NATURA SLOVENIAE 20(1): 19-32
SCIENTIFIC PAPER

Prejeto / Received: 7.12.2017
Sprejeto / Accepted: 14.5.2018

Changes in butterfly species richness (Lepidoptera: Papilionoidea) over two decades in the Koroška region, Northern Slovenia

Vid ŠVARA[1], Rudi VEROVNIK[2]

[1]Helmholtz Center for Environmental Research – UFZ, Department Effect Directed Analysis, Permoserstraße 15, 04318 Leipzig, Germany; E-mail: vid.svara@ufz.de
[2]University of Ljubljana, Biotechnical Faculty, Department of Biology, Jamnikarjeva 101, 1000 Ljubljana, Slovenia, E-mail: rudi.verovnik@bf.uni-lj.si

Abstract. Changes in butterfly fauna in the Koroška region in northeastern Slovenia have been compared over a period of 22 years. Records from 12 sampling sites from late July 2016 are compared with the same sites from late July/early August 1994. On average, 30% of species richness was lost per site, with a maximum loss of 80% at one site with complete habitat degradation. Records from 35 sampling sites from July 2016 are presented, including records of several rare habitat specialist species, such as *Lycaena dispar*, *Plebejus optilete*, *Boloria titania*, and *Phengaris arion*, the latter being of particular importance for conservation. All in all, habitat degradation has been confirmed to be the main driver of the loss of butterfly richness in the Koroška region.

Key words: species distribution, species richness, threatened species, habitat degradation

Izvleček. Spremembe v favni dnevnih metuljev (Lepidoptera: Papilionoidea) v dveh desetletjih na Koroškem, severna Slovenija – V članku primerjava podatke terenskih raziskav dnevnih metuljev na Koroškem med letoma 1994 in 2016. Povprečno se je število vrst metuljev na lokacijo zmanjšalo za 30 %, z največjo izgubo 80 % vrst na lokaciji s povsem degradiranim habitatom. Objavljava tudi vse podatke o pojavljanju dnevnih metuljev, zbranih na 35 lokacijah v drugi polovici julija 2016. Med njimi so tudi vrste habitatnih specialistov *Boloria titania*, *Phengaris arion* ter *Plebejus optilete*, izmed katerih po naravovarstveni vrednosti izstopajo najdbe *P. arion*. Glavni razlog za izgubo vrstne pestrosti dnevnih metuljev na Koroškem je degradacija habitatov.

Ključne besede: razširjenost vrst, pestrost vrst, ogrožene vrste, degradacija habitata

Introduction

Historical records and scientific reports of local species diversity are extremely valuable because they provide baseline data that can be used for the evaluation and preservation of biodiversity, which is the main goal of the Biodiversity Convention (UNEP 1992). Only a few historic and recent scientific works have focused on the species diversity of the butterfly fauna in the Koroška region, therefore, every additional contribution is very important in providing information that can help to protect and preserve its butterfly fauna and the species' habitats.

The landscape of the Koroška region is characterized by predominantly extensively farmed meadows and a patchy landscape of forests, mountains, and valleys (Senegačnik 2012), which contribute to high butterfly diversity. The butterfly fauna of the region is relatively well studied given the data included in the Atlas of Butterflies of Slovenia and its supplement (Verovnik et al. 2012, Čelik 2014). However, very little published information is available. The only overview covering the Koroška region dates back to 1983, when the butterfly fauna of the Podravje region was reviewed (Jež 1983). Important species distribution information is also available for the neighbouring part of Koroška in Austria (Thurner 1948, Hassler & Tschinder 1998). Two reports based on field work at the student research camps in 1994 and 1995 also added important new information on species distribution of the Koroška region (Verovnik 1995a, b). Most recently, a rigorous study of butterfly diversity of Mt Košenjak was published (Kadiš 2016).

Apart from general surveys of the butterfly fauna of the Koroška region, two cases of species extirpation in the region have been reported. The first concerns *Coenonympha tullia*, which was found in the Koroška region in 1962 (Lesar 1998) and at several additional sites in the 1990s (Verovnik et al. 2012). The species was last recorded in Koroška in 2001 and is considered locally extinct due to habitat degradation, including the overgrowing of wet meadows and drainage of mires (Čelik et al. 2005, Čelik 2012, Verovnik et al. 2012). The second case concerns *Colias myrmidone* (Esper, 1781), which was reported from several sites in the Koroška region up to 1989 (Predovnik & Verovnik 2004), but is now considered extinct in Slovenia (Verovnik et al. 2012). Both cases are examples of extreme effects of land use change on butterfly habitats.

Koroška also includes several important areas designated as Natura 2000 sites aimed at conserving qualifying butterfly species (Ur.l. RS 2004). Four qualifying species of butterflies have been observed in the Koroška region, i.e. *Colias myrmidone*, *Lycaena dispar*, *Euphydryas aurinia* and *E. maturna*. Already at the time when these areas were designated, the problem of intensive overgrowing and habitat deterioration was recognized as the main threat to the habitats of *Lycaena dispar* and *Euphydryas aurinia* in the area of Gornji Dolič and Razbor due to changes in land use (Čelik et al. 2005).

