Acta Bot. Croat. 73 (1), 107–129, 2014

CODEN: ABCRA 25
ISSN 0365-0588
eISSN 1847-8476

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

ANDRAŽ ČARNI[1*], VLADO MATEVSKI[2], URBAN ŠILC[1], RENATA ĆUŠTEREVSKA[2]

[1] Institute of Biology, Scientific Research Center of the Slovenian Academy of Sciences and Arts, Novi trg 2, SI 1000 Ljubljana, Slovenia

[2] Institute of Biology, Faculty of Natural Sciences of St. Cyril and Methodius University in Skopje, Gazi baba b/b, MK 1000 Skopje, Republic of Macedonia

Abstract – The work deals with habitats of *Romulea bulbocodium* and *Romulea linaresii* 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 colorful spring carpet.

* Corresponding author, e-mail: carni@zrc-sazu.si

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. linares*ii, 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).

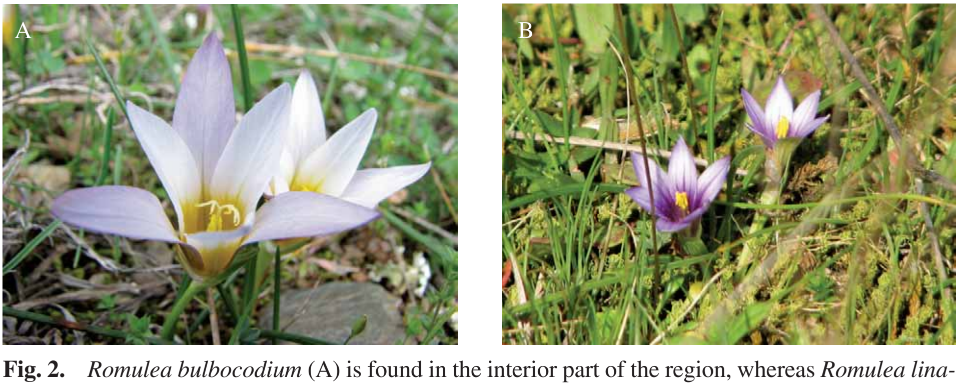

Fig. 2. *Romulea bulbocodium* (A) is found in the interior part of the region, whereas *Romulea linaresii* ssp. *graeca* (B) appears in the coastal part.

Romulea linaresii 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, ÖZDEMIR 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 (KALIGARIČ 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, VASSILEV 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).

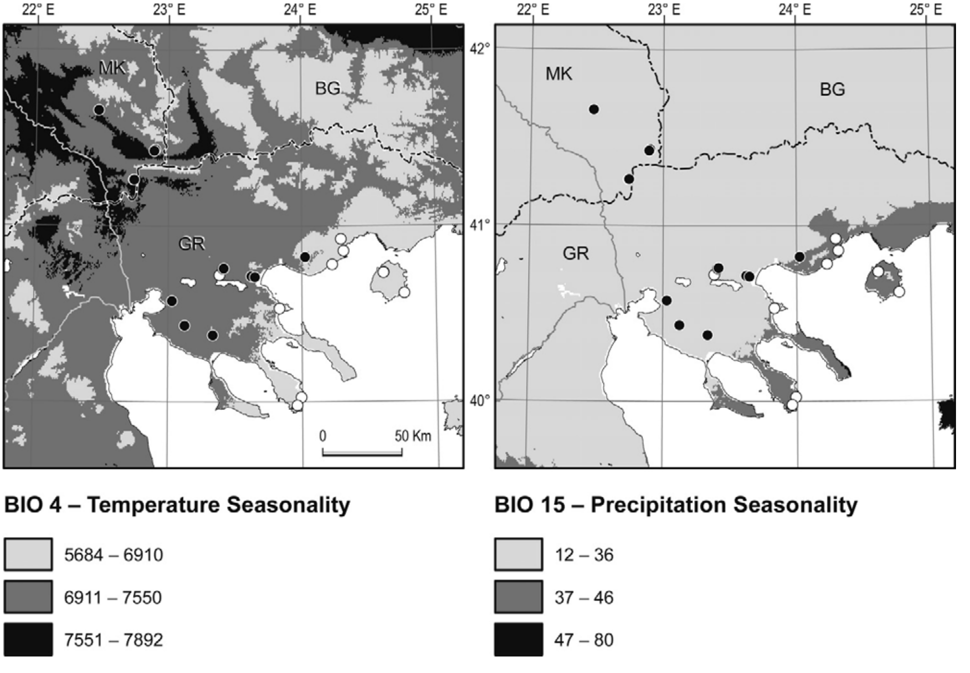

Fig. 3. Distribution of communities: communities with *Romulea bulbocodium* are distributed in the inland part and represented by full circles; communities with *Romulea linaresii* ssp. *graeca* are distributed in coastal areas and represented by empty circles. In the map two layers generated through 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 (HIJMANS 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, Chysopogon,* 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 (HIJMANS 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 prinicipal 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

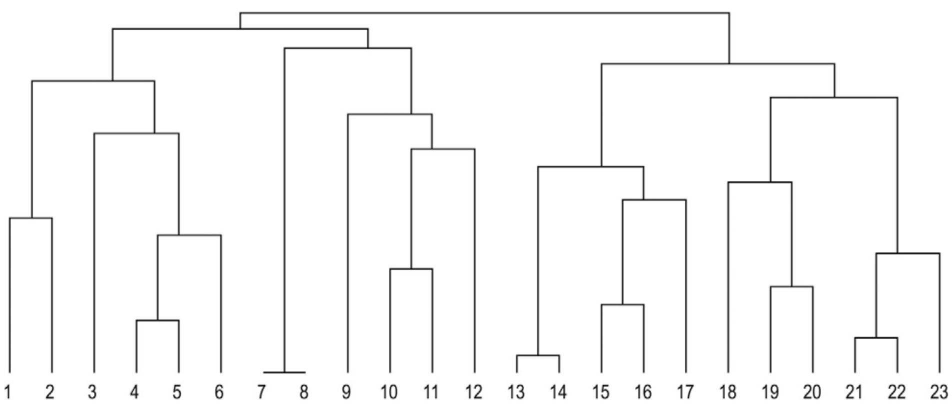

Fig. 4. Dendrogram of samples (relevés). Two main clusters can be seen, inland communities with *Romulea bulbocodium* are indicated by number 1–12, whereas the coastal communities with *Romulea linaresii* ssp. *graeca* are indicated by number 13–23.

