the original search, however, might also have been that July is already a bit late in the season for censusing that species (Mazej Grudnik & Triglav Brežnik 2015). In the summer evenings, the European tree frog (*Hyla arborea*) can be heard singing by the pond and the fire salamander (*Salamandra salamandra*) also occurs in the nearby forests.

The study area is evidently important for *B. bufo*, where between 500–1000 individuals migrate over the road every year (Tab. 2). However, our survey does present several limitations. Unfortunately, the counts are not very comparable over the years, since only in 2020 and 2021 the surveys were carried out every evening during the migration and the two days when the census was not conducted in 2024 could have been crucial, since those were the two days when the migration might have reached its peak. In 2019, only the northern road segment was surveyed and the shorter, parallel southern segment was only added in 2020. In 2019, the time of the beginning of the surveys was also variable and only one walk was conducted every evening. Furthermore, the annual fluctuations in amphibian population sizes have to be taken into account. Mavrič et al.

Table 2. Number of individuals of different amphibian species migrating over a road towards the spawning pond during spring migration at Razvanje (NE Slovenia) (according to sex and survival) between study years.
Tabela 2. Število osebkov različnih vrst dvoživk med spomladansko selitvijo čez cesto v Razvanju (SV Slovenija) na poti v ribnik, kjer mrestijo, ločeno glede na spol in glede na to, ali so bili najdeni živi ali povoženi med različnimi leti popisov.

Species	Male	Female	Male Dead	Female Dead	Total
		Year 2019			
B. bufo	790	67	71	9	937
R. temporaria	3	1	0	0	4
R. dalmatina	3	2	0	0	5
T. carnifex	0	0	0	0	0
		Year 2020			
B. bufo	1059	166	66	10	1301
R. temporaria	1	5	0	0	6
R. dalmatina	5	3	0	1	9
T. carnifex	0	0	0	1	1
		Year 2021			
B. bufo	407	97	17	8	529
R. temporaria	2	5	0	0	7
R. dalmatina	2	0	1	0	3
T. carnifex	2	0	0	0	2
		Year 2024			
B. bufo	424	46	31	2	503
R. temporaria	4	4	1	1	10
R. dalmatina	1	0	0	0	1
T. carnifex	0	0	0	0	0

(2019) report that in Ljubljana, *B. bufo* numbers during spring migration follow a three-year cycle pattern. The number of migrating individuals is also most likely an underestimation since, due to the absence of the protective fence, several individuals most likely crossed the road unnoticed. Nevertheless, the results show that numbers of migrating individuals are comparable or even higher than in some well-known road-kill hotspots in Slovenia, such as Zaton-Petanjci (Gorički & Strah 2021), yet species diversity is much higher there than at Razvanje. The reason for such large dominance of *B. bufo*, besides them being explosive breeders, could also have been the presence of fish in the spawning pond, which pose a greater threat to other amphibian species. *B. bufo* tadpoles contain toxins that avert fish predation (Manteifel & Reshetnikov 2002; Bókony et al. 2016).

The sex structure in the population of *B. bufo* shows a large surplus of males over females (between 4–12:1), concordant with observations at other road-kill hotspots (Stanković et al. 2010; Bolčina et al. 2021). Mortality rate of *B. bufo* was not very high (between 5% and 12%), considering no protective fence, which is often implemented at road-kill hotspot surveys (e.g. Bolčina et al. 2021). Relatively low mortality can also be attributed to low amounts of overall traffic and curfew during covid pandemic in 2021. Mortality, however, could still have been reduced by placing the protective fence for amphibians during the time of migration or at least by a traffic sign that would alert the drivers about the presence of amphibians on the road during spring migration.

Migration pattern of *B. bufo* varied between years (Fig. 2). In 2019, migration lasted for 26 days and had two distinctive peaks both during migration towards and from the pond. Next year, it lasted for 21 days with one distinctive peak and another smaller one when individuals were returning. In the following year, the migration was repeatedly interrupted by low temperatures, as the first amphibians were spotted already on the 24th of February and the migration was again interrupted by low temperatures and snow between the 15th and 24th of March. In 2024, the migration lasted for 16 days, however, the peak was most likely missed.

It has been suggested that during migration amphibians show highest activity at dusk, during the first hours of night (Sinsch 1989). With every successive walk in 2020 and 2024, a generally lower number of amphibian individuals were found (Fig. 3), and according to the Kruskal-Wallis Test, the difference was statistically significant ($\chi 2(2) = 13.03$, $p = 0.001$). A post-hoc Dunn's test, performed with a Bonferroni-corrected alpha level of 0.025 revealed a statistically significant difference between the first and the second walks ($Z = 3.40$, $p = 0.0003$), as well as the first and third walks ($Z = 2.13$, $p = 0.017$). Differences between the second and third walks were not statistically significant ($Z = 0.22$, $p = 0.414$). However, as the third walk was carried out only nine times, it is hard to distinguish whether such a result represents a genuine effect or it is just an artefact of a low number of replicates. The reason for the decline in amphibian activity through the night could have been the decline in temperature. According to the Spearman's correlation coefficient, there has been a moderate positive correlation between the air temperature and the number of amphibian individuals, which was statistically significant ($\rho(87) = 0.66$, $p = 2.03*10^{-12}$). Linear regression, however, explained only 23% of the variance in the data ($R^2 = 0.23$) (Fig. 4).

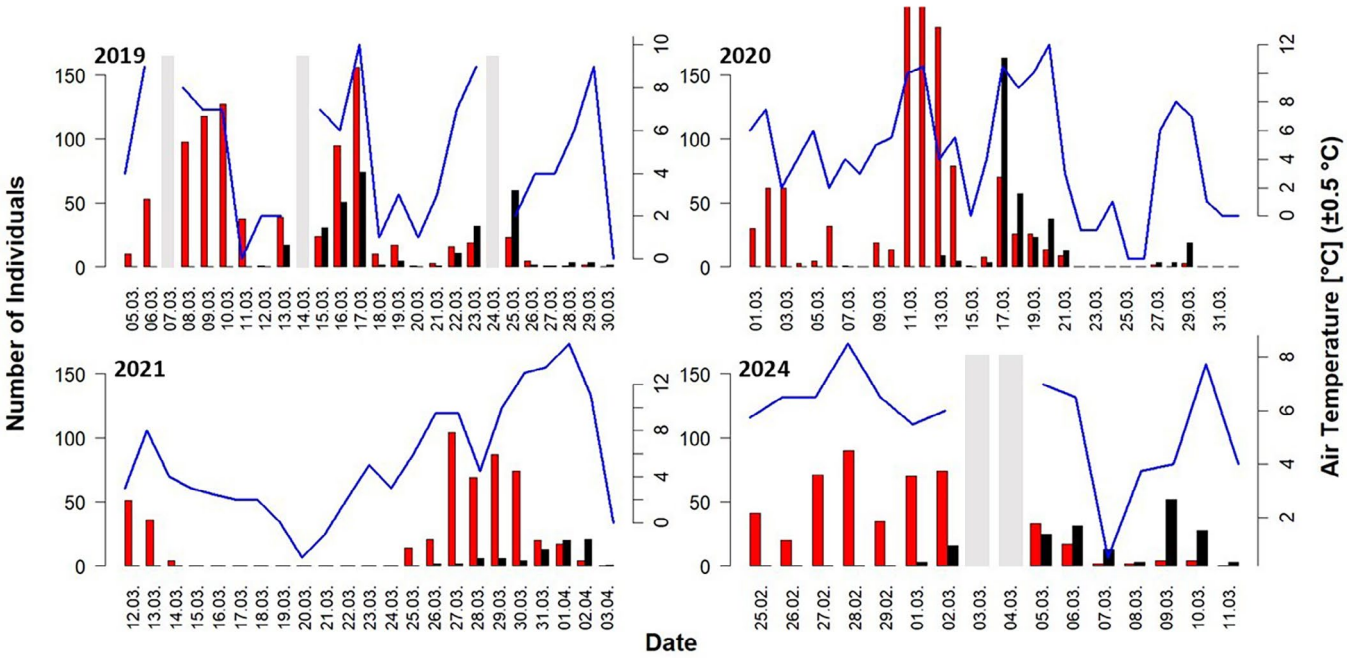

Figure 2. Common toad (*B. bufo*) migration pattern during spring migration over a road at Razvanje (NE Slovenia) in 2019 (top left), 2020 (top right), 2021 (bottom left) and 2024 (bottom right). Blue line represents the air temperature (measured on site, 1 m above ground), red bars are individuals on the way into the spawning pond and black bars represent individuals returning back from the spawning pond. Shaded are days when the survey was not carried out.

Slika 2. Selitveni vzorec navadne krastače (*B. bufo*) med spomladansko selitvijo čez cesto v Razvanju (SV Slovenija) v letih 2019 (zgoraj levo), 2020 (zgoraj desno), 2021 (spodaj levo) in 2024 (spodaj desno). Modra črta ponazarja temperature zraka (merjene na lokaciji, 1 m nad tlemi), rdeči stolpci so osebki na poti v ribnik, ki služi kot mrestišče, črni stolpci pa ponazarjajo osebke na vračanju iz ribnika. Osenčeni so dnevi, ko popis ni bil opravljen.

