NAT. CROAT. | VOL. 22 | No 1 | 157–169 | ZAGREB | June 30, 2013

original scientific paper /izvorni znanstveni rad

THE IMPACT OF GRAZING, OVERGROWTH AND MOWING ON SPRING BUTTERFLY (LEPIDOPTERA: RHOPALOCERA) ASSEMBLAGES ON DRY KARST MEADOWS AND PASTURES

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Jugovic, J., Črne, M. & Fišer Pečnikar, Ž.: The impact of grazing, overgrowth and mowing on spring butterfly (Lepidoptera: Rhopalocera) assemblages on dry karst meadows and pastures. Nat. Croat., Vol. 22, No. 1, 157–169, 2013, Zagreb.

Karst meadows belonging to the class *Festuco-Brometea* are regarded as species-rich habitats of national and European importance. Biodiversity in these areas is relatively high, but unlike most other semi-natural habitat types, it is highly influenced and facilitated by human activities. In the present study we document the presence and estimate abundance of butterfly species from three sampling plots in Kraški rob (SW Slovenia): two dry karst meadows and one pasture, which also includes an overgrown area. Over 16-day sampling occasions in May and June 2012, 63 species (including species complexes) were recorded. Nearly all of the species were recorded from dry karst meadows (60 ssp., 95%), while pasture (34 spp., 54%) and the overgrown site (28 spp., 44%) were less diverse. The abundance of butterflies was the lowest on the overgrown area. Although both grazing and overgrowth result in a decline in the number and abundance of species, we believe that traditional land use positively affects butterfly diversity, as it maintains open grasslands, a habitat that is preferred by most butterfly species to the later phases of succession. We therefore recommend the maintenance of a mosaic landscape structure, as it supports a wide range of butterfly fauna.

Key words: traditional land-use, grazing, Kraški rob (Karst edge), habitat management

Jugovic, J., Črne, M. & Fišer Pečnikar, Ž.: Utjecaj ispaše, sukcesije i košnje na proljetnu faunu danjih leptira (Lepidoptera: Rhopalocera) na suhim krškim livadama i pašnjacima. Nat. Croat., Vol. 22, No. 1, 157–169, 2013, Zagreb.

Krške livade razreda *Festuco-Brometea* su vrstama bogata staništa od nacionalne i europske važnosti. Bioraznolikost na tim područjima je relativno visoka, no u suprotnosti s nekim drugim poluprirodnim staništima, njihova bioraznolikost je pod velikim utjecajem ljudske aktivnosti. U ovom istraživanju smo zabilježili prisutnost i procijenili brojnost danjih leptira na tri uzorkovane plohe na Kraškom rubu (jugozapadna Slovenija): dvije krške livade i jednom pašnjaku koji je uključivao i zarasla područja. Tijekom 16-dnevnog terenskog istraživanja u svibnju i lipnju 2012., zabilježili smo 63 vrste leptira (uključujući i komplekse vrsta). Gotovo sve vrste su bile zabilježene na suhim krškim livadama (60 vrsta, 95%), dok je na pašnjaku (34 vrste, 54%) i na zaraslom području (28 vrsta, 44%) raznolikost bila manja. Brojnost leptira je bila najmanja na zaraslim površinama. Iako i zaraštanje i ispaša imaju za posljedicu opadanje u broju vrsta i brojnosti, smatramo da tradicionalno korištenje zemlje pozitivno

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utječe na raznolikost leptira. Razlog za to je prije svega sprječavanje zaraštanja livada, koje leptiri preferiraju više od staništa u kasnijim fazama sukcesije. Zato predlažemo održavanje mozaične strukture krajolika, jer će na taj način on biti primjeren za veći broj vrsta leptira.

Ključne riječi: tradicionalna uporaba zemlje, ispaša, Kraški rob, gospodarenje staništima

INTRODUCTION

The specific ecological requirements of butterflies (Lepidoptera, Rhopalocera) make them good bioindicators (Čelik, 2007): (1) for most species, the taxonomy is well resolved and the ecology well understood, (2) in most cases they are species-specific towards their host plants (both larvae and adults), (3) being pollinators, prey for other species and hosts for parasites, they play an important role in the ecosystem. Moreover, they are active during the daylight and in most cases easy to identify to species rank, which makes them an easy target for biodiversity research.

As indicators, butterflies respond rapidly to environmental changes, such as temperature and land use, which may both have negative impacts on their community and species (Stefanescu *et al.*, 2004). Stefanescu *et al*. (2004) argued that in the Mediterranean climate, butterfly diversity is negatively correlated to increasing temperature and positively correlated to the amount of rainfall (except for the extremes), but human activity affects their diversity as well. Agricultural landscapes and urbanization frequently lead to impoverishment of diversity, so the greater the human impact, the lower the diversity. The increase in intensive agricultural practices results in fragmentation and eventually loss of suitable butterfly habitats. Intensive land use finally leads to a decrease in diversity, abundance and species composition in areas influenced by such changes (Stefanescu *et al.*, 2004).

