

## Early spring ephemeral therophytic non-nitrophilous grasslands as a habitat of various species of *Romulea* in the southern Balkans

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**Abstract** – The work deals with habitats of *Romulea bulbocodium* and *Romulea linairesii* ssp. *graeca* in the southern Balkans. Both species appear in early spring ephemeral therophytic non-nitrophilous grasslands in regions under the influence of the Mediterranean climate. These communities are classified within the *Romulion* alliance, which encompasses such communities from the eastern Mediterranean area. It was established that the main climatic factor causing the diversity of these communities is seasonality in precipitation and temperature. Two associations are presented, as *Lagopo-Poetum bulbosae* and *Romuleo graecae-Poetum bulbosae*.

**Key words:** Balkans, climate, grassland, nomenclature, *Romulea*, vegetation

**Abbreviations:** ESETG – early spring ephemeral therophytic non-nitrophilous grasslands, ICPN – International Code of Phytosociological Nomenclature

### Introduction

In the early spring, from the end of February to the end of March, carpets of flowering plants belonging to the genus *Romulea* appear in areas under the influence of the Mediterranean climate (Fig. 1). Later, at the end of April and beginning of May, when these species-rich communities are optimally developed for sampling, *Romulea* species are already in fruit and can no longer be identified. In summer, early spring ephemeral therophytic non-nitrophilous grasslands (ESETG) dry out due to the hot and dry Mediterranean climate. Only a few drought-resistant species can then be found, e.g., *Achnatherum bromoides*, due to C4 assimilation syndrome (PYANKOV et al. 2010), and only green-grey remains of the colourful spring carpet.

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**Fig. 1.** View of ESETG in the end of March. *Romulea* in full flower. At the time of sampling in the beginning of May up to 100 plant species can be found in a single plot.

The genus *Romulea* comprises about 95 taxa, of which 80 occur in South Africa and the Arabian peninsula (MANNING and GOLDBLATT 2008), while the others can be found in the Mediterranean basin (PERUZZI et al. 2011). Our study deals with the habitats of two species: *Romulea bulbocodium*, which is widespread in the Mediterranean basin, and *Romulea linaresii* ssp. *graeca*, an endemic species of the Balkan Peninsula (FRIGNANI and IIRITI 2011) (Fig. 2). Two other subspecies of *R. linaresii*, subsp. *linaresii* and *abyssinica*, are endemic to Sicily and Ethiopia, respectively (PIGNATTI 1982).

*Romulea bulbocodium* is a quite tall plant up to 15 cm and has 1–6 flowers that are lilac or violet, often greenish outside with a yellow throat and tube (Fig. 2A). It has a wider distribution in the Balkans than *R. linaresii*, being found along the Adriatic coast, in Macedonia, Bulgaria, Greece and Turkey (NIKOLIĆ 2000, STEŠEVIĆ 2002, GUSSEV 2011, NATCHEVA and IVANOVA 2011).



**Fig. 2.** *Romulea bulbocodium* (A) is found in the interior part of the region, whereas *Romulea linaresii* ssp. *graeca* (B) appears in the coastal part.

*Romulea linearesii* ssp. *graeca* is smaller than *R. bulbocodium*. It can be up to 5 cm tall with 1–2 dark violet-purple flowers (Fig. 2B) and is distributed only in the southern part of the Balkans and Turkey (e.g. STEŠEVIĆ 2002, ÖZDEMİR et al. 2007, PETROVA and VLADIMIROV 2009, BERGMEIER et al. 2011, GUSSEV 2011, RAKAJ 2011).

There is lively interest in the taxonomical peculiarities and distribution of *Romulea* species in the Balkans but there have been only a few investigations dealing with the habitats of these species: ESETG (OBERDORFER 1954, BOLÒS et al. 1996). Sampling of these communities is rather difficult due to high biological and phenological diversity.

Grasslands are species-rich communities established over centuries of permanent grazing (KALIGARIĆ et al. 2006, CATORCI et al. 2012). As well as by grazing, grasslands in the Mediterranean area are also maintained by periodic fires (KAVGACI et al. 2010, TÜRKMEN and DÜNZENLI 2011). In recent years, due to land use change (BRACCHETTI et al. 2012), grasslands have become among the most threatened habitats (JANIŠOVÁ et al. 2011, VASILEV et al. 2011), since the communities often become overgrown (BARBERO and QUEZEL 1976, ČARNI et al. 2010). OBERDORFER (1954) sampled such habitats in 1944 in the areas around Thessaloniki, southern Macedonia, Thrace, Thessaly, Attica and close to Corinth. He designated these communities that are mainly dominated by *Poa bulbosa* ssp. div. and which can be found on fresh, fine argillous soils around intensively grazed places. He described the alliance *Romulion* within this framework. He also stated that such vegetation is rarely found on limestone since *Cisto-Micromerietea* vegetation mainly appears there. BOLÒS et al. (1996) later also elaborated such habitats on Cephalonia (Ionian islands, Greece).

In addition to ESETG found in areas under the influence of the Mediterranean climate, other types of therophytic grasslands exist in more continental parts of the Balkans (e.g., in Bulgaria and the Republic of Macedonia). These communities are classified within *Trifolion cherleri*. The classification of the latter alliance into higher rank syntaxa is still under consideration, since they mediate between the group of (sub-) Mediterranean therophytic grasslands (*Helianthemetea*) and more continentally influenced perennial grasslands (*Festuco-Brometea*) (MICEVSKI 1970, TZONEV et al. 2009). There are even discrepancies at the association level, for instance within *Erysimo-Trifolietum* (MICEVSKI 1977, SOPOTLIEVA and APOSTOLOVA 2007).

There is a well recognizable climatic gradient in the southern Balkans: Mediterranean – sub-Mediterranean – continental, which provides the opportunity to study in detail the turn-over of plant species and communities under changing climatic conditions (ĆUŠTEREVSKA et al. 2012).

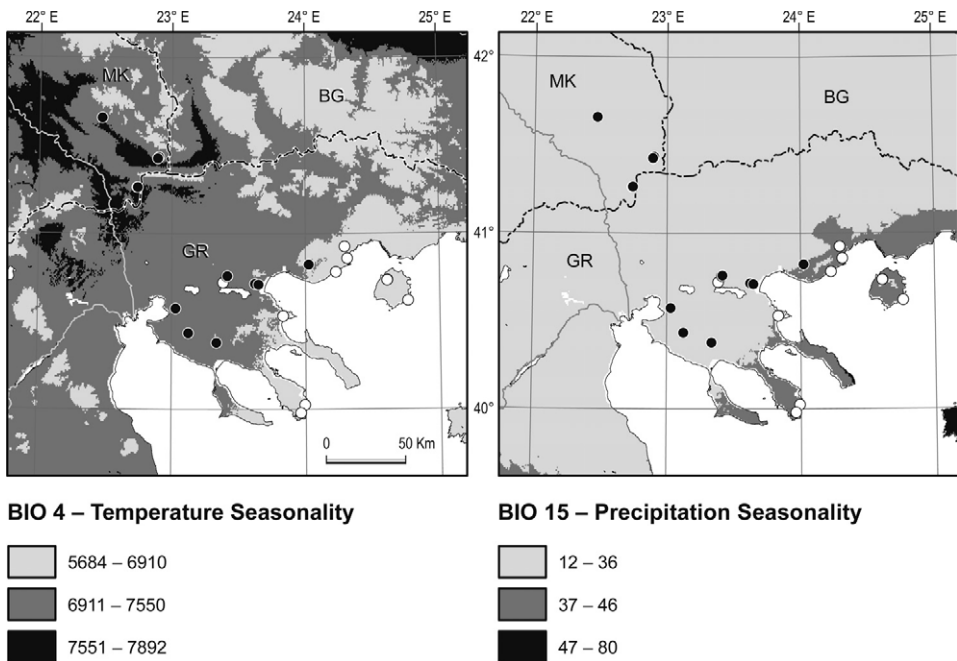
RODWELL et al. (2002) defined the alliance *Romulion* as eastern Mediterranean ephemeral vegetation on humid salty soils. They place this alliance within *Saginetea maritimae*, a class of ephemeral vegetation with winter annuals on bare or disturbed salt-marsh mud and sand.

The aim of the study was to sample ESETG in the southern Balkans and define the habitats of *Romulea* species in the region. We have tried to present in the paper the floristic composition of communities and to analyze their structural and choraological spectrum. We have determined the most important climatic factor for diversity within communities and correlated it with their geographical distribution. We have attempted to discover the ecological and syntaxonomic position of ESETG and have performed a nomenclatural revision of these syntaxa.