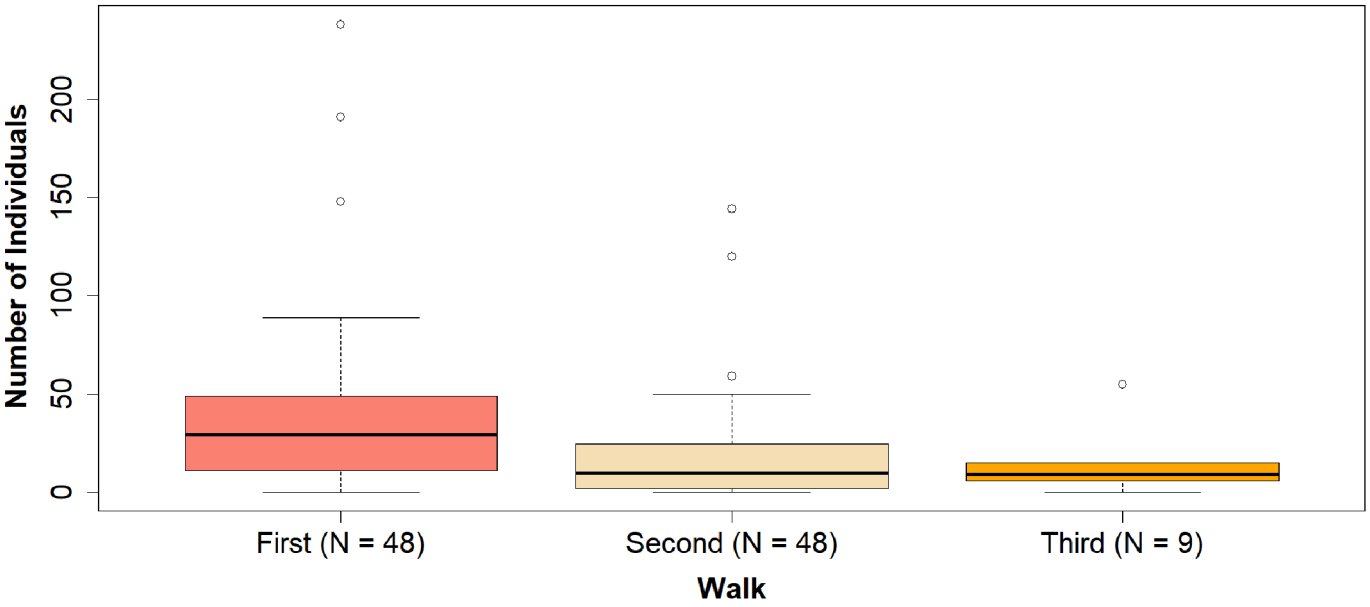

Figure 3. Descriptive statistic of the number of found living individuals of amphibians per consecutive transect walk within a single evening. Line represents the mean, the box is interquartile range, whiskers are maxima and minima and dots are outliers. N = the number of walks included in the data set, out of 69 survey evenings. Only data from evenings in which at least one individual was found were included. Censuses were carried out during spring migration over a road at Razvanje (NE Slovenia) in 2020, 2021 and 2024. Data from censuses from the year 2019 were not included as only one walk was carried out at that time and survey times were not consistent.
Slika 3. Vrednosti opisne statistike števila najdenih živih osebkov dvoživk med zaporednimi obhodi transekta znotraj istih večerov. Vodoravna črta ponazarja povprečje, škatla je medkvartilni razpon in pike so izrazite vrednosti. N = število obhodov, vključenih v set podatkov od skupno 69 popisnih večerov. Vključeni so samo podatki iz večerov, ko je bil najden vsaj en osebek. Popisi so bili opravljeni med spomladansko selitvijo dvoživk čez cesto v Razvanju (SV Slovenija) v letih 2020, 2021 in 2024. Podatki iz popisov iz leta 2019 niso vključeni, ker je bil takrat opravljen le en obhod in čas začetka ni bil konsistenten.

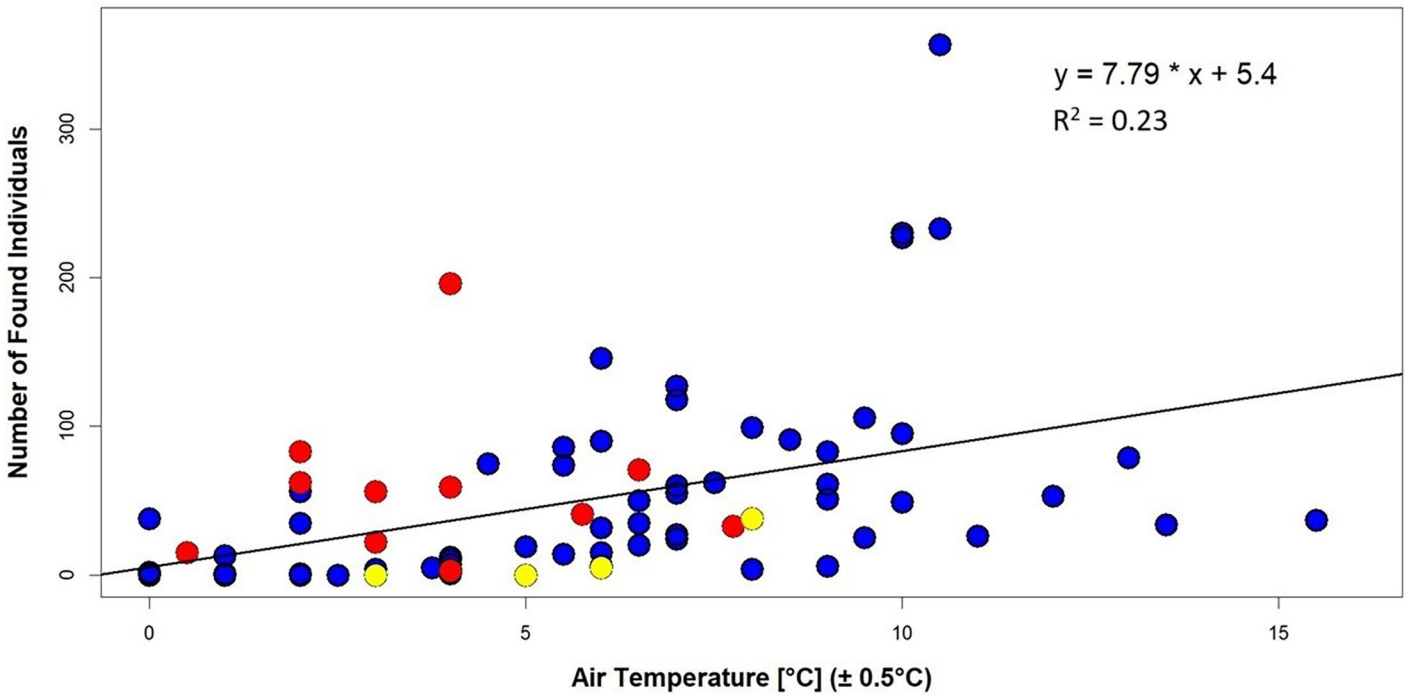

Figure 4. Linear regression of the number of all amphibian individuals found alive during spring migration over a road at Razvanje (NE Slovenia) in 2019, 2020, 2021 and 2024, and the average air temperature (measured on site, 1 m above ground) in a certain survey evening. Red dots represent rainy evenings and yellow dots represent windy evenings.
Slika 4. Linearna regresija med številom vseh živih osebkov dvoživk, najdenih med spomladansko selitvijo čez cesto v Razvanju (SV Slovenija) v letih 2019, 2020, 2021 in 2024, ter povprečno temperaturo zraka (merjeno na lokaciji, 1 m nad tlemi) v določenem popisnem večeru. Rdeče pike ponazarjajo deževne večere, rumene pike pa vetrovne večere.

As a part of the Interreg project »Varstvo dvoživk in netopirjev v regiji Alpe-Jadran«, criteria for classifying road segments as potential road-kill hotspots, have been established. They have been partially adopted from the Austrian Ministry of Transport Infrastructure (RVS 3.04 Amphibienschutz an Straßen) and adjusted to the conditions in Slovenia (Poboljšaj et al. 2018). According to the criteria, the most critical road segments are prioritised according to the number of migrating individuals of amphibians, the number of species and how endangered those are (Poboljšaj et al. 2018). According to the number of individuals, the road segment at Vinogradniška pot belongs into the fourth category (between 1,000 and 3,000) and according to the number of species into the second category (with four species present). In regard to how endangered those species are, the road segment would fall into the first category, since all the species found are listed as vulnerable on the red list (Ur. l. RS 2002). Furthermore, *R. dalmatina* is listed in the Annex IV and *T. carnifex*, is listed both in the Annex II and IV of the Habitats Directive (OJ EC 1992). It has also been suggested that the presence of *T. carnifex* would place the segment into an additional first category, since it is considered one of the most endangered amphibian species in Slovenia (Cipot et al. 2011; Poboljšaj et al. 2018). A road segment is classified as a road-kill hotspot if it belongs into the first category according to any of the three criteria, or if it falls into any of the first four categories according to the number of migrating individuals (Poboljšaj et al. 2018). Thus, the road segment at Vinogradniška pot classifies as a road-kill hotspot. Lastly, the road-kill hotspots that are shorter than 10 km are recognised as the 10% most critical ones (Poboljšaj et al. 2018). The segment at Vinogradniška pot, with its length of about 1.4 km, would also satisfy this criterion.

Our results indicate the importance of monitoring spring migration of amphibians over low-traffic roads, which are often overlooked. Nonetheless, populations of amphibians with significant sizes can be under threat also along low-traffic roads, such as at Razvanje, where between 500–1000 individuals of *B. bufo* migrate to their spawning site every year. Even though the percentage of individuals killed on the road was relatively low, the absolute number of killed individuals is still fairly high, due to the sheer number of migrating individuals; mortality is probably much higher in years when the action is not carried out (due to anti-mortality methodology). The location is also important because of the occurrence of other three amphibian species, which are listed as vulnerable in Slovenia (Ur. l. RS 2002), and especially *T. carnifex*, which is one of the most endangered amphibian species in Slovenia (Cipot et al. 2011; Poboljšaj et al. 2018). The road-kill hotspot satisfies the criteria for a critical road-kill hotspot (Poboljšaj et al. 2018). Unfortunately, no traffic sign has been placed so far at the segment that would alert the drivers of the presence of amphibians during their spring migration.

POVZETEK

Zaradi degradacije in fragmentacije njihovega habitata ima lahko gradnja cestne infrastrukture hude posledice za populacije dvoživk (Rytwinski & Fahring 2012). V Sloveniji je bilo do sedaj registriranih več kot 1500 odsekov cest, kjer prihaja do množičnih povozov dvoživk (t.i. črnih točk) (Strašek 2012), ti pa najhuje prizadenejo populacije navadnih krastač (*Bufo bufo*) in sekulj (*Rana temporaria*) (Poboljšaj et al. 2018). V tem prispevku predstavljamo prve podatke o črni točki na Vinogradniški poti v Razvanju (SV Slovenija), ki po našem vedenju še ni bila registrirana kot črna točka.

Seleče se dvoživke smo prenašali čez cesto in šteli ločeno glede na vrsto in spol na 800 m dolgem odseku na Vinogradniški poti v letih 2019, 2020, 2021 in 2024. Od leta 2020 smo pregledovali še dodaten 600 m dolg vzporedni odsek ceste (Sl. 1). Datumsko smo s popisi začeli, ko so bili na cesti opaženi prvi osebki dvoživk, ter zaključili, ko vsaj tri dni zapored na cesti nismo našli več nobene dvoživke. S popisi smo začenjali vsak večer ob 19.30 in opravili dva obhoda, saj zaščitne ograje nismo uporabljali. V letu 2019 ura začetka ni bila konsistentna in vsak večer je bil opravljen le en obhod. Ob začetku in koncu vsakega popisa smo zabeležili še stanje vremena in temperaturo zraka (merjeno na lokaciji, 1 m nad tlemi). Samce navadnih krastač smo prenašali v ločenem vedru od samic in ampleksusov, krastače pa smo prav tako prenašali ločeno od rjavih žab. Izračunali smo Spearmanov korelacijski koeficient in napovedno moč linearne regresije med povprečno temperaturo zraka in številom najdenih osebkov dvoživk v določenem večeru.

