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Seed banks as a partnership for global plant conservation

Semenske banke kot oblika partnerstva za globalno varovanje rastlinskih vrst

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Abstract: A seed bank is a collection of plant seeds stored under appropriate conditions in which seeds are periodically checked for their germination ability – viability of seeds. Botanic gardens have been issuing lists of seeds (*Index seminum*) for several centuries. This old tradition has also encouraged the formation of botanic gardens seed banks. University Botanic Gardens Ljubljana actively works on plant diversity conservation. In 2013, the Garden participated in the collection of seeds for the Millennium Seed Bank in order to contribute to a faster achievement of the goal of seed banking of 25 % of the total world flora. For this reason, in 2013, seeds of 59 target plant species of Slovenian flora (already selected before for routine collection) and seeds of 24 other randomly selected plant species for the Millennium Seed Bank were collected.

Keywords: seed bank, *ex-situ* conservation, *in-situ* conservation, Slovenia, endangered plants

Izvleček: Semenska banka je zbirka rastlinskih semen, ki so shranjena pod specifičnimi pogoji. V njej se periodično preverja njihova sposobnost kaljivosti – živost semen. Botanični vrtovi so sezname semen (*Index seminum)* izdajali že vrsto stoletij. Ta dolga tradicija je botanične vrtove vzpodbudila k ustanavljanju lastnih semenskih bank. Tudi Botanični vrt Univerze v Ljubljani aktivno sodeluje pri varovanju rastlinske pestrosti. V letu 2013 je Botanični vrt prispeval semena v Milenijsko semensko banko, z namenom čim prej doseči cilj, katerega namen je zbrati semena 25 % rastlin svetovne flore. Zaradi tega razloga smo v letu 2013 za Milenijsko semensko banko nabrali semena 59 ciljnih vrst (že vnaprej določenih) in semena 24 naključno nabranih rastlinskih vrst slovenske flore.

Ključne besede: semenska banka, *ex-situ* varstvo, *in-situ* varstvo, Slovenija, ogrožene rastlinske vrste

Introduction

A seed bank is a collection of plant seeds stored under appropriate conditions in which seeds are periodically checked for their germination ability – viability of seeds. Natural seed banks are a viable seed reservoir present in soil (Roberts 1981). However, seed banks are much more than seed

storage. They also play the role of gene banks, which is a broader concept and encompasses *ex-situ* conservation of seeds as well as pollen, other germplasm, such as as in vitro culture and whole plants grown in the cultures. It requires storage under appropriate conditions enabling the preservation of viability for a longer period. A seed bank is thus only a part of the broader concept of gene banks. Seeds banks are one of the ways to preserve species outside their natural habitat. As suggested by the Global Strategy for Plant Conservation, seed banks are the most useful method for off-site, or *ex-situ*, conservation of wild plants. Seeds are compact, dormant germplasm packages, which can be easily stored (Guerrant and McMahan 1997).

For several centuries, botanic gardens have been issuing lists of seeds for exchange (*Index seminum*). It is an old tradition and this has also encouraged the establishment of botanic gardens seed banks (Heywood 1964, Bavcon 2009). Botanic gardens started with the seed exchange quite early. Seed exchange based on a seed index presumably started in 1648, when Jacob Bobart compiled the first index of seeds collected in the Oxford Botanic Garden. According to Aplin et al. (2007) this was considered to be the first printed seed index, even though a 1614 manuscript of the "*Semina Horti Medici*" from the Botanic Garden Padova (Orto botanico di Padova) exists (Cappelleti and Ongaro 2008). The seed exchange between gardens has a long tradition (Bavcon 2009, 2012), while seed banks started in 1920s for crop plants. For native plants seed banks were organized 50 years later. For wild plants seed dormancy still creates some problems. Seed dormancy is not a new phenomenon and was discovered by Kerner (1894). Nowadays, seed banks with their specific storage conditions are one of the most cost-effective methods of providing resources for long-term *ex-situ* conservation of genetic material of plants. Long- term storage techniques were first developed for crop plants by different organizations: the International Plant Genetic Resources Institute (IPGRI), previously the International Board of Plant Genetic Resources (IBPGR), and the Food and Agricultural Organization of the United Nations (FAO). The main advantage of seed banking is that it allows large populations to be preserved and minimizes genetic erosion by providing optimum conditions and reducing the need for regeneration (Laliberte 1997, Given 1987). In Spain a seed bank for wild plants (UPM) was established in 1966 at the Polytechnic University of Madrid. It was the pioneer seed bank for wild plant species with the aim of a long-term *ex-situ* conservation of wild taxa and supply of seed material for basic or applied research (Gomez and Campo 1997). The beginning of the seed bank in Royal Botanic Gardens Kew dates back to late 1960s in the Kew's Living Collections Division to support the annual exchange of plant material among botanic gardens. With the aim of *ex-situ* conservation of wild flora some partnerships were established as well as some international cooperation initiatives, such as Ensconet project. On the national level, collaboration to the same aim was also established, such as Ribes in Italy (Rossi et al. 2012). There were also plenty of regional initiatives with the aim to collect and store the seeds of the regional flora (Tinti et al. 2012, Civiale et al. 2012, Magrini et al. 2012, Rossi and Mandoni 2012, Zappa et al. 2012, Aztzeri et al. 2012). To help the Global Strategy for Plant Conservation, different activities on the international (Wyse Jackson 2011) and national level were started (Kiehn and Berg 2011, Puchalski et al. 2011).

One of the most comprehensive and expensive conservation projects in the field is the Millenium Seed Bank Project, launched by the Royal Botanic Kew Gardens in the UK in 2000. The motivation for the Millenium Seed Bank Project is the need to protect the increasingly endangered plant species in the natural habitat. By storing seeds, a greater number of specimens of a single species can be stored, which helps to preserve its natural diversity. The goal of the project is very ambitious. In 2010, the Millenium Seed Bank collected seeds from flowering plants from the whole England and 10% of the seed material from all over the world, with a special focus on plants from dry tropical regions. By 2020 their goal is to collect as much as 25% of the seed material of the world flora. The bank receives seeds mostly from similar institutions abroad, donations and, above all, partnerships with local botanists. The goal of this immense undertaking is to collect and safely store seed material in order to preserve plant species for research purposes and repopulation of the species in their natural habitats. A special importance is devoted to the endangered species that are facing

a population decline or extinction, focusing not only on economically important plants, but also on other ones.

University Botanic Gardens Ljubljana actively works on plant diversity conservation. Besides plants and seed collecting in the wild, they grow them in *ex-situ* conditions. There is also a project of *in-situ* plant conservation on a natural dry meadow in the surroundings of the capital city Ljubljana (Bavcon and Marinček 2004, Bavcon 2008, 2010a, b). It includes reintroduction purposes. A more recent case of successful reintroduction is the reintroduction of *Pastinaca sativa* var. *fleischmanni* L. (Hladnik) Burnat to its original location at the Ljubljana castle in 2011 (Bavcon 2013).