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

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
LAGOPO-POETUM BULBOSAE																							
Romulea bulbocodium	3	3	3	3	3	3	2	2	+	3	4	3	.	.	.	.	2	.	1	1	.	.	.
Myosotis ramosissima	+	+	+	+	+	+	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Teucrium capitatum	.	.	.	.	.	+	+	+	+	+	+	+	.	.	.	.	.	.	.	+	.	.	.
Alyssum desertorum	.	.	.	+	+	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Achillea coarctata	+	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex caryophyllea	.	+	.	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
ROMULEO GRAECAE-POETUM BULBOSAE																							
Romulea linaresii ssp. *graeca*	.	+	+	.	.	.	.	.	.	.	.	.	1	2	1	1	.	1	1	+	1	1	1
Galium murale	.	.	.	.	.	.	.	.	+	.	.	+	+	+	+	+	+	+	.	.	.	+	+
Hordeum murinum ssp. *leporinum*	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	+	.	+	.	+	+	+	.
Lagurus ovatus	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	1	1	+
Crepis zacintha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	+	.	+	+
Urospermum picroides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	+	+
ROMULION																							
Hedypnois rhagadioloides	.	.	+	.	.	.	.	.	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+
Hypochoeris cretensis	.	.	1	+	+	+	+	+	+	.	.	.	+	+	+	.	+	.	+	+	.	.	+
Allium guttatum	.	.	.	.	+	+	.	.	.	.	+	+	.	.	.	+	.	+	+	+	+	+	.
Linaria simplex	.	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	.	.	+	.	.	.	+
Ornithogalum collinum	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	2	2	.	+	+
Lotus angustissimus	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
HELATHEMETALIA,HELIATHEMETEA																							
Poa bulbosa	3	2	3	2	3	2	4	4	4	3	3	2	4	3	3	3	3	4	3	2	2	3	2
Psilurus incurvus	.	+	+	+	+	1	+	+	.	+	2	+	+	2	+	+	+	+	+	+	+	+	+
Vulpia ciliata	.	+	1	+	+	+	+	+	+	.	.	+	+	.	1	1	+	+	1	+	3	1	+
Tuberaria guttata	.	1	2	+	3	2	+	.	.	.	.	+	1	+	2	2	2	1	1	+	2	1	2
Trifolium campestre	+	.	1	2	2	+	.	.	.	+	.	+	+	+	1	.	+	2	1	+	+	+	1
Ornithopus compressus	+	.	1	1	+	.	+	+	.	.	.	+	1	+	+	2	+	+	+	+	.	+	+
Trifolium angustifolium	+	.	+	+	+	+	.	.	+	1	.	2	.	+	+	+	.	1	+	+	+	1	+
Hypochaeris glabra	.	1	+	+	+	+	+	+	.	.	.	+	+	.	.	+	+	.	+	+	+	+	+
Trifolium arvense	.	.	+	1	1	+	+	+	.	+	.	1	.	.	.	+	+	+	+	+	+	1	+
Plantago bellardii	.	.	.	1	+	2	+	.	.	.	+	2	.	1	+	2	1	+	+	1	1	2	1
Linaria pelisseriana	.	.	+	+	+	+	+	.	.	.	.	.	.	+	+	+	1	+	+	+	+	+	+
Trifolium subterraneum	3	2	2	+	+	.	+	.	.	.	.	.	2	+	+	2	+	.	.	+	.	1	+
Trifolium cherleri	.	.	1	.	1	2	+	.	.	.	.	1	.	.	+	+	+	3	2	4	+	+	2