The main goal of this study is to compare the change of species richness in the Koroška region over the past 22 years. The basis of our comparison is a field survey report on the species richness of butterflies in the Koroška region from 1994, when 14 localities were visited at the end of July and beginning of August (Verovnik 1995a). A total of 61 species were observed during the survey, including some rare species associated with wet grasslands like

Lycaena dispar, *Phengaris teleius*, and *P. nausithous*. In order to implement a comparable survey of butterfly fauna in the region, we revisited 13 of the 14 previously surveyed localities in the second half of July 2016 during the Biology Students Society's (DŠB) research camp. By comparing 12 of the revisited sites, we wished to elucidate particularly the changes in butterfly richness, the loss of butterfly diversity in the region, and to provide comments on the causes of the decline.

Materials and methods

Butterflies were surveyed in the second half of July 2016. In total, 35 localities were visited; among them, 13 localities were revisited after 22 years (Fig. 1). The 22 new localities were selected based on known distribution records of rare and endangered butterfly species (Verovnik et al. 2012) and Google Earth satellite images where potentially extensive or partially overgrown grasslands, which could host a large number of butterfly species, were identified. Adult butterflies were captured using entomological nets and released after identification. For identification purposes, the field guide Butterflies of Britain and Europe (Tolman & Lewington 2008) was used.

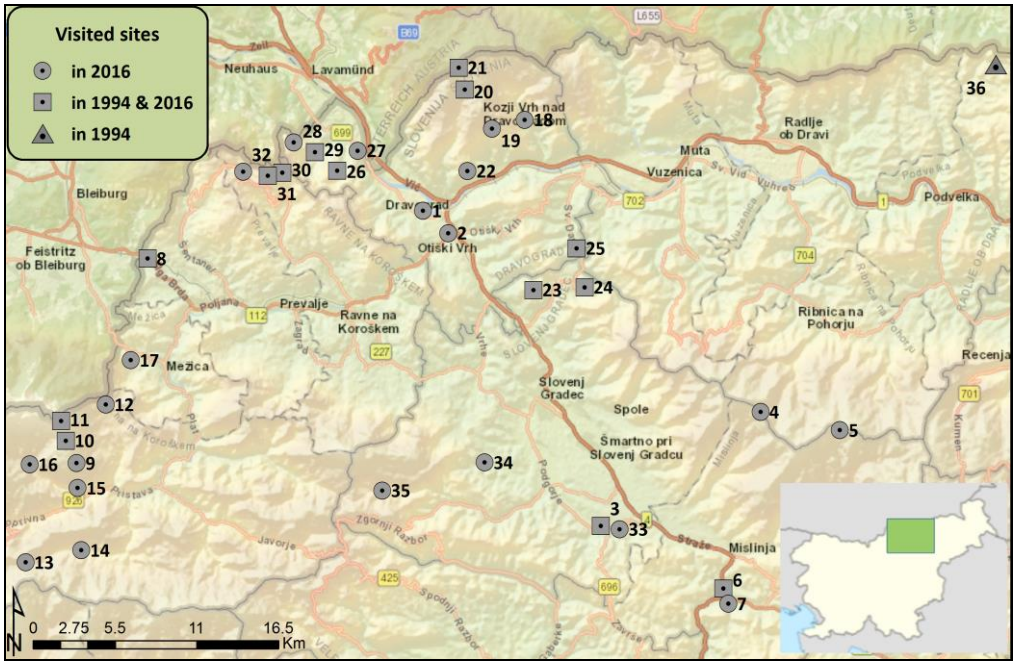

Figure 1. A map of locations in the Koroška region where butterflies were sampled. Circles indicate locations sampled exclusively in 2016, triangles in 1994, while squares denote locations sampled in 1994 and 2016.
Slika 1. Zemljevid prikazuje lokalitete, kjer smo vzorčili dnevne metulje na Koroškem. Krogi prikazujejo lokalitete, ki smo jih vzorčili samo v letu 2016, trikotniki v letu 1994, kvadrati pa lokalitete, ki smo jih vzorčili v obeh letih.

Sampling sites

The list of localities contains the relevant toponyms, a short description of the habitat, altitude, coordinates (WGS 1984), and dates of the visits. The locations in bold represent those that were also surveyed in 1994 and are included in the comparison herewith.

