**BUTTERFLY (LEPIDOPTERA: RHOPALOCERA) DIVERSITY AND AGRICULTURAL LAND USE IN SOLČAVA AREA, N SLOVENIA**

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**Abstract** - The article presents a contribution to the knowledge of butterfly diversity (Lepidoptera: Rhopalocera) of the Solčavsko, an important area for nature conservation in Slovenia. Survey took place from June to August 2014 at six localities. Field observations were performed twice per month. The localities are characterised by different agricultural land use: pastures and meadows. Altogether 50 butterfly species were recorded at the surveyed localities. Eight species are reported for this area for the first time, two of them threatened and/or protected in Slovenia: *Boloria selene* and *Lycaena alciphron*. The study shows that surveyed pastures have predominantly higher butterfly diversity than meadows.

**KEY WORDS:** butterflies, diversity, agriculture, Solčava, Slovenia

**Izveleček** - PESTROST METULJEV (LEPIDOPTERA: RHOPALOCERA) IN KMETIJSKA RABA ZEMLJIŠČ NA SOLČAVSKEM, SLOVENIJA.

Članek predstavlja prispevek k poznavanju pestrosti dnevnih metuljev (Lepidoptera: Rhopalocera) na Solčavskem, ki je pomembno območje ohranjanja narave v Sloveniji. Podatki so bili zbrani v obdobju med junijem in avgustom 2014 na šestih lokacijah, in sicer dvakrat mesečno. Na vzorčenih lokacijah je prisotna različna kmetijska raba:

pašniki in travniki. Skupaj je bilo opaženih 50 vrst metuljev. Med njimi je bilo 8 vrst metuljev prvič opaženih na tem območju; od tega sta dve ogroženi in/ali zavarovani vrsti v Sloveniji: *Boloria selene* in *Lycaena alciphron*. Ugotovili smo, da je bila na vzorčenih pašnikih pestrost metuljev večinoma večja kot na travnikih.

KLJUČNE BESEDE: metulji, pestrost, kmetijstvo, Solčava, Slovenija

## Introduction

Altogether, 180 butterfly species (Lepidoptera: Rhopalocera) are known from Slovenia, and 59 species were recorded in the Solčavsko area (Verovnik et al., 2012; Russel et al., 2014). Solčavsko lies below the summits of the Kamnik-Savinja Alps and is an important nature conservation area within Slovenia. Almost 80 % of the area is inside Natura 2000 sites. Two Landscape parks (IUCN category V) are located in the area: Robanov kot and Logarska dolina (Nature Conservation Atlas, 2014; ARSO, 2014). Geographically, Solčavsko is situated in the border area with Austria at the headwaters of Savinja River. The special features of Solčavsko are three parallel alpine glacial valleys: Logarska dolina, Robanov kot and Matkov kot (TIC Solčava, 2014).

The average temperature of the coldest month is  $-3^{\circ}\text{C}$  and the temperature of the warmest is above  $10^{\circ}\text{C}$ . The average annual rainfall of the area is between 1600 and 3000 mm, with intense rainfall between October and May (Ogrin, 1996). Forest cover in Solčavsko reaches 80% of the area. The dominant types of forest are fir-beech forest, mountain forest and Alpine beech forest. At higher altitudes spruce forest is dominant although there are also pine forests on steep slopes. The timberline is around 1600 meters high, varying locally because of the orientation or orographic obstacles (Lipnik et al., 2009). Farming, forestry and tourism are the main human activities in the area. During industrialization alpine cattle grazing decreased and many areas were subjected to afforestation, however, due to modern day livestock farming many of the pastures and meadows still remain active (Muri, 2005). Intensification in more productive regions and concurrent abandonment of less accessible and populated ones are the major threat in reducing biological diversity in agricultural landscapes (Stoate et al., 2009). Nilsson et al. (2008) revealed that decline in butterfly diversity coincided with the loss of flower-rich open habitats that had been maintained by late cutting.

The aim of this article is to contribute to a better knowledge of butterfly fauna in the Solčavsko area. Furthermore, the article tries to survey the impacts of agricultural land use on diversity of butterflies in this highly valuable area for nature conservation.

## Materials and Methods

The survey was carried out from June to August 2014 (dates of the field trips (FT): 7.6.2014, 29.6.2014, 12.7.2014, 24.7.2014, 9.8.2014, 29.8.2014). Field observations were performed twice per month (in the first and second half), between 10:00 AM and 4:00 PM in the sunny or partly cloudy weather. Six observation localities were spread across the Solčava area. The localities have different agricultural land use.