Compared to mowing (i.e. intensive and constant loss of nutrients from the grounds), grazing is beneficial to the environment, as nutrients are not completely lost from the soil but are mainly restored through the excrement of grazers (Kooijman & Smith, 2001). However, traditional mowing carried out on dry and semi-dry meadows once or twice per year maintains the characteristic grasslands and prevents them becoming overgrown (e.g. see Baba, 2003).

Extensive grazing has been proved to be extremely important for conservation of pastures as its impact may have both positive and negative consequences. On the positive side, grazing increases plant biodiversity with defoliation of competitive plant species (Grime, 2001; Bakker, 1989; Bullock *et al.*, 2001; Huntly, 1991); soil heterogeneity is positively correlated with the biodiversity of soil fauna and it is increased by the grazers' excrement and grazers may also play an important role as pollinators and seed dispersers (Fischer *et al.*, 1996). On the other hand, overgrazing may change the composition of plant species in a community because edible plants are more affected, resulting in the expansion of less edible species (Hartley & Mitchell, 2005; Jewell *et al.*, 2005; Krahulec *et al.*, 2001; Louault *et al.*, 2005; Pakeman, 2004). Negative impacts may also show as reduced reproductive success of some plants because grazers frequently feed on the most nutritious parts of plants (e.g. seeds, flowers) (Peterlin & Gorkič, 1998).

Dry karst meadows and pastures in southwestern Slovenia are composed of dry grasslands (class *Festuco-Brometea*), which host high species diversity and represent one of the most diverse habitats in Europe. Two main associations can be found there: the association *Carici-Centauretum* on pastures and *Danthonio-Scorsoneretum* on meadows

(Kaligarič, 2005). While karst pastures develop in dry, warm conditions where soil is rocky and shallow, karst meadows develop in more moist conditions, where soil is deeper and humified (Pipenbaher *et al.*, 2011). Although extensively used karst meadows represent rare and threatened habitats, they are in fact the result of human activities (Kaligarič, 2005; Stergaršek, 2009). The abandonment of traditional agricultural practices leads to grasslands becoming overgrown, changing over time into scrublands and later to pioneer forests. Scrubs with *Juniperus communis* are also rather common in the area and they represent a different succession stadge of dry habitats. Even though they are not rare in the region, they are listed as the Natura 2000 classification habitat type (*Juniperus communis* formation on heaths or calcareous grasslands). The occurrence of *Juniperus communis* is linked with selective grazing, where edible plants are consumed, while non-edible plants, such as the juniper, are left intact (Stergaršek, 2009).

Kraški rob (SW Slovenia, Natura 2000 site) is a part of sub-Mediterranean Slovenia and known as one of the butterfly hot-spots in Slovenia (e.g. see Verovnik *et al.*, 2012). The region was included in the Natura 2000 network as „Slovenian Istria". In the sub-Mediterranean region of Slovenia, 152 butterfly species (85% of all confirmed for Slovenia) have been recorded (Verovnik *et al.*, 2012). Some of them have been listed on red lists of endangered species in Slovenia and/or the wider area (Verovnik *et al.*, 2012). Five species of Lepidoptera *Euphydryas aurinia* Rottemburg 1775, *Coenonympha oedippus* Fabricus 1787, *Eriogaster catax* (Linnaeus, 1758), *Callimorpha quadripunctaria* (Poda, 1761), *Erannis ankeraria* (Staudinger, 1861) are also qualifying species for the Natura 2000 site Slovenian Istria.

The objective of this study was to investigate spring butterfly species diversity in three sampling plots with different features (two dry karst meadows and one pasture) on Kraški rob. Our hypotheses were: (1) habitat use is reflected in butterfly species diversity and can change in space and time; and (2) butterfly density and abundance are important indicators of the degradation rate in a given environment.

MATERIAL AND METHODS

The study area of Kraški rob lies in the northwestern part of the Dinarides (Western Balkans) and stretches from the Italian coast north of Trieste through southwestern Slovenia and ends in the coastal area of the Croatian part of the Istrian Peninsula. The selected study plots are located in the sub-Mediterranean part of Slovenia, near the villages Rakitovec and Zazid (municipality of Koper). Two extensive dry karst meadows near Rakitovec (R1 and R2) and a pasture grazed by cattle with a neighbouring overgrowing area near Zazid (Z) were selected (see Tab. 1 for details). All three sampling plots were roughly of the same size (Tab. 1) and are close together, the most distant two being approximately three kilometers apart and the third one in between. On the pasture, cattle are present throughout the warmer period of the year. Nevertheless, for the purpose of interpretation, the sampling plot near Zazid (Z) was subdivided into two parts, part A (Z_A; fenced part of the pasture) and part B (Z_B; neighbouring overgrowing area and shrubs).