Na lokaciji so se čez cesto selile štiri vrste dvoživk, in sicer navadna krastača (*Bufo bufo*), sekulja (*Rana temporaria*), rosnica (*R. dalmatina*) in veliki pupek (*Triturus carnifex*) (Tab. 2). Najštevilčnejša je bila navadna krastača z okoli 500–1000 osebki, selečimi se čez cesto na leto, kar je pomenilo 99 % osebkov vseh najdenih vrst. Samci so prevladovali v populaciji navadne krastače v razmerju 4–12:1, smrtnost osebkov pa je bila dokaj nizka (5–12 %), kar je delno posledica nizke prometnosti ceste in delno uspeha naših reševalnih akcij. Selitev navadne krastače je trajala med 12 in 24 dni, v letu 2021 pa je bila nekajkrat prekinjena zaradi nizkih temperatur (Sl. 2). Leta 2020 smo občasno opravili tudi tretji obhod, a je bilo število najdenih osebkov dvoživk glede na Kruskal-Wallisov test z vsakim obhodom statistično značilno nižje ($\chi 2(2) = 9{,}22$, $p = 0{,}010$) (Sl. 3). Ugotovljena je bila statistično značilna zmerna pozitivna korelacija med številom najdenih osebkov in povprečno temperaturo zraka ($\rho(87) = 0{,}63$, $p = 3{,}62*10^{-11}$). Napovedna moč linearne regresije je bila 23 % ($R^2 = 0{,}23$) (Sl. 4). Odsek ceste na Vinogradniški poti v Razvanju ustreza kriterijem za t.i. »kritično črno točko«, rezultati pa tako poudarijo pomen takšnih monitoringov tudi na manj prometnih cestah, ki so v podobnih raziskavah pogosto spregledane.

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SUPPLEMENTARY MATERIAL

Table S1. Individual amphibian survey dates per study year during amphibian spring migration over a road in Razvanje (NE Slovenia). The table is available as an online supplement at https://doi.org/10.14720/ns.19547.

Tabela S1. Posamezni datumi popisov dvoživk med spomladansko selitvijo čez cesto v Razvanju (SV Slovenija), glede na popisno leto. Tabela je dostopna kot spletni suplement na naslovu https://doi.org/10.14720/ns.19547.

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Rezultati popisa na študentskem biološkem taboru potrjujejo visoko vrstno bogastvo netopirjev (Chiroptera) v jugozahodni Sloveniji

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IZVLEČEK

Jugozahodna Slovenija je poznana po visokem vrstnem bogastvu netopirjev, saj leži na stiku med submediteranskim in dinarskim svetom. Izraziti prehodi med biogeografskimi enotami se kažejo tudi v raznolikosti življenjskih okolij, kar ustreza številnim vrstam. Med 17. in 23. julijem 2022 smo v okviru študentskega biološkega raziskovalnega tabora Biocamp 011 na širšem območju Pivke popisovali netopirje s ciljem, da pregledamo čim več možnih najdišč in prispevamo k poznavanju netopirjev te regije. Podnevi smo netopirje popisovali v zatočiščih, ponoči pa smo jih lovili v mreže, kar smo občasno nadgradili s spremljanjem eholokacijskih klicev. Popisali smo 23 vrst netopirjev, vključujoč nekatere varstveno zanimivejše. Zaznali smo sedem kotišč *Rhinolophus hipposideros* ter eno kotišče *Myotis brandtii*. Slednje je bilo sicer poznano že od prej, vendar smo v času našega obiska zabeležili bistveno večje število živali kot v prehodnih raziskavah. Prav tako smo več kot podvojili število do sedaj ujetih *Nyctalus lasiopterus* v Sloveniji. Precejšen uspeh mreženj je verjetno posledica izredno sušnega poletja, ki je netopirje prisililo k zbiranju ob še obstoječih vodah. Visoko število zabeleženih vrst, ki ga lahko pripišemo tudi visoki prostorski raznovrstnosti z opaznimi prehodi med različnimi življenjskimi okolji, ponovno potrjuje visoko bogastvo netopirjev v JZ Sloveniji. Zaključujemo, da je smiselno nadaljevati s spremljanjem netopirjev na tem vrstno bogatem območju.

ABSTRACT

Survey results from a students' biological camp reaffirm high species richness of bats (Chiroptera) in South-western Slovenia

Southwestern Slovenia is known for its high bat species richness, since it is located at the junction of the Submediterranean and Dinaric regions. Sharp transitions between biogeographic entities are also reflected in habitat diversity, which in turn suits multiple species. Between 17th and 23rd July 2022, we surveyed bats in a wider region surrounding Pivka as part of the students' biological research camp Biocamp 011. Our goal was to visit as many potential bat sites as possible and to contribute to the knowledge of bats in the region. During the day, we surveyed bats at their roosts, while during the night we utilised the mist-netting method. Occasionally, the latter was upgraded with detecting bat echolocation calls. We detected 23 bat species, including some of greater conservational interest. We recorded seven *Rhinolophus hipposideros* nurseries and one nursery of *Myotis brandtii*. The latter had already been known, however, during our visit we noted a marked increase in present individual count in comparison to previous research. We also more than doubled the number of caught *Nyctalus lasiopterus* for Slovenia. The high success when performing mist-nettings is likely due to the extreme drought in the summer of 2022, which forced bats to aggregate near still existing water bodies. High numbers of detected species, which can also be attributed to high spatial heterogeneity with marked transition between different habitats, reaffirm high bat species richness of SW Slovenia. We conclude that it is sensible to continue with bat surveys in this species rich area.

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UVOD

V Sloveniji po zadnjih podatkih živi 31 vrst netopirjev (Mammalia: Chiroptera) (Presetnik 2021; Josić et al. 2024). Večino vrst najdemo tudi v jugozahodnem predelu države, kjer je teden dni v juliju 2022 potekal študentski raziskovalni tabor Biocamp 011 (v organizaciji Društva varstvenih biologov – Biodiva). Na taboru je delovala skupina za netopirje, ki je popisovala na Pivškem v okolici taborskega središča (Dolnja Košana). Tu so med drugim že potekali biološki raziskovalni tabori s sodelovanjem netopirske skupine (Zidar 2013; Presetnik 2014; Gojznikar 2022) ter druge terenske aktivnosti (npr. Presetnik et al. 2021a). Nekatera znana najdišča so tudi vključena v državni monitoring netopirjev (Presetnik et al. 2023). Podatkovna zbirka Centra za kartografijo favne in flore je do 20. 2. 2022 na območju v neposredni bližini navajala 25 vrst (CKFF 2022), zato bi lahko neposredno okolico tabora s stališča netopirjev opredelili kot razmeroma dobro raziskano. Tudi na širšem območju Postojne, Pivke in Ilirske Bistrice je bilo v preteklosti zabeleženo večje število vrst netopirjev. Medtem ko na toplejših in nižjih legah srečamo vrste, ki jih lahko opredelimo kot mediteranske, na primer dolgonogega (*Myotis capaccinii* (Bonaparte, 1837)) in dolgorepega netopirja (*Tadarida teniotis* (Rafinesque, 1814)) (npr. Presetnik et al. 2009; Presetnik & Šalamun 2019), lahko na višjih dinarskih pogorjih srečamo tudi vrste borealnega tipa, kot sta dvobarvni (*Vespertilio murinus* Linnaeus, 1758) in severni netopir (*Eptesicus nilssonii* (von Keyserling & Blasius, 1839)) (npr. Presetnik et al. 2013; Pavlovič et al. 2024). Visoko vrstno bogastvo netopirjev jugozahodne Slovenije se kaže tudi v lokalnih »vročih točkah«, med katerimi prednjačijo Škocjanske jame (Presetnik 2017), kjer je bilo na območju okoliškega Parka do sedaj zabeleženih kar 24 vrst netopirjev (Presetnik & Zamolo 2021a).

Za cilj popisa med taborom smo se odločili obiskati čim več različnih habitatov, upoštevajoč raznolikost pokrajine, in s tem prispevati k poznavanju netopirjev v tej vrstno bogati regiji. Rezultati našega dela so predstavljeni v tem prispevku.

MATERIALI IN METODE

Terensko delo je potekalo v okolici Pivke in Ilirske Bistrice v jugozahodni Sloveniji (Sl. 3) med 17. in 23. 7. 2022 v obdobju izredno sušnega vremena. Popisovali smo na širokem območju (40×30 km; med približno 400 in 1800 metri nadmorske višine). Raziskovalno območje s severa omejuje Postojnsko polje s porečjem Nanoščice, na vzhodu dinarsko-kraški planoti Javornikov in Snežnika, na jugu in jugozahodu Brkini ter na zahodu in severozahodu Slavinski Ravnik in planota Vremščice. V osrednjem delu dinarsko-kraško površje seka Pivško podolje z reko Pivko, v južnem pa ga v smeri od jugovzhoda proti severozahodu preči reka Reka. Območje leži na prehodu iz submediteranskega v dinarski svet. Nižavja, kjer prevladuje kmetijstvo s travniki, njivami in naselji ter občasne površinske vode, so v izrazitem kontrastu z višje ležečimi planotami z listopadnimi in mešanimi gozdovi, ki zaradi kraškega značaja premorejo le redke vode. Zlasti na višjih legah planote Javornikov in Snežnika najdemo tudi združbe (sub)alpinskega značaja (npr. Surina & Rakaj 2007). Ogrin (1996) podnebje na zahodnih predelih območja opredeljuje kot zaledno submediteransko, v osrednjem delu kot zmerno kontinentalno, na vrhovih Javornikov in Snežnika pa kot podnebje nižjega gorskega sveta.

Mesta popisov smo izbirali na podlagi lastnih izkušenj, nekaterih literaturnih virov (npr. Presetnik et al. 2009; Presetnik 2014; Pavlovič et al. 2020; Gojznikar 2022) in izpisa iz podatkovne zbirke Centra za kartografijo favne in flore (CKFF 2022). Podnevi smo pregledovali zatočišča, kjer smo si pomagali s svetilkami, živali pa smo občasno ujeli z ročnimi mrežami. V stavbe, ki niso bile zapuščene, smo vstopali le ob izrecnem dovoljenju upravljalcev ali lastnikov, sicer smo opravili le zunanji pregled. Ponoči smo netopirje popisovali z metodo lova v mreže (Kunz & Kurta 1988), pri čemer smo na preletnih koridorjih v višino 3–5 metrov razpeli tanke najlonske mreže. Vsem živalim, ujetim tako med pregledom zatočišč kot v mreže, smo izmerili dolžino podlakti in nekatere druge dolžine, jih stehtali in ugotavljali vrsto s pomočjo določevalnih ključev v Dietz et al. (2009) ter Dietz & Kiefer (2016). S pomočjo priročnika Haarsma (2008) smo opredelili tudi njihove spolne in starostne znake. Netopirje smo nepoškodovane izpustili na mestu ulova oz. jih vrnili v zatočišče. Terensko delo je potekalo v skladu z dovoljenjema Ministrstva za okolje in prostor št. 35606-55/2022-2550-4 in 35601-59/2020-6.

