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ŠKOFJELOŠKO HILLS: STRONGHOLD OF THE ENDANGERED LARGE BLUE *PHENGARIS ARION* AND ALCON BLUE *PHENGARIS ALCON* (LEPIDOPTERA: LYCAENIDAE) IN SLOVENIA

Luka Šturm[1*], Jure Zaman[2], Andrej Peternel[3]

[1] Department of Food Science and Technology, Biotechnical faculty, University of Ljubljana, Jamnikarjeva 101, 1000 Ljubljana, Slovenia, E-mail: lukalory@gmail.com, luka.sturm@bf.uni-lj.si
[2]E-mail: jure.zaman@gmail.com
[3]Fisheries Research Institute of Slovenia, Spodnje Gameljne 61a, 1211 Ljubljana - Šmartno, Slovenia; E-mail: andrej.peternel@gmail.com
*Corresponding author

Abstract – *Phengaris arion* and *Phengaris alcon* are two species of butterflies from the family Lycaenidae which are threatened at a local and global level. Both species are known from Škofjeloško, Cerkljansko and Rovtarsko Hills, from where only a handful localities were reported until 2018. Furthermore, both species have already disappeared completely from some of the historical localities. During our surveys between 2018 and 2023 a total of 27 new localities for one or both species were discovered. One strong population with numerous individuals was discovered for *P. alcon*, while 26 new localities were discovered for *P. arion*, establishing Škofjeloško Hills as one of the strongholds of the species in Slovenia. The newly discovered populations are not only important from the conservation perspective for both species, but also present the opportunity to widen the now well-established regular monitoring of the threatened Slovenian butterflies.
KEY WORDS: *Phengaris*, Rovtarsko Hills, Cerkljansko Hills, new localities, Natura 2000

Izvleček – Škofjeloško hribovje: utrdba ogroženih metuljev velikega *Phengaris arion* in sviščevega mravljiščarja *Phengaris alcon* (Lepidoptera: Lycenidae) v Sloveniji

Phengaris arion in *Phengaris alcon* sta vrsti metuljev iz družine Lycaenidae, ki sta ogroženi tako na lokalnem kot globalnem nivoju. Obe vrsti sta poznani tudi iz

Škofjeloškega, Cerkljanskega in Rovtarskega hribovja, kjer sta bili do leta 2018 razmeroma redki, iz nekaterih nahajališč pa sta že popolnoma izginili. Kljub temu pa je bilo tekom popisov med letoma 2018 in 2023 odkritih kar 27 novih nahajališč, kjer smo potrdili bodisi eno ali obe vrsti. Pri tem je bila za *P. alcon* odkrita ena populacija s številnimi osebki, za *P. arion* pa je bilo odkritih kar 26 novih nahajališč, s čimer se je Škofjeloško hribovje uveljavilo kot ena izmed utrdb vrste v Sloveniji. Novoodkrite populacije sicer niso pomembne le z varstvenega vidika obeh vrst, ampak predstavljajo tudi priložnost, da nekatere od njiju vključimo v zdaj že dobro uveljavljen monitoring ogroženih slovenskih metuljev.
KLJUČNE BESEDE: *Phengaris*, Rovtarsko hribovje, Cerkljansko hribovje, nove lokalitete, Natura 2000

Introduction

Phengaris (previously *Maculinea*) is one of the most studied of Palearctic butterflies, well known for its complex parasitic lifestyle, which includes both - a specific larval host plant, as well as a specific larval host ant from the genus *Myrmica*. Both differ depending on the species of the butterfly and region (Arnaldo et al. 2013, Tartally et al. 2019). Out of all *Phengaris* species, four are found in Europe, including Slovenia, namely *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). The first two species are found on humid extensive grasslands, both depending on the *Sanguisorba officinalis* L. as their larval host plant. On the other hand, *P. arion* is restricted to dry extensively used grasslands, utilizing either *Thymus* sp. or *Origanum vulgare* L. as the host plants for the early stages of their caterpillars. *P. alcon* can be found on humid, as well as dry extensive grasslands. Due to this habitat type division, the species was considered as two different spices for a time: i) *P. alcon* - inhabiting wet extensive grasslands and moist bogs at lower altitudes, predominantly laying eggs on *Gentiana pneumonanthe* L.; ii) *Phengaris rebeli* - inhabiting dry extensive grasslands, usually at higher altitudes, even above 2000 m, laying eggs predominantly on the plants of *Gentiana cruciata* L. (Verovnik et al. 2012, Arnaldo et al. 2013). Anyhow, genetic, morphological and other studies in the last decades dismissed this division, with the ″two″ species now being considered as only one – *P. alcon* (Steiner et al. 2005; Verovnik et al. 2012; Tartally et al. 2019). In Slovenia, all the afore-mentioned species are still present throughout the country, however most of them are in decline (Verovnik et al. 2012; Zakšek et al. 2021; Zakšek et al. 2022).