Fieldwork was carried out between 15th May and 29th June 2012. Within this period, surveys were carried out at least every second (or third) day. The only longer gap was between 8th and 14th June, due to bad weather conditions. Each survey day represented a sampling occasion. All butterfly species (or species complexes) were identified in the field using the Collins Butterfly guide (Tolman & Lewington, 2008). The species com-

Tab. 1. Summary data on sampling plots

Settlement	Sampling plot*	Aggregate habitat type (short description)	Area [ha]	Altitude [m. a. s. l.]	Distance R1-R2-Z [m]
Rakitovec	R1	extensive dry grasslands (partially mowed and partially in an early stage of overgrowing)	5.32	520–540	0-1430-3160
Rakitovec	R2	extensive dry grasslands (mainly mowed)	5.18	500–520	1430-0-1770
Zazid	Z	extensive dry grasslands (Z_A: fenced pasture & Z_B: shrubs and overgrowing area)	5.76	600–620	3160-1770-0
			16.26	500–620	

* Geographic position of the three sampling plots: R1 - 45° 28′ 19.37“, 13° 57′ 29.32“; R2 - 45° 28′ 52.80“, 13° 56′ 35.03“; Z - 45° 29′ 43.76“, 13° 55′ 56.10“

plexes comprise the following groups or pairs of species: *Pyrgus malvae / malvoides*, *Leptidea sinapis / juvernica*, *Colias hyale / alfacariensis*, *Plebejus idas / argyrognomon*, and *Melitaea athalia / aurelia / britomartis* (de Jong, 1987; Friberg, 2007; Dinca *et al.*, 2011; Koren & Jugovic, 2012; see also Tolman & Lewington, 2008).

The abundance of each species (or species complex) per each sampling day was estimated using the following scale: 0 = unnoticed; 1 = single individual; 2 = 2–5 individuals; 3 = 6–10 individuals; 4 = 11–20 individuals; 5 = 20–50 individuals; 6 = >50 individuals. For each plot or subplot, average abundances per each sampling occasion were calculated. Only butterfly species that were present on a sampling occasion on a given plot or subplot (i.e. abundance ≥ 1, see above) were included in the calculations.

During most field occasions, air temperature was above 18°C (but never below 14°C). Time spent at each sampling plot was proportional to size and terrain complexity, so the plots were surveyed with the same intensity according to size. With species accumulation curves the rate of discovering new species throughout the sampling period was tested. When the curves for different sampling plots achieve a plateau, or when the decline in the discovery of new species (when the season is not over but sampling is finished) is similar for all the sites, direct comparison of diversity among them is possible.

Species lists were prepared for each sampling day and sampling site. Species lists are shown separately for each of the two meadows (R1, R2). Results for data subsets from the sampling plot Z are shown separately for the fenced part of the pasture (Z_A) and its neighbouring area of a meadow with shrubs (Z_B) because of the clear habitat differences.

In order to detect spatial and temporal changes in butterfly assemblages of the investigated sites, species richness, defined as the number of species per sampling day per sampling plot or subplot, were plotted on a graph. For the same reason, Operational Units (OUs) were classified into groups by means of Ward's method of clustering. OU was defined as one sampling day per plot or subplot, based on categories of abundance (see the scale above). As a measure of dissimilarity, Euclidean distance was used (see Hammer, 1999–2012). Analyses were performed using Microsoft Excel 2010 and the freely available software Palaeontological Statistics, version 2.16 (*folk.uio.no/ohammer/past/*).

RESULTS

The data revealed significant differences in the sampling plots and their parts (Tab. 2). A total of 63 species / species complexes were recorded over 16 sampling occasions. Nearly all species were recorded on dry karst meadows (R1 + R2; 60 ssp., 95%), while the fenced pasture (Z_A: 34 spp., 54%) and its neighbouring overgrown site (Z_B: 28 spp., 44%) were less diverse. Altogether, only 36 species were recorded in the sampling plot near Zazid (Z = Z_A + Z_B). Both dry meadows near Rakitovec (R1 and R2) were characterised by the highest diversity, while the lowest number of species was recorded for a fenced pasture near Zazid (Z_A) and its neighboring overgrowing area (Z_B).

Tab. 2. List of spring butterfly species from three sampling plots (Rakitovec 1 and 2: R1, R2; Zazid: Z = Z_A [fenced pasture] + Z_B [overgrown area]).