### Material and methods

The research area was the southern part of the Balkans (Fig. 3). According to the Map of Natural Vegetation of Europe (BOHN et al. 2003), the northern part of the area in which *Romulea* species appear lies in the zone of thermophilous deciduous broadleaved forests (*Carpinus orientalis-Quercus pubescens* zone), whereas the southern part along the Aegean coast lies in the zone of Mediterranean evergreen forests dominated by *Quercus ilex*. The northern limit of growth of *Romulea* species corresponds to the northern boundary of thermophilous deciduous broadleaved forests as defined by HORVAT et al. (1974) and the distribution of *Quercus coccifera* scrub or forest (OBERDORFER 1947).

The climatological station in Valandovo (southern part of the Republic of Macedonia) reports that there is 611 mm mean annual precipitation and the mean annual temperature is 14.6 °C; in Thessaloniki, on the coast, there is 458 mm of mean annual precipitation and a mean annual temperature of 15.8 °C. In both stations, the highest peak of precipitation is in November with a less pronounced peak in May in Valandovo and in March and May in Thessaloniki (MATEVSKI and ČARNI 2003).



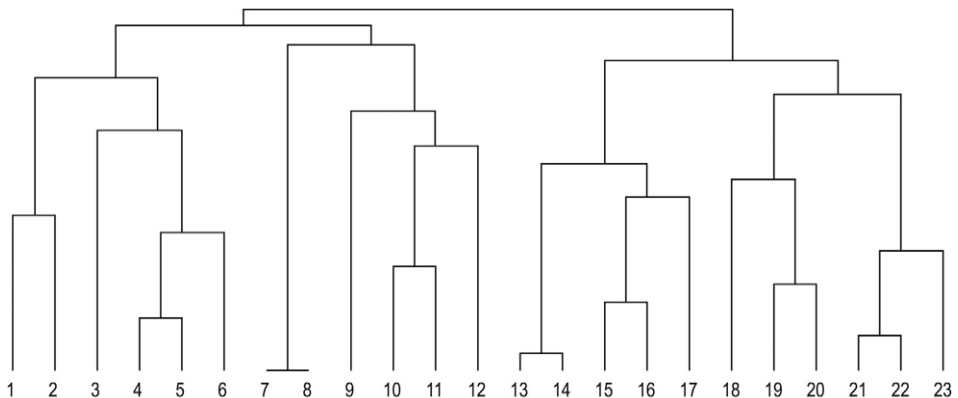
**Fig. 3.** Distribution of communities: communities with *Romulea bulbocodium* are distributed in the inland part and represented by full circles; communities with *Romulea linaresii* ssp. *graeca* are distributed in coastal areas and represented by empty circles. In the map two layers generated through interpolation of climate data stored in WorldClim database are presented. The numbers in BIO 4 present the coefficient of variation as standard deviation of the weekly mean temperatures expressed as a percentage of the annual mean, in this case multiplied by 100, whereas BIO 15 also presents the coefficient of variation as previously, although in this case precipitation is multiplied by 10 (HJMMANS et al. 2005).

Sampling was performed according to the standard Braun-Blanquet method (BRAUN-BLANQUET 1964). The layer is not indicated, because all species appear in the herb layer. Since it is practically impossible to determine *Romulea* species when they are fruiting, we visited the sites three times. In early spring, we surveyed the whole area, identified potential plots for sampling communities and noted geophytes, such as *Romulea*, *Gagea*, *Ornithogalum* etc. At the end of April and beginning of May, we performed field sampling of vegetation. At this time, we made an inventory of plants and estimated coverage. We visited plots once more in summer, in order to find plants, above all grasses, which had not been in flower at sampling time. These species mainly possess a C4 photosynthesis pathway and do well under high light intensity and high temperatures. They include *Achnatherum*, *Bothriochloa*, *Chrysopogon*, and also the non-grass *Portulaca*.

After elaboration of the plant material, we constructed a table (Tab. 1), which was subjected to numerical analysis. Classification was then carried out by PC-ORD (MCCUNE and MEFFORD 2011), run in the JUICE 7.0 programme (TICHÝ 2002). A dendrogram was drawn using Ward's method and Euclidean distance as a measure of resemblance (Fig. 4).

The characteristic species of individual groups were determined by calculating the species' fidelity and they are presented in the analytic table (Tab. 1). The phi coefficient was used as a fidelity measure and calculated in the JUICE program. The threshold phi value (multiplied by 100 in the JUICE program) for species to be considered characteristic was set at 40 (CHYTRÝ et al. 2002).

All the climatic data available in the WorldClim database (HUMANS et al. 2005, available at <http://worldclim.org/>) were extracted for each sample plot. Before elaboration, we firstly performed detrended correspondence analysis (DCA) of data and discovered that the gradient is less than 3 SD, indicating linearity, and we therefore used principal component analysis (PCA) and redundancy analysis (RDA) in further analysis. Since climatic data were provided from an external source and not from a species inventory of ESETG (such as life forms and chorotypes), RDA was used to test the possible effect of climatic variables on vegetation composition. Each variable was entered separately, each in turn, for analysis and



**Fig. 4.** Dendrogram of samples (relevés). Two main clusters can be seen, inland communities with *Romulea bulbocodium* are indicated by number 1–12, whereas the coastal communities with *Romulea linarsis* ssp. *graeca* are indicated by number 13–23.

**Tab. 1.** Analytical table of the early spring ephemeral therophytic non-nitrophilous grasslands in the Southern Balkan.

Relevé number	1 1 1												1 1 1 1 1 1 1 2 2 2 2											
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	
<i>LAGOPO-POETUM BULBOSAE</i>																								
<i>Romulea bulbocodium</i>	3	3	3	3	3	3	2	2	+	3	4	3	.	.	.	.	2	.	1	1	.	.	.	
<i>Myosotis ramosissima</i>	+	+	+	+	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	
<i>Teucrium capitatum</i>	.	.	.	.	.	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	+	.	.	
<i>Alyssum desertorum</i>	.	.	.	+	+	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Achillea coarctata</i>	+	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Carex caryophylla</i>	.	+	.	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	
<i>ROMULEO GRAECAE-POETUM BULBOSAE</i>																								
<i>Romulea linarsii</i> ssp. <i>graeca</i>	.	+	+	.	.	.	.	.	.	.	.	.	1	2	1	1	.	1	1	+	1	1	1	
<i>Galium murale</i>	.	.	.	.	.	.	.	.	+	.	.	+	+	+	+	+	+	+	.	.	.	+	+	
<i>Hordeum murinum</i> ssp. <i>leporinum</i>	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	+	.	+	.	+	+	+	.	
<i>Lagurus ovatus</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	1	1	+	
<i>Crepis zacintha</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	+	.	+	+	
<i>Urospermum picroides</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	+	+	
<i>ROMULION</i>																								
<i>Hedynois rhagadioloides</i>	.	.	+	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+	1	+	+	+	+	
<i>Hypochoeris cretensis</i>	.	.	1	+	+	+	+	+	+	.	.	.	+	+	+	.	+	.	+	+	.	+	+	
<i>Allium guttatum</i>	.	.	.	.	+	+	.	.	.	.	+	+	.	.	.	+	.	+	+	+	+	+	.	
<i>Linaria simplex</i>	.	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	.	.	+	.	.	.	+	
<i>Ornithogalum collinum</i>	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	2	2	.	+	+	
<i>Lotus angustissimus</i>	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	
<i>HELATHEMETALIA, HELIATHEMETEA</i>																								
<i>Poa bulbosa</i>	3	2	3	2	3	2	4	4	4	3	3	2	4	3	3	3	3	4	3	2	2	3	2	
<i>Psilurus incurvus</i>	.	+	+	+	+	1	+	+	.	+	2	+	+	2	+	+	+	+	+	+	+	+	+	
<i>Vulpia ciliata</i>	.	+	1	+	+	+	+	+	+	.	.	+	+	.	1	1	+	+	1	+	3	1	+	
<i>Tuberaria guttata</i>	.	1	2	+	3	2	+	.	.	.	.	+	1	+	2	2	2	1	1	+	2	1	2	
<i>Trifolium campestre</i>	+	.	1	2	2	+	.	.	.	+	+	+	+	+	1	.	+	2	1	+	+	+	1	
<i>Ornithopus compressus</i>	+	.	1	1	+	.	+	+	.	.	.	+	1	+	+	2	+	+	+	+	.	+	+	
<i>Trifolium angustifolium</i>	+	.	+	+	+	+	.	.	+	1	.	2	.	+	+	+	.	1	+	+	+	1	+	
<i>Hypochaeris glabra</i>	.	1	+	+	+	+	+	+	.	.	.	+	+	.	.	+	+	.	+	+	+	+	+	
<i>Trifolium arvense</i>	.	.	+	1	1	+	+	+	.	+	.	1	.	.	.	+	+	+	+	+	+	+	1	+
<i>Plantago bellardii</i>	.	.	.	1	+	2	+	.	.	.	.	+	2	.	1	+	2	1	+	+	1	1	2	1
<i>Linaria pelisseriana</i>	.	.	+	+	+	+	+	.	.	.	.	.	.	+	+	+	1	+	+	+	+	+	+	
<i>Trifolium subterraneum</i>	3	2	2	+	+	.	+	.	.	.	.	.	2	+	+	2	+	.	.	+	.	1	+	
<i>Trifolium cherleri</i>	.	.	1	.	1	2	+	.	.	.	.	1	.	.	+	+	+	3	2	4	+	+	2	