Tab. 1. – continued

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Aira elegantissima	.	.	2	1	+	+	.	.	.	.	.	.	+	.	1	+	+	+	+	.	+	1	+
Asterolinon linum-stellatum	.	.	1	.	.	.	.	+	+	+	+	+	+	.	+	.	.	1	.	+	+	+	+
Galium divaricatum	.	+	+	+	+	+	.	.	.	.	+	.	.	.	.	+	.	+	+	+	+	.	.
Medicago minima	.	.	.	.	1	+	2	2	1	+	.	+	1	+	.	.	.	+	.	1	.	.	.
Arenaria leptoclados	+	.	.	.	.	+	+	+	+	+	1	+	.	+	+	.	.	.	.	.	.	.	.
Filago gallica	.	+	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	+	+	+	+	+
Trifolium stellatum	+	.	.	.	.	.	.	1	+	.	.	.	+	+	2	.	.	.	.	.	+	1	+
Briza maxima	.	.	.	.	.	.	.	+	.	.	.	+	.	.	+	+	.	+	+	.	1	1	+
Tolpis umbellatum	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	+	+	.	+	+	+	.
Helianthemum salicifolium	.	.	.	.	.	+	+	2	2	+	+	.	.	.	.	.	.	.	.	1	.	.	.
Velezia rigida	.	.	.	.	.	.	.	+	+	.	+	+	+	+	+	.	.	.	.	.	.	.	.
Taeniatherum caput-medusae	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	+	+	+	.	.	+
Sedum caespitosum	+	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	+	.	.	.	.	.	.
Trachynia distachya	.	.	.	.	.	2	2	1	.	+	1	.	.	.	.	.	.	+	.	.	.	.	.
Hymenocarpos circinnatus	.	.	.	.	.	.	.	.	2	.	.	2	1	+	+	.	+	.	.	.	.	.	.
Viola kitaibeliana	+	+	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
Arenaria serpyllifolia	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.
Vulpia myuros	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+
Rostraria cristata	.	.	.	.	+	.	.	+	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.
Crucianella latifolia	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	+
Alkanna tinctoria	.	.	.	.	.	.	+	+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.
Medicago disciformis var. disciformis	.	.	.	.	.	.	.	.	1	+	.	+	+	+	.	.	.	.	.	.	.	.	.
Helianthemum aegyptiacum	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.
Petrorhagia prolifera	.	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Medicago disciformis var. strumensis	.	.	.	.	.	.	+	2	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Clypeola jonthlaspi	.	.	.	.	.	.	+	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Dasypyrum villosum	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	+	.	.	.	.
FESTUCO-BROMETEA																							
Trifolium scabrum	+	+	+	+	+	+	+	+	+	1	1	+	+	+	1	+	.	1	+	1	+	+	+
Eryngium campestre	+	+	.	+	.	+	.	+	+	.	+	.	+	.	.	.	+	.	1	+	.	.	.
Aegilops triuncialis	.	.	+	.	.	.	+	.	+	+	+	1	.	.	.	.	+	1	.	+	+	.	+
Chrysopogon gryllus	.	.	.	+	.	1	+	+	+	+	+	.	.	.	.	.	+	.	+	+	.	.	+
Medicago rigidula	.	.	.	.	+	+	+	+	1	+	+	+	+	+	.	.	.	.	.	+	.	.	.
Thymus substristus	+	+	+	+	+	.	+	+	+	.	.	.	.	+	.	.	.	.	+	.	.	.	.
Scleranthus verticillatus	+	+	.	+	+	+	+	+	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.

Tab. 1. – continued

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Chondrilla juncea	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.
Potentilla recta ssp. *laciniosa*	.	.	+	+	+	+	.	.	.	+	.	+	.	.	.	.	.	+	+	+	.	.	.
Bromus squarrosus	.	.	.	.	+	+	+	+	.	+	.	+	.	.	.	.	.	+	.	.	+	.	.
Arabidopsis thaliana	.	+	+	.	.	+	.	+	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.
Centaurea grisebachii	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Hypericum perforatum	.	.	+	.	.	.	+	+	+	.	.	.	.	.	.	.	.	+	+	.	.	.	.
Koeleria splendens	.	.	.	.	+	.	+	+	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.
Achillea setacea	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Sanguisorba minor	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Convolvulus cantabrica	.	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astragalus onobrychis	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.
Thymus striatus	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	1	+	.	.	.
Allium sphaerocephalon	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.
OTHER SPECIES																							
Cynodon dactylon	+	+	+	+	1	1	.	.	+	.	+	1	+	+	+	+	1	.	+	+	+	+	+
Parentucellia latifolia	+	1	1	1	+	1	+	+	+	.	+	.	+	+	.	2	+	.	+	+	.	+	1
Filago germanica	+	+	+	+	+	+	+	.	.	+	+	+	+	+	+	+	+	+	+	+	.	.	.
Anthemis auriculata	+	+	+	.	.	.	1	1	+	1	.	+	1	+	1	1	+	.	1	+	1	+	1
Petrorhagia velutina	.	+	+	.	+	+	+	+	.	.	.	+	1	+	+	+	+	1	+	+	1	+	1
Sherardia arvensis	+	+	1	.	+	+	.	.	1	+	+	+	+	.	+	+	.	1	.	+	+	+	+
Plantago lagopus	+	+	+	.	+	.	.	.	2	3	+	3	1	3	+	.	1	.	+	1	2	+	3
Erodium cicutarium	+	+	.	.	+	+	+	.	+	+	+	+	1	+	+	+	2	.	+	+	.	.	+
Achnatherum bromoides		.	.	+	.	+	.	+	+	1	+	.	|	.	.	+	.	+	+	+	+	.	++
Avena barbata	.	.	+	.	+	.	.	+	+	+	+	+	.	.	.	.	+	+	+	+	+	+	+
Veronica arvensis	.	+	+	+	+	.	.	.	+	.	.	.	+	.	+	+	1	+	.	.	.	+	+
Cistus incanus ssp. *creticus*	.	+	+	.	.	.	.	.	+	+	.	+	+	+	.	+	+	+	.	.	+	.	+
Trifolium retusum	.	.	+	+	+	.	.	.	.	.	.	+	.	.	+	1	.	1	+	+	+	+	+
Valerianella turgida	.	+	+	.	+	+	.	.	+	.	+	+	.	.	.	.	+	+	.	+	.	.	+
Senecio vulgaris	.	.	+	.	.	.	+	+	+	.	.	.	+	+	.	+	+	.	+	+	.	.	+
Trifolium nigrescens	+	.	+	+	+	+	.	.	.	.	.	.	+	.	.	+	.	.	+	+	+	.	.
Trifolium tenuifolium	+	.	+	+	+	.	+	.	.	.	.	+	.	.	+	+	.	.	+	.	.	1	.
Carthamus lanatus	+	+	.	.	+	+	+	+	.	+	.	.	.	.	.	.	.	.	+	+	.	+	.
Dactylis glomerata	+	.	+	.	+	.	.	.	+	.	.	+	.	.	.	.	.	+	+	.	+	+	+
Vicia lathyroides	+	.	.	+	+	.	+	+	.	.	.	+	+	+	.	.	.	.	.	.	+	.	+
Anagallis arvensis	.	.	+	.	+	.	+	+	+	+	+	+	.	.	+	.	.	+	.	.	.	.	.
Bothriochloa ischaemum	.	.	.	.	+	.	+	+	.	+	+	+	.	.	.	+	+	.	+	+	.	.	.
Polycarpon tetraphyllum	1	.	+	.	.	.	.	.	+	.	.	+	1	+	.	+	+	.	.	.	.	.	1