	R1	R2	Z_A	Z_B		Conservation status*	
						RS SLO	RS Ev
HESPERIIDAE							
Erynnis tages (Linnaeus, 1758)	+	+	-	-		-	LC
Spialia sertorius (Hoffmannsegg, 1804)	-	+	-	-		V	LC
Pyrgus malvae/malvoides	+	+	+	-		-/-	LC/LC
Heteropterus morpheus (Pallas, 1771)	-	+	-	-		-	LC
Thymelicus lineola (Ochsenheimer, 1808)	+	+	+	+		-	LC
Thymelicus sylvestris (Poda, 1761)	-	+	-	-		-	LC
Thymelicus acteon (Rottemburg, 1775)	-	+	-	-		V	NT
PAPILIONIDAE							
Zerynthia polyxena (Dennis & Schiffermüller, 1775)	+	+	-	-		V	LC
Parnassius mnemosyne (Linnaeus, 1758)	+	-	-	-		V	NT
Iphiclides podalirius (Linnaeus, 1758)	+	+	+	+		-	LC
Papilio machaon (Linnaeus, 1758)	+	+	+	-		-	LC
PIERIDAE							
Leptidea sinapis/juvernica	+	+	+	+		-/-	LC/LC
Anthocharis cardamines (Linnaeus, 1758)	+	+	-	-		-	LC
Aporia crataegi (Linnaeus, 1758)	+	+	+	+		-	LC
Pieris brassicae (Linnaeus, 1758)	+	-	-	-		-	LC
Pieris rapae (Linnaeus, 1758)	+	+	-	-		-	LC
Pieris napi (Linnaeus, 1758)	-	+	-	-		-	LC
Pontia edusa (Fabricius, 1777)	+	+	-	-		-	LC
Colias croceus (Geoffroy, 1785)	+	+	+	+		-	LC
Colias hyale/alfacariensis	+	+	+	+		-/-	LC/LC
Gonepteryx rhamni (Linnaeus, 1758)	+	+	+	+		-	LC
LYCAENIDAE							
Lycaena phlaeas (Linnaeus, 1761)	-	-	+	+		-	LC

Satyrium ilicis (Esper, 1779)	+	+	+	+		-	LC
Cupido minimus (Fuessly, 1775)	+	+	+	-		-	LC
Glaucopsyche alexis (Poda, 1761)	+	+	-	-		-	LC
Plebejus argus (Linnaeus, 1758)	+	+	+	+		-	LC
Plebejus idas/argyrognomon	-	+	-	-		-/V	LC/LC
Cyaniris semiargus (Rottemburg, 1775)	-	+	-	-		-	LC
Polyommatus amandus (Schneider, 1792)	+	+	+	+		-	LC
Polyommatus thersites (Cantener, 1835)	+	+	-	-		E	LC
Polyommatus icarus (Rottemburg, 1775)	+	+	+	+		-	LC
Polyommatus bellargus (Rottemburg, 1775)	+	+	+	+		-	LC
NYMPHALIDAE							
Argynnis aglaja (Linnaeus, 1758)	-	+	+	-		-	LC
Argynnis adippe (Dennis & Schiffermüller, 1775)	+	+	+	-		-	LC
Argynnis niobe (Linnaeus, 1758)	+	+	+	+		-	LC
Issoria lathonia (Linnaeus 1758)	-	+	-	-		-	LC
Brenthis daphne (Bergsträsser, 1780)	+	-	-	-		-	LC
Brenthis hecate (Dennis & Schiffermüller, 1775)	+	+	-	-		-	LC
Boloria dia (Linnaeus, 1767)	-	+	+	-		-	LC
Vanessa atalanta (Linnaeus, 1758)	-	+	-	-		-	LC
Vanessa cardui (Linnaeus, 1758)	+	+	-	-		-	LC
Aglais urticae (Linnaeus, 1758)	+	-	-	-		-	LC
Euphydryas aurinia (Rottemburg, 1775)	+	+	-	+		V	LC
Melitaea cinxia (Linnaeus, 1758)	+	+	+	-		-	LC
Melitaea phoebe (Dennis & Schiffermüller, 1775)	+	+	+	+		-	LC
Melitaea trivia (Dennis & Schiffermüller, 1775)	-	+	-	-		V	LC
Melitaea didyma (Esper, 1778)	+	+	+	-		-	LC
Melitaea diamina (Lang, 1789)	+	-	-	-		V	LC
Melitaea athalia/aurelia/britomartis	+	+	-	-		-/V/V	LC//NT/NT
Pararge aegeria (Linnaeus, 1758)	+	-	-	-		-	LC
Lasiommata megera (Linnaeus, 1767)	+	+	+	+		-	LC
Lasiommata maera (Linnaeus, 1758)	-	+	-	-		-	LC
Coenonympha arcania (Linnaeus, 1761)	+	+	+	+		-	LC
Coenonympha glycerion (Borkhausen, 1788)	+	+	-	+		-	LC
Coenonympha pamphilus (Linnaeus, 1758)	+	+	+	+		-	LC
Aphantopus hyperantus (Linnaeus, 1758)	-	-	+	+		-	LC
Maniola jurtina (Linnaeus, 1758)	+	+	+	+		-	LC
Erebia medusa (Dennis & Schiffermüller, 1775)	+	+	+	+		-	LC
Melanargia galathea (Linnaeus, 1758)	+	+	+	+		-	LC
Satyrus ferula (Fabricius, 1793)	+	+	+	+		V	LC