Due to the excellent seed storage facilities at the Millenium Seed Bank, University Botanic Gardens Ljubljana has collected and donated seeds of some Slovenian indigenous plant species. Apart from the long tradition of seed collection and plant species protection in our own seed bank, our seeds are now stored in a much more elaborate institution which will facilitate the reintroduction of any of the preserved plants in case of extinction or endangerment in their natural habitat.

Material and methods

Sampling site description

Collection sites were chosen on the basis of our past knowledge about the distribution of plant species. For seed collection, only locations with big population of target species were chosen, which was performed in 37 different locations (Figure 1). Area size for seeds collection ranged between 50 m^2 and 500 m^2. According to M. Wraber (1969), Slovenia can be divided into six phytogeographic regions, of which the majority of our locations for seed collection was located in the Submediterranean and the Dinaric phytogeographic regions. Habitat types of the collected plants were very diverse, ranging from grasslands to forest edges. Only a few of the collection locations were in the Dinaric beech forest.

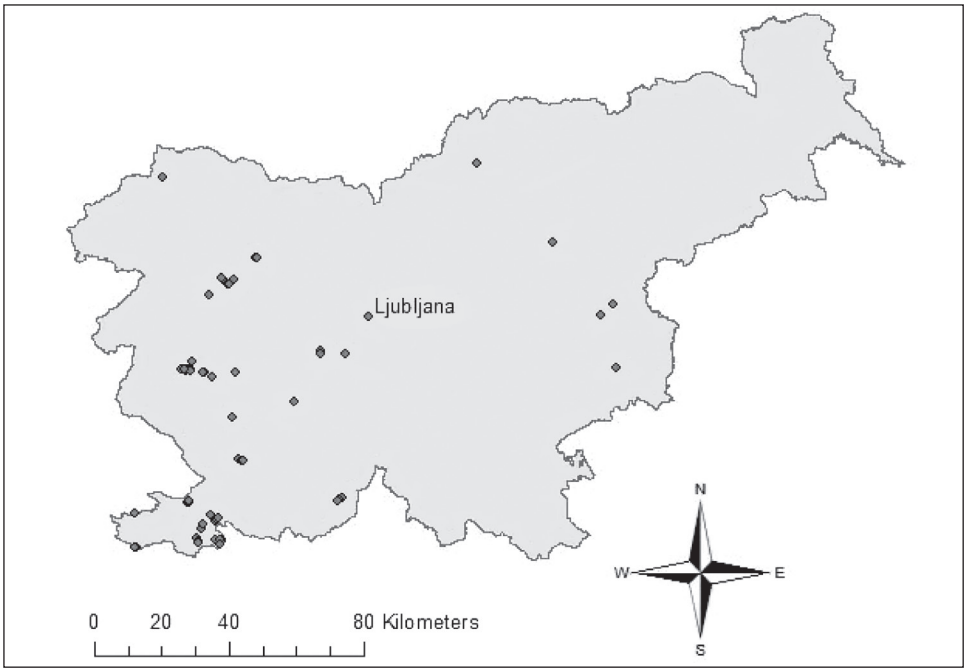

Figure 1: Map of localities in Slovenia where seeds were collected (the number of locality points on the map is smaller than in the reality because some localities are very close to each other)

Slika 1: Zemljevid Slovenije z lokalitetami kjer smo nabirali semena (število točk z označenimi lokacijami je manjše kot v resnici, saj so nekatere lokacije zelo blizu skupaj)

Field work

In 2012, before the seed-collecting season, we prepared the target species list, which was then accepted by the Millenium Seed Bank. Our plant selection was based on the following criteria: all chosen plants species are native, some of them are endemic, endangered or vulnerable, truly representing the Slovenian flora. The key factor for selecting the target plant species, the seeds of which we wanted to use for collaborative project with the MSB, was mainly its conservation status on the local and global scale (Wraber and Skoberne 1989, Official Gazette RS, No. 82/2002). Plant seeds for the Millenium Seed Bank were collected in 2013. Due to a rather long winter and consequently late fruiting of plants in spring, we started field work in May and continued until December. Every month we had to carry out one or more days of field work. All locations with target species were first visited in the blooming season in order to collect a flowering plant of every target species as herbarium specimens. The seeds were collected on a day with favourable weather (without rainfall and without heavy wind). We never collected seeds after rain because this prolongs the drying phase and increases the risk of fungi infections. Seeds were always collected from as big as possible plant populations. When collecting the seeds, proper identification of plant species and seed maturity was performed. Seeds of each plant species were collected into a separate bag, labelled accordingly with plant species name, location and collection date. All collected seeds were taken to the botanic garden and were desiccated to the proper level of moisture content. In the Garden we used a traditional way of curing in the air, leaving the seeds on the stems in a dry place at room temperature to fall of the fruit on their own. Depending on the species, this lasted from late spring to late autumn through winter when the seeds were cleaned by hand. The cleaned seeds were then packed into paper and cotton bags, labelled with species name, identification number, locality and date of collection. When collecting seeds for each location and for each species, the collection forms were filled out according to the MSB collection protocol (Figure 2). A certain amount of seeds from each species collected was also stored in our own seed bank. All plant species were prepared to be inserted into herbarium. Herbarium sheets were appropriately labelled with the basic information about the plant (plant name, collector, collecting date, state). Seeds and herbarium sheets were then shipped to the Millenium Seed Bank in England.

Results

In 2013 we collected seeds of 59 target plant species of the Slovenian native flora (pre-selected for collection) and seeds of 24 other randomly selected plant species for the Millennium Seed Bank. Among the target plant species the only species we could not collect seeds from is *Allium victorialis* L., which did not bloom that year. The rest comprise three Slovenian endemic species, thirteen protected species, eight vulnerable species, one rare species and one species with an under-researched conservation status. We carried out 44 days of field work of seeds collection on 37 localities with additional 10 days needed for observation of phenological phases of the target species. For most species we were able to collect the required quantity of seeds. The only exceptions were the following species: *Arabis sagittata* (Bertol.) DC., *Cortusa matthioli* L., *Eryngium alpinum* L., *Lonicera alpigena* L. and *Primula carniolica* Jacq.

The seeds of the selected plant species were collected in six different phytogeographical regions where the seeds of the majority of the species (45) were collected in the Submediterranean phytogeographical region while the rest were collected in the Alpine phytogeographical region (Table 1). Seed collection started in May and lasted until December. Seeds of the majority of the species were collected in September (27) and June (25). These were mostly late-spring blooming species in lower altitudes and early-spring blooming species in higher altitudes, which were under snow for a long time in 2013. Seeds of the least number of species, mostly summer and autumn blooming, were collected in November (7) and December (1). We were able to collect the seeds of some species from early summer until late autumn due to their after-blooming.