Tab. 1. – continued

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Plantago lanceolata	+	1	+	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	+	.
Plantago coronopus	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	.	.	+	+	+
Cerastium semidecandrum	+	.	.	.	.	.	+	1	+	.	+	.	1	+	.	+	.	.	.	.	.	+	.
Moenchia erecta	.	+	+	+	+	.	.	.	.	.	.	.	.	.	+	.	+	.	+	+	.	.	+
Bromus hordeaceus	.	+	.	.	1	+	.	.	.	+	.	+	.	.	.	.	.	+	1	+	+	.	.
Aegilops geniculata	.	.	.	.	+	+	.	+	.	1	.	.	.	.	+	.	.	+	+	1	.	.	+
Onobrychis caput-galli	.	.	.	.	.	+	2	+	.	.	+	1	+	+	+	.	.	.	1	.	.	.	.
Asparagus acutifolius	.	.	.	.	.	.	+	+	.	+	+	.	.	.	.	+	.	+	.	+	.	+	+
Verbascum sinuatum	+	.	+	.	.	.	+	+	+	.	.	.	+	.	.	+	.	.	.	.	+	.	.
Veronica verna	+	.	.	+	.	+	.	+	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.
Cerastium glomeratum	.	+	+	.	.	.	.	.	.	.	.	1	.	.	+	+	.	+	.	+	.	.	+
Portulaca oleracea	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	+	.	+	+	+
Eragrostis minor	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	+	+	+
Cynosurus echinatus	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	+	+	+
Crupina crupinastrum	.	.	+	.	.	.	+	+	.	+	+	+	.	.	+	.	.	.	+	.	.	.	.
Catapodium rigidum	.	.	+	.	.	.	.	.	+	+	1	+	+	.	+	.	.	+	.	.	.	.	.
Silene gallica	.	.	+	.	.	.	.	.	.	+	.	+	.	.	+	+	.	+	.	.	+	.	+
Crepis neglecta	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	.	+	.	.	+	+	+	+
Linum corymbulosum	.	.	.	.	.	+	+	.	+	+	+	.	.	.	+	.	.	+	.	+	.	.	.
Aphanes microcarpa	+	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+
Rumex acetosella	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Capsella bursa-pastoris	.	+	.	.	+	.	.	.	.	.	.	.	+	+	.	.	+	.	+	+	.	.	.
Crepis foetida ssp. *rhoedifolia*	.	.	+	.	.	+	+	.	.	.	.	+	.	.	+	.	.	.	.	.	+	+	.
Valerianella coronata	.	.	+	.	.	.	.	.	.	+	.	.	+	+	+	.	.	+	.	+	.	.	.
Echium plantagineum	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	+	+
Daucus guttatus	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	+	.
Astragalus pelecinus ssp. *pelecinus*	.	.	.	.	+	.	+	2	.	.	.	.	+	+	.	.	.	.	+	.	.	.	+
Centaurea benedicta	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+	+	.	.	+	.	+	.
Holosteum umbellatum	+	.	.	.	.	.	+	+	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.
Herniaria incana	+	.	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	+	+	.	.	.	.
Erysimum crassistylum	+	.	.	.	.	.	.	.	+	+	+	.	.	+	.	.	.	.	+	.	.	.	.
Lolium perenne	.	.	+	.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	+	+	.
Anisantha tectorum	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	+	+	+
Crepis sancta	.	.	.	.	.	.	.	+	+	+	.	.	.	+	+	+	.	.	.	.	.	.	.
Medicago praecox	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	+	.	+	.	+	.	.	.
Anisantha madritensis	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+	.	.	+	+	.
Ranunculus ficaria	+	.	.	+	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.

Tab. 1. – continued

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Euphorbia helioscopia	.	+	.	.	+	.	.	.	+	.	.	.	+	.	.	+	.	.	.	.	.	.	.
Minuartia hirsuta ssp. *falcata*	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	.	.	+	.	.	.
Crepis setosa	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	1	+	.	.	.
Teesdalia coronopifolia	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	+
Vicia sativa ssp. *nigra*	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.
Thymus heterotrichus	.	.	.	+	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	+
Anthoxanthum odoratum	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	2	+
Neatostema apulum	.	.	.	.	.	1	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.
Allium flavum	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	+	.	.	+
Melica ciliata	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+	.	+	.	+	.
Rorippa thracica	1	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.
Geranium molle ssp. *brutium*	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.
Filago arvensis	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Teucrium chamaedrys	+	.	.	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Nigella arvensis	.	.	+	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Convolvulus elegantissimus	.	.	+	.	.	.	.	.	+	.	.	.	2	+	.	.	.	.	.	.	.	.	.
Sedum hispanicum	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+
Anthemis ruthenica	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.
Sedum rubens	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+
Colchicum autumnale	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	.	.	+	.	.	.
Galium setaceum	.	.	.	.	.	.	.	.	+	.	+	.	+	+	.	.	.	.	.	.	.	.	.
Leopoldia comosa	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	+	.	.	.
Calicotome villosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	+
Centaurea orphanidea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+