Ponoči smo netopirje popisovali tudi s pomočjo ultrazvočnih detektorjev. Uporabili smo heterodine detektorje (modela D200 in D240x, Pettersson Elektronik), občasno pa smo eholokacijske klice tudi posneli z desetkratno upočasnitvijo časa. V ta namen smo detektor D240x (Pettersson Elektronik) povezali s snemalnikom DR-100MKIII (TASCAM). Snemali smo bodisi peš ali iz stoječega vozila. Posnetke smo analizirali s programom BatSound 4.7 (Pettersson Elektronik), upoštevajoč značilnosti posnetih klicev, kot sta na primer struktura klica in njegove frekvenčne ter časovne lastnosti. Za določitev posameznih taksonov eholokacijskih klicev smo si pomagali s priročniki Dietz & Kiefer (2016), Barataud (2020) in Russ (2021).

REZULTATI

V šestih terenskih dneh smo zabeležili 23 različnih vrst netopirjev. Pri veliki večini (21) smo zabeležili tudi znake razmnoževanja tako pri samcih kot samicah (Tab. 1). Pri slednjih je posebej izstopala samica *N. noctula* (Sl. 1), ki je dojila v tekočem koledarskem letu.

Obiskali smo 133 različnih lokacij, od teh pa smo netopirje ali njihove sledi zabeležili na 61 lokacijah (Tab. 2, Sl. 3). Na sedmih najdiščih smo zabeležili porodniške skupine *R. hipposideros,* na enem pa porodniško skupino *M. brandtii*. Zabeležili smo tudi samico *P. auritus* z neobičajno pigmentiranim predelom hrbtnega kožuha (Sl. 2).

Tabela 1. Vrste netopirjev, ki smo jih zabeležili med popisi v sklopu Biocamp 011. Okrajšave pomenijo: **N –** število najdišč; **Znaki razmnoževanja:** F-LP – laktirajoče samice ali samice, ki so v tekočem letu že dojile, M-ET – samci z nabreklimi modi in obmodki, JUV – mlade živali; **RS –** opredelitev vrste na Rdečem seznamu ogroženih rastlinskih in živalskih vrst v Sloveniji (Ur. l. RS 2002): E – prizadeta vrsta, V – ranljiva vrsta, O1 – vrsta zunaj nevarnosti, R – redka vrsta, K – premalo znana vrsta; **HD –** uvrščenost na Prilogo II Direktive o habitatih (vse slovenske vrste netopirjev so uvrščene tudi na Prilogo IV; Ur. l. ES 1992)

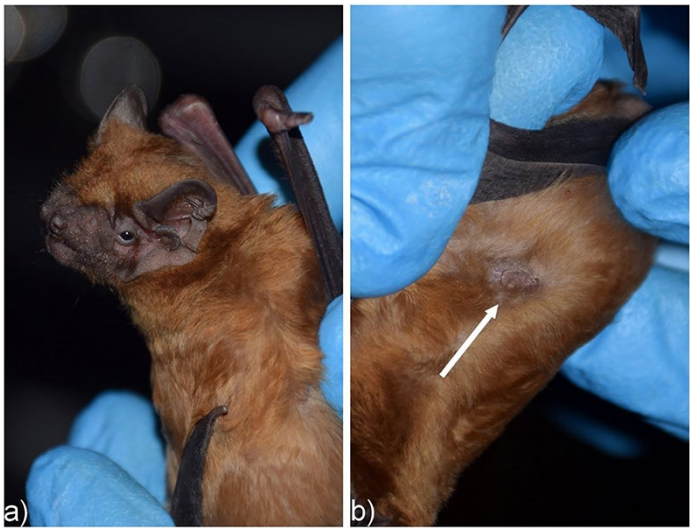
Table 1. Bat species detected while surveying during Biocamp 011. Abbreviations refer to: **N –** number of observations; **Signs of reproduction:** F-LP – lactating or parous females, M-ET – males with swelled testes or epidydimes, JUV – juvenile individuals; **RS –** species categorisation on the Slovene Red list of endangered plant and animal species (Ur. l. RS 2022), E – endangered species, V – vulnerable species, O1 – non-threatened/recovered species, R – rare species, K – data deficient species; **HD –** listing of the species on Annex II of the EU's Habitats Directive (all Slovene bat species are also listed on Annex IV; Ur. l. ES 1992).

Vrsta / Species	N	Opaženi znaki razmnoževanja / Observed signs of reproduction	RS	HD
mali podkovnjak – *Rhinolophus hipposideros* (André, 1797)	15	F-LP, M-ET, JUV	E	II
veliki podkovnjak – *Rhinolophus ferrumequinum* (Schreber, 1774)	2	–	E	II
navadni netopir – *Myotis myotis* (Borkhausen, 1797)	4	F-LP, M-ET	E	II
ostrouhi netopir – *Myotis blythii* Tomes, 1857	1	M-ET	E	II
velikouhi netopir – *Myotis bechsteinii* (Kuhl, 1817)	1	M-ET	E	II
resasti netopir – *Myotis nattereri* (Kuhl, 1817)	3	F-LP, M-ET	V	–
vejicati netopir – *Myotis emarginatus* (E. Geoffroy, 1806)	9	F-LP, M-ET	V	II
brkati / brkonosi netopir – *Myotis mystacinus* (Kuhl, 1817) / *Myotis davidii* (Peters, 1869)	8	F-LP, M-ET, JUV	O1 / –	–
Brandtov netopir – *Myotis brandtii* (Eversmann, 1845)	2	F-LP, JUV	R	–
dolgonogi netopir – *Myotis capaccinii* (Bonaparte, 1837)	2	F-LP, JUV	E	II
obvodni netopir – *Myotis daubentonii* (Kuhl, 1817)	5	M-ET	O1	–
mali netopir – *Pipistrellus pipistrellus* (Schreber, 1774)	5	M-ET, JUV	O1	–
drobni netopir – *Pipistrellus pygmaeus* (Leach, 1825)	3	M-ET	K	–
belorobi netopir – *Pipistrellus kuhlii* (Kuhl, 1817)	1	F-LP	O1	–
Savijev netopir – *Hypsugo savii* (Bonaparte, 1837)	4	M-ET	O1	–
pozni netopir – *Eptesicus serotinus* (Schreber, 1774)	3	M-ET	O1	–
veliki mračnik – *Nyctalus lasiopterus* (Schreber, 1780)	2	M-ET	K	–
navadni mračnik – *Nyctalus noctula* (Schreber, 1774)	1	F-LP (Sl. 1)	O1	–
gozdni mračnik – *Nyctalus leisleri* (Kuhl, 1817)	2	M-ET	V	–
dvobarvni netopir – *Vespertilio murinus* Linnaeus, 1758		M-ET	V	–
rjavi uhati netopir – *Plecotus auritus* (Linnaeus, 1758)	4	F-LP, M-ET, JUV	V	–
širokouhi netopir – *Barbastella barbastellus* (Schreber, 1774)	5	F-LP, M-ET, JUV	V	II
dolgokrili netopir – *Miniopterus schreibersii* (Kuhl, 1817)	1	–	E	II

RAZPRAVA

Med terenskim delom smo zabeležili 23 vrst netopirjev, kar je več kot dve tretjini (~74,2 %) vrst, živečih na območju Slovenije. Dve kotišči *R. hipposideros* do sedaj še nista bili poznani, pri drugih pa smo potrdili predhodna opažanja (CKFF 2022; Pavlovič et al. 2020; Gojznikar 2022). Visoko število najdišč *R. hipposideros* je verjetno posledica metode terenskega dela, saj gre za lahko opazno vrsto, ki za zatočišča pogosto izbira stavbe (Presetnik & Zamolo 2021b), ki smo jih načrtno pregledovali. Posledično smo tudi večkrat našli nekatere druge vrste, kot so npr. *M. emarginatus*, *M. mystacinus*/*davidii* in *P. pipistrellus,* ki redno uporabljajo zunanje opaže gozdnih koč na območju Javornikov in Snežnika (npr. Pavlovič et al. 2020; Gojznikar 2022). Povsem možno sicer je, da smo med terenskim delom dejansko srečali še kakšno vrsto več. V času raziskovanja namreč še ni bilo mogoče razlikovati med *M. mystacinus* in *M. davidii*. *M. davidii* je bil na območju Slovenije potrjen v zadnjem desetletju (Çoraman et al. 2020; glej tudi Presetnik 2021), pri čemer do nedavnega nismo poznali dobrih morfoloških znakov za njegovo razlikovanje od *M. mystacinus* (Milchram et al. 2023). Naš seznam vrst tudi sicer ni popoln, saj se na popisnem območju pojavljajo tudi druge nezabeležene vrste, kot sta na primer usnjebradi uhati (*Plecotus macrobullaris* (Kuzjakin, 1965)) in nimfni netopir (*Myotis alcathoe* von Helversen & Heller, 2001) (Presetnik & Zamolo 2021b; Presetnik et al. 2021b).

Na našem seznamu zbujajo pozornost tudi nekatere posamezne najdbe. Posebej je zanimivo ujetje samice *N. noctula* v zgornjem toku reke Reke, ki je zelo verjetno dojila v koledarskem letu 2022. V Sloveniji v poletnih mesecih srečujemo pretežno samce te vrste, razmnoževanje *N. noctula* pa je bilo nakazano šele v istem časovnem obdobju kot naša raziskava, ko so 20. julija 2022 ob reki Muri Presetnik et al. (2023) ujeli mlado samico. Naše ujetje dodatno nakazuje na možnost, da tudi v okolici zgornjega toka reke Reke obstaja porodniška gruča te vrste, ker pa nismo zabeležili aktivne laktacije, tega ne moremo povsem potrditi. Šlo bi namreč lahko tudi za samico, ki je (npr. zaradi izgube mladiča) že zapustila porodniško kolonijo.



Slika 1. Odrasla samica *N. noctula* (a), ujeta v zgornjem toku reke Reke (Tab. 2, ID = 1). Čeprav aktivne laktacije nismo zabeležili, pomanjkanje dlake v območju seska, nabreklost in razvlečenost seskov (b) nakazujeta, da je v letu 2022 dojila mladiča (foto: Jan Gojznikar).

Figure 1. An adult female of *N. noctula* (a) caught in the upper stream of the Reka River (Tab. 2, ID = 1). Although we didn't register active lactation, the lack of fur surrounding the nipple, swelling and nipple dilatation (b) indicate it had a pup in the year 2022 (photo: Jan Gojznikar).

Slika 2. Samica *P. auritus*, ujeta ob reki Reki (Tab. 2, ID = 1), s svetlim delom kožuha na temenu in vratu (foto: Rok Lobnik).

Figure 2. *P. auritus* female, caught along the Reka river (Tab. 2, ID = 1), with a bright fur patch on the top of the head and neck (photo: Rok Lobnik).

Tabela 2. Najdbe netopirjev med študentskim biološkim raziskovalnim taborom Biocamp 011. Okrajšave pomenijo:
ID – številke v stolpcu ustrezajo številkam ob točkah na Sl. 3; **Najdišče:** lat. – geografska širina (°N), long. – geografska dolžina (°E), nv (m) – nadmorska višina v metrih; **Najdbe:** krepka pisava – številčnost in spolna/starostna struktura potrjujeta pričujočnost porodniške kolonije, * – novo odkrita kotišča; **Starost/spol:** ad – odrasla žival, juv – mlada žival/mladič, F – samica, M – samec, un – osebek neznanega spola/starosti; **Met.** – metoda: M – mreženje, O – opazovanje, R – lov z roko/v ročne mreže, HD – določitev s heterodinim detektorjem, TE – določitev glede na posnetek z upočasnitvijo časa.