Appendix 1 Passport (Collecting) Data Form

FIELDS IN GREY ARE MANDATORY

Accession ID									**Collection Number** *(same as bag number)*		
Collection date		YYYY		MM		DD					
Main Collector Surname & First Name *(CAPITALS)*									**Institution**		
Other collectors Names and Institutions											
Taxon name											
Vernacular name(s) (+ language)											
Herbarium Voucher	Yes/No Number:	**Number of mature plants found** (tick one)	1..... 2-5..... 5-10..... 10-25.... 25-50.... 50-100.. 100-1000..... 1000+...		**Number of plants sampled** (tick one)	1..... 2-5..... 5-10..... 10-25.... 25-50.... 50-100.. 100-1000..... 1000+...			**Phenology status** *(tick one)*		
Soil sample	Yes/No Number:								More flowers than fruits..... More fruits than flowers..... Only fruits..... Fruits already dispersed.....		
Sampling Method *(tick one)*	Random..... Regular..... Transect (linear).... Core of population. Edge of population. Other.....										
Sampling area visited (m x m)					**Seeds / fruits collected from ground?** YES NO Partially						
Photos *(give references)*											
Country					**Primary subdivision**						
Secondary subdivision *(council, municipality…)*											
Locality											
Latitude Y		**Longitude X**			**Units** (tick one)	Degrees Meters			**EPSG Code** (see codes)		
Altitude (m)		**Water depth** (aquatics) (m)							**Altitude Accuracy** (m)		
Geocode provided by collector?	**Geocode Method** *(tick one)*	**Altitude Method** *(tick one)*	**Prevalent Aspect** *(tick one)*		**Slope** *(tick one)*				**Soil texture** *(tick one)*	**Soil pH** *(tick one)*	
Yes No	GPS DGPS Estimate Map Google Earth	Altimeter DEM GPS Estimate Map	N N-E E S-E S S-W W N-W		Level 0-5% Undulating 6-10% Rolling 11-20% Moderate 21-31% Steep >30%				Gravel Sand Sandy loam Loam Clay loam Clay Peat No soil	Acidic Alkaline Neutral	
EUNIS Habitat Code *(see codes)*		**Land Use Code** *(see codes)*			**Threats**						
Site Notes (observations or any relevant information)											
Associated species (SPECIFY 3-5 rare or abundant species)											
Collecting Notes (e.g. problems encountered, collecting method, estimate of seed nos., flower colour etc)											

Figure 2: Scan of the seed collecting protocol made by Milennium Seed Bank
Slika 2: Kopija protokola za nabiranje semen, izdelanega s strani Milenijske semenske banke

Table 1: List of the collected species per phytogeographical region (1-alpine, 2-subalpine, 3-dinaric, 4-subdinaric, 5-submediterranean, 6-subpannonian) and their conservation status
Table 1: Seznam nabranih semen v posamezni fitogeografski regiji (1-alpska, 2-predalpska, 3-dinarska, 4-predinarska, 5-submediteranska, 6-subpanonska)

	Status	1	2	3	4	5	6
Abies alba Mill.	least			*			
Aconitum variegatum L.				*			
Allium senescens L.				*		*	
Anthericum ramosum L.				*		*	
Arabis sagittata (Bertol.) DC.				*		*	
Arabis turrita L.				*		*	
Asphodelus albus Mill.	vulnerable					*	
Briza media L.					*		
Caltha palustris L.			*				
Centaurea rupestris L.				*		*	
Cirsium pannonicum Link			*			*	
Colchicum autumnale L.						*	
Coronilla emerus L. subsp. *emeroides* Boiss. & Spruner						*	
Cortusa matthioli L.	rare	*					
Cotinus coggygria Scop.						*	
Crithmum maritimum L.						*	
Dentaria enneaphyllos L.			*				
Dianthus tergestinus Rchb.	protected	*				*	
Dictamnus albus L.						*	
Dryas octopetala L.		*		*			
Echinops ritro L. subsp. *ruthenicus* (Bieb.) Nyman.				*		*	
Epimedium alpinum L.					*		
Eranthis hyemalis Salisb.	protected						*
Eriophorum angustifolium Roth	vulnerable					*	
Eriophorum latifolium Hoppe	vulnerable					*	
Eryngium alpinum L.	protected			*			
Eryngium amethystinum L.						*	
Fritillaria meleagris L.	protected		*				
Gentiana asclepiadea L.			*				
Gentiana clusii E. P. Perrier & Songeon	protected			*			
Gentiana lutea L. subsp. *symphyandra* Murbeck	vulnerable					*	
Gentiana pannonica Scop.	protected			*			
Gladiolus illyricus W. D. J. Koch	vulnerable		*				
Globularia punctata Lapeyr.					*	*	
Grafia golaka (Hacq.) Rchb.				*			
Hacquetia epipactis DC.			*				
Hladnikia pastinacifolia Rchb.	endemic			*			
Homogyne alpina Cass.		*					
Hypochoeris maculata L.							*
Hyssopus officinalis L.						*	
Inula ensifolia L.						*	
Inula hirta L.				*		*	
Iris sibirica L. subsp. *erirrhiza* (Pospichal) T. Wraber	endemic					*	
Juniperus communis L.						*	
Jurinea mollis Rchb.						*	
Laserpitium siler L.				*			
Leontopodium alpinum Cass.	protected			*			

Leucojum aestivum L.	vulnerable			*	*		
Leucojum vernum L.			*				*
Libanotis sibirica W. D. J. Koch						*	
Ligusticum seguieri Vill.				*			
Lilium carniolicum Bernh.	protected					*	
Linum narbonense L.				*		*	
Lonicera alpigena L.				*			
Lychnis flos-cuculi L.				*			
Marrubium incanum Desr.						*	
Narcissus poeticus L. subsp. *radiiflorus* (Salisb.) Baker	vulnerable					*	
Paeonia officinalis L.	vulnerable					*	
Petasites albus Gaertn.			*				
Petasites hybridus (L.) G. Gaertn., B. Mey. & Scherb.				*			
Primula auricula L.				*			
Primula carniolica Jacq.	endemic		*				
Pulsatilla montana Rchb.	protected					*	
Pulsatilla nigricans Storck	protected				*		
Rosa glauca Pourr.				*			
Rosa pendulina L.				*			
Ruscus aculeatus L.	protected					*	
Ruta divaricata Ten.				*		*	
Salvia pratensis L.						*	*
Satureja montana L.						*	
Satureja subspicata Bartl. ex Vis. subsp. *liburnica* Šilić						*	
Scabiosa graminifolia L.				*			
Scopolia carniolica Jacq.			*				
Smyrnium perfoliatum L.						*	
Stipa eriocaulis Borb.	protected					*	
Thalictrum aquilegiifolium L.				*		*	
Thalictrum minus L.						*	
Tragopogon dubius Scop.						*	
Trifolium rubens L.	lack of knowledge					*	
Trollius europaeus L.		*					
Veratrum album L. subsp. *lobelianum* (Bernh. in Schrader) Suessenguth				*			
Veratrum nigrum L.	vulnerable			*			