Tab. 1. – continued

Relevé number												1	1	1	1	1	1	1	2	2	2	2		
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	
<i>Aira elegantissima</i>	.	.	2	1	+	+	.	.	.	.	.	.	+	.	1	+	+	+	+	.	+	1	+	
<i>Asterolinon linum-stellatum</i>	.	.	1	.	.	.	.	+	+	+	+	+	+	.	+	.	.	1	.	+	+	+	+	
<i>Galium divaricatum</i>	.	+	+	+	+	+	.	.	.	.	+	.	.	.	.	+	.	+	+	+	+	.	.	
<i>Medicago minima</i>	.	.	.	.	1	+	2	2	1	+	.	+	1	+	.	.	.	+	.	1	.	.	.	
<i>Arenaria leptoclados</i>	+	.	.	.	.	+	+	+	+	+	1	+	+	.	+	.	.	.	.	.	.	.	.	
<i>Filago gallica</i>	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	+	+	+	
<i>Trifolium stellatum</i>	+	.	.	.	.	.	.	.	1	+	.	.	+	+	2	.	.	.	.	.	+	1	+	
<i>Briza maxima</i>	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	+	.	+	+	.	1	1	+	
<i>Tolpis umbellatum</i>	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	+	+	.	+	+	+	.	
<i>Helianthemum salicifolium</i>	.	.	.	.	.	+	+	2	2	+	+	.	.	.	.	.	.	.	.	.	1	.	.	
<i>Velezia rigida</i>	.	.	.	.	.	.	.	.	.	+	+	.	+	+	+	.	.	.	.	.	.	.	.	
<i>Taeniatherum caput-medusae</i>	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	+	+	+	.	.	+	
<i>Sedum caespitosum</i>	+	.	.	.	.	.	.	.	.	+	+	.	+	+	.	.	+	.	.	.	.	.	.	
<i>Trachynia distachya</i>	.	.	.	.	.	.	2	2	1	.	+	1	.	.	.	.	.	.	+	.	.	.	.	
<i>Hymenocarpus circinnatus</i>	.	.	.	.	.	.	.	.	.	.	2	.	2	1	+	+	.	+	.	.	.	.	.	
<i>Viola kitaibeliana</i>	+	+	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.	
<i>Arenaria serpyllifolia</i>	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	
<i>Vulpia myuros</i>	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	
<i>Rostraria cristata</i>	.	.	.	.	+	.	.	+	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	
<i>Crucianella latifolia</i>	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	.	.	.	+	
<i>Alkanna tinctoria</i>	.	.	.	.	.	.	.	.	+	+	.	.	+	+	+	.	.	.	.	.	.	.	.	
<i>Medicago disciformis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
var. <i>disciformis</i>	.	.	.	.	.	.	.	.	.	.	1	+	+	+	.	.	.	.	.	.	.	.	.	
<i>Helianthemum aegyptiacum</i>	+	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	
<i>Petrorhagia prolifera</i>	.	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Medicago disciformis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
var. <i>strumensis</i>	.	.	.	.	.	.	.	.	+	2	.	.	.	.	+	.	.	.	+	.	.	.	.	
<i>Clypeola jonthlaspi</i>	.	.	.	.	.	.	.	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	
<i>Dasypyrum villosum</i>	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	.	
<b>FESTUCO-BROMETEA</b>																								
<i>Trifolium scabrum</i>	+	+	+	+	+	+	+	+	+	+	+	1	1	+	+	+	1	+	.	1	+	1	+	+
<i>Eryngium campestre</i>	+	+	.	+	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.	1	+	.	.	
<i>Aegilops triuncialis</i>	.	.	+	.	.	.	.	.	.	+	+	+	1	.	.	.	.	.	+	1	.	+	+	
<i>Chrysopogon gryllus</i>	.	.	.	.	+	.	1	+	+	+	+	+	.	.	.	.	.	.	+	+	+	.	+	
<i>Medicago rigidula</i>	.	.	.	.	+	+	+	+	+	1	+	+	+	+	.	.	.	.	.	.	+	.	.	
<i>Thymus substritus</i>	+	+	+	+	.	.	.	+	+	+	.	.	.	+	.	.	.	.	.	+	.	.	.	
<i>Scleranthus verticillatus</i>	+	+	.	+	+	+	+	+	+	.	.	+	.	.	.	.	.	.	.	+	.	+	.	

Tab. 1. – continued

Relevé number												1	1	1	1	1	1	1	2	2	2	2		
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	
<i>Chondrilla juncea</i>	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	
<i>Potentilla recta</i> ssp. <i>laciniosa</i>	.	.	+	+	+	+	.	.	.	.	+	+	.	.	.	.	.	.	+	+	+	.	.	
<i>Bromus squarrosus</i>	.	.	.	.	+	+	+	+	.	+	.	+	.	.	.	.	.	.	+	.	.	+	.	
<i>Arabidopsis thaliana</i>	.	+	+	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	+	+	.	.	.	
<i>Centaurea grisebachii</i>	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	
<i>Hypericum perforatum</i>	.	.	+	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	+	+	.	.	.	
<i>Koeleria splendens</i>	.	.	.	.	+	.	+	+	+	+	.	.	.	.	.	.	.	.	.	+	.	.	.	
<i>Achillea setacea</i>	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	
<i>Sanguisorba minor</i>	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Convolvulus cantabrica</i>	.	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Astragalus onobrychis</i>	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	
<i>Thymus striatus</i>	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	+	.	.	
<i>Allium sphaerocephalon</i>	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	
OTHER SPECIES																								
<i>Cynodon dactylon</i>	+	+	+	+	1	1	.	.	+	.	+	1	+	+	+	+	1	.	+	+	+	+	+	
<i>Parentucellia latifolia</i>	+	1	1	1	+	1	+	+	+	.	+	.	+	+	.	2	+	.	+	+	.	+	1	
<i>Filago germanica</i>	+	+	+	+	+	+	+	.	.	+	+	+	+	+	+	+	+	+	+	+	.	.	.	
<i>Anthemis auriculata</i>	+	+	+	.	.	.	1	1	+	1	.	+	1	+	1	1	+	.	1	+	1	+	1	
<i>Petrorhagia velutina</i>	.	+	+	.	+	+	+	+	.	.	.	+	1	+	+	+	+	1	+	+	1	+	1	
<i>Sherardia arvensis</i>	+	+	1	.	+	+	.	.	.	1	+	+	+	+	.	+	+	.	1	.	+	+	+	
<i>Plantago lagopus</i>	+	+	+	.	+	.	.	.	.	2	3	+	3	1	3	+	.	1	.	+	1	2	+	3
<i>Erodium cicutarium</i>	+	+	.	.	+	+	+	.	+	+	+	+	1	+	+	+	2	.	+	+	.	.	+	
<i>Achnatherum bromoides</i>	.	.	+	.	+	.	+	+	+	1	+	.		.	.	+	.	+	+	+	+	+	++	
<i>Avena barbata</i>	.	.	+	.	+	.	.	+	+	+	+	+	.	.	.	.	+	+	+	+	+	+	+	
<i>Veronica arvensis</i>	.	+	+	+	+	.	.	.	+	.	.	.	+	.	+	+	1	+	.	.	.	.	+	
<i>Cistus incanus</i> ssp. <i>creticus</i>	.	+	+	.	.	.	.	.	.	+	+	.	+	+	.	+	+	+	.	.	+	.	+	
<i>Trifolium retusum</i>	.	.	+	+	+	.	.	.	.	.	.	+	.	.	+	1	.	1	+	+	+	+	+	
<i>Valerianella turgida</i>	.	+	+	.	+	+	.	.	+	.	+	+	.	.	.	.	+	+	.	+	.	.	+	
<i>Senecio vulgaris</i>	.	.	+	.	.	.	+	+	+	.	.	.	+	+	.	+	+	.	+	+	.	.	+	
<i>Trifolium nigrescens</i>	+	.	+	+	+	+	.	.	.	.	.	.	+	.	.	+	.	.	+	+	+	.	.	
<i>Trifolium tenuifolium</i>	+	.	+	+	+	+	.	.	.	.	.	+	.	.	+	+	.	.	+	.	.	1	.	
<i>Carthamus lanatus</i>	+	+	.	.	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.	+	+	.	+	
<i>Dactylis glomerata</i>	+	.	+	.	+	.	.	.	+	.	.	+	.	.	.	.	.	.	+	+	.	+	+	
<i>Vicia lathyroides</i>	+	.	.	+	+	.	+	+	.	.	.	+	+	+	.	.	.	.	.	.	.	+	+	
<i>Anagallis arvensis</i>	.	.	+	.	+	.	+	+	+	+	+	+	.	.	+	.	.	.	.	.	.	.	.	
<i>Bothriochloa ischaemum</i>	.	.	.	.	+	.	+	+	.	+	+	+	.	.	.	+	+	.	+	+	.	.	.	
<i>Polycarpon tetraphyllum</i>	1	.	+	.	.	.	.	.	.	.	+	.	1	+	.	+	+	.	.	.	.	.	1	