Hipparchia fagi (Scopoli, 1763)	+	+	+	+		-	NT
Hipparchia semele (Linnaeus, 1758)	-	+	+	+		V	LC
Brintesia circe (Fabricius, 1775)	+	+	+	+		-	LC
No of species/sampling site	**47**	**55**	**34**	**28**			
No of species/habitat type (meadow *vs.* pasture)	**60**		**36**				
No of species	**63**						

* **RS SLO**: Regulation on the classification of endangered plant and animal species in the Red List (Official Gazette 82/2002, 42/2010). Ex? – presumably extinct species; E – endangered species; V – vulnerable species; R – rare species (after Verovnik *et al.,* 2012). **RS Ev**: Threat status of butterflies on a continental scale, following Van Swaay *et al.,* 2010): EN – endangered species; VU – vulnerable species; NT – near threatened species; LC – least concern species. The nomenclature follows Van Swaay *et al.,* 2010.

For all plots or subplots (R1, R2, Z_A and Z_B), species accumulation curves approach a plateau at the end of sampling period or at least show a similar decline in the discovery of new species (Fig. 1).

The number of species per sampling plot or subplot and sampling occasion is shown in Fig. 2. The highest cumulative number of species (n = 29) was recorded on 8th of June 2012. Daily counts of species from dry meadows (with one exception, see Fig. 2) exceeded the number of daily counts from pasture (Z_A) or its neighbouring overgrown area (Z_B). Moreover, daily counts of species in dry meadows were also higher than in these two sub-plots combined (Z, with only two exceptions). The number of species slowly decreased after 14th June, coinciding with the mowing of (parts of) the two dry meadows near Rakitovec (Fig. 2). However, the same decrease was also noticed on a pasture near Zazid (sampling plot Z).

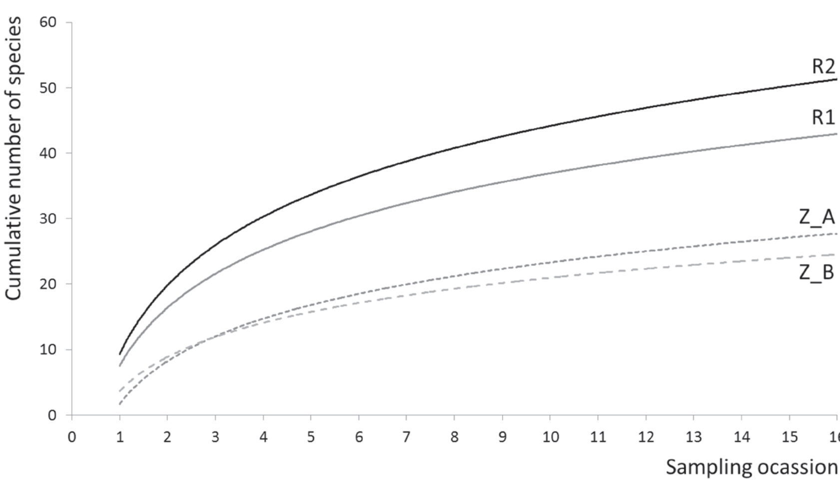

Fig. 1. Species accumulation curves during 16 sampling days (15th May–29th June 2012) for sampling (sub)plots on Kraški rob (R1, R2: dry karstic meadows near Rakitovec; Z_A and Z_B: pasture and neighbouring overgrowing area near Zazid, respectively).