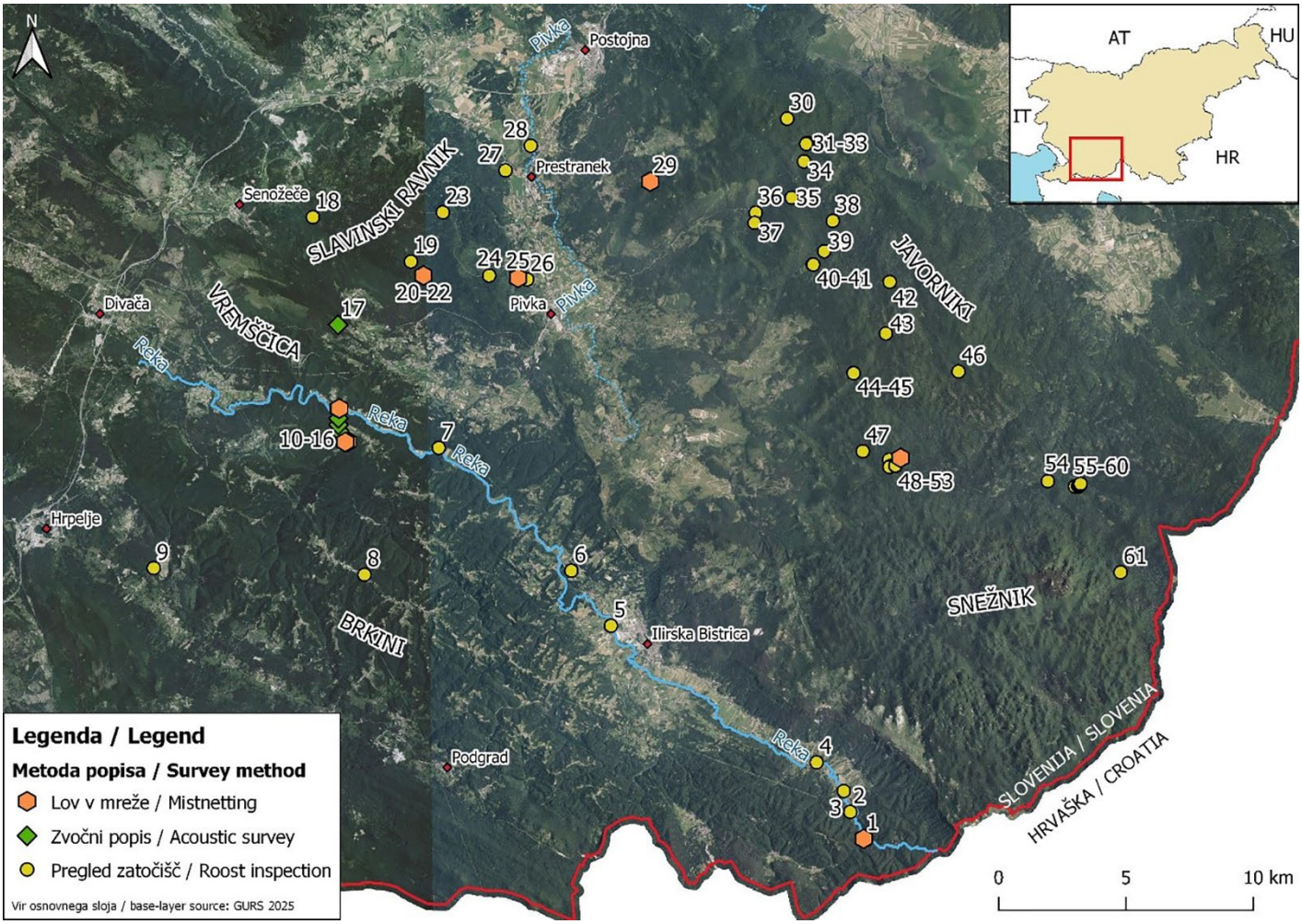
Table 2. Bat records made during students' biological research camp Biocamp 011. Abbreviations refer to:
ID – numbers correspond to point numbering in Fig. 3; **Site:** lat. – latitude (°N), long. – longitude (°E), a.s.l. (m) – altitude above sea level in metres; **Findings:** marked bold - presence of nursery groups, determined by the number and sexual/age structure of animals, * - newly discovered nurseries; Age/sex: ad – adult animal, juv – juvenile animal, F – female, M – male, un – individual of unknown sex/age; Met. – method: M – mist-netting, O – observation, R – capture by hand/with hand-nets, HD – determination by heterodyne detector, TE – determination by time-expansion recording

ID	Najdišče [lat., long., nv] / Site [WGS84 latitude & longitude, altitude]	Datum / Date	Najdba [število/spol, starost] / Finding [number/sex, age]	Met.
1	Reka Reka pri mostu 785 m JZ od vrha Šešnovice, Zabiče [45.498128, 14.352841, 470 m]	23. 7. 2022	*M. myotis* [4 ad M]	M
			M. bechsteinii [3 ad M]	M
			M. emarginatus [1 ad F]	M
			M. mystacinus/davidii [3 ad M, 1 ad F]	M
			M. daubentonii [3 ad M]	M
			P. pygmaeus [1 ad M]	M
			N. noctula [1 ad F]	M
			N. leisleri [3 ad M, 1 un]	M
			E. serotinus [1 ad M]	M
			P. auritus [1 ad F] – piebaldistična (Sl. 3)	M
			B. barbastellus [1 juv M]	M
2	Most čez Reko na cesti Zabiče - Jelšane, J od Zabič [45.507592, 14.34617, 450 m]	19. 7. 2022	*M. daubentonii* [1 un]	O
3	Most čez Reko na Z obrobju Zabič [45.514951, 14.342897, 442 m]	19. 7. 2022	*M. daubentonii* [2 un]	O
4	Most čez Reko pri Kuteževem [45.525008, 14.329244, 432 m]	19. 7. 2022	mala količina gvana male velikosti	O

ID	Najdišče [lat., long., nv] / Site [WGS84 latitude & longitude, altitude]	Datum / Date	Najdba [število/spol, starost] / Finding [number/sex, age]	Met.
5	Most čez Reko na cesti Ilirska Bistrica - Rečica, Ilirska Bistrica [45.573068, 14.226021, 402 m]	19. 7. 2022	Vespertilionidae [1 un]	O
6	Opuščena hiša pri potoku Podstenjšku ob glavni cesti na J Mereč [45.592429, 14.206131, 397 m]	19. 7. 2022	***R. hipposideros*** [3 ad F, 8 ad, 3 juv]	O
			Chiroptera [1 un]	O
			mala količina srednjega gvana	O
7	Opuščeno gospodarsko poslopje pri Ambrožičevem mlinu, Nova Sušica 37 [45.635566, 14.139546, 375 m]	22. 7. 2022	*R. hipposideros* [1 ad]	O
8	Cerkev sv. Mavra, Rjavče [45.591035, 14.102264, 758 m]	20. 7. 2022	mala količina gvana male velikosti	O
9	Kapelica Matere Božje na križišču ceste Brezovica – Rožice – Bač pri Materiji [45.593328, 13.996456, 543 m]	20. 7. 2022	mala količina gvana srednje velikosti	O
10	Okolica mostu čez Suhorico na cesti Kozjane – Buje [45.637754, 14.093928, 380 m]	20. 7. 2022	*P. kuhlii/nathusii* [1 un]	TE
			B. barbastellus [1 un]	TE
11	Sotočje Padeža in Suhorice [45.637607, 14.092641, 375 m]	20. 7. 2022	*R. ferrumequinum* [1 ad F]	M
			M. myotis [1 ad F]	M
			M. mystacinus/davidii [1 ad M]	M
			M. daubentonii [1 ad M]	M
			M. capaccinii [1 ad F]	M
			P. pygmaeus [1 ad M]	M
12	Okolica križišča ceste med Bujami, Suhorjem in Kozjanami [45.641533, 14.089556, 373 m]	20. 7. 2022	Chiroptera [1 un]	TE
13	Cesta med Suhorjem 1b in razcepom ceste Suhorje-Kozjane [45.643691, 14.089221, 372 m]	20. 7. 2022	*Hypsugo savii* [1 un]	TE
14	Okolica kmetije Suhorje 1b [45.645908, 14.089156, 369 m]	20. 7. 2022	*Pipistrellus kuhlii/nathusii* [2 un]	TE
			Hypsugo savii [1 un]	TE
			Pipistrellus/Miniopterus [1 un]	TE
			Vespertilionidae [1 un]	TE
15	Okolica mostu čez Reko v Bujah [45.649332, 14.089418, 365 m]	20. 7. 2022	*N. noctula/lasiopterus* [1 un]	HD
			Pipistrellus/Hypsugo [1 un]	TE
16	Reka Reka nad mostom v Bujah [45.649413, 14.089637, 360 m]	20. 7. 2022	*M. daubentonii* [2 ad M]	M
			M. capaccinii [4 ad F, 1 ad M, 8 juv M]	M
			P. pygmaeus [1 ad M]	M
17	Okolica zapuščenega kamnoloma c. 1 km SZ od Čepnega [45.678768, 14.089011, 620 m]	23. 7. 2022	*P. kuhlii/nathusii* [1 un]	TE
			B. barbastellus [1 un]	TE
18	Podzemna soba takoj V od koče 2,1 km JJZ od cerkve v Lažah, Senožeče [45.716495, 14.076349, 625 m]	23. 7. 2022	*R. hipposideros* [1 ad]	O
19	Osrednji objekt na Poligonu za uničevanje neeksplodiranih ubojnih sredstev Gornja Košana [45.700945, 14.12559, 582 m]	23. 7. 2022	mala količina gvana male velikosti	O
20	Košanski spodmol, Gornja Košana [45.69605, 14.13192, 579 m]	22. 7. 2022	*R. hipposideros* [2 ad F, 2 ad M]	M
			M. nattereri [1 ad M]	M
			M. emarginatus [2 ad M]	M
21	Lovska koča LD Košana, Gornja Košana [45.695993, 14.132241, 590 m]	22. 7. 2022	mala količina gvana male velikosti	O
		23. 7. 2022	*E. serotinus* [1 un]	
			mala količina gvana male velikosti	O
22	Pokrito kurišče S od Lovske koče Košana, Gornja Košana [45.696275, 14.132315, 587 m]	23. 7. 2022	mala količina gvana male velikosti	O
23	Lovska koča LD Prestranek, Koče [45.718162, 14.141645, 629 m]	23. 7. 2022	mala količina gvana male velikosti	O
24	Vikend koča 720 m JV od vrha Kravjeka, Selce [45.695999, 14.164872, 612 m]	23. 7. 2022	mala količina gvana male velikosti	O