Discussion

The University Botanic Gardens Ljubljana has a long tradition of seed collecting for its own seed bank and for exchange through the *Index seminum*. Each year we try to collect the seeds from as many plant species as possible, in the garden or in the wild. Each year, we try to regenerate the seed stock of the endangered species or the species of special importance for Slovenian flora. In case of a drastic reduction of populations of a certain plant species the seeds stored in our seed bank enable us to reintroduce the species and in this way contribute to conservation of plant diversity. A successful reintroduction was carried out for the *Degenia velebitica* (Deg.) Hay. (Strgar 1979) already in the 70's and early 80's of the last century in the Botanic Garden of University in Ljubljana. We were therefore pleased to accept the possibility to participate the seed collection campaign for the Millennium seed bank in order to contribute to a faster achievement of the goal to collect seeds for 25 % of the total world flora. At the same time, this is a good opportunity for the seeds of the rich

Slovenian flora to be stored in such a superior seed bank as the Millennium Seed Bank and introduce the reach biodiversity beyond Slovenia. The key factor for selecting the target plant species was mainly their conservation status at the local and global level. We have therefore selected the target species that are especially important for Slovenia. Among them were native plant species, having their *locus classicus* in Slovenia or endemic for this or the neighbouring region (Scopoli 1772, Host 1827-1831, Mayer 1960, Zupančič and Wraber 1996). On the basis of various conventions, these species should be especially protected near their origin.

In 2013, seed collection started only in May because of long winter and wet weather in early spring. Bad weather conditions caused a late onset of spring and consequently also a delay in blooming as well as fruiting of many plant species. Another problem for seed collection in spring time was the expansion of snail populations which arose due to high humidity and precipitation, eating fruits of many spring plant species, like the *Leucojum vernum* L.. We also noticed that many spring species did not develop fruits and seeds at all, although the left-overs of flowers were seen (e.g. *Cortusa matthioli* L.). The reason for this could be the absence of pollinators, because at the time of blooming either the temperatures were to low for most pollinators, or precipitations very frequent, decreasing the number of pollinators even further. These phenomena were observed for *Scopolia carniolica* Jacq. on a sampling site near Kamnik. The whole plant population was without fruits, while at higher altitude localities, where the plants were blooming later in spring, we were able to collect them. We also tried to collect seeds of its yellow flowering forma (*Scopolia carniolica* Jacq. f. *hladnikiana* (Biatz. & Fleischm.) near Kamnik, but because of unforeseeable weather conditions, unexpected cold spells and late snowing, we could not find any flowering specimens. Therefore we could not mark the populations and separate them from the original brown-flowering species. Different animals were the reason of fruit absence for some other plant species as well. The fruits of *Iris sibirica* L. subsp. *erirrhiza* (Pospichal) T. Wraber and *Paeonia officinalis* L. subsp. *officinalis* were eaten by deer and flowers of *Eryngium alpinum* L. were consumed by sheep. This could be a consequence of extreme draught. In hot and dry periods, animals namely look for every juicy plant part. Drought in the last couple of years and high temperatures also thinned local population of *Leontopodium alpinum* Cass. in Trnovski gozd. Hardly any flowering or fruiting plants were seen although the population was quite large. Therefore we collected these seeds at the top of Mt. Snežnik.

During field work we noticed that natural populations of some plant species are affected by overgrowing, such as the *locus classicus* population of *Gentiana pannonica* Scop. on the hill of Porezen. Its population was reduced for several years due to omission of mowing in the 1970s (Seljak 2002, Bavcon 2008). However, overgrazing has had an even worse effect on its distribution, which is why populations could not increase. In this place, only 20-54 plants flower each year. The entire population consists of about 100 plants which do not all flower in the same year. Measures should be taken to use grassland in this area in a proper way again and so prevent overgrowing with trees, tall herbs and shrubs (Bavcon 2008). The same has happened to *Eryngium alpinum* L., on the Porezen hill where species became endangered due to abandonement of pastures and overgrowing in 1980s (Seljak 2002). With pasture restoration they are now spreading again (Bavcon 2008, Bavcon 2013). If areas are not be left to occasional pasture, the species will sooner or later be threatened with extinction.

Another problem that can affect many grassland species is inappropriate landscape management, like early mowing and intensive agriculture. Populations of *Fritilaria meleagris* L. at the Ljubljana moor are decreasing because of fertilizer use and early spring mowing (Bavcon 2010a). As a result, the plants do not finish blooming and can reproduce only vegetatively by bulb division. The population decline because of early mowing is also notable for species like *Gladiolus illyricus* Koch., *Cirsium pannonicum* Link. and *Linum viscosum* L.. Therefore all those species are protected *in-situ* on a dry meadow near the Sava river by the University Botanic Garden Ljubljana (Bavcon 2008, 2010a).

However, we were positively surprised by the population increase for the endemic species *Primula carniolica* Jacq. This is the species the distribution of which has been increasing in the last decades (Wraber 1990). Population size is

now big enough everywhere. Even grazing did not decrease its populations. On its natural sites which were discovered in 1980s (Bavcon 1987, Bavcon and Terpin 1991), there are still many plants despite pasture. Their dispersion is even larger than before.

Despite a long winter and rainy spring in 2013 we were able to collect the seeds of Slovenian endemics and protected plant species as required by the collecting standards of the Millennium Seed Bank. Field work within this project has also given us a possibility to monitor the populations of some plant species and to predict solutions for its conservation.