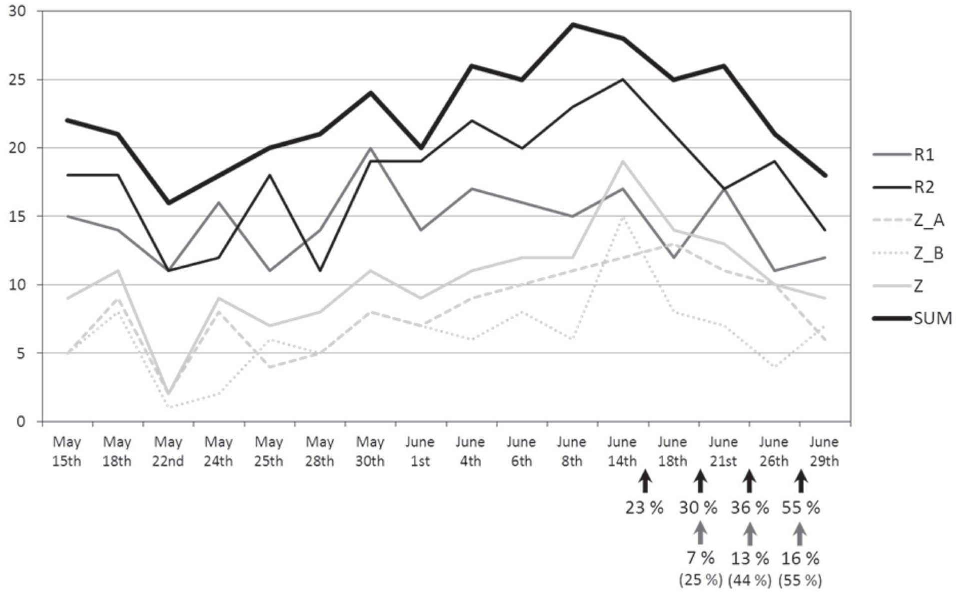

Fig. 2. Butterfly species richness (ordinate: number of species) per sampling plot or subplot for 16 sampling days from May 15th to June 29th 2012 at dry karst meadows (near Rakitovec; R1, R2) and pasture (near Zazid; Z_A: fenced and grazed by cattle; Z_B: overgrowing part outside the fence; Z: cumulative number of species noticed on Z_A and Z_B) on Kraški rob. SUM: cumulative numbers of species per sampling day. Arrows indicate cumulative percentages of mowed area on R1 (grey arrows; percentages without consideration of overgrowing areas are shown in brackets) and R2 (black arrows), respectively.

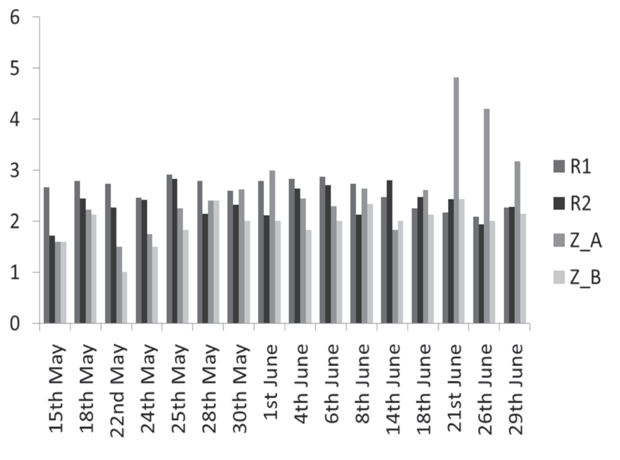

Fig. 3. Average daily abundances (ordinate) of butterfly species recorded during 16 sampling days from four (sub)plots (R1, R2: dry karstic meadows near Rakitovec; Z_A and Z_B: pasture and neighbouring overgrowing area near Zazid, respectively) in Spring 2012 (calculated from encoded data of abundances, see Materials and methods).

Average abundances of species calculated (from encoded abundances) for the four plots or subplots were (all data pooled; average ± standard deviation): R1 – 2.59 ± 0.27; R2 – 2.35 ± 0.31; Z_A – 2.59 ± 0.90; Z_B – 1.96 ± 0.36. Average daily abundances of butterfly species present on each plot or subplot per sampling occasion during the study are shown in Fig. 3.

A total of 64 OUs were included in cluster analysis using Ward's method. OUs were divided into two distinct clusters, corresponding fairly well to the different habitat types (meadows *vs.* pasture and the neighbouring overgrown area). Both clusters connect at dissimilarity rate that exceeds 55% (Fig. 4). The first group (hereafter named Zazid) mostly included samples from the sampling plot near Zazid (37 OUs), reflecting the butterfly assemblage of the pasture and overgrowing area. However, eight OUs from this group correspond to dry meadows near Rakitovec (four from each meadow). All except one of these eight OUs were recorded during the last four sampling occasions (from 18th June onwards), when both meadows had already been partly mown (Fig. 2). The second group (named Rakitovec) included all other samples from dry meadows (R1, R2), together with three samples from sampling plot near Zazid (all from subplot Z_A, sampled between the end of May and the beginning of June). Rakitovec could be further subdivided according to time scale into two subgroups: the first consisted of 19 OUs between 15th May and 4th June, and the other of eight OUs between 4th June and the end of the study period. Similarly (but with more temporal overlap) two subgroups were apparent within Zazid: The first one consisted of 25 samples, all of which were from Zazid (except for two samples from Rakitovec), between 15th May and 18th June. The second one consisted of samples from all three sampling plots between 14th and 29th June.