1. Dravograd, Dravski otok; bushes along the road, 350 m, 46°35'8.84"N 15°0'31.65"E, 18.7.2016, 22.7.2016.
2. Dravograd, at the roundabout in the direction of Ravne na Koroškem; intensively managed meadow, 340 m, 46°34'35.5"N 15°01'27.0"E, 18.7.2016.
3. **Podgorje, Šmiklavž**; wet meadow and intensive meadows, 470 m, 46°27'16.54"N 15°6'58.37"E, 18.7.2016.
4. Pohorje, at Grmovškov dom; extensively managed dry meadow, forest edge, 1370 m, 46°30'7.74"N 15°12'45.99"E, 18.7.2016.
5. Ribnica na Pohorju, Ribniški vrh and Ribniško jezero; extensively managed dry meadows, forest edge, and a bog, 1480 m, 46°29'40,41"N 15°15'38.38"E, 18.7.2016.
6. **Mislinja, Zgornji Dolič, west of the main Mislinja–Velenje road**; wet meadows and a fen, 540 m, 46°25'42.65"N 15°11'25.19"E, 18.7.2016.
7. Mislinja, Zgornji Dolič below the road to Zreče; overgrown fens, 540 m, 46°25'19.96"N 15°11'35.68"E, 18.7.2016.
8. Holmec, railway station; overgrowing meadow, intensively managed meadow, 510 m, 46°33'57.45"N 14°50'32.40"E, 19.7.2016.
9. Peca, below Planinski dom na Peci; path and clearings in coniferous forest, 1440 m, 46°28'50,87"N 14°47'58.32"E, 19.7.2016.
10. **Mala Peca, saddle**; partially abandoned pastures, forest edge, 1690 m, 46°29'24.61"N 14°47'34.54"E, 19.7.2016.
11. **Peca, trail to the Kordeževa glava peak**; alpine meadows mostly overgrown with Pinus mugo, 1880 m, 46°29'54.03"N 14°47'24.18"E, 19.7.2016.
12. Peca, Karavla; forest edge, 1030 m, 46°30'18.58"N 14°49'1.51"E, 19.7.2016.
13. Črna na Koroškem, Bistra, Kozja peč; rocky slopes in the gorge, 1080 m, 46°26'22.28"N 14°46'7.29"E, 20.7.2016
14. Črna na Koroškem, Bistra, Plaznik homestead; intensively managed meadow, 840 m, 46°26'40,45"N 14°48'8.57"E, 20.7.2016.
15. Črna na Koroškem, Topla, first part of the valley; rocky slopes, 750 m, 46°28'13.57"N 14°48'0,55"E, 20.7.2016.
16. Črna na Koroškem, Topla, Fajmut homestead; intensively managed meadow, 940 m, 46°28'49.04"N 14°46'15.99"E, 20.7.201626.
17. Mežica, at the Sušec stream; wet meadow, 640 m, 46°31'25.28"N 14°49'56.36"E, 20.7.2016.
18. Dravograd, upper part of the Velka stream valley; dirt road with stream and bushes in the forest, 600 m, 46°37'25.04"N 15° 4'12.97"E, 21.7.2016.
19. Dravograd, Sveti Duh, under homestead; extensive mesophilic meadow, 900 m, 46°37'11.97"N 15° 3'2.07"E, 21.7.2016.
20. **Dravograd, Košenjak, below the mountain hut**; extensive humid grasslands, pastures, 1190 m, 46°38'10,20"N 15° 2'2.31"E, 21.7.2016.
21. **Dravograd, Košenjak, top of the mountain**; extensive dry subalpine meadow, 1510 m, 46°38'42.83"N 15° 1'49.20"E, 21.7.2016.

22. Dravograd, Ojstrica; extensive dry meadow, rocky slope, 680 m, 46°36'8.29"N 15°2'8.54"E, 21.7.2016.
23. **Pameče, Anski vrh**; intensively managed meadow, 750 m, 46°33'10,24"N 15° 4'31.65"E, 21.7.2016.
24. **Pameče, Jesenk**; meadows overgrown by bushes and intensively managed meadows, 640 m, 46°33'14.25"N 15° 6'23.14"E, 21.7.2016.
25. **Trbonje, Reka stream valley**; intensively managed meadow, forest edge, 430 m, 46°34'12.78"N 15° 6'6.02"E, 21.7.2016.
26. **Črneče, Črneška gora**; intensively managed meadow, 690 m, 46°36'8.95"N 14°57'25.12"E, 22.7.2016.
27. Črneče, Rener homestead; extensive dry meadow, 360 m, 46°36'38.68"N 14°58'9.82"E, 22.7.2016.
28. Libeliče, Flori homestead; dry meadow, 770 m, 46°36'51.31"N 14°55'50,53"E, 22.7.2016.
29. **Libeliče, Libeliška gora**; dry meadow, forest edge, 560 m, 46°36'36.66"N 14°56'36.64"E, 22.7.2016.
30. **Prevalje, Strojna, Janeš homestead**; dry meadow, 960 m, 46°36'5.81"N 14°55'25.83"E, 22.7.2016.
31. **Prevalje, Strojna, at the school**; dry meadow and pastures, 1010 m, 46°36'1.25"N 14°54'54.33"E, 22.7.2016.
32. Prevalje, Strojna, Smrečnik homestead; wet meadow and forest edge, 880 m, 46°36'7.36"N 14°54'0.34"E, 22.7.2016.
33. Slovenj Gradec, Šmiklavž, Jenina; intensively managed wet meadow, 480 m, 46°27'11.86"N 15°7'39.57"E, 24.7.2016.
34. Raduše, valley under Smrčun homestead, west from the village; wet meadow and forest road, 500 m, 46°28'51.85"N 15°2'46.06"E, 24.7.2016.
35. Slovenj Gradec, Podgorje, Plešivčnikov mlin; partially overgrown wet meadows, 860 m, 46°28'9.91"N 14°59'3.01"E, 24.7.2016.
36. Remšnik, Potočnikov potok; wet meadows and thermophilic slope, 650 m, 46°38'47.6"N 15°21'17.8"E, 1.8.1994 (Verovnik 1995a).

The data distributions from the two years were tested for normality using Q-Q plot and Shapiro-Wilks test, and for homogeneity of variances with Levene's test. The data was then compared using the Student's Paired t-test. The mean values and standard errors were plotted. Comparisons were performed using R statistical software (R Core Team 2015).

Results

Species lists from 1994 and 2016

A total of 70 butterfly species were recorded at the 35 sampled locations in the Koroška region during the 2016 surveys (Tab. 1). In 1994, 61 species were observed at 14 sampled locations (Tab. 1). Overall, there are 11 species that were recorded during the first survey, but were not observed again in 2016 (Tab 1.). On the other hand, 21 species that were recorded in 2016 had not been observed in 1994 (Tab. 1).