Povzetek

Semenska banka je zbirka semen rastlin, skladiščenih pod ustreznimi pogoji, kjer se občasno preverja kalivost – živost semen. Naravna semenska banka je skupek semen, shranjenih v tleh. V sodobni semenski banki pa morajo biti semena skladiščena pod ustreznimi pogoji, kar omogoča ohranjanje živosti za daljše obdobje. Za vsako vrsto je potrebno izdelati protokol hranjenja, preverjanja kalivosti in obnavljanja zalog. Semenske banke so eden izmed načinov ohranitve vrst izven naravnih razmer, kar imenujemo tudi *ex-situ* varstvo rastlinskih vrst. V botaničnih vrtovih je izdajanje seznamov semen (*Index seminum*) že nekaj stoletij stara tradicija in prav to je tudi vzpodbudilo nastanek semenskih bank botaničnih vrtov, ki pa so relativno nove. Prve so se začele pojavljati v šestdesetih letih prejšnjega stoletja. V tem času je tudi botanični vrt Kew Garden začel s prvimi zametki semenske banke, ki je do leta 2000 prerasla v milenijsko semensko banko. Tedaj so odprli povsem nov kompleks v podružnici botaničnega vrta Kew Gardens v kraju Wakehurst. Njen cilj je bil do leta 2010 zbrati 10 % svetovne flore, do leta 2020 pa so si za cilj zadali zbrati 25 % svetovne flore. V ta namen botanični vrt Kew Gardens išče ustrezne partnerje v različnih delih sveta. Botanični vrt Univerze v Ljubljani je leta 2013 dobil možnost sodelovanja pri tem projektu. V ta namen smo najprej pripravili listo semen rastlin, ki so jih v botaničnem vrtu Kew Gardens pregledali, ocenili in potrdili. Spomladi smo začeli s terenskim delom. Cilj milenijske semenske banke je, da polovica materiala ostane v matični inštituciji, polovica materiala pa gre v milenijsko semensko banko. Za vsako vrsto je bilo potrebno napisati protokol, nabrati herbarijski material in minimalno število semen, kar pomeni vsaj 500 semen, zaželjeno število pa je 5000 semen. V toku ene sezone smo zbrali semena 59 vrst iz potrjene liste in še 24 dodatnih. Semena smo nabirali od maja do decembra v vseh fitogeografskih območjih Slovenije. Zaradi vremenskih razmer, pozne zime in velike namočenosti tal ter hladne pomladi, mnoge vrste niso tako obilno semenile kot v prejšnjih letih, na nekaterih delih pa semen sploh ni bilo. V poletnem času so bile problem izredno visoke temperature in s tem povezana suša, kar je produkcijo semen pri nekaterih vrstah zopet zmanjšalo. Kljub temu smo uspeli zbrati semena vseh vrst, le bistveno več terenskega dela je bilo potrebnega. Semena so sedaj shranjena v milenijski semenski banki botaničnega vrta Kew Gardens in v Botaničnem vrtu Univerze v Ljubljani. Z omenjenim projektom se je potrdilo sodelovanje s to elitno ustanovo, ki je že leta 1889 naročila prva semena iz Botaničnega vrta v Ljubljani na osnovi tedaj prvič natisnjene publikacije *Index seminum*, ki izhaja vse do današnjih dni.

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Association *Amelanchiero ovalis-Pinetum mugo* in northwestern Slovenia

Asociacija *Amelanchiero ovalis-Pinetum mugo* v severozahodni Sloveniji

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Abstract: We conducted a phytosociological study of dwarf pine stands on torrential fans and glacial material (moraine, till) in cirques of several Alpine valleys (Tolminka, Možnica) and on steep, shady erosion slopes (Struje above the Zadlaščica valley) in the belt of montane beech forests in the Julian Alps. Based on comparisons with similar communities in northern Italy we classified these stands into the association *Amelanchiero-Pinetum mugo* and into the new geographical variant with *Rhamnus fallax*. Floristically slightly similar dwarf pine stands in the altimontane and subalpine belts on sunny slopes of the Tolmin-Bohinj Mts. are classified into the new variant *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata*.

Keywords: phytosociology, synsystematics, *Amelanchiero-Pinetum mugo*, *Rhodothamno-Pinetum mugo*, Natura 2000, Julian Alps, Slovenia

Izvleček: Fitocenološko smo preučili ruševje, ki uspeva na hudourniških vršajih in ledeniškem gradivu (morena, til) v krnicah nekaterih alpskih dolin (Tolminka, Možnica) in na strmih osojnih erozijskih pobočjih (Struje nad dolino Zadlaščice) v pasu montanskih bukovih gozdov v Julijskih Alpah in ga na podlagi primerjav s podobnimi združbami v severni Italiji uvrstili v asociacijo *Amelanchiero-Pinetum mugo* in v novo geografsko varianto z vrsto *Rhamnus fallax*. Floristično nekoliko podobno ruševje v altimontanskem in subalpinskem pasu na prisojnih pobočjih Tolminsko-Bohinjskih gora uvrščamo v novo varianto *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata*.

Ključne besede: fitocenologija, sinsistematika, *Amelanchiero-Pinetum mugo*, *Rhodothamno-Pinetum mugo*, Natura 2000, Julijske Alpe, Slovenija

Introduction

In terms of phytosociology, dwarf pine stands in Slovenia have been extensively studied. In the last ten years, Zupančič and colleagues (Zupančič et al. 2004, 2006, 2007, Zupančič and Žagar 2007, Zupančič 2007, 2013) presented with analytical tables the following syntaxa at the rank of association: *Hyperico grisebachii-Pinetum mugo*, *Rhodothamno-Rhododendretum hirsuti* var. geogr. *Paederota lutea* = *Rhodothamno-Pinetum mugo* Zupančič et Žagar in Zupančič 2013 and *Sphagno-Pinetum mugo*. An analytical table of dwarf pine stands in the Slovenian Alps was published also

by Rozman (2008). Later on, we published a description of similar syntaxa (*Rhododendro hirsuti-Betuletum carpaticae*, *Rhodothamno-Pinetum mugo* var. *Alnus viridis* and var. *Peucedanum ostruthium*) – Dakskobler et al. (2012, 2013a,b). In the article on forest vegetation of the Bovec region (Dakskobler 2004: 28) we discussed also the association *Amelanchiero ovalis-Pinetum mugo*. This association was described by Minghetti in the province of Trentino in northern Italy. His first relevés were published in the excursion guide by F. Pedrotti in 1994 and a comprehensive account came out in an article published in 1996. He classified the colline-montane form of pioneer dwarf pine stands on talus and established screes with initial soils into this association. Minghetti made the relevés at the elevations ranging from 475 m to 850 m. His stands are differentiated from other forms of southern-Alpine dwarf pine communities by thermophilous species such as *Amelanchier ovalis*, *Viburnim lantana*, *Berberis vulgaris*, *Coronilla emerus*, *Cotinus coggygria*, *Fraxinus ornus* and *Ostrya crapinifolia*. Phytosociological tables of this association were later published also by Poldini and Vidali (1999) and Poldini et al. (2004), mainly on the basis of the relevés from the Carnian and western Julian Alps in Friuli (northeastern Italy). Zupančič et al. (2006) classified the Friuli relevés into the syntaxon *Rhodothamno-Rhododendretum hirsuti* forma *Amelanchier ovalis* (= *Rhodothamno-Pinetum mugo* forma *Amelanchier ovalis*). According to them, these relevés characterise a transitional form between the stands of the association *Rhodothamno-Pinetum mugo* and *Amelanchiero-Pinetum mugo*, but are closer to the first rather than the latter. During our research in the Julian Alps (especially in the Tolmin region), as well as in the Karavanke Mts. (the Draga valley under Begunjščica) and in the Kamnik Alps (Jezersko – Makekova Kočna and Ravenska Kočna), we observed dwarf pine stands with characteristics very similar to the dwarf pine stands classified by Minghetti (ibid.) and Poldini et al. (ibid.) into the association *Amelanchiero-Pinetum mugo*, so we wanted to confirm the occurrence of this association in Slovenia with an analysis and comparison of our relevés with the already published relevés from northern Italy. For the time being, we have focused on the relevés from the Julian Alps (Figure 1), as we are still conducting research into similar stands in the Karavanke Mts. and in the Kamnik Alps (Rozman in Dakskobler, in litt.). Similar *Pinus mugo* communities have been recorded and researched (but results not yet published) also in southern Carinthia in Austria (Franz, in litt.).