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: +; *Centaurium erythraea* ssp. *rumelicum* 13: +; *Centaurium 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. *niciciana* 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 tricornutum* 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 panicultata* ssp. *thracica* 2: +, 1: +; *Oenanthe silaifolia* 14: +; *Onobrychis aequidentata* 3: 1; *Ononis reclinata* 20: +; *Orchis species* 13: +; *Orlaya daucoides* 19: +; *Ornithogalum armeniacum* 5: +; *Paliurus spina-christi* 14: +, 22: +; *Pallenis spinosa* 22: +, 20: +; *Papaver rhoeas* 10: +; *Parvotrisetum myrianthum* 22: +, 4: +; *Petrorhagia illyrica* ssp. *illyrica* 23: +, 2: +; *Petrorhagia 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 annuum* 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 annuum* 23: +, 1: +, 20: +;

Localites of relevés, details of relevé are indicated in the following order: relevé number, country code, date (year/month/day), relevé area (m^2), 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 Sohos, 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 Prinos, 40.73500, 24.60870; 14.GR, 20060427, 40, 338, 180, 8, 90, Thasos, Megalos Prinos, 40.73328, 24.60799; 15. GR, 20070512, 30, 11, 180, 2, 90, Thasos, Aliki, 40.17827, 24.60262; 16. GR, 20070513, 30, 255, 180, 3, 100, Chalkidiki, between Olimpiada and Stratoni, 40.52979, 23.83467; 17. GR, 20060426, 40, 67, 135, 7, 90, Kokkinochoma (Kavala), 40.92415, 24.29526; 18. GR, 20070513, 30, 200, 225, 2, 90, Mirtofito, 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, Skala Sikias, 40.02384, 23.99353; 23. GR, 20060428, 30, 41, 180, 4, 100, Kavala, 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

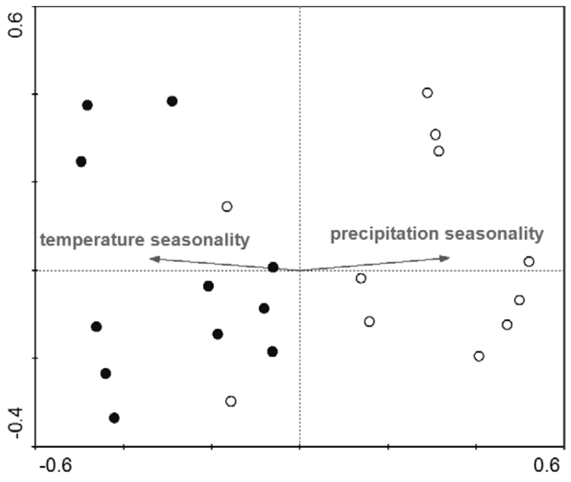

Fig. 5. Ordination diagram of sampling plots based on redundancy analysis (RDA). Only the two most important variables are included: seasonality in precipitation and temperature. Communities with *Romulea bulbocodium* are distributed in the interior part and represented by full circles; communities with *Romulea linaresii* 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 distibution 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).

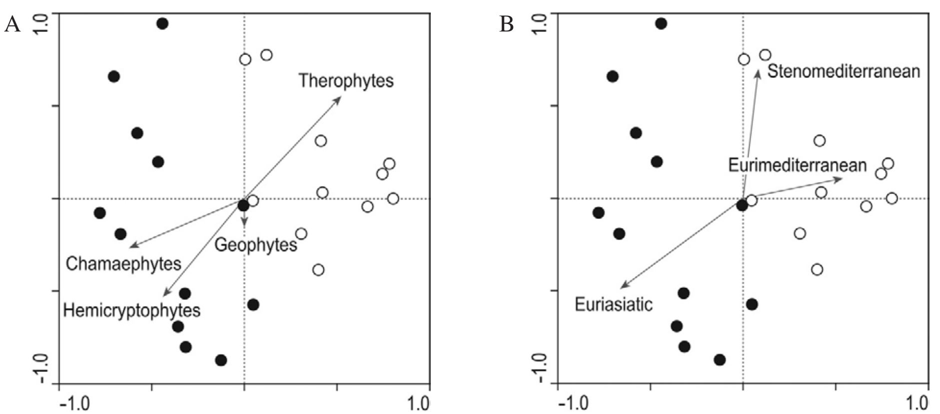

Fig. 6. Principal component analysis (PCA) of samples (relevés) with passive projection of life forms (A) and chorotypes (B). Communities with *Romulea bulbocodium* are represented by full circles and communities with *Romulea linaresii* ssp. *graeca with* empty circles. Eigenvalues of axes 1 and 2 are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

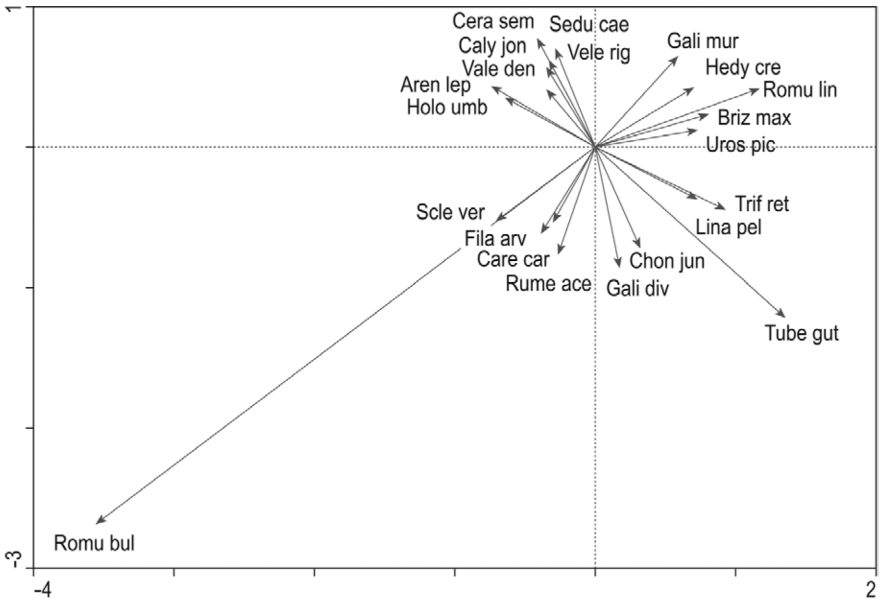

Fig. 7. PCA ordination of species. Fit for inclusion of species into ordination diagram was set to 45. The species are presented by 4 letters for genus and 3 for species, for explanation compare table1.