Table 1. List of butterflies recorded during survey in the Koroška region in 2016 with a comparison to the 1994 survey. The nomenclature follows the European Red list of Butterflies (Van Swaay et al. 2010) with some modifications. The numbering of locations is the same as in the list of the locations. An »x« marks the species that were not found in the corresponding sampling session.

Tabela 1. Seznam dnevnih metuljev, opaženih med terenskim delom na Koroškem v letu 2016, ter primerjava s popisom iz leta 1994. Poimenovanje je povzeto po European Red List of Butterflies (Van Swaay et al. 2010) z nekaterimi modifikacijami. Številčenje lokacij je enako kot v seznamu lokacij. »x« označuje vrste, ki v posameznem letu vzorčenja niso bile najdene.

Taxon	No. of location in 2016	No. of location in 1994
Papilionidae		
Papilio machaon Linnaeus, 1758	9, **10**, **29**	6, 23, 30, 31
Iphiclides podalirius (Linnaeus, 1758)	**23**	6, 29, 30, 31
Pieridae		
Pieris brassicae (Linnaeus, 1758)	7, 18, 27, 28, **29**, **30**, 32	6, 10, 21, 26, 29
Pieris rapae (Linnaeus, 1758)	1, **6**, 8, **10**, **24**, 27, **30**	6, 10, 11, 20, 23, 24, 26, 29, 32
Pieris bryoniae (Hübner, 1805)	9, **11**	10, 11, 26
Pieris napi (Linnaeus, 1758)	8, 19, **20**, 22, **26**, 28, **30**, 32	3, 23, 24, 25, 26, 29, 36
Anthocharis cardamines (Linnaeus, 1758)	9	x
Colias crocea (Geoffroy, 1785)	1, **3**, 7, 8, **24**, **29**, **31**	3, 6, 10, 11, 20, 21, 23, 24, 25, 29, 30, 31
Colias hyale (Linnaeus, 1758)	7	x
Gonepteryx rhamni (Linnaeus, 1758)	5, 7, 9, **10**, **11**, 13, 16, 17, 18, **21**, **29**, **30**, **31**, 32, 33, 34	6, 10, 20, 23
Leptidea sinapis/juvernica	7, 15, 18, **23**, **24**, 27, **30**, 34	6, 10, 20, 24, 25, 26, 29
Lycaenidae		
Satyrium spini (Denis & Schiffermüller, 1775)	9, 13	x
Lycaena phleas (Linnaeus, 1761)	8, 16, 22, **29**, **31**, 32	29
Lycaena dispar (Haworth, 1802)	8	25
Lycaena virgaureae (Linnaeus, 1758)	13, 15, 16, 28, **29**, **30**, **31**	10, 20, 24, 26, 29, 30, 31
Lycaena tityrus (Poda, 1761)	8, 27, **29**	23, 29
Lycaena alciphron (Rottemburg, 1775)	**29**	x
Lycaena hippothoe (Linnaeus, 1761)	4, **10**	3, 10
Celastrina argiolus (Linnaeus, 1758)	1	26, 29
Cupido argiades (Pallas, 1771)	8, **29**	x
Cupido minimus (Fuessly, 1775)	7, **30**	6

Taxon	No. of location in 2016	No. of location in 1994
Glaucopsyche alexis (Poda, 1761)	x	10
Phengaris arion (Linnaeus, 1758)	19, 22, **29**, **31**	x
Phengaris nausithous (Bergsträsser, 1779)	x	8
Phengaris teleius (Bergsträsser, 1779)	x	8
Plebejus optilete (Knoch, 1781)	4, 5	x
Plebejus argus (Linnaeus, 1758)	8, **24**, **29**, 34	6, 29
Plebejus idas (Linnaeus, 1761)	22	x
Aricia agestis (Dennis & Schiffermüller, 1775)	x	29
Cyaniris semiargus (Rottemburg, 1775)	4, 9, **10**, **11**	x
Polyommatus dorylas (Dennis & Schiffermüller, 1775)	x	29
Polyommatus amandus (Schneider, 1792)	5	x
Polyommatus bellargus (Rottemburg, 1775)	35	x
Polyommatus icarus (Rottemburg, 1775)	1, **3**, **6**, 7, 14, **23**, **26**, 27, **30**	23, 25, 29, 30, 31
Nymphalidae		
Apatura iris (Linnaeus, 1758)	32	20, 25, 30, 31
Limenitis populi (Linnaeus, 1758)	1, 15, 16	x
Neptis rivularis (Scopoli, 1763)	13, 18, **24**, 32	x
Nymphalis polychloros (Linnaeus, 1758)	**20**	x
Nymphalis antiopa (Linnaeus, 1758)	**31**, **32**	10, 21, 29
Aglais io (Linnaeus, 1758)	**3**, 4, 5, 7, 9, **10**, **11**, 13, 17, **20**	6, 10, 11, 20, 21, 26
Aglais urticae (Linnaeus, 1758)	4, 5, 9, **10**, **11**, 13, 19, 28	10, 11, 20, 21, 25, 30, 31
Vanessa atalanta (Linnaeus, 1758)	**3**, 4, 5, 7, 9, **10**, 17, 18, **20**, **23**, **26**, **30**, 32, 35	3, 6, 10, 11, 20, 21, 26, 29
Vanessa cardui (Linnaeus, 1758)	4, 5, 8, 9, **10**, 14, 16, 17, **20**, **21**, **26**, 28	3, 10, 11, 20, 21, 23, 25, 30, 31
Araschnia levana (Linnaeus, 1758)	7, 8, 18, 19, **25**, **26**, **29**, 35	x
Polygonia c-album (Linnaeus, 1758)	9, 18, **20**	10, 20, 23, 24, 25, 26
Issoria lathonia (Linnaeus, 1758)	**21**	10, 20, 21, 23, 30, 31
Argynnis paphia (Linnaeus, 1758)	9, 13, 14, 15, 17, **20**, 34, 35	6, 10, 23, 24, 26, 29
Argynnis aglaja (Linnaeus, 1758)	4, **10**, **11**, 12, 16, **20**, **21**, 22, **25**, **30**, **31**, 32	10, 20, 21, 23, 25, 26, 29, 30, 31