Methods

Dwarf pine stands in the Julian Alps were recorded applying the central-European phytosociological method (Braun-Blanquet 1964). Relevés were entered into the FloVegSi database (Seliškar et al. 2003). Combined cover-abundance values were transformed into ordinal values 1– 9 (van der Maarel 1979). The relevés were mutually compared by means of hierarchical classification and two ordination methods: Principal Coordinates Analysis (PCoA, similarity ratio) and Non-metric Multidimensional Scaling (NMDS) with Goodman-Kruskal'S γ coefficient; they were subsequently arranged into two analytical tables based on the results of the "(unweighted) average linkage" – UPGMA method, using Wishart's coefficient similarity ratio. SYN-TAX 2000 (Podani 2001) software package was used in these comparisons. The comparison of floristic composition of dwarf pine stands from the Julian Alps with dwarf pine stands from the association *Amelanchiero-Pinetum mugo* from northern Italy was also conducted by means of hierarchical classification (UPGMA, similarity ratio) and with the Principal Coordinates Analysis (PCoA, similarity ratio). Geoelemental, ecological and phytosociological designation of plant species follows the Flora alpina (Aeschimann et al. 2004a, b, c). Phytosociological groups (= groups of diagnostic species) were formed based on our own criteria, but with consideration of this source. The nomenclature source for the names of vascular plants is Martinčič et al. (2007), Martinčič (2003, 2011) for the names of mosses, Suppan et al. (2000) for the names of lichens, and Zupančič (2007, 2013) and Šilc and Čarni (2012) for the names of syntaxa.

Short ecological description of the study area

Dwarf pine stands were recorded in the southern and western part of the Julian Alps, in the elevation

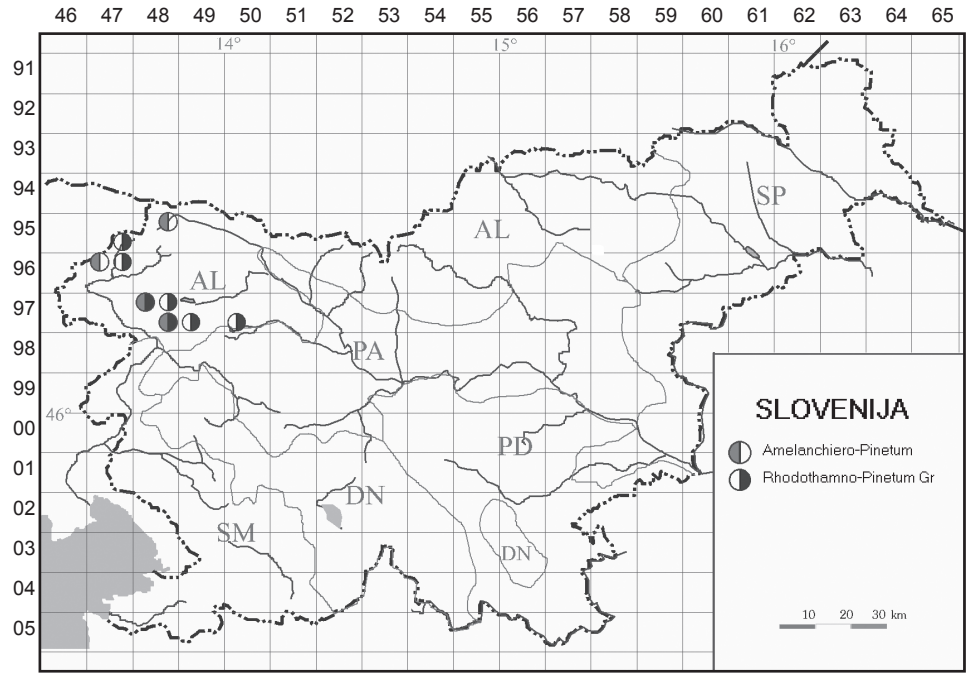

Figure 1: Approximate localities of the studied dwarf pine communities in the map of Slovenia
Slika 1: Približna nahajališča preučevanih združb v rušja (*Pinus mugo*) na zemljevidu Slovenije

belt from 800 m to 2000 m. Most of the relevés were made in the Tolmin region (in the valleys of the Tolminka, the Zadlaščica, the Knežica and the Bača or on their slopes), under the ridge of the Tolmin-Bohinj Mts. from Dravh, Šoštar, Zovh (Rušni vrh), Črna prst, Hohkovbl (Matajurski vrh), Rodica, to Vogel, Žabijski Kuk, Tolminski Migovec and Mahavščck, as well as in the Bovec region (in the valleys of the Loška Koritnica, the Možnica, the Bala, Vrsnik and the Mlinarica); one relevé was made under the Stol ridge (Mali Muzec) and one relevé above the valley of Mala Pišnica near Kranjska Gora. The geological bedrock on relevé plots is limestone, dolomite, dolomite limestone, talus, torrential deposits and glacial material (till) – Buser (2009); the soil is initial, lithosol or shallow rendzina. The climate in the study area of the Julian Alps is humid, with mean annual precipitation exceeding 2000 mm, totalling about 2500 mm to 3000 mm and more in the Tolmin-Bohinj and Stol ridges (B. Zupančič 1995, 1998) and relatively warm, with the mean annual temperature of around 2 °C – 6 °C (Cegnar 1998) and with the snow cover duration of 100 to 150 days. Differences in the local climate are considerable, which is especially relevant for the relevés on shady aspects where the snow cover is long-lasting and the vegetation period short. Stands on sunny slopes and lower elevations (below 1000 m) occur in a warmer local climate and the snow in the areas where snow slides do not accumulate soon melts in the spring. The prevailing forest vegetation in the area is beech forest from the associations *Anemono-Fagetum, Homogyno sylvestris-Fagetum* and *Polysticho lonchitis-Fagetum.* Only sporadically (for example in Kožljak above the Tolminka valley and in Mala Pišnica valley) do researched stands occur also in contact with the stands of southern-Alpine black and (or) Scots pine association *Fraxino orni-Pinetum nigrae* (incl. subassociation *pinetosum sylvestris*). Most of the relevés were made in areas that have not been much affected by human activity, except for grazing of small ruminants in the past. A significant ecological factor are snow slides, in some

locations also raging torrents, earthquakes and related rockfall.