Two researchers surveyed butterfly fauna at each location for 30 minutes using the linear transect method. Butterflies were caught using butterfly nets (35 cm diameter), determined by field guides (Polak, 2009; Tolman & Lewington, 2008) and immediately released. Only unknown or interesting specimens were collected, photographed and deposited in a private collection of co-author J. Debets.

Vegetation from five quadrants (1 square meter) was randomly sampled each time on each location. A number of entomophilous blossoming flowers in each quadrant were counted. The results were ranged into four class intervals (1: 0-10, 2: 10-20, 3: 20-30, 4: more than 30 blossoming flowers). Because of looseness of the classes, the median of results was used. A number of entomophilous blossoming plant species was also defined using the same method. Number of species and arithmetic mean for each location were calculated. Spearman rank correlation was used to determine if the number of entomophilous blossoming plant species and total number of entomophilous blossoming flowers have any impact on butterfly diversity and their abundance.

Shanon-Wiener Diversity Index was calculated to compare diversity on the locations. This Index measures species diversity in a given community. It is a commonly used diversity index that takes into consideration both abundance and evenness of species present in the community (Henderson, 2003; Tome, 2006).

The list of localities and a short description of the habitat, coordinates and latitude:

**Gočova pustota:** The meadow is located in the Robanov kot valley. The meadow is fertilized with liquid manure every three to five years. The location is used for mowing twice per year and for cattle grazing at the end of summer. Y: 477631.2, X: 138879.9, 651 m.

**Bevska pustota:** The pasture is located in the Robanov kot valley. It is used for cattle grazing (cows). Y: 477631.2, X: 138879.9, 651 m.

**Klemenče njive:** The meadow is located near panoramic road above Logarska dolina. The site is fertilized with liquid manure once annually. The location is annually used for mowing and for cattle grazing. Y: 472589.4, X: 142563.1, 1153 m.

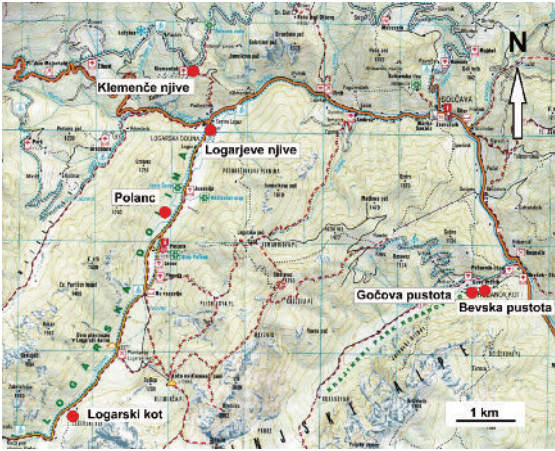
**Logarjeve njive:** The meadow is located by the entry in the Logarska dolina valley. The area is fertilized with liquid manure every three years. The location is used for mowing (twice annually). Y: 472790.6, X: 141570.9, Z: 732 m.

**Polanc:** The pasture is located in the Logarska dolina valley. The site is fertilized with liquid manure every three years. The location is usually used for cattle grazing and at times for mowing. Y: 472205.2, X: 140120.3, 738 m.

**Logarski kot:** The pasture is located in the Logarska dolina valley. The area is not fertilized. The location is used only for grazing (donkeys). Y:470590.6, X:136717.7, 905 m.

## Results and Discussion

Altogether 50 butterfly species were recorded at six locations in Solčava. Tab. 1 presents a list of observed species, their locations and abundance at each location.



**Fig. 1.** Map of six studied locations (marked with red spots) in the Solčava area.

**Fig. 2.** The Logarjeve njive meadow (Locality D) (Foto: Neža Orel, July, 2014)



**Fig. 3.** The pasture at Polanc (Locality E) (Foto: Neža Orel, June, 2014)

According to the Atlas of butterflies (Lepidoptera: Rhopalocera) of Slovenia (Verovnik et al., 2012) 59 butterfly species were expected in the Solčava area. Species that we did not find were: *Carterocephalus palaemon*, *Hesperia comma*, *Parnassius mnemosyne*, *Iphiolides podalirius*, *Leptidea reali*, *Colis alfacariensis*, *Lycaena virgaurea*, *Cupido minimus*, *Phengaris alcon*, *Aricia agestis*, *Aricia artaxerxes*, *Polyommatus coridon*, *Araschnia levana*, *Melitaea athalia*, *Neptis rivularis*, *Apatura iris*, *Erebia euryale* and *Brintesia circe*. However, eight new species, not recorded in this area in the Atlas, were observed (marked with \* in Tab. 1). Out of these, two are endangered and/or protected (*Boloria selene* and *Lycaena alciphron*). In total, 5 endangered and/or protected species were observed. They are described briefly below.