Taxon	No. of location in 2016	No. of location in 1994
Argynnis niobe (Linnaeus, 1758)	**10**, 19	10, 29
Brenthis daphne (Bergsträsser, 1780)	**20**	x
Brenthis ino (Rottemburg, 1775)	3, 8, 17	x
Boloria titania (Esper, 1793)	9	10
Boloria euphrosyne (Linnaeus, 1758)	9	x
Boloria selene (Denis & Schiffermüller, 1775)	7	6
Boloria dia (Linnaeus, 1767)	x	20, 23
Melitaea diamina (Lang, 1789)	14	x
Melitaea didyma (Esper, 1778)	x	23, 25
Melitaea athalia (Rottemburg, 1775)	4, 5, **21**, 28, **30**, **31**, 32	10, 21, 29
Melitaea aurelia Nickerl, 1850	**21**	36
Melanargia galathea (Linnaeus, 1758)	7, 8, 9, 12, 17, 18, 19, **20**, 22, **23**, **26**, 27, 28, **29**, **30**, **31**, 32, 34, 35	6, 10, 20, 21, 23, 25, 26, 29, 30, 31
Minois dryas (Scopoli, 1763)	2, 34	23, 25
Brintesia circe (Fabricius, 1775)	x	24, 26
Erebia ligea (Linnaeus, 1758)	9, **20**	36
Erebia euryale (Esper, 1805)	4, 9, **20**, **21**, 35	10, 11, 20, 21
Erebia aethiops (Esper, 1777)	x	6, 11, 26
Erebia medusa (Denis & Schiffermüller, 1775)	**10**	x
Erebia stiria (Godart, 1824)	13	10
Maniola jurtina (Linnaeus, 1758)	**3**, 7, 8, 12, 13, 14, 16, 17, 18, 19, 22, **23**, **24**, **25**, **26**, 27, 28, **29**, **30**, **31**, 32, 33, 34, 35	3, 6, 10, 20, 21, 23, 24, 25, 26, 30, 31
Aphantopus hyperantus (Linnaeus, 1758)	**3**, 8, 18, **20**, **26**, **29**, **30**, **31**, 32, 33	20, 25, 26, 29
Coenonympha arcania (Linnaeus, 1761)	4, 9, 13, **20**	10,
Coenonympha glycerion (Borkhausen, 1788)	8	23
Coenonympha pamphilus (Linnaeus, 1758)	**3**, 7, 8, **24**, **26**, 28, **29**, **30**	3, 6, 30, 23, 24, 25, 26, 30, 31
Pararge aegeria (Linnaeus, 1758)	9	6, 25, 26
Lasiommata megera (Linnaeus, 1767)	x	21, 23, 29, 30, 31
Lassiommata petropolitana (Fabricius, 1787)	x	10
Lasiommata maera (Linnaeus, 1758)	9, **10**, **11**, 13, **20**, **21**	x

Taxon	No. of location in 2016	No. of location in 1994
Hesperiidae		
Erynnis tages (Linnaeus, 1758)	**6**, 8, 9, **29**	3, 6, 23, 25, 29
Thymelicus lineola (Ochsenheimer, 1808)	**3**, 4, 7, 12, 16, 17, 19, **20**, **21**, 22, **24**, **25**, 27, 28, **30**, **31**, 35	26, 29, 30, 31
Thymelicus sylvestris (Poda, 1761)	9, 16, **24**	6, 20, 24, 29, 31
*Hesperia comma (*Linnaeus, 1758)	8	6, 23, 24, 25, 29, 30, 31
Ochlodes sylvanus (Esper, 1777)	**6**, 9, 12, 13, 15, 16, 17, **29**, 32, 35	25, 26

Comparison of the two surveys

Twelve locations were sampled in both years, which enabled us to prepare a complete list of the species observed and to make their direct comparisons (excluding locations 8 and 36, which were only partially sampled in 1994). In 1994, 57 species had been observed at these locations and 48 in 2016. Therefore, in total, nine species fewer were observed in 2016, marking a 16% decline. Looking at the species, 18 of those observed in 1994 were not seen at these same locations in 2016. On the other hand, 10 new species were observed in 2016.

The mean value of the number of species per site was 18.3 in 1994 and 12.8 in 2016 (Tab. 2). Therefore, the calculated mean number of the species detected per site in 2016 is by 30% lower than in 1994. The difference between the means is significant when tested with the Student's Paired t-test (t=2.088; p=0.017), at a confidence interval of 95% (Fig. 2). When looking at the locations, nine out of 12 of the compared locations had lower species richness in 2016 (Tab. 2).