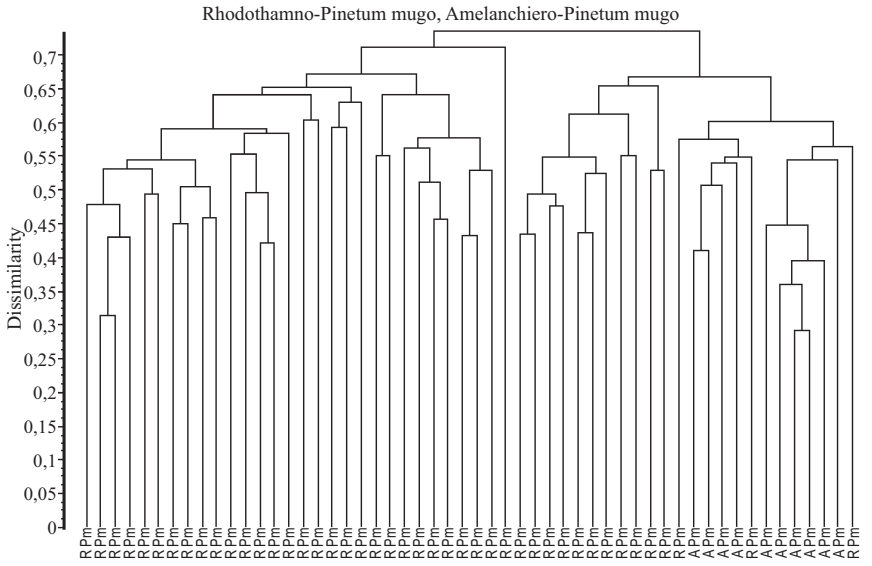

Figure 2: Dendrogram of relevés of dwarf pine stands in western and northwestern Slovenia (UPGMA, similarity ratio); RPm *Rhodothamno-Pinetum mugo,* APm *Amelanchiero-Pinetum mugo*

Slika 2: Dendrogram popisov sestojev rušja (*Pinus mugo*) v zahodni in severozahodni Sloveniji (UPGMA, similarity ratio); RPm *Rhodothamno-Pinetum mugo,* APm *Amelanchiero-Pinetum mugo*

Results and discussion

In hierarchical classification, 54 relevés of dwarf pine stands formed two larger groups (Figure 2). The second group (on the right) comprised also the stands classified, based on the site and floristic composition, into the association *Amelanchiero-Pinetum mugo*. On the basis of Figure 2 we made two analytical tables for this group of relevés (Tables 1 and 2) and included into them dwarf pine stands from Alpine valleys and those dwarf pine stands from the altimontane-subalpine belt that are the most floristically similar to them. The floristic composition of two of the syntaxa determined in this way was compared to the floristic composition of dwarf pine stands on the southern and partly western side of the Julian Alps and with two forms of the association *Amelanchiero-Pinetum mugo* from northern Italy (Minghetti 1996, Table 1, Poldini and Vidali 1999, Table 3). For the comparison we used our, still unpublished relevés originating from the same areas as the relevés of the studied community. Previously published relevés by Zupančič et al. (2006) are generally more species-rich and less suitable for this comparison. We obtained a synthetic table with five columns and compared them with hierarchical classification and two-dimensional ordination (Figures 3 and 4).

Legend to Figures 3 and 4:

RPm *Rhodothamno-Pinetum mugo* s. lat., Julian Alps, Dakskobler (in litt.)

RPmgr *Rhodothamno-Pinetum mugo* var. *Genista radiata*, Julian Alps (Table 2 in this article)

APm-JA *Amelanchiero-Pinetum mugo*, Julian Alps (Table 1, this article)

APm-Tr *Amelanchiero-Pinetum mugo*, Trentino, northern Italy (Minghetti 1996, Table 1)

APm-F *Amelanchiero-Pinetum mugo*, Friuli, northeastern Italy (Poldini and Vidali 1999, Table 3).

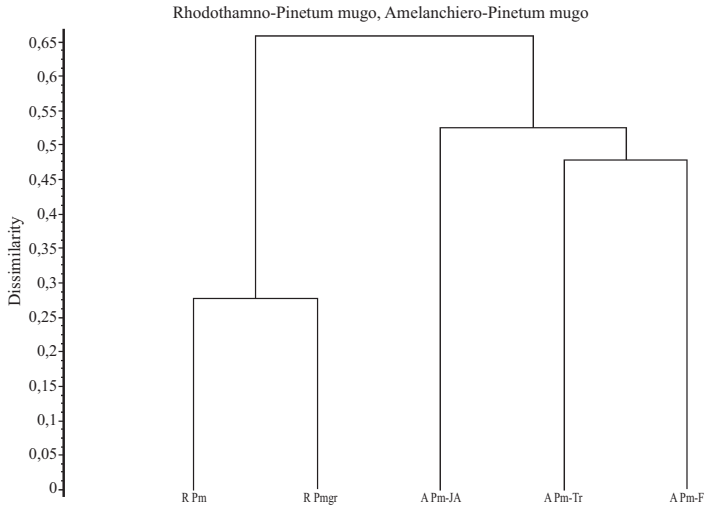

Figure 3: Dendrogram of dwarf pine stands from (north)western Slovenia and north Italy (UPGMA, similarity ratio)
Slika 3: Dendrogram ruševja iz (severo)zahodne Slovenije in severne Italije (UPGMA, similarity ratio)

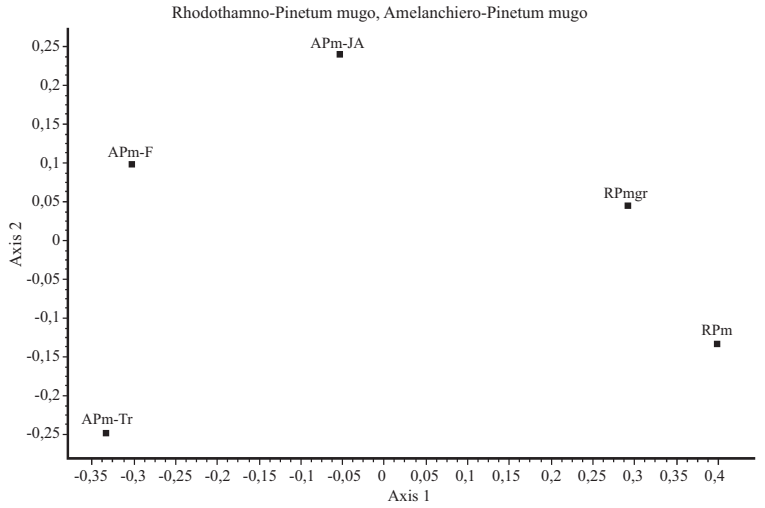

Figure 4: Two-dimensional scatter diagram of dwarf pine stands from (north)western Slovenia and northern Italy (PCoA, similarity ratio)
Slika 4: Dvorazsežni ordinacijski diagram ruševja iz severozahodne Slovenije in severne Italije (PCoA, similarity ratio)