Phengaris alcon (Dennis & Schiffermüller, 1775)

P. alcon is the most widespread *Phengaris* species in the country, being the most widespread on the southern ridges of Trnovski gozd Plateau and S parts of central Slovenia. There were also many populations in Goričko (Sáfián et al. 2012;

Verovnik et al. 2012) but the few remaining populations are currently among the most threatened in the country (Zakšek Barbara, pers. comm.). Just like the other species from this genus, it is included in the Red List of Butterflies of Slovenia (Ur. l. RS 2002) and the Regulation on protected wild animal species (Ur. l. RS 2004b). Unlike for the other three species of *Phengaris* butterflies, however, no scheme for monitoring its abundance was set up within the country (Verovnik et al. 2011), as the butterfly is not listed in the habitat directive. This is somehow unfortunate, given the fact that the marshland populations of the species are among the most endangered and are declining fast in Slovenia, disappearing from large parts of its former range (Verovnik et al. 2012). It is the only *Phengaris* species in the country classified as endangered (other being classified as vulnerable) (Ur. l. RS 2004b). It should be noted, that *P. alcon* was considered a separate species linked to humid grasslands at that time. The species is classified as near-threatened or least concerned, according to the Red List of European butterflies (Van Swaay et al. 2010). In Škofjeloško, Cerkljansko and Rovtarsko Hills the species was previously known from 12 localities (Verovnik et al. 2012; CKFF 2023). A single locality on Mt. Blegoš N of Hotavlje was already reported by the authors (Šturm et al. 2021). The other known localities in the relative vicinity of the surveyed area are those around Črni vrh (Polhograjsko Hills, NW of Polhov Gradec), Idrijsko Hills (Verovnik et al. 2012) and those found in the surrounding of the towns of Logatec and Vrhnika (CKFF 2023).

Phengaris arion (Linneaus, 1758)

P. arion is the largest species from this genus in Slovenia and is found in dry, extensive and thermophilic grasslands throughout the country, excluding coastal and karst regions, lower parts of Prekmurje, Slovenske gorice, as well as some parts of SE Slovenia. Its largest populations are located in Haloze, while also being quite numerous in certain areas NW of Pohorje, Zasavje and Polhograjsko Hills (Verovnik et al. 2012). It is included in the Red List of Butterflies of Slovenia (Ur. l. RS 2002) and Regulation on protected wild animal species (Ur. l. RS 2004b), in which it is classified as vulnerable. Unlike *P. alcon*, however, it is considered the most endangered species among *Phengaris* butterflies in Europe, being classified as endangered (Van Swaay et al. 2010). The scheme for monitoring the abundance of *P. arion* was established in 2010-2011 (Verovnik et al. 2011) and starting in 2015, the species is surveyed once every two years. The general results show, that the species is in decline, albeit the numbers between years and localities can vary drastically (Verovnik et al. 2015, Zakšek et al. 2017, Zakšek et al. 2019, Zakšek et al. 2021, Zakšek et al. 2023). In Škofjeloško, Cerkljansko and Rovtarsko Hills the species was observed mainly on localities from Trebija towards Cerkno in the NW (Verovnik 2000; Verovnik et al. 2012; Zakšek et al. 2023). Additional localities were recently reported from Davča (CKFF 2023) and Mt. Blegoš (Šturm et al. 2021), while it was historically recorded in Gorenja vas (Withrington 1984). Populations of the species are also known from the vicinity of the surveyed area, mainly from Bača and Idrijca valleys, and especially from the Polhograjsko Hills

(Verovnik et al. 2012), where the monitoring of its populations is ongoing (Verovnik et al. 2015, Zakšek et al. 2023). A few other individual sampling localities between Trebija and Cerkno (including Ermanovec peak) are also regularly monitored (Verovnik et al. 2015, Zakšek et al. 2017, Zakšek et al. 2019, Zakšek et al. 2021, Zakšek et al. 2023). Despite brief surveying of the Škofjeloško, Cerkljansko and Rovtarsko Hills areas in the past (Verovnik et al. 2011), any mayor population densities of *P. arion* were not observed (Verovnik et al. 2012; CKFF 2023).

The aim of this study was to survey the area of Škofjeloško, Cerkljansko and Rovtarsko Hills specifically targeting suitable habitats where new populations of *P. arion* and *P. alcon* could survive. Thus, we aimed at providing a more accurate distribution of the two species in the surveyed area and evaluate the conservation value of these populations.

Methods

The surveys of the area took place from 2018 to 2023, with the majority of research completed during the summer of 2018, 2020 and 2023. During each survey, each locality was thoroughly checked and all butterflies belonging to the *Phengaris* genus were recorded. Many different localities throughout Škofjeloško, Cerkljansko and Rovtarsko Hills were surveyed, however, only the localities where at least a single *Phengaris* butterfly or their eggs were found are included in the list and description of localities (Tab. 1). Among the reported localities, two were further broken down into several micro-localities, since the distances between the observed imagines were too great to be attributed to a single locality, but too short for butterflies to not be considered as part of a potentially connected population. The surveying was performed using a butterfly net and identification was done in the field. Butterflies were not collected, with the exception of dead specimens, or the specimens which were too damaged to fly. The permission for disturbance and catching of the butterflies was obtained from the Slovenian Environment Agency (ARSO), number 35601-41/2018-4 (all authors). Butterflies were determined using the standard butterfly guide (Tolman & Lewington 2008), while localities were selected based on past surveys (Verovnik et al. 2011, 2012, 2015), 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.