#### *Lycaena alciphron*

This protected species was observed at 29.6.2014 at the locality Logarjeve njive meadow. The species is common at the middle altitudes (Verovnik et al., 2012). It is univoltine and adults can be seen from June until the end of July. Larvae feed on *Rumex acetosa* and *Rumex acetosella*. The species is on the Red list of endangered butterflies in Slovenia.

#### *Lycaena hippothoe*

This protected species was common at location Logarski kot at the end of June and at the beginning of July. This butterfly is usually common in damp meadows and hillside bogs. Species has two generations annually from May till June and from June till August. Larvae feed on *Rumex* spp. and *Polygonum* spp. The species is on the Red list of endangered butterflies in Slovenia.

#### *Boloria selene*

We found this protected species in Logarski kot at 24.7.2014. The species usually lives in extensive damp meadows and moist headlands (Polak, 2009). Adults can be seen in two generations; first from May till June and second from July till September. Larvae feed on *Viola* spp. The species is on the Red list of endangered butterflies in Slovenia.

#### *Nymphalis antiopa*

This species was observed several times in August 2014 at different locations (Gočova pustota meadow, Klemenče njive and Polanc). It was observed on the meadows, which are surrounded by forest. This species of butterfly has strong migratory behaviour; usually migrates immediately after hatching from pupae (Polak, 2009). Adults can be seen as one generation from June to July. Larvae feed on *Salix* spp. and *Populus* spp.

#### *Melitaea diamina*

This protected species was found only at Polanc on 29.6. 2014 and 12.7.2014. It is common in wet meadows and is rarely found on dry meadows (Polak, 2009). It is univoltine and adults can be found from May till July. Larvae feed on *Valeriana officinalis*. Species is listed in the Red list of endangered butterflies in Slovenia.