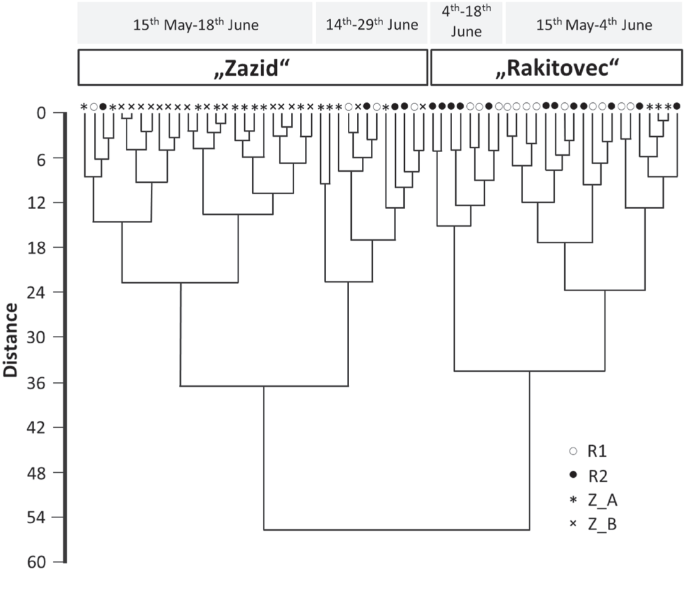

Fig. 4. Cluster analysis (Euclidean distance, Ward's method) of 64 OUs of butterfly species recorded at three sampling plots from Kraški rob (15th of May–29th of June, 2012). Abbreviations: Z – pasture near Zazid (Z_A – fenced and grazed part; Z_B – neighbouring overgrowing area); R1, R2: dry meadows near Rakitovec (R1: partly overgrown).

DISCUSSION

Intensive grazing and overgrowth both have the potential to change the species composition of flowering plants (Poldini, 2009), which may in turn affect the nectar feeding of adult butterflies. However, when grazing is not constant, its effects are minimal compared to the constant increase of overgrowth that has been going on in the past few decades in this area, and can lead to a decrease in biodiversity (Kaligarič & Čarni, 1991). Furthermore, grazing can slow down the overgrowth process (Kaligarič & Čarni, 1991), leaving some space for earlier stages of succession.

This study showed clear differences in butterfly assemblages among habitat types and localities (see Tab. 2). The main factor differentiating the three sampling plots appeared to be grazing and overgrowth; grazing is present throughout the warmer part of year on the investigated pasture. As the diversity of butterflies was found to be the lowest on the pasture, grazing appears to negatively affect abundance of butterflies (see also Stefanescu *et al.*, 2004). It should be noted, however, that the area of overgrowth outside the pasture also contains a low number of species. Although this area (Z_B) is the smallest of the investigated plots or subplos, this suggests that overgrowth too may negatively affect butterfly diversity. Saarinen & Jantunen (2005) reported a similar butterfly fauna under two different management forms (mowing and grazing), where meadows were preferred by more species, which is in line with our findings. Nevertheless, abundance of flowering plants is possibly at least equally important as management for butterfly assemblages, as we noticed much lower diversity in both sampling plots with the lowest abundances of flowering plants (i.e. pasture and its neighbouring overgrown area: Z_A and Z_B). As the three sampling plots (R1, R2, Z) are not in very close proximity the similarity between the grazed (Z_A) and overgrown (Z_B) subplots could even be simply because they were away from the mowed sampling plots (R1, R2).

Although we did detect temporal segregation of species (OUs), spatial segregation appeared to be more pronounced. Within each of the two time frames (i.e. earlier and later part of the study period; Fig. 4), species richness was always higher on meadows and lower on the pasture and its overgrown neighbouring area. The few exceptions, in which OUs from a pasture fell into a cluster of meadows, can be explained by the abundance of flowering plants on the pasture at the end of May and beginning of June, despite grazing. Likewise, only OUs of meadows from the end of the study period clustered together with OUs from pastures. This period coincided with the time of mowing resulting in similar reduction of flowering plants. At least for some species (e.g. *Aporia crataegi*, in prep.), these habitats are not important only for the adults but they serve also as important larval habitats. It should also be noted that in the meantime, the number of recorded species on pasture was decreasing (second half of June, Fig. 2). Hence, mowing does not appear to be the only factor influencing species diversity, at least not in our case. Finally, the end of the flight period of the spring butterfly species (or spring generations of some others) could be another reason for the observed decline in species richness (e.g. compare species list in Tab. 2 with data on flying periods of adult butterflies in Tolman & Lewington, 2008).