ID	Najdišče [lat., long., nv] / Site [WGS84 latitude & longitude, altitude]	Datum / Date	Najdba [število/spol, starost] / Finding [number/sex, age]	Met.
25	Zajetje potoka Jarkovec, 370 m Z od cerkve sv. Trojice v Gradcu [45.695203, 14.17932, 571 m]	17. 7. 2022	*M. myotis* [1 ad M]	M
			M. mystacinus/davidii [1 ad F]	M
			P. kuhlii [1 ad F]	M
			H. savii [1 ad M]	M
			N. noctula/lasiopterus [1 un]	HD
			P. auritus [3 ad F, 1 juv F]	M
			M. schreibersii [2 ad F, 1 ad M]	M
26	Cerkev sv. Trojice, Gradec [45.694685, 14.184008, 584 m]	22. 7. 2022	***R. hipposideros*** [49 ad F, 11 ad, 56 juv, 2 un]	O
			M. blythii [1 ad M]	R
27	Grad Prestranek, Na Gradu 1 [45.732879, 14.173062, 546 m]	22. 7. 2022	***R. hipposideros*** [7 ad F, 9 juv, 2 un]	O
28	Mrliška vežica pri cerkvi v Matenji vasi [45.741552, 14.185737, 522 m]	22. 7. 2022	majhna količina gvana srednje velikosti	O
29	Betonska mlaka 700 m JV od hriba Bukov vrh, Žeje [45.72898, 14.245737, 621 m]	18. 7. 2022	*M. nattereri* [3 ad F, 1 ad M, 1 un]	M
			M. mystacinus/davidii [1 ad F]	M
			P. pipistrellus/pygmaeus [1 juv F]	M
			P. pipistrellus [1 un]	TE
			H. savii [1 ad M]	M
			N. lasiopterus [4 ad M]	M, TE
			P. auritus [6 ad F, 7 ad M]	M
			B. barbastellus [1 ad F, 2 ad M]	M
30	Vikend hiša Kožlek 1, 540 m JV od Debelega vrha [45.751005, 14.314448, 1174 m]	18. 7. 2022	*P. pipistrellus* [1 ad M]	R
31	Vikend hiša Trnje 78 [45.742368, 14.325166, 979 m]	18. 7. 2022	mala količina gvana srednje velikosti	O
32	Vikend hiša 50 m ZSZ od Trnje 78 [45.742405, 14.324278, 991 m]	18. 7. 2022	mala količina gvana male velikosti	O
33	Vikend hiša 50 m Z od Trnje 78 [45.742167, 14.324022, 985 m]	18. 7. 2022	srednja količina gvana male velikosti	O
34	Gozdarska hiša Debeli Kamen, Trnje 77, Trnje [45.736034, 14.322923, 880 m]	18. 7. 2022	*M. emarginatus* [1 un]	O
			srednja količina gvana male velikosti	O
35	Opuščena hiša Pri Janezu, 420 m JZ od hriba Bršljanovec, Trnje [45.723329, 14.316763, 844 m]	18. 7. 2022	*R. hipposideros* [1 un]	O
36	Vikend hiša Petelinjske luže, Trnje [45.718068, 14.298653, 720 m]	18. 7. 2022	mala količina gvana male velikosti	
37	Drvarnica J pri Lovskem domu LD Pivka, Trnje [45.714497, 14.298118, 741 m]	18. 7. 2022	***R. hipposideros*** [5 ad F, 5 juv]*	O
			Myotis sp. (mali) [1 un]	O
38	Kapelica pri Gozdarski hiši Nova hiša, Palčje [45.715186, 14.337362, 854 m]	18. 7. 2022	mala količina gvana male velikosti	O
39	Gozdarska hiša Stara hiša – Windischgraetzov dvorec, Palčje [45.704552, 14.333077, 816 m]	18. 7. 2022	***R. hipposideros*** [24 ad F, 7 ad, 26 juv]	O
			M. mystacinus/davidii [1 juv M]	R
40	Gozdarska koča Vrh Korena, Palčje 66 [45.699998, 14.327324, 882 m]	18. 7. 2022	*P. pipistrellus* [1 juv M]	R
			E. serotinus [1 ad M, 1 un]	R, O
			V. murinus [1 ad M]	R
			Vespertilionidae [1 un]	O
41	Spremljevalni objekt pri Gozdarski koči Vrh Korena, Palčje [45.699862, 14.327562, 882 m]	18. 7. 2022	*R. hipposideros* [1 ad]	O
42	Lovska koča Jelen, Jurjeva dolina, Juršče [45.69381, 14.365979, 931 m]	18. 7. 2022	*Myotis* sp. (mali) [vsaj 5 un]	O
43	Gozdarska hiša S od gozdarske hiše Stare Ogence, Juršče [45.675699, 14.364009, 1011 m]	18. 7. 2022	***M. brandtii*** [13 ad F, 7 juv F, 4 juv M, vsaj 50 un]	R, O
44	Gozdarska koča Blatna dolina, Bač [45.661896, 14.347715, 1007 m]	21. 7. 2022	***R. hipposideros*** [8 ad F, 6 ad, 14 juv]	O
			R. ferrumequinum [2 un]	O

ID	Najdišče [lat., long., nv] / Site [WGS84 latitude & longitude, altitude]	Datum / Date	Najdba [število/spol, starost] / Finding [number/sex, age]	Met.
45	Gozdna koča takoj J od Gozdarske koče Blatna dolina, Bač [45.661764, 14.347842, 1008 m]	21. 7. 2022	mala količina gvana male velikosti	O
46	Hiša na Vekslu, J od hiše Juršče 103, [45.662355, 14.400481, 1086 m]	18. 7. 2022	*M. emarginatus* [1 un]	O
			mala količina gvana male velikosti	O
47	Gozdna koča 600 m SV od Vrh Vil, Koritnice [45.634376, 14.352465, 997 m]	21. 7. 2022	*M. mystacinus/davidii* [1 ad F]	R
			Myotis sp. (mali) [1 un]	O
			V. murinus [1 ad M]	R
48	Stavba S od osrednjega gospodarskega poslopja pri nekdanji črpalki Mašun, Snežnik [45.631439, 14.365686, 1025 m]	21. 7. 2022	mala količina gvana male velikosti	O
49	Gozdarska hiša Mašun, Mašun 4 [45.629161, 14.36619, 1023 m]	21. 7. 2022	mala količina gvana velike in srednje velikosti	O
50	Opuščena stavba Mašun 3 [45.628823, 14.365824, 1022 m]	21. 7. 2022	***R. hipposideros*** [3 ad F, 4 ad, 3 juv, 4 un]*	O
			M. mystacinus/davidii [1 ad M]	R
			Myotis sp. (mali) [4 un]	O
			P. pipistrellus [1 ad M]	R
			mala količina gvana velike velikosti	O
51	J stolpič gradu Mašun, Snežnik [45.629172, 14.368789, 1016 m]	21. 7. 2022	*R. hipposideros* [1 ad F, 1 juv]	O
52	S stolpič gradu Mašun, Snežnik [45.629363, 14.368821, 1016 m]	21. 7. 2022	*M. emarginatus* [1 ad M]	R
53	Mlaka 370 m SV od gradu Mašun, Snežnik [45.63204, 14.371498, 1008 m]	21. 7. 2022	*M. myotis* [2 ad F, 1 ad M]	M
			M. nattereri [1 ad F]	M
			M. mystacinus/davidii [2 ad F, 2 ad M, 1 juv M]	M
			M. brandtii [2 ad F]	M
			N. lasiopterus [7 ad M]	M
			N. leisleri [2 ad M]	M
			V. murinus [2 ad M]	M
			P. auritus [1 ad F]	M
			B. barbastellus [2 ad M]	M
54	Bunkerski kompleks na okljuku ceste 250 m S od Male Kalvarije, Kozarišče [45.62388, 14.445354, 870 m]	21. 7. 2022	*R. hipposideros* [1 ad F, 1 juv]	O
55	Hiša Kozarišče 109 [45.622003, 14.45898, 812 m]	21. 7. 2022	*M. emarginatus* [1 un]	O
56	Vikend hiša Kozarišče 107 [45.622175, 14.460584, 796 m]	21. 7. 2022	*M. emarginatus* [1 un]	O
57	Vikend hiša Kozarišče 106 [45.622036, 14.460833, 796 m]	21. 7. 2022	*P. pipistrellus* [1 juv M]	R
58	Hiša Kozarišče 100 [45.622534, 14.461031, 792 m]	21. 7. 2022	mala količina majhnega gvana	O
59	Hiša Kozarišče 105 [45.622568, 14.461642, 787 m]	21. 7. 2022	*M. emarginatus* [2 un]	O
60	Osrednji objekt (gozdarska hiša) v Leskovi dolini, Kozarišče [45.622945, 14.461743, 787 m]	21. 7. 2022	*M. emarginatus* [4 un]	O
61	Gozdna hiša na Mezelišču, 770 m VSV od Gašperjevega hriba, Kozarišče [45.591855, 14.48188, 1200 m]	21. 7. 2022	*R. hipposideros* [2 ad]	O



Slika 3. Mesta najdb netopirjev. Številke ob točkah se nanašajo na stolpec ID v Tab. 2.

Figure 3. Sites of bat findings. Point numbers refer to the ID column in Tab. 2.

Dietz & Kiefer (2016) navajata, da *N. noctula* pričnejo zapuščati kotišča ob koncu julija, vrsta pa je znana po izrazitem selitvenem vedenju zlasti pri samicah (npr. Lehnert et al. 2018).

Na istem nahajališču kot *N. noctula* smo ujeli tudi samico *P. auritus* s poljem svetlega kožuha (Sl. 2). Običajno obarvani *P. auritus* je po hrbtni strani telesa enotno rjave barve. Na podlagi omejenega območja pomanjkanja pigmenta lahko samico opredelimo kot primer piebaldizma (Lucati & López-Baucells 2016). Variacije v obarvanosti so sicer pri netopirjih razmeroma pogoste (Haarsma 2008; Lucati & López-Baucells 2016). Za *P. auritus* Lucati & López-Baucells (2016) tako navajata 11 virov z opažanji neobičajno pigmentiranih živali, vključujoč pet primerov piebaldizma.