Table 2. Comparison of butterfly species richness in the Koroška region between 1994 and 2016 at 12 locations, with the change in species richness indicated by the colour code (green – increase, orange – minor decrease of up to 5 species, red – decrease by more than 5 species). The locations are numbered as in the list of sampling sites.
Tabela 2. Primerjava pestrosti vrst dnevnih metuljev na 12 lokacijah na Koroškem v letih 1994 in 2016 z navedenimi spremembami številčnosti, prikazanimi z barvno lestvico (zeleno – povečanje št. vrst, oranžno – manjše zmanjšanje št. vrst do 5, rdeče – zmanjšanje št. vrst za več kot 5). Lokacije so oštevilčene tako kot v seznamu lokacij.

Location	3	6	10	11	20	21	23	24	25	26	29	30, 31
No. 1994	8	20	27	9	19	14	22	12	20	21	29	18
No. 2016	9	18	28	7	17	10	6	9	4	9	17	20
Difference	**+1**	**-2**	**+1**	**-2**	**-2**	**-4**	**-16**	**-3**	**-16**	**-12**	**-12**	**+2**

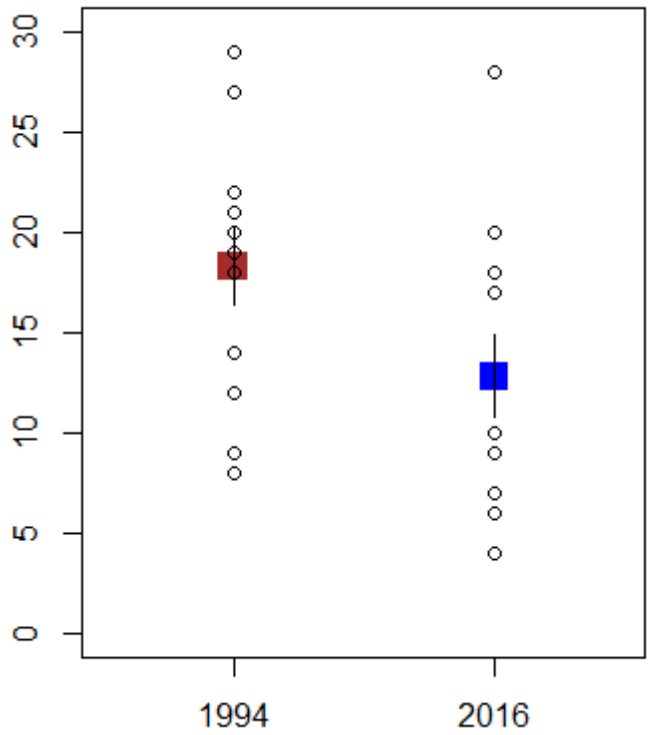

Figure 2. Comparison of butterfly species richness mean values per sampled location between 1994 and 2016. The squares indicate the mean value in each year. The lines denote standard error for the given mean value. The empty circles indicate the number of observed species at each location.
Slika 2. Primerjava srednjih vrednosti števila vrst dnevnih metuljev glede na lokacijo med letoma 1994 in 2016. Kvadrata prikazujeta srednjo vrednost vrst v posameznem letu. Liniji označujeta standardno napako vsake srednje vrednosti. Točke ponazarjajo število opaženih vrst na posamezni lokaciji.

Discussion

At first glance, the total number of species observed in 2016 (70) surpasses the number of species in 1994 (61). However, not all of the locations from the surveys can be directly compared as the 2016 survey involved more than twice as many sites and a larger area. When only the sites surveyed in both years are compared, a 16% decline in richness is evident in 2016. Additionally, several species not recorded in 1994 are the result of a partial mismatch in the timing of both surveys and potential seasonal differences as several species typically flying in spring, such as *Anthocharis cardamines*, *Brenthis ino*, *Boloria euphrosyne*, and *Erebia medusa*, were observed only in 2016. The absence of species not recorded in 2016 could, however, not be interpreted by their phenology. According to the implemented statistical test, the negative change in species richness is significant for the analyzed sites. The loss of more

than six species on average per site is alarming as it is equal to 30% fewer species observed (Fig. 2). The four sites with the most drastic declines (Tab. 2) have been transformed from flower rich meadows to intensive grasslands, supporting a much lower number of butterfly species, which are mostly habitat generalists (Dolek & Geyer 1997, Van Swaay et al. 2016).

The loss of wet meadows is evident in the entire Koroška region (authors' pers. observ.). None of the aforementioned wet grassland specialists, including *Phengaris teleius*, and *P. nausithous* were observed during the 2016 survey (Tab. 1). *P. alcon* was not found at a historically known location (location 33) (Verovnik et. al. 2012). Even their larval host plants were missing from those sites. These wet grassland specialist butterfly species disappeared from the Koroška region before 2010 (Verovnik et al. 2012, Verovnik pers. observ.). Another species associated to wet grasslands was observed after a long absence: *L. dispar* was found again at a new site close to the border crossing Holmec at location 8 in 2016 (Tab. 1). In remaining fragments of wet meadows and fens, we found only *Melitaea diamina*, *Brenthis ino*, and *Boloria selene*, which are generally not exclusively linked to wetland habitat types in Slovenia (Verovnik et al. 2012). All visited sites where the three mentioned species had been found in the past were in different stages of overgrowing with tall herbs, bushes, and trees, hence unsuitable for other specialist butterfly species.