Geographical characteristics of the region

Škofjeloško and Cerkljansko Hills are among the highest mountain chains in Slovenia outside the Alps, with Mt. Blegoš (1562 m) and Mt. Porezen (1630 m) as

their highest peaks, respectively. Rovtarsko Hills, on the other hand, is a small transitional hill chain between the Škofjeloško, Polhograjsko and Idrijsko Hills, with the highest peak being Vrh Sv. Treh Kraljev (888 m) (Mlinar 2018). All hill chains are positioned in the SW part of the country on the border between the Gorenjska and Primorska regions (Geodetski Zavod Slovenije et al. 2005). Due to their location they form a barrier between three different climates: continental to the east and south, alpine to the north and sub-Mediterranean to the southwest. Due to their specific geological structure and climate they are also very diverse, including many different habitats, which is reflected in the diverse fauna and flora of the region (Ilešič 1938; Polajnar 1960; Šifrer 1974). Due to the rich diversity and unique habitats, some parts of the surveyed region are included in the Natura 2000 network, including Mt. Blegoš (Blegoš - SI3000260), areas W of Cerkno (Cekno-Zakriž - SI3000020) and NW of Otalež (Otalež-Lazec - SI3000023) (Ur. l. RS 2004a).

The three mountain chains are predominantly composed of Mesozoic carbonate rocks (limestone and dolomite) and Mesozoic, Permian and Carboniferous clastites. The valleys are mainly filled by alluvial deposits, and the feet of the slopes are regularly covered by scree, both of Quaternary age (Jemec and Kotac 2013; Mlinar 2018). Due to the predominantly carbonate base, the dry calcareous grasslands abound in the region.

Škofjeloško and most parts of the Cerkljansko and Rovtarsko Hills have a typical continental climate characteristic, with alpine climate influences at higher altitudes. On warmer southern slopes the influence of the neighbouring sub-Mediterranean climate is evident (Ilešič 1938; Polajnar 1960; Marinček and Wraber 1980; Jemec and Kotac 2013; Mlinar 2018). The wider area of all three hill chains has high annual rainfall of around 1600-2000 mm on average, while the average temperature in July is between 16-20 °C for most parts, excluding the highest peaks, where the average temperature in July is between 12-16 °C (Marinček and Wraber 1980; Vertačnik and Bertalanič 2017; Mlinar 2018).

Considering the amount of precipitation and geology, the region is characterised by dense mixed woods (Ilešič 1938; Marinček and Weber 1980). The highest parts of Mt. Blegoš and Mt. Porezen are covered with extensive grasslands and pastures, which are present also on the southern slopes. These are of anthropogenic origin, which can be seen in an advanced overgrowth in some areas, as well as in a very high upper tree line, which nowadays reaches up to 1500 m on Mt. Blegoš (Ilešič 1938; Marinček and Weber 1980). The main agricultural activity at this altitude is grazing (Ilešič 1938; Polajnar 1960), which is slowly returning to the area. The valley floors are mostly covered by intensive grasslands and fields, with occasional mixed woods, while a bit raised above them on the lower slopes the last dry, and sometimes even humid, low-altitude extensive grasslands still persist. The bogs and marshes are extremely rare and have all but disappeared. The biggest stretches of suitable extensive grasslands enabling high biodiversity of fauna and flora, including *Phengaris* butterflies, are found mostly in vicinity of Mt. Blegoš, Mt. Kucelj, Mt. Slajka and Mt. Porezen.

List and description of the localities

Table 1. The list of localities surveyed during the study includes a description of each locality and its habitat, coordinates, and altitude. Coordinates are given in WGS-84 decimal degrees, latitude (Lat.), followed by longitude (Long.).

Tabela 1. Seznam lokalitet vzorčenih tekom študije, skupaj z opisom vsake lokalitete in njenega habitata, koordinatami ter nadmorsko višino. Koordinate so podane v WGS-84 decimalnih stopnjah kot zemljepisna širina (Lat.) in zemljepisna dolžina (Long.).