Zabeležili smo tudi nekatere redkejše in varstveno zanimivejše vrste, opredeljene na Rdečem seznamu (Ur. l. RS. 2002) in/ali uvrščene na Prilogo II Habitatne direktive EU (Ur. l. ES. 1992). Takšen primer je *M. brandtii* pri Starih Ogencah, kjer smo obiskali njegovo porodniško kolonijo, domujočo za naoknicami gozdarske hiše, ki je za zdaj edino potrjeno kotišče te vrste v Sloveniji (Pavlovič et al. 2020; Presetnik et al. 2021b). Pavlovič et al. (2020) so 9. 8. 2019 tam našteli 19 osebkov (med njimi enega mladiča in eno laktirajočo samico), 4. junija 2021 pa so Presetnik et al. (2021b) tam zabeležili 27 osebkov (vključujoč brejo samico). V letu 2022 smo našli vsaj 13 odraslih samic in 11 mladičev *M. brandtii*, istočasno pa je po najnižji oceni izza naoknic izletelo še vsaj 50 osebkov neznanega statusa, kar je občutno višje število kot v preteklih letih. Razlike v poročanih številih bi lahko med drugim kazale na porast številčnosti v koloniji, nedostopnost živali med prejšnjimi pregledi, pridružitev živali iz drugega kotišča ali sezonske razlike, povezane z obdobjem našega obiska. Kolonijo bo vsekakor treba spremljati tudi v prihodnje. Smiseln bi bil tudi ponoven obisk Windischgraetzovega dvorca, kjer sta vrsto leta 2024 zabeležila Presetnik & Šabec Korbar (2024), in dva kilometra oddaljeno Lovsko kočo Jurjeva dolina, kjer smo v ostenju ostrešja zabeležili vsaj pet manjših predstavnikov rodu *Myotis*, ki pa so nam žal ostali nedostopni. Samice *M. brandtii* se lahko premikajo med zatočišči (Dombrovski 2018), zato je možno, da sta ti stavbi njihovo občasno zatočišče.

Med popisi smo dvakrat ujeli *N. lasiopterus*, vrsto, ki je bila v Sloveniji po več kot 85 letih ponovno zabeležena šele leta 2014 (Presetnik & Knapič 2015). Ponovni najdbi je v letu 2017 sledilo prvo ujetje (Zidar 2020), od takrat pa je sledilo še več zabeležb, nekatere med njimi tudi na območju našega raziskovanja (Presetnik et al. 2024). Vrsto smo med taborom ponovno (Gojznikar 2021) ujeli pri betonirani mlaki na vojaškem vadbišču Poček, novo pa je najdišče pri mlaki v gozdu na Mašunu. Zanimiva je bila tudi številčnost vrste na Mašunu – sedem ujetih odraslih

samcev na enem mestu je več kot dvakratnik kateregakoli prejšnjega ujetja te vrste v Sloveniji (Presetnik et al. 2024). Če sedmim ujetim *N. lasiopterus* na Mašunu prištejemo še štiri samce, ujete pri mlaki na Počku, smo v roku enega tedna več kot podvojili število ujetih *N. lasiopterus* za Slovenijo (z 10 na 21). Večje število ujetih osebkov je morda posledica popisa na območju stalnega pojavljanja vrste (Presetnik et al. 2024), kjer se netopirji zbirajo ob redkih obstoječih površinskih virih pitne vode.

Pomen površinskih virov pitne vode tudi na sploh je bil verjetno še posebej izrazit v obdobju našega popisa, ko je celotno državo prizadelo izredno obdobje hude hidrološke suše (Kobold 2022). Amorim et al. (2018) nakazujejo na izreden pomen voda za netopirje v daljših sušnih obdobjih, saj jim le-ta poleg vira pitne vode ponujajo tudi morebiten lovni habitat. Visoko vrstno bogastvo, ki smo ga zabeležili med mreženjem ob vodah, je zato skoraj nedvomno posledica tudi hude poletne suše v letu 2022, ki je netopirje prisilila k uporabi preostalih ne-presušenih površinskih voda.

Visoko vrstno bogastvo je nedvomno tudi odsev velike raznolikosti pokrajine, ki se kaže v razlikah med toplejšimi nižavji in hladnejšimi hribovji. V našem primeru smo v razponu med približno 350 in 1200 m nadmorske višine zabeležili 23 vrst netopirjev. Do podobnih ugotovitev smo že prišli med terenskim delom na območju Vipavske doline in Trnovskega gozda (Gojznikar et al. 2020), kjer smo v območju med približno 50 in 1100 metri nadmorske višine zabeležili 20 vrst, in na območju Javornikov in širše okolice Postojne, kjer smo zabeležili 19 vrst (Gojznikar 2022). Uspešnost navedenih popisov lahko pripišemo podobni izbiri raziskovalnega območja, saj višje ležeče dinarske planote ustrezajo na gozd vezanim in/ali hladnoljubim vrstam (npr. *M. brandtii*), nižje ležeče ravnine pa vrstam odprtih habitatov in toploljubim vrstam (npr. *P. kuhlii*).

Naši podatki ponovno potrjujejo, da območje Pivškega in širše območje jugozahodne Slovenije premore visoko vrstno bogastvo netopirjev. Kljub naši in drugim raziskavam pa vseeno ostaja še veliko neodgovorjenih vprašanj. Razreševanje slednjih je zlasti pomembno v luči načrtovanih posegov v prostor, med katerimi lahko postavimo v ospredje predvideno izgradnjo avtocestnega odseka Postojna-Jelšane (MOP 2021). Morebitna izgradnja predlagane trase bi presekala popisno območje skoraj po polovici, kar bi lahko prineslo negativen vpliv na povezljivost populacij netopirjev na obeh straneh avtoceste. V prihodnosti je zato nujno preučiti morebitne premike med našimi in drugimi znanimi najdišči, raziskati letalne in selitvene poti na območju ter opredeliti izrabo prehranjevalnih habitatov. Prihodnje raziskave se morajo osredotočiti zlasti na zatočišča v neposredni bližini predvidene trase.

SUMMARY

South-west Slovenia is marked by significant bat species richness, which is likely connected to a high degree of geographic variation of landscape and climate. This high habitat heterogeneity suits many bat (Chiroptera) species. Between 17th and 23rd July 2022, as a part of biological student's research camp Biocamp 011, we surveyed bats in a wider region surrounding Pivka town, visiting Javorniki-Snežnik Dinaric massif, Slavinski Ravnik and the Reka River valley. During the day, we sought bats by inspecting potential roosts and during the night by conducting mist-nettings. We also supplemented night excursion by implementing both heterodyne detectors and occasionally recording echolocation calls with time-expansion. Overall, we detected 23 different species of bats (out of 31 currently occurring in Slovenia; Presetnik 2021; Josić et al. 2024) on 61 sites. Among them, we detected seven nursery roosts of the Lesser horseshoe bat (*Rhinolophus hipposideros*) and one of Brandt's bat (*Myotis brandtii*), with signs of local reproduction in many other species. Previous work in this part of Slovenia (Presetnik et al. 2009; Presetnik 2014; Pavlovič et al 2020; Gojznikar 2022; CKFF 2022) has unravelled high bat species richness, which we were able to reaffirm. We attribute such high richness to the large variation of habitats, since our research area is situated at the junction of the Dinaric and Submediterranean regions, with sharp and easily observable transition areas, and encompassed a notable span in altitude (between 350 and 1,200 m). Success during mist-netting at water bodies can also be attributed to an extremely dry summer (Kobold 2022). The ostensibly numerous findings of *R. hipposideros* can be attributed to the method of field work, since these bats are easily observed. Among our findings, we highlight the capture of 11 different males of the Greater noctule bat (*Nyctalus lasiopterus*) on two sites. Apart from adding new sites for the species, this number more than doubles the present count of caught individuals for Slovenia (Presetnik et al. 2024). We also noted a significant number of *M. brandtii* individuals at the only known nursery roost of the species in the country (Presetnik et al. 2021b) at a forest lodge near Stare Ogence. A capture of a single parous female of the Common noctule (*N. noctula*), showing signs of recent reproduction, opens the possibility of species forming nursery roosts also in or near SW Slovenia, the second indication of reproduction for the country (Presetnik et al. 2023). Additionally, we also recorded a piebaldistic female of the Brown long-eared bat (*Plecotus auritus*), with a white patch on the dorsal part of its head and neck. In conclusion, we reaffirm that SW Slovenia harbours high diversity of bat species and that further attention should be given to this particular area.

ZAHVALA

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First record of the terrestrial isopod *Porcellio rucneri* Karaman, 1966 (Crustacea: Isopoda) in Slovenia

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ABSTRACT

The terrestrial isopod *Porcellio rucneri* was originally described from Croatia in 1966, but has not been collected since its description. Several individuals of this species were collected in 2024 and 2025 near Postojna, Slovenia. These are the first records of *P. rucneri* from Slovenia and its northernmost records. Some previously undescribed morphological features of the species are presented.

IZVLEČEK

Prva najdba kopenskega enakonožca vrste *Porcellio rucneri* Karaman, 1966 (Crustacea: Isopoda) v Sloveniji

Vrsta kopenskega enakonožca *Porcellio rucneri* je bila opisana s Hrvaškega leta 1966, od takrat pa je niso več zasledili. Več osebkov te vrste smo nabrali v bližini Postojne v letih 2024 in 2025. To so prve najdbe vrste *P. rucneri* v Sloveniji ter njene najsevernejše najdbe. Predstavljamo nekaj prej neopisanih morfoloških značilnostih vrste.

While the fauna of terrestrial isopods (Oniscidea) in the Western Balkans was extensively studied in the 20th century, many species have not been recorded since their initial description, and data on their distribution patterns are limited (Potočnik 1993).

Karaman (1966) described the terrestrial isopod *Porcellio rucneri* on the basis of material collected by Dragutin Rucner at two localities in western Croatia. Karaman considered *P. rucneri* to be a particularly interesting part of the terrestrial isopod fauna of the Balkans, as the remainder of the *orarum* group within the diverse genus *Porcellio* has a Tyrrhenian distribution. However, no further records of *P. rucneri* have been published since its description and the species remained largely unknown, as attested by the fact that it was not included in the catalogue of the terrestrial isopod fauna of the former Yugoslavia (Potočnik 1989).

On 22. 9. 2024, two males and two females of a *Porcellio* species were collected by the author in the shrubs around the ruins of the Postojna (Adelsberg) Castle on Sovič Hill near Postojna, Slovenia (45.779333 N, 14.210083 E; 650 m a.s.l.). After detailed examination, the isopods were found to match the description of *P. rucneri* published by Karaman (1966). The isopods and their dissected appendages are kept in the author's collection at the Department of Biology, Biotechnical Faculty, University of Ljubljana. Two additional females were observed at the Postojna (Adelsberg) Castle (45.779194 N, 14.210694 E; 660 m a.s.l.) on 2. 5. 2025 (Fig. 1A).