The most encouraging finding of the surveys in 2016 is the observation of *Phengaris arion* at several sites on Mt Strojna and Mt Košenjak. The species is limited to extensively managed dry grasslands with an abundance of thyme (*Thymus* spp.) or origanum (*Origanum vulgare*) and is considered vulnerable (VU) in Slovenia (Ur. l. RS 2002). It has been historically recorded from only two locations in the Koroška region (Verovnik et al. 2012) until several colonies were discovered on Mt Košenjak in 2009 (Kadiš 2016). In 2016, we confirmed its presence on Mt Košenjak, and made new sightings on Mt Strojna. Only single specimens were observed at all sites, however, *P. arion* is generally known to occur in low densities (Mouquet et al 2005). Additional interesting records of specialists are: *Boloria titania*, which was observed on Mt Peca at 1440 m, within the main altitudinal belt of its distribution in Slovenia (Verovnik et al. 2012), *Plebejus optilete*, found again within its range in the western part of Pohorje Mts (Jež & Verovnik 2012), and *Erebia stiria*, which was found at Kozja peč in Bistra valley on screes and rocky slopes, a typical habitat of the species in Slovenia (Jutzeler et al. 2001).

Several locations visited during the 2016 survey are located within Natura 2000 sites (Ur.l. RS 2004): Grintovci (ID: SI5000024, locations 9, 10, 11, 15, 16), Huda luknja (ID: SI3000224, locations 6, 7), Peca (ID: SI3000132, locations 9, 10), Pohorje (ID: SI3000270, locations 4, 5), Razbor (ID: SI3000166, locations 34, 35), and Zahodni Kozjak (ID: SI3000337, locations 18, 19). Huda luknja and Razbor are listed as areas where *L. dispar* is present (Ur. l. RS 2004), however, the habitats formally suitable for *L. dispar* are currently almost completely overgrown with trees and bushes and the presence of the species could not be confirmed at either site. *Colias myrmidone* is a qualifying species in the Pohorje Natura 2000 area, but is considered extinct in Slovenia (Verovnik et al. 2012). The presence of both *Euphydryas* species could not be verified during our surveys, as they fly earlier in the season. The goal of the Natura 2000 sites, to preserve and, at best, improve the quality of the protected species' habitats (Ur. l. RS 2004), has not yet been met in the Koroška region.

Even more disappointingly, drastic negative habitat changes are evident in the last decades and are ongoing in many areas included in this study (authors' pers. observ.). Although there is sufficient legislative support for the conservation of threatened butterfly species and their habitats in Slovenia, the implementation is completely lacking and the negative processes of either abandonment or intensification continue. We fear that without the engagement of landowners, local communities, and authorities, coupled with regular monitoring, we will be faced with continuous erosion of butterfly species richness in the Koroška region. To halt this negative trend, the appropriate funding by the state and development of nature oriented tourism will be of great importance—the sooner the better!

Povzetek

V članku primerjamo podatke terenskih raziskav dnevnih metuljev na Koroškem med letoma 1994 in 2016. V letu 2016 smo ponovno vzorčili 13 lokalitet, katerih podatki so predstavljeni v poročilu terenskega dela iz leta 1994 (Sl. 1). Primerjali smo 12 lokalitet, za katere imamo kompletne podatke o favni metuljev v obeh letih. Dodatno smo obiskali še 22 drugih lokalitet (Sl. 1) in pripravili pregled razširjenosti vrst (Tab. 1) na Koroškem v drugi polovici julija.

Iz rezultatov je razviden upad skupne pestrosti vrst na primerjanih lokacijah za 16 %, ter kar za 30 % manjše povprečno število opaženih vrst, ko primerjamo stanje na posamezni lokaciji. Povprečno znižanje vrst med dvema letoma je tudi statistično značilno glede na Student's paired t-test.

Razlika v srednji vrednosti števila vrst glede na lokaliteto med obema letoma je več kot šest vrst (Sl. 2). Največje razlike so bile opažene med habitati, na katerih se je raba travnika intenzivirala oz. se habitat intenzivno zarašča. Na teh lokacijah se je število vrst znižalo tudi do 80 %. Poleg tega v letu 2016 nismo našli dveh vrst, vezanih na mokrotne travnike (*Phengaris teleius*, *P. nausithous*), kar je dodatni kazalec izgube mokrotnih travnikov na Koroškem. Nadaljnje uničenje travnikov in povirij po eni strani ter intenzivno zaraščanje po drugi, bosta v prihodnje privedla tudi do poslabšanja stanja drugih specializiranih vrst, ki nam jih je v letu 2016 še uspelo potrditi (*Melitaea diamina*, *Brethis ino*, *Boloria selene*).

Kljub vsemu je najdba 70 vrst dnevnih metuljev v drugi polovici julija na območju Koroške v letu 2016 spodbudna, še posebej pa dajejo upanje nove najdbe *Phengaris arion* na dveh lokalitetah na ovršju Strojne. Ekstenzivna raba travnikov na tem območju omogoča rast materine dušice (*Thymus* spp.), hranilne rastline tega metulja. Gledano v celoti je stanje predvsem mokrotnih travnikov na Koroškem kritično, saj kljub vzpostavitvi območij Natura 2000, ki naj bi ščitila kvalifikacijske vrste dnevnih metuljev (*Lycaena dispar*) in njihovih habitatov, ti pospešeno izginjajo, kar bo prispevalo k nadaljevanju erozije vrstne pestrosti metuljev na Koroškem.