No.	Name	Location	Habitat type	Coordinates(Lat., Long.)	Altitude (m)
1	Mt. Blegoš (peak)	Mt. Blegoš, 300 m S of the peak	Dry pasture, Alpine-like meadows, forest edge	46.161504, 14.112855	1440 - 1470
2	Mt. Blegoš (gravel road)	Mt. Blegoš, gravel road 850 m S of the peak	Forest clearing by the gravel road with dry extensive meadows and rocky wall	46.155432, 14.108854	1210 - 1230
3	Likar's hayfield	Lower part of the hayfield, S of Mt. Blegoš	Dry extensive meadows, forest edge, small stony path	46.142864, 14.119888	900 - 960
4a	Likar's farm (S grassland)	Grassland S of the Likar's farm, S of Mt. Blegoš	Flowery intensive grassland	46.138004, 14.119624	760
4b	Likar's farm (E grassland)	Grassland E of the Likar's farm, S of Mt. Blegoš	Dry extensive grasslands, forest edge	46.141511, 14.123149	780
4c	Likar's farm (N pasture)	Pasture N above the Likar's farm, S of Mt. Blegoš	Dry pastures with gravel road, forest edge	46.139784, 14.119488	780
5a	Podgora (ravine)	Small ravine NW of Podgora (sunny grassland)	Steep extensive dry and in places wet grasslands, small stream, forest edge	46.105904, 14.105010	480 - 500
5b	Podgora (ravine)	Small ravine NW of Podgora (shady grassland)	Steep extensive wet and in places dry grasslands, small stream, forest edge	46.104651, 14.106968	450 - 480
6	Podgora (W above the village)	Grasslands NW of Podgora and NE above Trebija	Steep extensive dry grasslands, forest edge, patches of *Verbascum* sp.	46.100372, 14.102794	480 - 580
7	Trebija	NW part of Trebija (ravine towards Stara Oselica)	Steep extensive dry and wet grasslands (in overgrowth), forest edge	46.101299, 14.089888	490 - 510
8	Podgora (S over the river)	Grassland at the N of Bostajnova's ravine, S of Podgora	Extremely steep extensive dry and in places wet grasslands (in overgrowth), forest edge	46.095186, 14.115329	460 - 500
9	Studor	W of Studor, near the quarry towards Mt. Kucelj	Steep extensive-to-intensive grasslands near query, forest edge	46.136429, 14.090006	840 - 880
10	Mt. Kucelj	Wider grassy area S of Mt. Kucelj (S of Studor)	Mostly dry extensive grasslands, patches of shrubland	46.128534, 14.089533	780 - 840

11	Jelovica (S under Mt. Blegoš)	At the end of gravel road from Likar's farm, S of Mt. Blegoš	Steep dry extensive grasslands (partly in overgrowth)	46.148818, 14.128369	810 - 880
12	Mt. Slajka	Grassland 100 m S of mountain cottage/farms	Steep rocky dry extensive grassland with many *Thymus* and *Oregano* sp., forest edge	46.112594, 14.099770	790 - 810
13	Selo pri Žireh	Grassland N of Selopri Žireh, above the main road	Extremely steep extensive unmoved dry grassland near Sora river, forest edge	46.068796, 14.097182	460 - 480
14	Žiri-Brekovice	Grassland S of Žiri's equestrian club, towards Brekovice	Intensive and partially dry and wet extensive grasslands near Sora river, forest edge	46.030679, 14.113919	480 - 500
15	Žirovnica-Idršek	Valley SW of Žirovnica and E of Idršek	Steep dry and partially wet extensive grasslands above small stream, forest edge	46.013953, 14.074917	550 - 580
16	Otalež	Grassland NE of Otalež, besides tractor path	Steep wet and dry extensive and intensive grasslands, forest edge	46.080725, 13.995426	640 - 680
17	Gorenji Vrsnik	Grassland N above Gorenji Vrsnik	Wet extensive grasslands with lots of fern and some birch (in overgrowth), forest edge	46.030347, 14.090646	680 - 690
18	Račeva	Grassland N above Račeva	Wet to dry extensive grasslands, forest edge, bushes	46.020447, 14.166734	640 - 660
19	Dolenja Ravan	Grassland E of Dolenja Ravan	Extensive and intensive grasslands near a stream, forest edge	46.150753, 14.140394	620 - 630
20	Javorje	Grassland besides Javorje-Mlaka main road	Intensive grasslands near fields, orchard and bushes	46.162255, 14.181922	760
21	Gorenje Brdo	Grassland besides main road S of Gorenje Brdo	Dry extensive and intensive grasslands near the main road, forest edge, bushes	46.125372, 14.143899	700
22	Hotavlje (NW above the village)	Grassland NW above Hotavlje, W of the Kopačnica river	Dry extensive grasslands, forest edge, bushes	46.117646, 14.107985	440 - 500
23	Hotavlje (near the village)	Grassland N of Hotavlje, above the main road to Kopačnica	Intensive flowery grassland, forest edge, bushes	46.117241, 14.111737	420
24	Podjelovo Brdo (central part of the village)	Grasslands E below the main road in Podjelovo Brdo	Dry extensive and intensive grasslands, forest edge, bushes	46.101434, 14.042163	800 - 830
25	Podjelovo Brdo (SW part of the village)	Grassland in the S part of Podjelovo Brdo, under the road	Dry extensive and intensive grasslands, forest edge, bushes	46.098394, 14.036169	700 - 720
26	Lanišče	Grassland S of Lanišče, under the main road	Dry extensive and intensive grasslands above the ravine, forest edge	46.082143, 14.023128	730 - 740
27	Javorjev dol	Grassland W of Javorjev dol besides the main road	Dry extensive and intensive grasslands near Javorščica stream, forest edge	46.069048, 14.039042	710 - 720