Tab. 1. – continued

Relevé number												1	1	1	1	1	1	1	2	2	2	2	
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3
<i>Plantago lanceolata</i>	+	1	+	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	+	.
<i>Plantago coronopus</i>	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	.	+	+	+
<i>Cerastium semidecandrum</i>	+	.	.	.	.	.	+	1	+	.	+	.	1	+	.	+	.	.	.	.	.	+	.
<i>Moenchia erecta</i>	.	+	+	+	+	.	.	.	.	.	.	.	.	.	+	.	+	.	+	+	+	.	+
<i>Bromus hordeaceus</i>	.	+	.	.	1	+	.	.	.	+	.	+	.	.	.	.	.	.	+	1	+	+	.
<i>Aegilops geniculata</i>	.	.	.	.	+	+	.	+	.	1	.	.	.	+	.	.	.	+	+	1	.	.	+
<i>Onobrychis caput-galli</i>	.	.	.	.	.	+	2	+	.	.	+	1	+	+	+	.	.	.	1	.	.	.	.
<i>Asparagus acutifolius</i>	.	.	.	.	.	.	+	.	+	+	+	.	.	.	+	.	+	.	+	.	+	+	+
<i>Verbascum sinuatum</i>	+	.	+	.	.	.	+	+	+	.	.	.	+	.	.	+	.	.	.	.	+	.	.
<i>Veronica verna</i>	+	.	.	+	.	+	.	+	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.
<i>Cerastium glomeratum</i>	.	+	+	.	.	.	.	.	.	.	.	1	.	.	+	+	.	+	.	+	.	.	+
<i>Portulaca oleracea</i>	.	+	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	+	+	.	+	+	+
<i>Eragrostis minor</i>	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	+	+	+
<i>Cynosurus echinatus</i>	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	+	+	+
<i>Crupina crupinastrum</i>	.	.	+	.	.	.	+	+	.	+	+	+	.	.	+	.	.	.	+	.	.	.	.
<i>Catapodium rigidum</i>	.	.	+	.	.	.	.	.	.	+	+	1	+	+	.	+	.	.	+	.	.	.	.
<i>Silene gallica</i>	.	.	+	.	.	.	.	.	.	.	+	+	.	.	+	+	.	+	.	.	+	.	+
<i>Crepis neglecta</i>	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	.	+	.	.	+	+	+	+
<i>Linum corymbulosum</i>	.	.	.	.	.	+	+	.	+	+	+	.	.	.	+	.	.	+	.	+	.	.	.
<i>Aphanes microcarpa</i>	+	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+
<i>Rumex acetosella</i>	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
<i>Capsella bursa-pastoris</i>	.	+	.	.	+	.	.	.	.	.	.	.	+	+	.	.	+	.	+	+	.	.	.
<i>Crepis foetida</i> ssp. <i>rhoedifolia</i>	.	.	+	.	.	+	+	.	.	.	.	+	.	.	+	.	.	.	.	.	+	+	.
<i>Valerianella coronata</i>	.	.	+	.	.	.	.	.	.	.	+	.	+	+	+	.	.	+	.	+	.	.	.
<i>Echium plantagineum</i>	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	+	+
<i>Daucus guttatus</i>	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	+
<i>Astragalus pelecinus</i> ssp. <i>pelecinus</i>	.	.	.	.	+	.	+	2	.	.	.	.	+	+	.	.	.	.	+	.	.	.	+
<i>Centaurea benedicta</i>	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	.	+	.	+	.	.	.
<i>Holosteum umbellatum</i>	+	.	.	.	.	.	+	+	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.
<i>Herniaria incana</i>	+	.	.	.	+	.	.	.	.	+	.	.	.	.	+	.	+	+	.	.	.	.	.
<i>Erysimum crassistylum</i>	+	.	.	.	.	.	.	.	.	+	+	+	.	+	.	.	.	.	+	.	.	.	.
<i>Lolium perenne</i>	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.	.	+	+	.
<i>Anisantha tectorum</i>	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	+	+	+	+
<i>Crepis sancta</i>	.	.	.	.	.	.	.	+	+	+	.	.	.	+	+	+	.	.	.	.	.	.	.
<i>Medicago praecox</i>	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	+	.	+	.	+	.	.	.
<i>Anisantha madritensis</i>	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+	.	+	+	.	.
<i>Ranunculus ficaria</i>	+	.	.	+	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.

Tab. 1. – continued

Relevé number	1 1 1												1 1 1 1 1 1 1 2 2 2 2											
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	
<i>Euphorbia helioscopia</i>	.	+	.	.	+	.	.	.	+	.	.	.	+	.	.	+	.	.	.	.	.	.	.	
<i>Minuartia hirsuta</i> ssp. <i>falcata</i>	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	.	.	
<i>Crepis setosa</i>	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	1	+	.	.	.	
<i>Teesdalia coronopifolia</i>	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	+	
<i>Vicia sativa</i> ssp. <i>nigra</i>	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	+	+	.	
<i>Thymus heterotrichus</i>	.	.	.	.	+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	+	
<i>Anthoxanthum odoratum</i>	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	2	+
<i>Neotostema apulum</i>	.	.	.	.	.	1	.	.	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	
<i>Allium flavum</i>	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	+	.	+
<i>Melica ciliata</i>	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	.	+	.	+	.	
<i>Rorippa thracica</i>	1	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	
<i>Geranium molle</i> ssp. <i>brutum</i>	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	
<i>Filago arvensis</i>	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Teucrium chamaedrys</i>	+	.	.	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	
<i>Nigella arvensis</i>	.	.	+	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	
<i>Convolvulus elegantissimus</i>	.	.	+	.	.	.	.	.	.	.	+	.	2	+	.	.	.	.	.	.	.	.	.	
<i>Sedum hispanicum</i>	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	
<i>Anthemis ruthenica</i>	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	
<i>Sedum rubens</i>	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	
<i>Colchicum autumnale</i>	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	.	.	+	.	.	.	
<i>Galium setaceum</i>	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	
<i>Leopoldia comosa</i>	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	+	+	+	.	.	.	
<i>Calicotome villosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	+	
<i>Centaurea orphanidea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	

**Other species:** *Agrostis stolonifera* 14: +, 13: +; *Alyssum corymbosoides* 18: +; *Aurinia corymbosa* 16: +; *Alyssum foliosum* 5: +; *Alyssum murale* 18: 1, 10: +; *Alyssum strigosum* 19: +, 6: +; *Alyssum umbellatum* 8: +, 7: +; *Amaranthus albus* 14: +, 13: +, 16: +; *Anemone pavonina* 12: +; *Apera spica-venti* 16: +; *Aphanes arvensis* 3: +, 16: +; *Asperula aristata* ssp. *scabra* 3: +; *Asphodeline lutea* 2: +, 1: 1; *Asphodelus ramosus* ssp. *ramosus* 2: +, 1: +, 4: +; *Astragalus spruneri* 20: +; *Bellis perennis* 11: +, 14: +; *Berteroa orbiculata* 9: +; *Anisatha sterilis* 19: +, 10: +; *Buglossoides arvensis* 3: +; *Bunias erucago* 6: 1, 7: +; *Bupleurum commutatum* 23: +, 9: +; *Calendula arvensis* 5: +, 6: +, 13: +; *Campanula phrygia* 14: +, 15: +, 16: +; *Cardamine hirsuta* 14: +, 22: +, 19: +; *Carex divisa* 8: 3; *Carex divulsa* ssp. *divulsa* 14: +, 22: +; *Carex flacca* ssp. *serrulata* 19: +; *Centaurea salonitana* 2: +, 3: +, 5: +; *Centaureum erythraea* ssp. *rumelicum* 13: +; *Centaureum maritimum* 16: +; *Cerastium brachypetalum* ssp. *tenoreanum* 21: +, 22: 1, 23: +; *Cerastium brachypetalum* ssp. *roeseri* 2: +, 19: +; *Cerastium comatum* 14: +, 12: +; *Cerastium pumilum* 4: 1, 9: +, 7: +; *Glebionis segetum* 16: +; *Cichorium intybus* 8: +, 14: +, 3: +; *Cistus incanus* ssp. *incanus* 2: +, 1: +; *Cistus salvifolius* 17: +; *Clinopodium arvensis* 2: +, 1: +; *Clinopodium vulgare* 21: +; *Convolvulus arvensis* 14: +; *Crassula tillaea* 6: +, 4: +, 7: +; *Crupina vulgaris* 3: +, 7: +; *Cuscuta epithymum* 20: +; *Daucus broteri* 2: +, 1: +, 7: +; *Dianthus monadelphus* ssp. *pallens* 3: +; *Dianthus viscidus* 19: +, 9: +; *Dittrichia viscosa* ssp. *viscosa* 13: +, 17: +; *Draba muralis* 14: +, 22: +, 18: +; *Echinaria capitata* 3: +; *Echinops sphaerocephalus* 2: +, 1: +; *Ephedra major* 14: +; *Epilobium hirsutum* 13: +; *Erodium hoefftianum* 13: +; *Erophila verna* ssp. *macrocarpa* 5: +; *Erophila verna* ssp. *praecox* 6: +; *Erophila verna* ssp. *verna* 8:

Tab. 1. – continued

+, 21: +; *Erysimum diffusum* 23: +, 1: +; *Euphorbia barrelieri* ssp. *thessala* 21: +, 23: +, 9: +; *Euphorbia chamaesyce* 17: +; *Euphorbia exigua* 3: +, 18: +; *Euphorbia falcata* 20: +; *Euphorbia myrsinites* 2: +, 1: +; *Euphorbia peplus* 12: +, 16: +, 7: +; *Euphorbia seguierana* ssp. *niciana* 8: +, 23: +; *Euphorbia taurinensis* 2: +, 1: +; *Festuca callieri* 19: +; *Festuca valesiaca* 21: +, 19: +; *Fumana thymifolia* 18: +, 20: +; *Gagea pusilla* 11: +; *Galium tenuissimum* 8: +, 3: +; *Galium tricoratum* 11: +, 21: +; *Gastridium ventricosum* 13: +, 17: +; *Genista carinalis* 21: +; *Geocaryum cynapioides* 16: +; *Geranium lucidum* 14: +, 22: +; *Geranium pusillum* 2: +; *Geranium robertianum* 14: +, 19: +; *Globularia alypum* 18: +, 20: +; *Gymnadenia conopsea* 16: +; *Hainardia cylindrica* 3: +, 20: +; *Herniaria glabra* 21: +; *Herniaria hirsuta* 11: +, 22: +, 4: +; *Herniaria hirsuta* ssp. *cinerea* 5: +, 6: +; *Hippocrepis ciliata* 3: +, 20: +; *Holcus annuus* ssp. *setiglumis* 13: +; *Hyparrhenia hirta* 22: +, 9: +; *Hypericum olympicum* 21: +; *Hypericum rumeliacum* 21: +, 23: +, 3: +; *Inula oculus-christi* 23: +; *Jasione heldreichii* 15: +; *Juncus capitatus* 4: +; *Kickxia elatine* 16: +; *Knautia species* 3: +; *Lagoecia cuminoides* 14: +, 12: +; *Lamium purpureum* 8: +, 11: +; *Lathyrus cicera* 2: +; *Lathyrus sphaericus* 19: +; *Legousia falcata* 14: +, 3: +, 15: +; *Lens nigricans* 19: +; *Leontodon saxatilis* 4: 1; *Limodorum abortivum* 16: +; *Linum nodiflorum* 18: +; *Filago minima* 2: +, 4: +; *Luzula forsteri* 14: +, 21: +, 22: +; *Lychnis coronaria* 14: +; *Matricaria chamomilla* 10: +; *Medicago arabica* 8: 1, 11: +; *Medicago coronata* 14: +; *Medicago falcata* 14: +, 19: +; *Medicago lupulina* 1: +, 3: 1, 18: +; *Medicago orbicularis* 18: +, 19: +, 13: +; *Melilotus neapolitanus* 1: +; *Mibora minima* 4: +; *Micromeria juliana* 14: +; *Microthlaspi perfoliatum* 3: +; *Micropyrum tenellum* 8: +, 5: +; *Minuartia glomerata* ssp. *macedonica* 2: +, 1: +; *Minuartia hybrida* 3: +, 19: +, 4: +; *Minuartia viscosa* 8: +, 21: +; *Moenchia mantica* 14: 2, 19: +, 16: +; *Myosotis incrassata* 4: +, 7: +; *Myosotis stricta* 4: +; *Neslia paniculata* ssp. *thracica* 2: +, 1: +; *Oenanthe silaifolia* 14: +; *Onobrychis aequidantata* 3: 1; *Ononis reclinata* 20: +; *Orchis species* 13: +; *Orlaya daucoidea* 19: +; *Ornithogalum armenicum* 5: +; *Paliurus spina-christi* 14: +, 22: +; *Pallenis spinosa* 22: +, 20: +; *Papaver rhoeas* 10: +; *Parvotrisetum myrianthum* 22: +, 4: +; *Petrorragia illyrica* ssp. *illyrica* 23: +, 2: +; *Petrorragia saxifraga* 4: +, 9: +; *Phleum phleoides* 10: +; *Piptatherum coerulescens* 18: +; *Plantago afra* 20: +; *Pleurochaete squarrosa* (only species in moose layer) 7: +; *Poa angustifolia* 11: +, 10: +; *Poa pratensis* 8: 1; *Polygonum aviculare* 4: +; *Potentilla argentea* 8: +, 11: +, 14: +; *Potentilla pedata* 8: +, 3: +, 10: +; *Prunella laciniata* 14: +; *Ranunculus isthmicus* 6: +; *Ranunculus millefoliatus* 8: +, 4: +, 7: +; *Ranunculus muricatus* 22: +; *Ranunculus psilostachys* 14: +; *Ranunculus rumelicus* 8: +, 11: +, 5: +; *Raphanus raphanistrum* 7: +; *Rhagadiolus stellatus* 3: +; *Rorippa lippizensis* 22: +; *Rubia tinctorum* 14: +; *Salvia verbenaca* 10: +; *Scabiosa argentea* ssp. *ucranica* 8: +, 23: +, 10: +; *Scabiosa sicula* 18: +, 19: +; *Scabiosa triniifolia* 22: +; *Prospero autumnale* 2: +, 1: +, 4: +; *Scolymus hispanicus* 4: +; *Podospermum canum* 11: +, 3: +, 10: +; *Securigera parviflora* 12: +; *Sedum amplexicaule* 19: +; *Sedum annum* 16: +; *Senecio leucanthemifolius* ssp. *vernalis* 8: +; *Sideritis montana* 18: +; *Sideritis romana* 5: +; *Silene subconica* 1: +; *Silene cretica* 19: +; *Sisymbrium officinale* 11: +, 5: +, 6: +; *Sonchus arvensis* 13: +; *Spergula arvensis* 11: +, 4: +; *Spergula pentandra* 5: +, 6: +, 4: +; *Stachys angustifolia* 19: +; *Stachys cretica* ssp. *cassia* 23: +; *Stellaria pallida* 14: +, 3: +; *Stipa capensis* 14: +, 20: +; *Stipa capillata* 20: +; *Taraxacum sect. Ruderalia* 8: +, 5: +; *Thymus odoratissimus* 23: +, 10: +; *Thymus sibthorpii* 15: +, 4: +; *Tolpis virgata* 7: +; *Tordylium apulum* 12: +; *Tordylium maximum* 3: +; *Torilis africana* 19: +, 13: +; *Tragopogon balcanicus* 18: +; *Tremastelma palaestinum* 3: +, 18: +, 20: 1; *Tribulus terrestris* 4: +, 16: +, 7: +; *Trifolium globosum* 7: 1; *Trifolium hirtum* 19: +, 16: +; *Trifolium pallidum* 8: +, 3: 1; *Trifolium repens* 11: 1; *Trifolium grandiflorum* 19: +, 16: +; *Trifolium vesiculosum* 14: +; *Medicago monspeliaca* 18: +, 20: +, 5: +; *Valantia muralis* 14: +, 12: +; *Valerianella dentata* 2: +, 1: +, 3: +; *Valerianella discoidea* 3: +; *Verbascum blattaria* 21: +, 22: +; *Verbascum densiflorum* 21: +, 22: +; *Vicia articulata* 17: +; *Vicia barbazitae* 8: +; *Vicia hirsuta* 21: +; *Vicia villosa* 10: +, 17: +, 16: +; *Xeranthemum annum* 23: +, 1: +, 20: +;