In pasture near Zazid (Z_A + Z_B), the butterfly fauna was dominated by species that are most widespread in the area. It should be noted that 29 out of 36 species (> 80%) that were found in sampling plot Z were also recorded in both meadows (R1, R2), and only two species (*Aphantopus hyperantus*, *Lycaena phlaeas*), were found at this plot only. While this was expected for *A. hyperanthus*, which prefers grassy and bushy places (Tolman &

Lewington, 2008), the records of *L. phlaeas* from sampling plot Z exclusively was not expected and it might had been overlooked in the other two plots. This species is quite common and widespread (see Tolman & Lewington, 2008). Stefanescu *et al.* (2004) reported similar observations from Catalonia, where most of the common species for the country were recorded in many places, but the most specialized ones were the first to be negatively affected by human activities. Stefanescu *et al.* (2004) proposed modern agriculture as an important factor that can negatively influence butterfly numbers through loss of breeding habitats and fragmentation or isolation of the remaining ones.

As well as species richness the abundance of butterflies too was lowest on the overgrown area, whereas in the grazed area some common species (e.g. *Melanargia galathea*) may be very abundant (see high abundance estimations during last three sampling occasions for Z_A). Although both overgrowth and grazing result in decrease of species richness, we believe that the latter has the potential to positively influence the biodiversity of (karst) meadows. It can decrease the rate at which habitats become overgrown and slow down the process of succession (Kaligarič & Čarni, 1991; Eler, 2007). Traditional grazing can thus hinder the natural succession on grasslands and maintain species-rich habitats (see Fahrig *et al.*, 2011). Rotational grazing, where different parts of the pasture are moderately grazed at different times, creating a dynamic mosaic of successional stages, has also been advocated as the best option for maintaining a rich butterfly biodiversity (Balmer & Erhardt, 2000). The presence of species of conservation concern (see Tab. 2) at all surveyed sites further supports the notion that traditional activities such as grazing are of great importance for the maintenance of mosaic land structure. Such a structure is vital for the feeding, resting, reproduction, growth and development of butterflies.

ACKNOWLEDGEMENTS

We would like to acknowledge the following people for useful advice, help during field work or discussing the manuscript: Elena Varljen Bužan, Bojan Lazar, Toni Koren, Peter Glasnović, Sara Zupan, Nataša Koprivnikar (University of Primorska, Koper, Slovenia), Barbara Horvath and Adam Toth (University of Pecs, Hungary). Toni Koren also kindly translated the abstract into Croatian. We would like to thank the Terček family (Zazid, Koper), managers of the pasture under study. Further thanks go to Tilen Genov (University of Primorska, Koper, Slovenia) for proof reading and improving the English. Special thanks for suggestions go to Romana Gračan (University of Zagreb, Croatia). We would like to thank the reviewers for their constructive comments. Mapping of habitat types was carried out within the LIFE-Nature project »Conservation of endangered habitats/species in the future Karst Park«, Project No.: LIFE02NAT/SLO/8587. Fieldwork was financed through the framework of CBC Programme Italy-Slovenia 2007–2013 (project BioDiNet - Network for the protection of biodiversity and landscape).

Received May 15, 2013

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SUMMARY

The impact of grazing, overgrowth and mowing on spring butterfly (Lepidoptera: Rhopalocera) assemblages on dry karst meadows and pastures

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Karst meadows belonging to the class *Festuco-Brometea* are regarded as habitats of national and European importance. Biodiversity in these areas is relatively high, but unlike most other semi-natural habitat types, it is highly influenced by human activities. As indicators, butterflies respond rapidly to environmental changes, such as temperature and land use, which may both have negative impacts on their communities and distribution. Agricultural landscapes and urbanization frequently lead to impoverishment of their diversity, so the greater the human impact, the lower the diversity. The main objective of our study was to investigate spring species diversity in three sampling plots with different habitat management (two dry karst meadows and one pasture) on Kraški rob in SW Slovenia. Both dry meadows near Rakitovec (R1 and R2) were characterised by highest biodiversity, while the lowest number of species was recorded for a fenced pasture near Zazid (Z_A) and the neighbouring overgrown area (Z_B). Daily counts of species from dry meadows (with one exception) exceeded the number of species from pasture (Z_A) or its neighbouring overgrowing area (Z_B). Moreover, daily counts of species in dry meadows were also higher than in these two sub-plots combined (Z, with only two exceptions). Based on cluster analysis (Ward's method), operational units were divided into two distinct clusters, corresponding fairly well to the different habitat types (meadows *vs.* pasture and its neighbouring overgrown area). Both clusters connect at dissimilarity rate that exceeds 55%. There were some mismatches (8 samples). These mismatches could be explained either by mowing of the meadows in late season or by peak period of flowering on the pasture. Not only species richness but also abundance was the lowest on the overgrowing area. Although both overgrowing and grazing result in a decrease of species richness, we believe that the latter has the potential to positively influence the biodiversity of (karst) meadows, by decreasing the rate of overgrowing and slowing down the process of succession. Traditional ways of management through grazing enabls the maintenance of these important grasslands, which host more butterfly species than areas in later phases of succession.