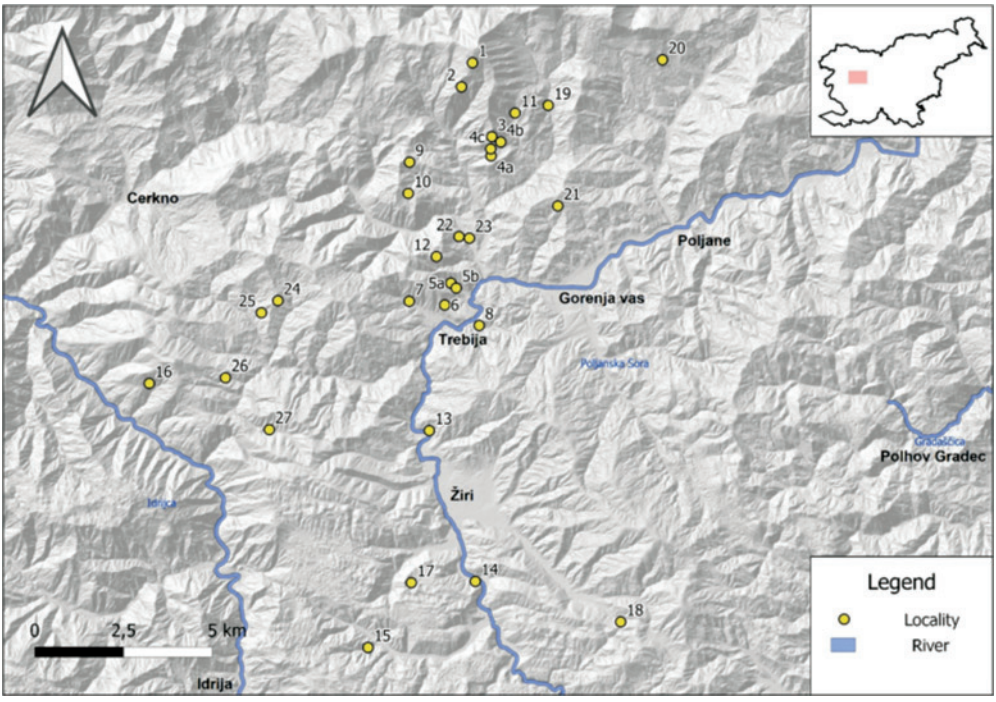

Figure 1: Map of the surveyed area with the localities of *Phengaris arion* or/and *Phengaris alcon*. The numbering of the localities corresponds to those in Table 1.

Slika 1: Zemljevid raziskovanega območja z lokacijami, kjer sta bila najdena *Phengaris arion*, *Phengaris alcon* ali oba. Številke lokacij so identične številkam lokacij podanih v tabeli 1.

Results

Table 2. Number of specimens/species found at particular locality and date(s) of the surveys during the 2018-2023 period in Škofjeloško, Cerkljansko and Rovtarsko Hills. The localities are numbered, as in the list and description of localities (Tab. 1).

Tabela 2. Število osebkov/vrsto najdenih na posamezni lokaciji na dan vzorčenja tekom popisov izvedenih v Škofjeloškem, Cerkljanskem in Rovtarskem hribovju med 2018-2023. Lokacije so označene s številkami od 1 do 27 kot v seznamu in opisu lokacij (Tab. 1).

Locality/ area	Microlocality	*Phengaris alcon* (no. of adults)	Date	*Phengaris arion* (no. of adults)	Date
1*	/	3	7.7.2018 (P, Š)	1	21.7.2018 (P, Š)
		5	20.7.2020 (Š, Z)		
2*	/	/	/	1	21., 30.7.2018 (P, Š)
3*	/	/	/	1	4.8.2018 (P, Š)

4	4a	/	/	1	14.7.2019 (Š)
	4b	/	/	1	20.7.2020 (Š, Z)
	4c	/	/	1	20.7.2020 (Š, Z)
5	5a	/	/	8+	19.7.2020 (Š, Z)
	5b	/	/	2	19.7.2020 (Š, Z)
6	/	/	/	3	19.7.2020 (Š, Z)
7	/	/	/	5+	19.7.2020 (Š, Z)
8	/	/	/	1	19.7.2020 (Š, Z)
9	/	/	/	6+	20.7.2020 (Š, Z)
10	/	/	/	1	20.7.2020 (Š, Z)
11	/	/	/	3	20.7.2020 (Š, Z)
12	/	/	/	7+	21.7.2020 (Š, Z)
13	/	/	/	1	21.7.2020 (Š, Z)
14	/	/	/	1	21.7.2020 (Š, Z)
15	/	eggs on *G. cruciata*	21.7.2020 (Š, Z)	1	21.7.2020 (Š, Z)
		7+	8.7.2023 (P, Š, Z)	1	8.7.2023 (P, Š, Z)
16	/	/	/	1	23.7.2020 (Š)
17	/	50+	24.7.2020 (P, Z)	/	/
		10+	8.7.2023 (P, Š, Z)	/	/
18	/	/	/	1	24.7.2020 (P, Z)
19	/	/	/	1	24.7.2020 (P, Z)
20	/	/	/	1	25.7.2021 (P)
21	/	/	/	1	8.7.2023 (P, Š, Z)
22	/	/	/	1	8.7.2023 (P, Š, Z)
23	/	/	/	2	8.7.2023 (P, Š, Z)
24	/	/	/	1	8.7.2023 (P, Š, Z)
25	/	/	/	1	8.7.2023 (P, Š, Z)
26	/	/	/	1	8.7.2023 (P, Š, Z)
27	/	/	/	1	8.7.2023 (P, Š, Z)