Localities of relevés, details of relevé are indicated in the following order: relevé number, country code, date (year/month/day), relevé area (m<sup>2</sup>), altitude (m), aspect (degrees), slope (degrees), cover herb layer (%), description of locality, latitude, longitude. 1. GR, 20060428, 50, 340, 270, 1, 100, between Vrasna and Sohós, 40.71429, 23.62406; 2. GR, 20070513, 30, 426, 45, 1, 100, near to Askos, 40.75845, 23.41808; 3. GR, 20070513, 25, 162, 135, 2, 100, above Vrasna, 40.70946, 23.64963; 4. MK, 20070516, 30, 514, 225, 3, 95, Strumica, Novo Selo, 41.43231, 22.90296; 5. MK, 20070516, 30, 361, 180, 4, 100, Strumica, Novo selo, 41.42425, 22.89463; 6. MK, 20070516, 30, 571, 180, 5, 90, Radoviš, Plačkovica, 41.65541, 22.47287; 7. MK, 20060424, 30, 247, 180, 8, 80, Nikolič, pasture in *Q. coccifera* zone, 41.26343, 22.73831; 8. MK, 20060424, 35, 265, 180, 15, 90, Nikolič, pasture in *Q. coccifera* zone, 41.26646, 22.73807; 9. GR, 20060426, 30, 225, 135, 5, 100, Kokinochori, *Q.*

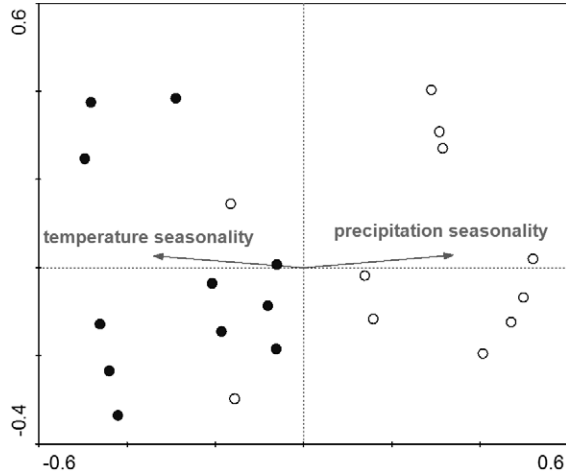
**Tab. 1.** – continued

*coccifera* zone, 40.82193, 24.02571; 10. GR, 20070515, 50, 320, 180, 2, 95, Chalkidiki, between Vavdos and Simantra., 40.37739, 23.33592; 11. GR, 20070515, 30, 233, 225, 5, 95, Thesaloniki, Panorama, 40.57318, 23.03191; 12. GR, 20070515, 30, 316, 180, 1, 100, Chalkidiki, Vasilika between Agios Antonios and Monopigado, 40.43548, 23.11874; 13. GR, 20060407, 30, 390, 180, 2, 90, Thasos, above Prinós, 40.73500, 24.60870; 14. GR, 20060427, 40, 338, 180, 8, 90, Thasos, Megalos Prinós, 40.73328, 24.60799; 15. GR, 20070512, 30, 11, 180, 2, 90, Thasos, Alikí, 40.17827, 24.60262; 16. GR, 20070513, 30, 255, 180, 3, 100, Chalkidiki, between Olimpiada and Stratóni, 40.52979, 23.83467; 17. GR, 20060426, 40, 67, 135, 7, 90, Kokkinochoma (Kavála), 40.92415, 24.29526; 18. GR, 20070513, 30, 200, 225, 2, 90, Mirtófito, 40.78824, 24.21881; 19. GR, 20070513, 30, 210, 180, 2, 100, Askos, along the road to highway, 40.72011, 23.38634; 20. GR, 20070513, 30, 486, 180, 6, 100, Askos, 40.75688, 23.40912; 21. GR, 20070514, 30, 213, 180, 2, 100, Chalkidiki, between Porto Koufo and Kalamitsi, 39.97878, 23.96423; 22. GR, 20070514, 30, 52, 90, 2, 90, Chalkidiki, Skála Sikias, 40.02384, 23.99353; 23. GR, 20060428, 30, 41, 180, 4, 100, Kavála, Nea Peramos, 40.85714, 24.31423.

its significance was assessed using the Monte Carlo permutation test with 999 permutations. The analysis was run with scaling for inter-sample distances to relate the gradient in the floristic composition to explanatory variables (TER BRAAK and ŠMILAUER 2002). Forward selection of explanatory variables was used to provide a ranking of the importance of specific variables and to avoid co-linearity (TER BRAAK and ŠMILAUER 2002). Variables with  $p=0.001$  were excluded from further analysis. We also calculated the total variance explained by individual variables and all variables together (LEPŠ and ŠMILAUER 2003) (Tab. 2). We estimated only the total explained variance, since it was impossible to make a model because, due to the high correlated climatic variable, the process would cause multi-co-linearity (SULLIVAN et al. 2011, ALAHUTA et al. 2011). We then presented the most explanatory statistical variables in a RDA diagram (Fig. 5).

**Tab. 2.** Results of forward selection: significant environmental variables and percentage of the total variance of species data explained (% TV), calculated with RDA.

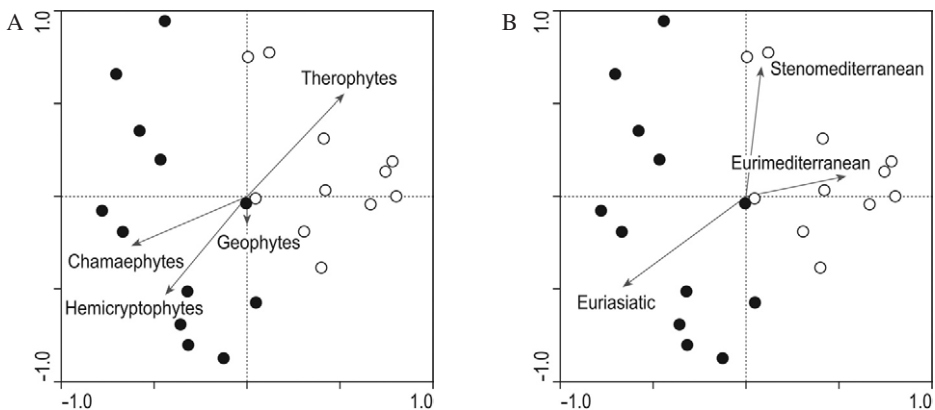
Variable	P	F	% TV
Temperature seasonality	0.001	2.75	11.6
Precipitation seasonality	0.001	2.75	11.6
Temperature annual range	0.001	2.72	11.5
Precipitation of coldest quarter	0.001	2.65	11.2
Precipitation of driest month	0.001	2.65	11.2
Precipitation of driest quarter	0.001	2.59	11
Precipitation of wettest month	0.001	2.55	10.8
Min temperature of coldest month	0.001	2.65	10.6
Mean diurnal range	0.001	2.44	10.4
Precipitation of wettest quarter	0.001	2.54	10.4
Precipitation of warmest quarter	0.001	2.32	9.9
Mean temperature of coldest quarter	0.001	2.25	9.7
Total			60.1



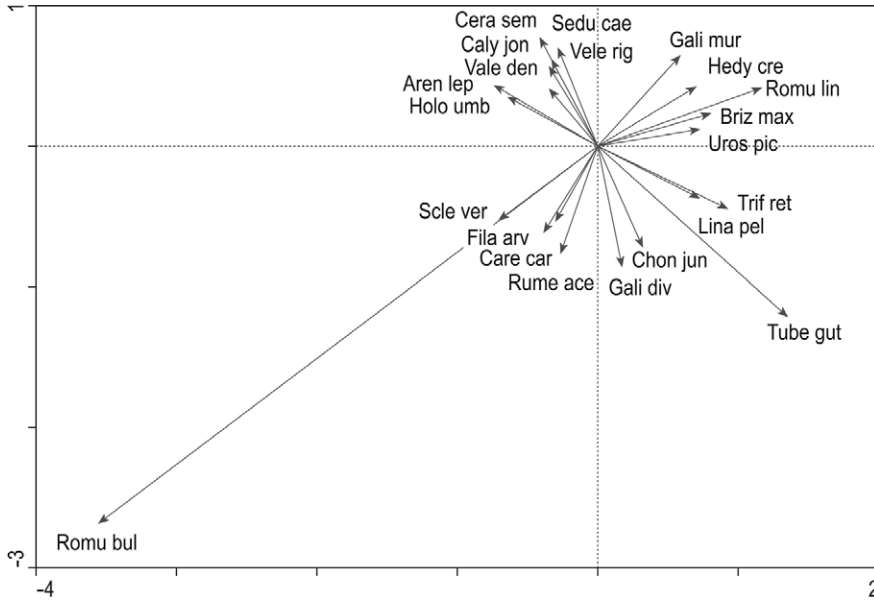
**Fig. 5.** Ordination diagram of sampling plots based on redundancy analysis (RDA). Only the two most important variables are included: seasonality in precipitation and temperature. Communities with *Romulea bulbocodium* are distributed in the interior part and represented by full circles; communities with *Romulea linairesii* ssp. *graeca* are distributed in coastal areas and represented by empty circles. First and second canonical axes have eigenvalues 0.117 and 0.050.