**Tab. 1.** The list of butterfly species and localities with the abundance (Fauna Europaea, 2014).

Family	Species	Locality						
		A	B	C	D	E	F	
<i>Hesperiidae</i>	<i>Erynnis tages</i> (Linnaeus 1758)						1	
	<i>Thymelicus lineola</i> (Ochsenheimer 1808)		1	4	1		1	
	<i>Thymelicus sylvestris</i> (Poda 1761)		1	11	2		2	
	<i>Ochlodes venata</i> (Bremer & Grey 1853)		4		3	1	5	
<i>Papilionidae</i>	<i>Papilio machaon</i> (Linnaeus 1758)		1	1	3	1		
	<i>Leptidea sinapis</i> (Linnaeus 1758)	3	4	1	1	2	2	
<i>Pieridae</i>	<i>Anthocharis cardamines</i> (Linnaeus 1758)		1				1	
	<i>Pieris brassicae</i> (Linnaeus 1758)			3	4	3	11	
	<i>Pieris rapae</i> (Linnaeus 1758)	5	7	8	48	12	56	
	<i>Pieris napi</i> (Linnaeus 1758)	2	7	1	5	3	5	
	<i>Colias croceus</i> (Fuorcroy 1785)			1	1			
	<i>Gonepteryx rhamni</i> (Linnaeus 1758)	3	3	18	8	7	40	
	<i>Hamearis lucina</i> (Linnaeus 1758)		2				1	
	<i>Lycaena tityrus</i> (Poda 1761)				1		1	
<i>Lycaenidae</i>	<i>Lycaena alciphron</i> * (Rottemburg 1775)				1			
	<i>Lycaena hippothoe</i> (Linnaeus 1761)				2		14	
	<i>Lycaena phlaeas</i> * (Linnaeus 1761)	1		1				
	<i>Callophrys rubi</i> * (Linnaeus 1758)						1	
	<i>Satyrion spini</i> (Denis & Schiffermüller 1775)				1			
	<i>Plebejus argus</i> (Linnaeus 1758)		1			7		
	<i>Cyaniris semiargus</i> (Rottemburg 1775)				1	1	3	
	<i>Polyommatus amandus</i> (Schneider 1792)	1						
	<i>Polyommatus icarus</i> (Rottemburg 1775)	3	2	7	10	12	2	
	<i>Celastrina argiolus</i> * (Linnaeus 1758)					1		
	<i>Polyommatus bellargus</i> * (Rottemburg 1775)				1	1	1	
	<i>Nymphalidae</i>	<i>Argynnis paphia</i> (Linnaeus 1758)	5	7	3	1	8	29
		<i>Argynnis aglaja</i> (Linnaeus 1758)		1	3	1	5	
		<i>Argynnis adippe</i> (Denis & Schiffermüller 1775)					1	
<i>Issoria lathonia</i> (Linnaeus 1758)				6		1		
<i>Boloria euphrosyne</i> (Linnaeus 1758)			1			1	3	
<i>Boloria selene</i> * (Denis & Schiffermüller 1775)							1	
<i>Vanessa atalanta</i> (Linnaeus 1758)		3	8	7	1	4	3	
<i>Vanessa cardui</i> (Linnaeus 1758)		1					3	
<i>Aglais io</i> (Linnaeus 1758)		1	1	3	1		34	
<i>Aglais urticae</i> (Linnaeus 1758)			2	13	1	1		
<i>Polygonia c-album</i> (Linnaeus 1758)			4			1	3	
<i>Nymphalis antiopa</i> (Linnaeus 1758)		1		1		1		
<i>Melitaea diamina</i> (Lang 1789)						3		
<i>Limenitis camilla</i> (Linnaeus 1764)			5				3	
<i>Pararge aegeria</i> (Linnaeus 1758)			1				1	
<i>Lasiommata maera</i> (Linnaeus 1758)		2	3	2	2		3	
<i>Coenonympha arcania</i> (Linnaeus 1761)		1	9	1		2	4	
<i>Coenonympha pamphilus</i> (Linnaeus 1758)		7	2	19	21	25	3	
<i>Aphantopus hyperantus</i> (Linnaeus 1758)		2	12		15	6		
<i>Maniola jurtina</i> * (Linnaeus 1758)		5	8	91	114	27	1	
<i>Erebia ligea</i> (Linnaeus 1758)		1	1			3	8	
<i>Erebia stirus</i> (Godart 1824)		1				1	1	
<i>Erebia pronoe</i> (Esper 1780)							1	
<i>Erebia medusa</i> * (Denis & Schiffermüller 1775)			1					
<i>Melanargia galathea</i> (Linnaeus 1758)				2				
<b>Number of species</b>		<b>19</b>	<b>27</b>	<b>22</b>	<b>26</b>	<b>29</b>	<b>33</b>	
<b>Number of specimens</b>		<b>48</b>	<b>99</b>	<b>205</b>	<b>250</b>	<b>141</b>	<b>248</b>	
<b>Shannon-Wiener Index (<i>H'</i>)</b>	<b>2.72</b>	<b>3.00</b>	<b>2.08</b>	<b>1.95</b>	<b>2.77</b>	<b>2.57</b>		

The number of butterfly species found was higher on observed pastures: Bevska pustota (Locality B), Polanc (Locality E) and Logarski kot (Locality F). On the other hand, abundance of specimens was the highest at Logarjeve njive meadow, Klemenče njive meadow and Logarski kot pasture. The Shannon-Wiener Diversity Index was calculated in order to compare diversity of the localities. Calculated values show that pastures had predominantly higher diversity than meadows (Tab. 1).

The aim of the study was also to determine if the number of entomophilous blossoming plant species and total number of entomophilous blossoming flowers have any impact on butterfly diversity and their abundance. Spearman rank correlation was used but no significant correlations were found. There are several possible reasons why the correlation between described variables cannot be confirmed. First, there are other environmental factors with influence on the behaviour of butterflies, such as air temperature and wind speed. Next, habitats surrounding the sampled locations were not systematically compared or clustered, because of their diversity. There is also one methodological limitation that could have affected the results, i.e. the relatively long time period of daily census of butterflies between 10 am and 4 pm, due especially to the mountain climate with warmest monthly temperature just above 10 °C.

However, as expected, there are significant positive correlations between number and diversity of entomophilous flowering plants ( $\rho = 0.484$ ,  $p < .01$ ,  $n = 36$ ) and between number and diversity of butterflies ( $\rho = 0.502$ ,  $p < .01$ ,  $n = 36$ ).

## Conclusions

Solčavsko is an important nature conservation area in Slovenia, therefore surveying butterfly fauna is valuable for planning nature conservation related activities in the area. In this study nine additional butterfly species were reported for the Solčava area, with two of them threatened and/or protected in Slovenia: *Boloria selene* and *Lycaena alciphron*. The study also confirmed that surveyed pastures had predominantly higher butterfly diversity than meadows.

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