Acknowledgements

We would like to thank the Biology Students Society (DŠB) for its organization of the biodiversity research camp in Dravograd in 2016, and to Andjela Ostojić, Iva Šutevski, Špela Zupančič, Tatiana Moreira, and Elena Motivans for their active participation during the fieldwork. Franc Verovnik contributed a valuable literature source, three anonymous reviewers made constructive suggestions regarding the paper, while Elena Motivans provided useful comments regarding language.

References

Čelik T. (2012): Munčev okarček *Coenonympha tullia* (Müller, 1764) (Lepidoptera: Nymphalidae) v Sloveniji ni izumrl. Acta entomol. slov. 20: 45–58.

Čelik T. (2014): Supplements to the atlas of butterflies (Lepidoptera: Rhopalocera) of Slovenia. Hacquetia 13: 1–41.

Čelik T., Verovnik R., Gomboc S., Lasan M. (2005): NATURA 2000 v Sloveniji: Metulji (Lepidoptera). Založba ZRC, ZRC SAZU, Ljubljana, 288 pp.

Dolek M., Geyer A. (1997): Influence of management on butterflies of rare grassland ecosystems in Germany. J. Insect Conserv. 1: 125–130.

Hassler L., Tschinder M. (1998): Ein Beitrag zur Schmetterlingsfauna von Unterkärnten (Insecta: Lepidoptera). Carinthia II 188/108: 437–451.

Jež M. (1983): Osnovne karakteristike favne dnevnih metuljev (Lepidoptera, Diurna) Slovenskega Podravja. Biol. vestnik 31: 83–106.

Jež M., Verovnik R. (2012): O pojavljanju in ogroženosti borovničevega mnogooka (*Plebejus optilete* (Knoch, 1781)) (Lepidoptera: Lycaenidae) v Sloveniji. Acta entomol. slov. 20: 125–134.

Jutzeler D., Rebeušek F., Sala G., Verovnik R. (2001): The confirmation of the specifity of *Erebia stirius* (Godart, 1824) and *Erebia styx* (Freyer, 1834), diagnosed by Lorković (1952) with a nomenclatural abstract concerning the specific names of the *styx/stirius*–complex (Lepidoptera: Nymphalidae, Satyrinae). Linn. Belg. 18: 113–124.

Kadiš A. (2016): Razširjenost in ogroženost dnevnih metuljev na Košenjaku (Koroška). Biotehniška fakulteta, Ljubljana, 76 pp.

Lesar T. (1998): *Coenonympha tullia* O. F. Müller 1764, na Slovenskem Koroškem (Lepidoptera: Satyridae). Acta entomol. slov. 6: 16.

Mouquet N., Thomas J.A., Elmes G.W., Clarke R.T., Hochberg M.E. (2005): Population dynamics and conservation of a specialized predator: a case study of *Maculinea arion*. Ecol. Monogr. 75: 525–542.

Predovnik Ž., Verovnik R. (2004): New records of rare pierids (Lepidoptera: Pieridae) in Slovenia. Nat. Slo. 6: 39–47.

R Core Team (2015): R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, URL https://www.R-project.org/ [accessed on 10.11.2017].

Senegačnik J. (2012): Slovenija in njene pokrajine. Modrijan, Ljubljana, 471 pp.

Thurner J. (1948): Die Schmetterlinge Kärntens und Osttirol, Faunistik und Ökologie Macros. Carinthia II, Sup ll, Klagenfurt, 10 pp.

Tolman T., Lewington R. (2008): Butterflies of Britain & Europe. Harper Collins Publishers, London, 384 pp.

UNEP (1992): Convention on biological diversity. URL http://www.cbd.int/doc/legal/cbd–en.pdf [accessed 10.11.2017].

Ur. l. RS (2002): Pravilnik o uvrstitvi ogroženih rastlinskih in živalskih vrst v rdeči seznam. Uradni list RS 82(02): 8893–8975.

Ur. l. RS (2004): Uredba o posebnih varstvenih območjih (območjih Natura 2000). Uradni list RS 49(04): 6414–6472.

Van Swaay C., Cuttelod A., Collins S., Maes D., Lopez Munguira M., Šašić M., Settele J., Verovnik R., Verstrael T., Warren M., Wiemers M., Wynhof I. (2010): European Red List of Butterfies. Publications Office of the European Union, Luxembourg, 47 pp.

Van Swaay C., Van Strien A.J., Aghababyan K., Åström S., Botham M., Brereton T. Carlisle B., Chambers P., Collins S. et al. (2016): The European Butterfly Indicator for Grassland species 1990–2015. Report VS2016.019, De Vlinderstichting, Wageningen, 42 pp.

Verovnik R. (1995a): Črneče '94 – Poročilo lepidopterološke skupine. In: Bedjanič M. (Ed.), Tabor študentov biologije Raka '92, Smast '93, Črneče '94. Zveza organizacij za tehnično kulturo Slovenije, Gibanje znanost mladini, Ljubljana, pp. 83–92.

Verovnik R. (1995b): Poročilo metuljarske skupine. In: Šuštaršič A. (Ed.), Mladinski ekološko-družboslovni raziskovlni tabor (Libeliče '95), Zbornik poročil. Mladi forum Združene liste socialnih demokratov, Ljubljana, pp. 33-45.

Verovnik R., Rebeušek F., Jež M. (2012): Atlas dnevnih metuljev (Lepidoptera: Rhopalocera) Slovenije. Center za kartografijo flore in favne, Miklavž na Dravskem polju, 456 pp.