The nomenclature of species follows the Euro+Med PlantBase (EURO+MED 2006), except *Amaranthaceae, Cistaceae, Dipsacaceae, Linaceae, Polygonacaea, Ranunculaceae, Rhamnaceae, Valerianaceae* and *Berteroa orbiculata* following FLORA EUROPAEA and *Medicago disciformis* var. *strumensis* Velč. et Bond., *Centaurium erythraea* ssp**.** *rumelicum* (Velen.) Melderis and *Pleurochaete squarrosa* (Brid.) Lindb. Syntaxonomic nomeclature 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, Hedypnois 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, Hedypnois 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 refuge 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 (Ćušterevska 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 (Peréz-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, ĆUŠTEREVSKA 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 (BAJOCCO 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 guttatii* 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 timolentis*« 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* Oberdofer 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 rhagadioloides, 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., *Stipo 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 zacyntha, Galium murale, Hedypnois 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).

Acknowledgement

We are grateful to Jean-Paul Theurillat for his nomenclature clarification. We thank Iztok Sajko for preparation of geographical maps and other figures. The authors acknowledge financial support from the state budget through the Slovenian Research Agency (P1-0236) and a bilateral Macedonian-Slovenian project (SLO-MK/06-07/3).

References

Alahuhta, J., Heino, J., Luoto, M., 2011: Climate change and the future distributions of aquatic macrophytes across boreal catchments. Journal of Biogeography 38, 383–393.

Allegrezza, M., Biondi, E., Felici, S., 2006: A phytosociological analysis of the vegetation of the central Adriatic sector of Italian peninsula. Hacquetia 5, 135–175.

Bajocco, S., de Angelis, A., Perini, L., Ferrara, A. Salvati, L., 2012: The impact of land use/land cover changes on land degradation dynamics: a Mediterranean case study. Environnemental Management 49, 980–989.

Barbero, M., Quezel, P., 1976: Les groupements forestiers de Grèce Centro-Méridionale. Ecologia Mediterranea 2, 3–86.

Bergmeier, E., Blockeel, T. Böhling, N., Fournaraki, C., Gotsiou, P., Jahn, R., Lansdown, R., Turland, N., 2011: An inventory of the vascular plants and bryophytes of Gavdopoula island (S Aegean, Greece) and its phytogeographical significance. Willdenovia 41, 179–190.

Biondi, E., Burrascano, S., Casavecchia, S., Copiz, R., Selvico, R., Galdenzi, D., Gigante, D., Lasen, C., Spampinato, G., Cenanzoni, R., Zivkovic, L., Blasi, C., 2012: Diagnosis and syntaxonomic interpretation of Annex I Habitats (Dir 92/43/EEC) in Italy at the alliance level. Plant Sociology 49, 5–37.

Bohn, U., Neuhäusel, R., Gollub, G., Hetter, C., Neuhäuslová, Z., 2003: Map of Natural Vegetation of Europe. Scale 1:2.500.000. Landwirtschaftsverlag, Münster.

BOLÒS DE, O., MASELLES, R. M., NINOT, J. M., VIGO, J., 1996: A survey on the vegetation of Cephalonia (Ionian islands). Phytocoenologia 26, 81–123.

BRACCHETTI, L., CAROTENUTO, L., CATORCI, A., 2012: Land-cover changes in a remote area of central Apennines (Italy) and management directions. Landscape and Urban Planning 104, 157–170.

BRAUN-BLANQUET, J., 1964: Pflanzensoziologie. Grudzüge der Vegetationskunde. 3. Auflage. Springer Verlag, Wien.

CANO, E., LADERO, M., GARCÍA-FUENTES, A., PINTO-GOMES, C. J., CANO-ORTIZ, A., 2007: Estado actual de la classe *Poetea bulbosae* en la Península Ibérica. Phytosociologia 37, 645–661.

CATORCI, A., OTTAVIANI, G., KOSIĆ, I. V., CESARETTI, S., 2012: Effect of spatial and temporal patterns of stress and disturbance intensities in sub-Mediterranean grasslands. Plant Biosystems 146, 352–367.

CHYTRÝ, M., TICHÝ, L., HOLT, J., BOTTA-DUKÁT, Z., 2002: Determination of diagnostic species with statistical fidelity measures. Journal of Vegetation Science 13, 79–90.

ČARNI, A., MATEVSKI, V., 2005: Comparison of short-lived ruderal vegetation of the inland and coastal regions in the southern part of the Balkan Peninsula. Fitosociologia 42, 97–107.

ČARNI, A. MATEVSKI, V., ŠILC, U., 2010: Morphological, chorological and ecological plasticity of *Cistus incanus* in the southern Balkans. Plant Biosystems 144, 602–617.

ĆUŠTEREVSKA, R., MATEVSKI, V., KOSTADINOVSKI, M., ČARNI, A., 2012: Dry grasslands communities of *Erysimo-Trifolietum* in the North-eastern part of the Republic of Macedonia. Hacquetia 11, 91–111.