+ indicates a minimal number of individuals found on a given date; * locality previously already reported by Šturm et al. (2021); letters in parenthesis denote the surveyors: P – Andrej Peternel, Š – Luka Šturm, Z – Jure Zaman

+ označuje minimalno število osebkov najdenih na dan vzorčenja; * lokaliteta, ki je bila predhodno že poročana v Šturm. in sod. (2021); črke v oklepaju označujejo popisovalce: P – Andrej Peternel, Š – Luka Šturm, Z – Jure Zaman

Discussion

During the surveying of Škofjeloško, Cerkljansko and Rovtarsko Hills in 2018-2023 period, 27 localities with either adults and/or eggs of *P. alcon*, *P. arion* or both were found. While *P. arion* was found in all but one listed locality (Gorenji Vrsnik, where humid, bogy forest clearings mostly overgrown with ferns are not suitable for its larval host plants), *P. alcon* was found in only three localities. The first right below the mountain top of Mt. Blegoš, one at Gorenji Vrsnik, and the last in a valley between Žirovnica and Idršek. However, while no more than eight and mostly only single individuals of *P. arion* were found per locality, *P. alcon* was always more numerous. At Gorenji Vrsnik we counted more than 50 individuals (it should be noted, however, that here the butterflies were observed on a relatively large area). In the case of *P. arion*, only four localities had five or more specimens counted. This shows that *P. arion* is more widespread in the surveyed region, but its population densities are much lower.

Phengaris alcon

P. alcon was previously known from Škofjeloško, Cerkljansko and Rovtarsko Hills from approximately 12 localities and all but four were known from the southernmost parts of Rovtarsko Hills (Verovnik et al. 2012; CKFF 2023). In Rovtarsko Hills, specifically, four localities were known from Žejna valley N of Hotedrščica and three NW of Logatec from the valley of river Reka. All of them were found relatively recently (CKFF 2023). One other possible locality was also reported from the UTM: VL38 square in 1996 (Čelik & Rebeušek 1996). However, due to the locality's unknown precise coordinates, as well as a big possibility that the actual locality lies outside of Rovtarsko Hills, it was not included in the distribution atlas (Verovnik et al. 2012). On the other hand, the only known locality from Cerkljansko Hills is from foothills of Gradišče peak NW of Ledine (Verovnik at al. 2012), where the species was observed in 2005, but was not recorded since. The remaining three localities are from Škofjeloško Hills. Two localities were discovered in Stara Oselica, one W of Ermanovec peak and one S of Štor peak (Withrington 2003; CKFF 2023). *P. arion* was also present at both those localities at the time. However, neither species was recorded at either locality since 1995, and recent surveys indicate that the locality near Ermanovec peak is no longer suitable for either of the species (Verovnik et al. 2015; Zakšek et al. 2017; Zakšek et al. 2019; Zakšek et al. 2021; Zakšek et al. 2023). *P. alcon* was recently reported from Mt. Blegoš, where the butterfly was discovered in 2018 and 2020 as reported by Šturm et al. (2021). Although *P. alcon* is quite rare in the Škofjeloško, Cerkljansko and Rovtarsko Hills, it is more widespread in the neighbouring regions. It is known from a several localities in the Julian Alps N of Bača and Selška Sora valleys, including one locality from Mt. Ratitovec, and from numerous localities in Polhograjsko and Idrijsko Hills (Verovnik et al. 2012; CKFF 2023), as well as from the outskirts of towns Logatec and Vrhnika (CKFF 2023).

The two new localities for *P. alcon* were found in Rovtarsko Hills. At the first locality, between Žirovnica and Idršek, only the eggs deposited on G. *cruciata* were first observed in 2020, but later at least seven individual butterflies were found in 2023. At the second, and also the most important locality for the species in the surveyed area, near Gorenji Vrsnik, the butterflies were observed in great abundance (more than 50 individuals) in 2020, albeit being observed over a larger area, measuring approximately 15 hectares. Since the butterflies were so numerous, the entire area was not searched and the actual number of adults was not determined. Also, since all the butterflies belong to the same population, the area was not broken down into several micro-localities, as in other cases. In 2023 the butterflies were observed again, but in smaller numbers (less than 20). However, it should be noted, that smaller area was searched in 2023 than in 2020. Anyhow, smaller number of individuals could also be attributed to different seasons in 2020 and 2023 (different peak of the population), as well as the fact, that the area is slowly becoming overgrown with ferns and small trees. As the overgrowing was already visibly worse in 2023, compared to 2020, the population is at risk of decline, or disappearing altogether.