The collected specimens have a smooth dorsal surface with minute tubercles only visible on the epimera, a weakly developed medial cephalic lobe and short, rounded lateral cephalic lobes (Fig. 1B). They share these features with other species of the *orarum* group. Both sexes are uniformly dark brown with very faint lighter patches at the bases of the pereon epimera and markedly lighter, orange-coloured posterior corners of the pereon epimera. In the examined males, the uropod protopodites are also orange (not shown). The glandular pore fields are positioned at the anterior corners of the pereon epimera (Fig. 2A). The d/c coordinates of the noduli laterales are between 0.9 and 1 on pereonites 1-4 and between 0.1 and 0.3 on pereonites 5-7 (Fig. 2B). Both articles of the flagellum of the second antenna are equal in length (Fig. 3A). The lateral margins of the pleotelson are concave with a sharp bend at the middle and the tip of the pleotelson is pointed (Fig. 2A). The carpus of the male pereopod 7 has a straight dorsal margin, the dorsal margin of the merus is evenly convex while the ventral margin of the ischium is straight (Fig. 3B). The exopodite of the male pleopod 1 has a width to length ratio of 0.75; its inner lobe is ovoid with a rounded posterior margin and is larger than the respiratory outer lobe of the exopodite (Fig. 3C). The exopodite of the male pleopod 2 has four large spines distally on its outer margin, with three spines positioned subterminally and one more proximally (Fig. 2D). The endopodite of the male pleopod 1 is straight (Fig. 3E) with a tuft of setae positioned slightly to the outer side of its tip (Fig. 3F). These features match the illustrations in the original description of *P. rucneri* (Karaman, 1966). The body length of the collected males is 10 mm and the body length of the collected females between 10 and 12 mm.

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Figure 1. The habitat and the habitus of the isopod *Porcellio rucneri*. A – the shrubs in the vicinity of the Postojna (Adelsberg) Castle where *P. rucneri* was collected; B – a *P. rucneri* female photographed at this location on 2. 5. 2025 (photo: M. Vittori).

Slika 1. Habitat in habitus enakonožca vrste *Porcellio rucneri*. A – grmičevje okoli razvalin gradu Postojna (Adelsberg), kjer smo našli vrsto *P. rucneri*; B – samica vrste *P. rucneri*, fotografirana na tej lokaciji 2. 5. 2025 (foto: M. Vittori).

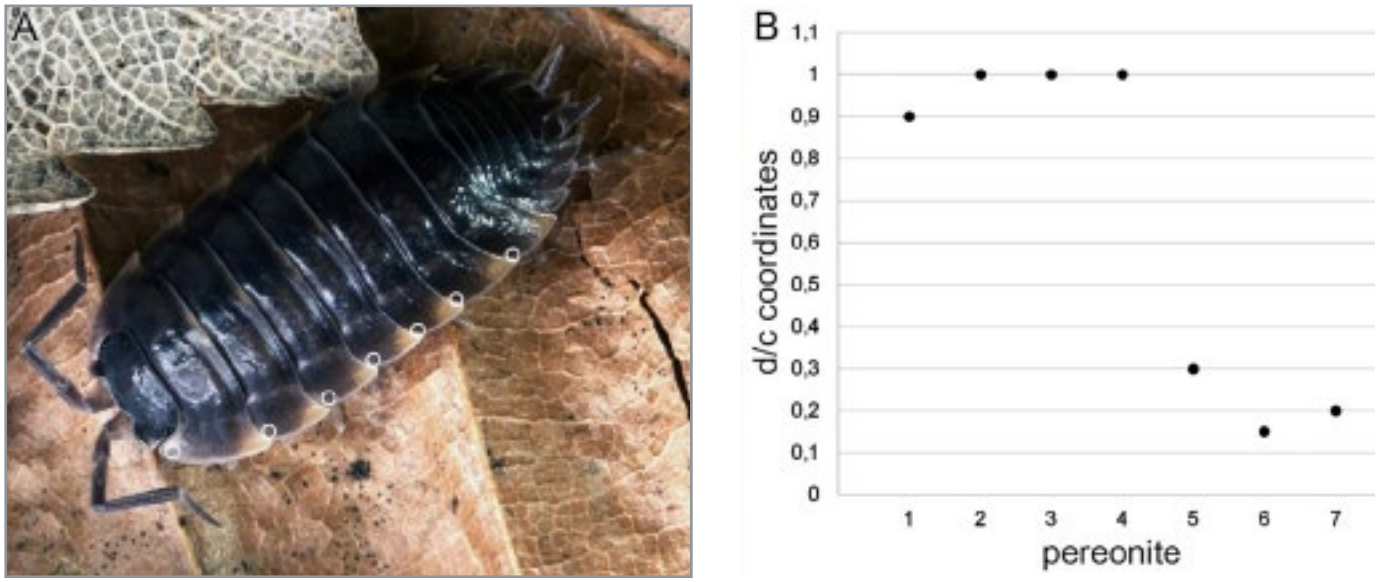

Figure 2. The position of glandular pores and noduli laterales in *Porcellio rucneri*. A – the positions of the glandular pore fields on the pereon epimera (shown with white circles); B – the d/c coordinates of noduli laterales on the pereonites (photo: M. Vittori).

Slika 2. Položaji žleznih por in lateralnih nodulov pri vrsti *Porcellio rucneri*. A – položaji polj žleznih por (prikazana z belimi krožci) na epimerah pereona; B – koordinate d/c lateralnih nodulov na pereonitih (foto: M. Vittori).

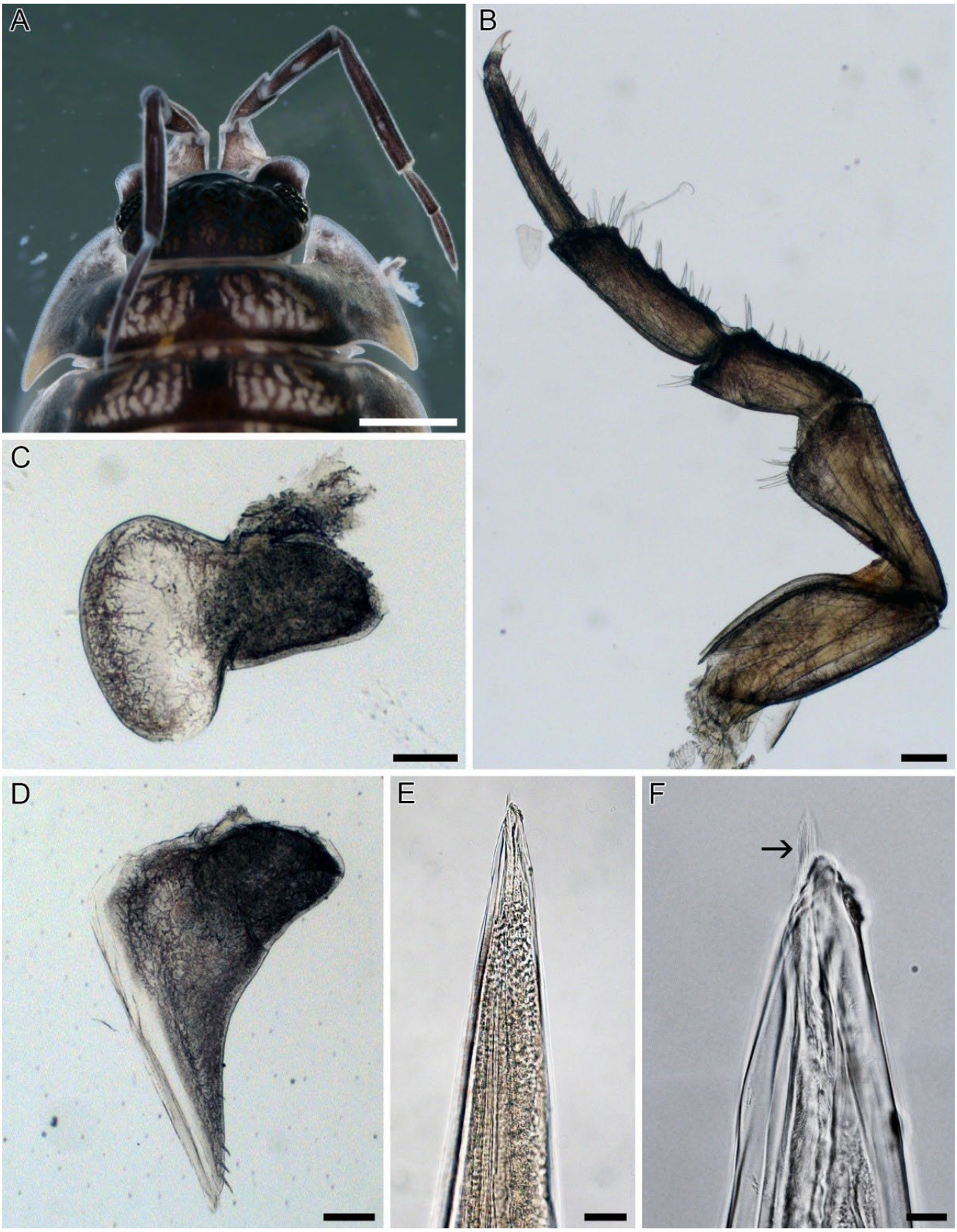

Figure 3. Identifying features of *Porcellio rucneri*. A – the second antennae, the cephalothorax and the pereonite 1 of a male; B – the male pereopod 7; C – the male pleopod 1 exopodite in ventral view; D – the male pleopod 2 exopodite in ventral view; E – the male pleopod 1 endopodite in ventral view; F – higher magnification of the tip of the male pleopod 1 endopodite. The tuft of setae at the outer side of the tip is marked with an arrow. Scale bars: 200 µm (A-D); 50 µm (E); 10 µm (F) (photo: M. Vittori).

Slika 3. Razpoznavni znaki vrste *Porcellio rucneri*. A – druge tipalke, glavoprsje in prvi pereonit samca; B – pereopod 7 samca; C – eksopodit pleopoda 1 samca z ventralne strani; D – eksopodit pleopoda 2 samca z ventralne strani; E – endopodit pleopoda 1 samca z ventralne strani; F – konica endopodita pleopoda 1 samca pri večji povečavi. Puščica označuje šop ščetin na zunanji strani konice. Merilca: 200 µm (A-D); 50 µm (E); 10 µm (F) (foto: M. Vittori).

A combination of several morphological features distinguishes the collected species from the other *Porcellio* species of the *orarum* group. The value of the d/c coordinates of the noduli laterales on pereonite 4 is greater than in other species of the group (Karaman 1966; Vandel 1962). The carpus of the male pereopod 7 lacks a dorsal ridge, which is pronounced in the similar species *Porcellio pumicatus* Budde-Lund, 1885 and in most subspecies of *P. orarum* Verhoeff, 1910 (except in *P. o. alpicola* Vandel, 1951) (Vandel 1962; Ferrara & Taiti 1978). The merus of male pereopod 7 is dorsally evenly convex and its ischium is ventrally straight.

This is the first recorded occurrence of *P. rucneri* in Slovenia and its northernmost known occurrence. Considering the two other known localities of the species, one near Rijeka and the other near Plitvice Lakes (Karaman 1966), *P. rucneri* is likely distributed throughout the northern Dinarides. Taking into account previous data on the Slovenian isopod fauna (Vittori et al. 2023; Jakob et al. 2024; Vittori 2024) and including the new record of *P. rucneri*, 77 species of Oniscidea have been recorded in Slovenia so far. The genus *Porcellio* is now the second most diverse genus of terrestrial isopods in Slovenia with 8 species known to occur in the country (Vittori et al. 2023; Jakob et al. 2024).

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