ELIÁŠ, P., SOPOTLIEVA D., DÍTĚ, D. HÁJKOVÁ, P. APOSTOLOVA, I., SENKO, D., MELEČKOVÁ, Z., HÁJEK, M., 2013: Vegetation diversity of salt-rich grasslands in Southeastern Europe. Applied Vegetation Science 16, 521–537.

EURO+MED (2006): Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity. Retrieved February 28, 2013 from http://ww2.bgbm.org/EuroPlus Med/.

FANELLI, G., BLANCO, P. M., DE SANCTIS, M., SERAFINI SAULI, A., 2010: The alliance *Trachynion distachyae* Rivas-Martínez 1978 in central Italy. Annali di Botanica 0, 39–51.

FARRIS, E., SECCHI, Z., FILIGHEDDU, R., 2007: Carattcerizzazione fitosociologica dell'habitat prioritario 6220- Pascoli substeppici di graminacee e piante annue dei *Thero-Brachypodietea*: caso di studio delle Sardegna settentrionale. Fitosociologia 44, 271–278.

FARRIS, E., FILIGHEDDU, R., DEIANA, P., FARRIS, G. A., GARAU, G., 2010: Short-term effects on sheep pastureland due to grazing abandonment in a Western Mediterranean ecosystem: A multidisciplinary approach. Journal of Nature Conservation 18, 258–267.

FILIBECK, G., CORNELINI, P., PETRELLA, P., 2012: Floristic analysis of s high-speed railway embankment in a Mediterranean landscape. Acta Botanica Croatica 71, 229–248.

FLORA EUROPAEA DATABASE: Royal Botanic Garden Edinburgh. Retrieved February 28, 2013 from http://rbg-web2.rbge.org.uk/FE/fe.html.

FRIGNANI, F., IIRITI, G., 2011: The genus *Romulea* in Italy: taxonomy, ecology and intraspecific variation in relation to the flora of Western Mediterranean islands. Fitosociologia 48 (Suppl. 1), 13–20.

GILINGHAM, P. K., PALMER, S. C. F., HUNTLEY, B., KUNIN, W. E. CHIPPERFIELD, J. D., THOMAS, C. D., 2012: The relative importance of climate and habitat in determining the distribution of species at different scales: a case study with ground beetles in Great Britain. Ecography 33, 831–838.

GUSSEV, C., 2011: Submediterranean pseudo-steppes with annual herbs. In: BISERKOV, V., GUSSEV, C., POPOV, V., HIBAUM, G., ROUSSAKOVA, V., PANDURSKI, I., et al. (eds.), Red data book of the Republic of Bulgaria, 3, Natural habitats, 152–154. IBEI-BAS & MOEV, Sofia.

HIJMANS, R. J., CAMERON, S. E. PARRA, J. L., JONES, P. G., JARVIS, A., 2005: Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25, 1965–1978.

HORVAT, I., GLAVAČ, V., ELLENBERG, H., 1974: Vegetation Südosteuropas. G. Fischer, Stuttgart.

JANIŠOVÁ, M., BARTHA, S., KIEHL, K., DENGLER, J., 2011: Advances in the conservation of dry grasslands: Introduction to contributions from the seventh European Dry Grassland meeting. Plant Biosystems 145, 507–513.

KALIGARIČ, M., CULIBERG, M., KRAMBERGER, B., 2006: Recent vegetation history of the North Adriatic grasslands: Expansion and decay of an anthropogenic habitat. Folia Geobotanica 41, 241–258.

KAVGACI, A., ČARNI, A., BAŞARAN, S., BAŞARAN, M. A., KOŠIR, P., MARINŠEK, A., ŠILC, U., 2010: Long-term post-fire succession of *Pinus brutia* forest in east Mediterranean. International Journal of Wildland Fire 19, 599–605.

LEPŠ, J., ŠMILAUER, P., 2003: Multivariate analysis of ecological data using CANOCO. Cambridge University Press, Cambridge.

LOHMANN, D., TIETJEN, B., BLAUM, N, JOUBERT, D. F., JELTSCH, F., 2012: Shifting thresholds and changing degradation patterns: climate change effects on the simulated long-term response of a semi-arid savanna to grazing. Journal of Applied Ecology 49, 814–823.

MANING, J., GOLDBLATT, P., 2001: A synoptic review of *Romulea* (*Iridaceae: Crocoideae*) in sub-saharian Africa, the Arabian Peninsula and Socotra. Adansonia 23, 59–108.

MATEVSKI, V., ČARNI, A., 2003: Spring nitrophyllous forest edge vegetation in the southern part of the Balkan Peninsula. Hladnikia 15–16, 73–83.

MCCUNE, B., MEFFORD, M. J., 2011: PC-ORD. Multivariate analysis of ecological data. Version 6. MjM Software, Gleneden Beach, Oregon.

MEDAIL, F., DIADEMA, K., 2009: Glacial refugia influence plant diversity patterns in the Mediterranean basin. Journal of Biogeography 36, 1333–1345.

MICEVSKI, K., 1970: *Astragalo-Potentilletalia*, a new order of dry grasslands in Macedonia (In Macedonian). Prilozi 2, 15–23.

MICEVSKI, K., 1977: *Erysimo-Trifolietum* Micev. ass. nov. in the vegetation of Macedonia (In Macedonian). Prilozi 9, 75–82.

MICEVSKI, K., 1985–2001: Flora of the Republic of Macedonia 1 (1–5) (In Macedonian). Makedonska akademija na naukite i umetnostite, Skopje.

MICEVSKI, K., MATEVSKI, V., 2005: Flora of the Republic of Macedonia 1 (6) (In Macedonian). Makedonska akademija na naukite i umetnostite, Skopje.

Nastos, P. T., Politi, N., Kapsomenakis, J., 2013: Spatial and temporal variability of aridity index in Greece. Atmospheric Research 119, 140–152.