The finding of a large population of *P. alcon* in Gorenji Vrsnik is especially important, since most of the other populations (e.g. those at Mt. Blegoš and between Žirovnica and Idršek) are already relatively small, with the number of observed individuals not exceeding 10 individuals. The remaining small populations, as well as those, which already disappeared (e.g. localities at Štor and Ermanovec peaks) are also indicating, that the species might have been relatively abundant in the surveyed area in the past, but is slowly losing its foothold, mostly due to the changes in agriculture practices and degradation of suitable habitats (drying, overgrowing, intensive agriculture). Consequently, appropriate actions (mowing, logging) for the conservation of the last remaining large population at Gorenji Vrsnik should be taken. On the other hand, while the population at Mt. Blegoš is included in the NATURA 2000 network (Ur. l. RS 2004a), its size is probably already too small for long term survival.

Phengaris arion

Similar to *P. alcon*, *P. arion* was known from Škofjeloško, Cerkljansko and Rovtarsko Hills from no more than 15 localities, with many becoming unsuitable for the species in the last two decades. Most of the known localities are from Škofjeloško Hills, especially from the vicinity of villages Podgora and Trebija, where the butterfly was found on one and three localities, respectively, and all were discovered around the turn of the millennium (Verovnik 2000; Withrington 2003; CKFF 2023). Two of these localities around Trebija were later also included in the regular monitoring of the species. Here the butterfly was last observed in 2021, when nine imagines in total were found (Zakšek et. al. 2021). In the vicinity, the species was also observed in Gorenja vas in 1981 (Withrington 1984), as well as on three localities near Ermanovec and Štor peaks in Stara Oselica (Verovnik 2000; Withrington 2003; CKFF 2023). However, the butterfly was never again observed in Gorenja vas, from where it has most probably disappeared altogether, nor from the two localities near the Ermanovec and Štor peaks (Verovnik et al. 2015; Zakšek et

al. 2017; Zakšek et al. 2019; Zakšek et al. 2021; Zakšek et al. 2023). However, the species is still present at the locality NE of Štor peak near Jezeršek farm in Stara Oselica. Recently, it was observed in 2017 (Zakšek et al. 2017), but was not confirmed in the last few surveys (Zakšek et al. 2019; Zakšek et al. 2021; Zakšek et al.

Figure 2: A) and B): *Phengaris alcon* from the locality beneath the summit of Mt. Blegoš caught on 7.7.2018 (A) and on 20.7.2020 (B); C) and D): Eggs of *P. alcon* found on *Gentiana cruciata* L. in the valley between Žirovnica-Idršek on 21.7.2020 (C) and the same valley photographed on 8.7.2023 (D); E): Forest clearing in Gorenji Vrsnik where the largest population of *P. alcon* was found photographed on 24.7.2020.

Slika 2: A) in B): *Phengaris alcon* iz lokacije pod vrhom Blegoša ujet 7.7.2018 (A) in 20.7.2020 (B); C) in D): Jajčeca *P. alcon* najdena na *Gentiana cruciata* L. v dolini med Žirovnico in Idrškom 21.7.2020 (C) in ista dolina slikana 8.7.2023 (D); E): Gozdna poseka pri Gornjem Vrsniku kjer je bila najdena največja populacija *P. alcon*, fotografirana 24.7.2020.

2023). The species is also known from three localities around Mt. Blegoš (Šturm et al. 2021) from where it was first reported by Carnelutti (1980), but without precise location. Other previously known localities for *P. arion* in the surveyed area all lie north of the 11 localities previously mentioned - at the junction of Škofjeloško and Cerkljansko Hills. Two localities are close to one another E of Cerkno, just below the Škofje peak. One of these localities was first reported by Verovnik (2000), while the other was discovered later in 2021 (Zakšek et al. 2021; CKFF 2023). At both localities the butterfly was last observed in 2021, when five adults were observed (Zakšek et al. 2021). The last remaining locality reported lies in a small valley of the river Davča just E of Mt. Porezen (CKFF 2023) and was discovered in 2014. It is the northernmost locality with the species in the region.

Despite the previously known localities for *P. arion* in Škofjeloško, Cerkljansko and Rovtarsko Hills, the butterfly was discovered on 26 localities during our surveys between 2018 and 2023. This makes the butterfly well established in this part of the country, especially in Škofjeloško Hills, where most of its populations are located. Therefore, it is somehow surprising that only three localities from Škofjeloško Hills are included in the monitoring of ″marginal and isolated populations″ for this species (Zakšek et al. 2023). Anyhow, unlike in the case of *P. alcon*, where the butterfly was more common in the vicinity of the surveyed area than in the surveyed area itself, *P. arion* remains relatively rare in the surrounding regions of Škofjeloško, Cerkljansko and Rovtarsko Hills. It is more widespread only in the Bača Valley, where it is known from three localities, and in Polhorgajsko Hills, where at least eight localities are known. These eight localities are included in the regular monitoring of the species, and at seven of them the butterfly was recently confirmed (Zakšek et al. 2021; Zakšek et al. 2023).