We plotted the layers of seasonality of temperature and seasonality of precipitation on a geographical map of distribution of samples (relevés) in the southern Balkans (ELIÁŠ et al. 2013) to test the significance of results provided by previous analyses.

Life forms and the chorological spectra of groups were also determined following RAUNKIAER 1934, PIGNATTI et al. 2005, MICEVSKI (1993–2001), MICEVSKI and MATEVSKI (2005) and were passively projected onto the PCA diagram (Fig. 6).



**Fig. 6.** Principal component analysis (PCA) of samples (relevés) with passive projection of life forms (A) and chorotypes (B). Communities with *Romulea bulbocodium* are represented by full circles and communities with *Romulea linairesii* ssp. *graeca* with empty circles. Eigenvalues of axes 1 and 2 are 0.279 and 0.189.



**Fig. 7.** PCA ordination of species. Fit for inclusion of species into ordination diagram was set to 45. The species are presented by 4 letters for genus and 3 for species, for explanation compare table 1.

The nomenclature of species follows the Euro+Med PlantBase (EURO+MED 2006), except *Amaranthaceae*, *Cistaceae*, *Dipsacaceae*, *Linaceae*, *Polygonaceae*, *Ranunculaceae*, *Rhamnaceae*, *Valerianaceae* and *Bertero orbiculata* following FLORA EUROPAEA and *Medicago disciformis* var. *strumensis* Velč. et Bond., *Centaurium erythraea* ssp. *rumelicum* (Velen.) Melderis and *Pleurochaete squarrosa* (Brid.) Lindb. Syntaxonomic nomenclature follows International Code of Phytosociological Nomenclature (ICPN) (WEBER et al. 2000).

## Results

ESETG appear in areas under the influence of the Mediterranean climate (Fig. 3). Their northern limit corresponds to the distribution area of *Quercus coccifera*. ESETG appear in the coastal region of the Aegean Sea and in the interior along the rivers Struma and Strumica, where the influence of the Mediterranean climate can penetrate into the continent. ESETG do not appear in either agricultural areas or forests, only in areas with extensive grazing. They cannot therefore be found in the fertile plains along the Strymonas or Axios rivers, but appear generally on the edges of these areas, where grazing is still maintained.

The dendrogram (Fig. 4) shows two well defined groups of communities. The first represents ESETG in which *Romulea bulbocodium* appear. These communities thrive in the interior part of the area and are co-dominated by *Carex divisa*, *Plantago lagopus*, *Poa bulbosa*, *Trifolium subterraneum* and *Tuberaria guttata*. *Romulea linaresii* ssp. *graeca* appears in the other group of ESETG. These communities are found along the coast of the Aegean Sea and are co-dominated by *Plantago lagopus*, *Poa bulbosa*, *Trifolium cherleri* and *Vulpia ciliata*.

Since the topological variables and management are fairly unique throughout the region, we tried to identify the main factor within all the climatic factors that causes the diversity of communities. We tested the significance of climatic data from WorldClim database. Since the significance of the following variables was low ( $p=0.001$ ), they were excluded from analysis: annual precipitation, isothermality, annual mean temperature, mean temperature of warmest quarter, mean temperature of wettest quarter, max temperature of warmest month and mean temperature of driest quarter. These variables mainly sum up annual averages. The results show that the most important climatic feature that enables the diversity of ESETG in the region is pronounced changes in precipitation and temperature i.e. seasonality (Tab. 2). Higher precipitation seasonality can be found in the coastal regions, where there is pronounced summer hydric stress, which is less pronounced in the interior. Precipitation of the warmest quarter is higher in the interior, more precipitation can be found on the coast in the wettest period (i.e., autumn) (graph not presented in the text). Precipitation is more evenly distributed in the interior (Fig. 5). The situation is the opposite with temperature, with which seasonality is more pronounced in the interior, where lower temperatures are found during the winter. Among significant variables are the minimal and mean temperature of the coldest month and quarter, respectively. This shows that the diversity of ESETG is also caused by cooler winter temperatures (Tab. 2, Fig. 5).

Structural analysis showed that communities in the coastal area contain more therophytes (e.g., *Briza maxima*, *Urospermum pycroides*, *Hedynois rhagadioloides*, *Galium murale*) (Fig. 6A). On the other hand, hemicryptophytes and chamaephytes are more abundant in the interior (*Scleranthus verticillatus*, *Carex caryophyllea*, *Rumex acetosella*).

In terms of chorological spectrum, there are more species with a Mediterranean distribution pattern (e.g., *Galium murale*, *Hedynois rhagadioloides*, *Velezia rigida*) in the coastal communities, whereas Euroasiatic species are more common (*Carex caryophyllea*, *Rumex acetosella*, *Filago arvensis*) inland (Fig. 6B).

It was decided to assign the plant communities elaborated to two associations. Communities from the interior part of the region in which *Romulea bulbocodium* appears were classified as *Lagopo-Poetum bulbosae* and the other one, found in the coastal region, as *Romuleo graecae-Poetum bulbosae*. Diagnostic species as well as typification are given in the section nomenclature.

## Discussion

Mediterranean vegetation is limited to the north, with a continental climate dominating the continental parts of the Balkans. The main climatic factor preventing penetration of Mediterranean vegetation into the interior of the Balkan Peninsula is winter frosts (ČARNI and MATEVSKI 2005, MEDAIL and DIADEMA 2009). At the same time, the Mediterranean climate, with summer droughts, is a strong ecological filter that does not allow continental flora to settle in the region (FILIBECK et al. 2012).

ESETG, often dominated by *Poa bulbosa*, can be found mainly on fresh fine clay soils on intensively grazed sites around settlements. Such vegetation is rarely found on carbonate bedrock, since erosion and degradation is faster (OBERDORFER 1954). It can be found on carbonate bedrock only in places (e.g., in the bottom of valleys) where colluvium offers a ref-

uge for these communities. Garrigue dominated by *Cistus creticus* is often found around these stands (ČARNI et al. 2010).

The vegetation growth of these communities correlates with the annual precipitation regime. Germination of spring annuals and growth of most perennials begins soon after the first autumn rains. Growth is fairly slow during the winter months but vegetation is usually well established by February. Growth is fast in spring, with the peak of growth and seed set in May–June. By the end of June, most of the herbaceous vegetation is dry and the seed dispersed. Summer species, in this case C4 grasses, such as *Achnatherum*, *Bothriochloa*, *Chrysopogon*, grow during the summer and seed in September–October (PÉREZ-CAMACHO et al. 2012).

Analysis of climatic variables derived from WorldClim database shows that they are the most important variables for explaining the variance among ESETG (60%) and are highly correlated (Tab. 3). It must be borne in mind that the Mediterranean climate provides a climatic envelope for ESETG on the large scale (GILINGHAM et al. 2012). On a smaller scale, the analysis showed that the most important factor for the variability of ESETG within the research area is seasonality. Variables that give information about average climatic conditions (mean temperature and precipitation) are of fairly low importance. Inter-annual changes in precipitation and temperature also appear to be responsible for variability in other grazed herbaceous communities (ZHANG et al. 2011, LOHMANN et al. 2012).

The RDA diagram shows that the highest seasonality of precipitation is within ESETG in which *Romulea linaresii* ssp. *graeca* appears and the lowest within that with *Romulea bulbocodium*. The situation is the reverse with temperature (Fig. 5).

Temperature seasonality (Fig. 3) is lowest on the coast of the Aegean Sea and at higher altitudes (ESETG do not appear there). On the other hand, precipitation seasonality is highest in the coastal area and diminishes gradually towards the continent (Fig. 3).

In the analysis of climatic variables, two outliers differing from the result of the classification (Fig. 4), can be found, relevés 19 and 20 in table 1. Both species of *Romulea* appear in these relevés. They were sampled above Lake Volvi (Chalkidiki, Greece) and the proximity of the lake probably influences the local climate.

The life forms spectrum shows the Mediterranean character of ESETG. In these communities, therophytic species form 65 % of the floristic inventory of inland (*Romulea bulbocodium*) communities and 73 % of coastal (*Romulea linaresii*) communities. Comparison with similar therophytic grasslands from Bulgaria (SOPOTLIEVA 2009) and the Republic of Macedonia (ČUŠTEREVSKA et al. 2012) showed that there are 47 % of therophytes in such grasslands in Bulgaria and 53–64% in those of the Republic of Macedonia.