Natcheva, R., Ivanova, D., 2011: Report 73. In: Vladimirov, V., Dane, F., Matevski, V., Stevanović, V., Tan, K.(eds.), New floristic records in the Balkans: 15. Phytologia Balcanica 17, 144.

Nikolić, T. (ed.), 2000: Flora Croatica. Index florae Croaticae, 3. Natura Croatica 9 (Suppl. 1), 1–324.

Oberdorfer, E., 1947: Gliederung und Umgrenzung der Mittelmeervegetation auf der Balkanhalbinsel. Berichte über das Geobotanisches Forschungsinstitut Rübel 1947, 84–111.

Oberdorfer, E., 1954: Nordägäische Kraut- und Zwergstrauchfluren im Vergleich mit den entsprechenden Vegetationseinheiten des westlichen Mittelmeergebietes. Vegetatio 5, 88–96.

Özdemír, C., Baran, P., Akyol, Y., 2007: Morfological and anatomical study on *Romulea linaresii* Parl. subsp. *graeca* Beg. (*Iridacaeae*). Journal of Science and Technology 1, 319–326.

Peréz-Camacho, L., Rebollo, S., Hernández-Santana, V., Garciá-Salgado, J., Pavón-García, J., Gómez-Sal, A., 2012: Plant functional trait responses to interannual rainfall variability, summer drought and seasonal grazing in Mediterranean herbaceous communities. Functional Ecology 26, 740–749.

Peruzzi, L., Iiriti, G., Frignani, F., 2011: Contribution to the kariological knowledge of Mediterranean *Romulea* species (*Iridaceae*). Folia Geobotanica 46, 87–94.

Petrova, A., Vladimirov, V., 2009: Red list of Bulgarian vascular flora. Phytologia Balcanica 15, 63–94.

Pignatti, S. (ed.), 1982: Flora d'Italia. Edagricole, Bologna.

Pignatti, S., Menegoni, P., Pietrosanti, S., 2005: Bioindicazione attraverso le piante vascolari. Valori di indicazione secondo Ellenberg per le piante della flora d'Italia. Braun-Blanquetia 39, 1–97.

Pyankov, V. I., Ziegler, H., Akhani, H., Deigele, C., Luttage, U., 2010: European plants with C4-photosynthesis: geographical and taxonomic distribution and relations to climatic parameters. Botanical Journal of Linnean Society 163, 283–304.

Rakaj, M., 2011: Floristic and chorological records for monocots of Lake Shkodra. In: Dursun, S., Zuchetti, M., Vosniakos, F. K., Mankolli, H. (eds.), Proceedings of the International Conference on Ecosystems, Tirana, 65–69.

Ribeiro, S., Ladero, M., Espírito-Santo, M. D., 2012: Floristic composition patterns of Mediterranean annual non-nitrophilous grasslands in Eastern Portugal. Plant Biosystems 146, 534–549.

Raunkiaer, C., 1934: The life forms of plants and statistical plant geography. Charendon Press, Oxford.

Rodwell, J. R., Schaminee, J. H. J., Mucina, L., Pignatti, S., Dring, J., Moss, D., 2002: The diversity of European vegetation. An overview of phytosociological alliances and their relationship to EUNIS habitats. Report EC-LNV 2002/054, Wageningen.

SOPOTLIEVA, D., 2009: *Poo bulbosae-Achilleetum pseudopectinatae*: a new plant association. Phytologia Balcanica 15, 235–244.

SOPOTLIEVA, D., APOSTOLOVA, I., 2007: The association *Erysimo-Trifolietum* Micev. 1977 in Bulgaria and some remarks on its mediteranean character. Hacquetia 6, 131–141.

STEŠEVIĆ, D., 2002: Taxonomical-ecological-phytogeographical characteristics of flora of hill Gorica in Podgorica. Natura Montenegrina 1, 15–39.

SULLIVAN, C. A., BOURKE, D., SKEFFINGTON, M. S., FINN, J. A., GREEN, S., KELLY, S., GORMALLY, M. J., 2011. Modelling semi-natural habitat area on lowland farms in western Ireland. Biological Conservation 144, 1089–1099.

TER BRAAK, J. F. C., ŠMILAUER, P., 2002: CANOCO Reference manual and CanoDraw for Windows, User's guide to Canoco for Windows: Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithaca, NY.

TZONEV, R. T., DIMITROV, M. A., ROUSSAKOVA, V. H., 2009: Syntaxa according to the Braun--Blanquet approach in Bulgaria. Phytologia Balcanica 15, 209–233.

TICHÝ, L., 2002: Juice, software for vegetation classification. Journal of Vegetation Science 13, 451–453.

TOMASELLI, V., DI PIETRO, R., SCIENDELLO, S., 2011: Plant communities structure and composition in three wetlands in southern Apulia (Italy). Biologia 66, 1027–1043.

TÜRKMEN, N., DÜNZENLI, A., 2011: Early post-fire changes in *Pinus brutia* forests (Amanos Mountains, Turkey). Acta Botanica Croatica 70, 9–21.

VASSILEV, K., PEDASHENKO, H., NIKOLOV, S. C., APOSTOLOVA, I., DENGLER, J., 2011: The effect of land abandonment on the vegetation of upland semi-natural grasslands in the Western Balkans MTS, Bulgaria. Plant Biosystems 145, 654–665.

WEBER, H. E., MORAVEC, J., THEURILLAT, J. P., 2000: International Code of Phytosociological Nomenclature. Journal of Vegetation Science 11, 739–768.

ZHANG, G., XU, X., ZHOU, C. ZHANG, H., OUYANG, H., 2011: Responses of grassland vegetation to climatic variations on different temporal scales in Hulun Buir Grasslands in the past 30 years. Journal of Geographical Sciences 21, 634–650.