The newly found localities in the surveyed area are predominantly from Škofjeloško Hills, especially in vicinity of Mt. Blegoš, Mt. Slajka and Mt. Mladi vrh, as well as the neighbouring valleys and settlements. Newly found localities are mostly concentrated in the area between Trebija, Podgora, Hotavlje, Mt. Blegoš and Mt. Kucelj, where 14 new localities, including additional micro-localities, were discovered. One of those localities was right beneath the summit of Mt. Blegoš above the altitude of 1400 m, while many were at altitudes between 750-1250 m. Additional five localities in Škofjeloško Hills were also found in the relative vicinity of the mentioned area. Given these records, it seems, that the species established a large, most probably connected population in the wider area of Trebija and Podgora, and possibly in the wider area as well, since some localities are most certainly still undiscovered. On the other hand, only three and four new localities were found in Cerkljansko and Rovtarsko Hills, respectively. Two of these localities from Rovtarsko Hills were found in the Žiri basin, bordering either Rovtarsko Hills near Stare Žiri, or Polhograjsko Hills near Selo. They were included in this report, however, as they could be attributed to either/neither of the two hill chains.

The results of this study show that *P. arion* is widespread in the Škofjeloško and Cerkljansko Hills, while in the Rovtarsko Hills and valley of Žiri it is sparser. Similarly, several new populations were recently discovered in Central Slovenia

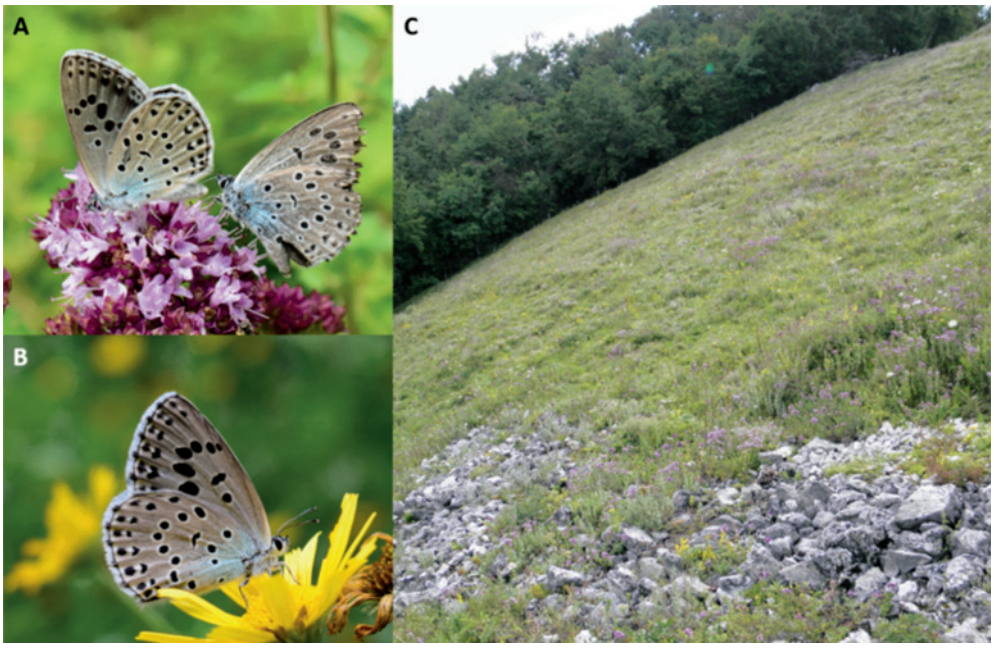

Figure 3: A) and B): *Phengaris arion* NW of Trebija in a ravine towards Stara Oselica on 19.7.2020 (A) and in a small ravine NW of Podgora (B); C) Habitat of *P. arion* on Mt. Slajka at the end of July in 2016.

Slika 3: A) in B): *Phengaris arion* SZ od Trebije v dolini proti Stari Oselici slikan 19.7.2020 (A) in v majhni dolini SZ od Podgore (B); C): Habitat *P. arion* na Slajki konec julija 2016.

(Šturm et al. 2023) indicting that the species is potentially more widespread in Slovenia than previously considered. Given the predominantly low densities of adults in the localities included in this survey, we are unable to evaluate their conservation value, so further surveys will be required to monitor the situation. This could be done through the regular national monitoring of the species in Slovenia, which could be expanded to include Škofjeloško Hills.

Conclusions

While the butterfly fauna of the Škofjeloško, Cerkljansko and Rovtarsko Hills is relatively well surveyed, many new localities of the threatened *P. arion* and one large population of *P. alcon* are important additions of our surveys between 2018 and 2023. Thus, 27 new localities (including some micro-localities) were discovered for both species together in the area. All but one previously known and newly found localities of *P. alcon* in the area are restricted to Rovtarsko Hills. On the other hand, *P. arion* is most widespread in Škofjeloško Hills, firmly establishing Škofjeloško Hills as one of the main strongholds of the species in Slovenia. Cerkljansko Hills, on

the other hand, hosts only a few *Phengaris* populations but their presence is still important for the biodiversity of the area. Our results show, that targeted species surveys are much more effective and should be expanded to other parts of the potential range of both species in Slovenia. We also propose, that at least some of the newly discovered localities should be included in the regular national monitoring of *P. arion*. In order to preserve both species in the surveyed area and beyond, more active conservation approach will be needed.

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