More therophytes can be found in the coastal communities, where summer drought is more pronounced. Summer drought is a limiting factor for perennials but they can extend their biological activity if water is available (PÉREZ-CAMACHO et al. 2012). More evenly distributed precipitation gives an advantage to perennials in inland communities. More elements of perennial dry grasslands from the class *Festuco-Brometea* can be found in the inland communities (Tab. 1).

Analysis of chorotypes (geo-elements) showed that 66% of species with a Mediterranean (in the widest sense) distribution pattern appear in coastal communities and 59 % in inland communities. Comparing these data with regions with more pronounced continentality



(SOPOTLIEVA 2009, ČUŠTEREVSKA et al. 2012), it can be seen that there are 41% of Mediterranean species in Bulgarian communities and 46–53% in those of the Republic of Macedonia. This indicates that Mediterranean are quite different from continental communities. Relevés of such communities further to the south have not been published but similar therophytic communities of olive grove grassland show 65% of Mediterranean species (ČARNI and MATEVSKI 2005).

In a comparison with the synthetic table made by OBERDORFER (1954) in the same region, many differences in the floristic composition of ESTEG can be found. However, these differences are very difficult to evaluate since changes appear in the management regime (abandonment), climatic changes, sometimes even differences in taxonomical concepts. In the period 1950–1999, precipitation decreased and summer temperatures rose in the eastern Mediterranean (NASTOS et al. 2013) while land use change and abandonment of traditional agriculture is one of the crucial problems in the Mediterranean landscape (BAJOCCHO et al. 2012).

### Nomenclature

OBERDORFER (1954) classified ESETG within the order *Helianthemetalia* and class *Thero-Brachypodietea*. The class *Thero-Brachypodietea* is nowadays limited to Mediterranean perennial pseudosteppe communities (RODWELL et al. 2002). The vegetation under consideration is classified within the class of Mediterranean terrestrial plant communities dominated by annual low-growing herbs and grasses *Helianthemetea guttati* (Br.-Bl. in Br.-Bl. et al. 1952) Rivas Goday et Rivas-Mart. 1963 and order of Mediterranean and sub-Mediterranean ephemeral communities on acid soils and fire-prone habitats *Helianthemetalia guttati* Br.-Bl. in Br.-Bl. et al. 1940 (RODWELL et al. 2002, ALLEGREZZA et al. 2006, FANELLI et al. 2010, RIBEIRO et al. 2012).

It would be also possible to classify the alliance *Romulion* - within the class *Poetea bulbosae* and order *Poetalia bulbosae*, which is found in Mediterranean and sub-Mediterranean heavily grazed pastures, trampled and manured by sheep (RODWELL et al. 2002, FARRIS et al. 2010) known till now only from the western Mediterranean region (CANO et al. 2007). As there appear climatic and floristic differences, the possible occurrence of these syntaxa in the eastern Mediterranean region should be studied in the future. ESETG cannot be classified within the class of ephemeral vegetation with winter annuals on bare or disturbed salt-marsh mud and sand *Saginetea maritimae*, since no halophilous plant species appear (e.g., TOMASELLI et al. 2011) and classification of the alliance *Romulion* in the list of alliances (RODWELL et al. 2002) should be reconsidered.

ESETG should be classified within the alliance *Romulion*, as proposed by OBERDORFER (1954). However, at first glance, OBERDORFER (1954) mentions only *Poa bulbosa* (that means a typical subspecies and not subspecies *timoleontis*) in list 1 (»Liste I«) as the dominant species of »Lagopeto-Poetum timoleontis« and »Tortileto-Poetum timoleontis«, which would cause an invalid publication of the associations and, consequently, the alliance (ICPN, art. 3f, 8). However, according to THEURILLAT (pers. com.), OBERDORFER (1954: 88) says about synthetic lists 1–3 (»synthetische Listen I–III«) »... *Brachypodium ramosum* oder *B. phoenicoides* treten vollkommen zurück und werden durch *Poa bulbosa* (div. ssp.) oder *Stipa tortilis* ersetzt.« It is true that in »List I« *Poa bulbosa* is indicated as a species but

in the other two lists («Liste II» and «Liste III»), it is »*Poa bulbosa* coll.«. We would therefore be inclined to consider that a printing error occurred in the first list and that here, too, it should be interpreted as »*Poa bulbosa* coll.« (including also the subspecies *timoleontis*) on the basis of what is said on page 88. In this sense, Oberdorfer would use the name of the aggregate species in the list (*Poa bulbosa* coll.) but, on the other hand, would use a more narrowly defined taxon in the association name (*Poa bulbosa* ssp. *timoleontis*). From the point of view of articles 3f and 43, both association names can thus be considered formally to be validly published, and so also the alliance name *Romulion* Oberdorfer 1954.

The correction of the name »*Romulion*« to »*Romulion graecae*« by BOLÒS et al. (1996) cannot be accepted. Names such as »*Romulion*« should stay without the addition of a specific name, since there is no rule in ICPN about the correction of these names, and recommendation 10C cannot be applied.

### ***Romulion* Oberdorfer 1954**

Lectotype: *Lagopo-Poetum bulbosae* Oberdorfer 1954 corr. Čarni et al. 2014 – *lectotypus hoc loco*. Diagnostic species (OBERDORFER 1954): *Allium guttatum*, *Alyssum minutum*, *A. repens*, *Campanula ramosissima*, *Gagea reticulata*, *G. chrysantha*, *Hedypnois rhaodiolooides*, *Hypochoeris cretensis*, *Lagoecia cuminioides*, *Linaria simplex*, *Lotus angustissimus*, *Ornithogallum collinum*, *Ornithogalum armeniacum*, *Picris pauciflora*, *Romulea bulbocodium*, *R. linaresii* ssp. *graeca*, *R. columnae*, *Sedum aetnense*, *Silene graeca* and *Ziziphora capitata*. Ecological conditions: early spring ephemeral therophytic grasslands on deeper soils in the eastern Mediterranean area.

The critical point of consideration of the nomenclature is the doubtful appearance of *Poa bulbosa* ssp. *timoleontis* (i.e., *Poa timoleontis*) in communities in the research area. During the field survey carried out in the southern part of the Republic of Macedonia and around Thessaloniki in Greece, we could not confirm *Poa bulbosa* ssp. *timoleontis* as appearing in the communities under consideration; only *Poa bulbosa* s. str. was identified. Since the area of research and also the species composition match Oberdorfer's »*Lagopeto-Poetum timoleontis*«, it was decided to correct the name of »*Lagopeto-Poetum timoleontis*« to *Lagopo-Poetum bulbosae*, on the basis of art. 43 of ICPN. We have not corrected the name of »*Toriletum-Poetum timoleontis*« appearing further to the south, since *Poa timoleontis* may appear there.

*Lagopo-Poetum bulbosae* Oberdorfer 1954 corr. Čarni et al. 2014 nom. corr. hoc loco

Neotype: Tab. 1, rel. 5 – *neotypus hoc loco*. Diagnostic species: *Achillea coarctata*, *Alyssum desertorum*, *Carex caryophyllea*, *Poa bulbosa*, *Romulea bulbocodium* and *Teucrium capitatum*. Ecological conditions: early spring ephemeral grasslands in the regions with less pronounced summer hydric stress.

Oberdorfer described this community under the name »*Lagopeto-Poetum timolentis*« [recte: »*Lagopeto-Poetum timoleontis*«]. Since the genus *Lagopus* has been validly published, the name »*Lagopeto-Poetum timoleontis*« must be maintained according to art. 14, and corrected to *Lagopo-Poetum timoleontis* Oberdorfer 1954 according to art. 41. At the same time, we would like to add a comment to the name »*Tortileto-Poetum timoleontis*«. Since no genus »*Tortilis*« exists, this must mean *Stipa tortilis* (art. 14), and the name should be corrected with the genus *Stipa*, i.e., *Stipa tortilis-Poetum timoleontis* Oberdorfer 1954.

We also describe a new association, as: *Romuleo graecae-Poetum bulbosae* ass. nova hoc loco Holotype: Tab. 1, rel. 15 – holotypus hoc loco. Diagnostic species: *Crepis zacyantha*, *Galium murale*, *Hedynois rhagadioloides*, *Hordeum murinum* ssp. *leporinum*, *Lagurus ovatus*, *Poa bulbosa*, *Romulea linaresii* ssp. *graeca*, *Urospermum pycroides*. Ecological conditions: early spring ephemeral grasslands in the regions with more pronounced summer hydric stress.

## Conclusions

ESETG are typical elements of Mediterranean landscapes that are maintained by traditional land use. Since these are among the most diverse habitats in the region, the class *Heliathemetea* and alliance *Romulion* for the eastern Mediterranean, respectively, therefore also deserve to be listed in syntaxonomic interpretation manuals of the Habitat Directive among habitats 6220 Pseudosteppe with grasses and annuals of the *Thero-Brachypodietea* (FARRIS et al. 2007, BIONDI et al. 2012).

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