The results corroborate the validity of our assumption that some forms of dwarf pine stands in cirques of the Slovenian Alps can be classified into the association *Amelanchiero ovalis-Pinetum mugo* as they are floristically more similar to other forms of this association from northern Italy known so far than to some more thermophilous forms of subalpine dwarf pine stands from the Julian Alps. Synthetic table (Table 3) and the analysis of the proportion of diagnostic species (Table 4) demonstrate certain differences and similarities between the compared syntaxa. Relevés of the association *Amelanchiero-Pinetum mugo* from the Julian Alps as compared to the relevés of the same association from northern Italy are specific in that some diagnostic species from the class *Rhamno-Prunetea* and order *Quercetalia pubescenti-petraeae* (for example *Viburnum lantana*, *Coronilla emerus, Cotinus coggygria*, *Quercus pubescens*, *Hierochloë australis*) and some diagnostic species from the class *Erico-Pinetea* (*Chamaecytisus purpureus, Daphne cneorum, Knautia ressmannii*) are absent. Absence of these diagnostic species makes them similar to some forms of subalpine dwarf pine stands from the association *Rhodothamno-Pinetum mugo*, which was established also by Zupančič et al. (2006). They are clearly differentiated from the stands of this association by *Amelanchier ovalis*, *Fraxinus ornus*, *Ostrya carpinifolia*, *Frangula alnus, Hieracium porrifolium, Leontodon incanus*, *Euphrasia cuspidata*, *Peucedanum oreoselinum*, *Vincetoxicum hirundinaria*, *Teucrium montanum*, *Inula ensifolia*, and to a lesser extent also by some other species. The proportion of diagnostic species of basophilous pine forests (class *Erico-Pinetea*), thermophilous oak forests (order *Quercetalia pubescenti-petraeae*), dry grasslands (class *Festuco-Brometea*) and screes (class *Thlaspietea rotundifolii*) in the stands of the association *Amelanchiero-Pinetum mugo* from the Julian Alps is considerably higher than in the stands of dwarf pine stands from the association *Rhodothamno-Pinetum mugo*, while the proportion of diagnostic species of spruce forests (class *Vaccinio-Piceetea*) and species of tall herbs and subalpine shrubs (class *Mulgedio-Aconitetea, Betulo-Alnetea viridis*) is considerably smaller (Table 4).

The studied stands of the association *Amelanchiero-Pinetum mugo* comprise all four character species of the association *Rhodothamno-Pinetum mugo*: *Rhodothamnus chamaecistus*, *Anemone trifolia, Laserpitium peucedanoides* and *Genista radiata*; this was expected because these species are characteristic of the southeastern-Alpine mountain region and occur also in other forest-scrub and grassland communities of the Julian Alps (for example in the stands of the beech association *Polysticho lonchitis-Fagetum* or in the stands of subalpine grasslands from the association *Ranunculo hybridi-Caricetum sempervirentis*). In this case, the entire species composition must be the decisive factor that justifies the classification into higher syntaxonomic units. Minghetti (1996) classified the association *Amelanchiero-Pinetum mugo* into the alliance *Berberidion*, and the order *Prunetalia spinosae* and class *Querco-Fagetea*, Poldini et al. (2004) into the alliance *Erico-Fraxinion orni* Horvat 1950, order *Erico-Pinetalia* and class *Erico-Pinetea*. Zupančič (2007, 2013) classifies the association *Rhodothamno-Pinetum mugo* into the suballiance *Rhodothamno-Pinenion mugo* Zupančič 2013, into the alliance *Erico-Pinion mugo* Leibundgut 1948, into the order *Vaccinio-Piceetalia* and class *Vaccinio-Piceetea*. The analysis of diagnostic species (Table 4) demonstrated that classification of dwarf pine stands from the association *Amelanchiero-Pinetum mugo* in the Julian Alps into the class *Vaccinio-Piceetea* is not possible, so we classify this association into the suballiance *Helleboro nigri-Pinenion* Zupančič 2007, into the alliance *Fraxino orni-Pinion nigrae-sylvestris* (Horvat 1958) Zupančič 2007, into the order *Erico-Pinetalia* and class *Erico-Pinetea*. Based on the comparison with forms from northern Italy we selected as diagnostic for this association the species *Amelanchier ovalis, Fraxinus ornus, Ostrya carpinifolia, Hieracium porrifolium* and *Frangula alnus*. The listed species in conjunction with some other species indicate a pioneer form of dwarf pine stands in the belt of montane beech forest where extreme site conditions (steep slopes, stony and dry sites, initial soil) hinder progressive development into the prevailing neighbouring forest vegetation. Stands from the Slovenian part of the Julian Alps are described also as a new geographical variant *Amelanchiero-Pinetum mugo* var. geogr. *Rhamnus fallax* var. geogr. nov. (the nomenclature type, *holotypus*, is relevé No. 7 in Table 1). *Rhamnus fallax* is a Southeast-European

montane shrub, characteristic for Illyrian beech forests from the alliance *Aremonio-Fagion* and for stony sites. Its western distribution borderline is in the western foothills of the Julian Alps (Stol ridge) and its northernmost localities are in southern Carinthia in Austria (Dakskobler et al. 2013). The differential species of the new geographical variant are also southeastern-Alpine endemic taxa *Aconitum angustifolium* and *Centaurea haynaldii* subsp. *julica*. Stands of this new syntaxon were found at the elevation between 770 m and 1230 m, both on shady and sunny aspects, on very steep and mild slopes, always on shallow initial soils. Two variants are distinguished. Stands of the frigophilous variant with *Carex firma* (differential species are also *Hylocomium splendens, Tofieldia calyculata*, *Salix appendiculata* and *Selaginella selaginoides*) were found on shady aspects, in the erosion area in Struje above the Zarobarska grapa gorge (the Zadlaščica valley) and in the Možnica valley. Stands of the thermophilous form, var. *Peucedanum oreoselinum* (differential species include *Fraxinus ornus, Viola hirta*, *Helleborus niger, Carduus crassifolius*, *Leucanthemum maximum* agg., *Vincetoxicum hirundinaria*, *Carex alba* and *Inula ensifolia*) occur mainly on sunny aspects and were recorded on glacial material (unconsolidated morain, till) in the gable of the Tolminka valley – Gnelice and in the Mala Pišnica valley. The dwarf pine stands from the Julian Alps that floristically most resemble the stands of the association *Amelanchiero-Pinetum mugo* are classified into the syntaxon *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata*. *Genista radiata* is supposed to be a character species of the association *Rhodothamno-Pinetum mugo*, but its frequency in the phytosociological table with 113 relevés (Zupančič et al. 2006, Phyt. Table 1) is only 14 %, which means it is not widely distributed in Alpine dwarf pine stands in Slovenia. In our opinion, it characterises warmer sites on sunny slopes of the sub-Alpine belt. The differential species of the variant is also *Amelanchier ovalis*. In terms of phytogeography, the stands of the syntaxon *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata* are characterised by the taxa *Centaurea haynaldii* subsp. *julica*, *Aconitum angustifolium*, *Anemone trifolia* and *Rhamnus fallax*, which differentiate them from similar dwarf pine stands elsewhere in the Eastern Alps. Relevés were made at the elevation of 1230 m to 1690 m, mainly still in the belt of altimontane and subalpine beech stands (*Anemono trifoliae-Fagetum. Polysticho lonchitis-Fagetum*), on sunny slopes of the Tolmin-Bohinj Mts. (two relevés also in the Bovec area). The upper line of occurrence of stands of the association *Amelanchiero-Pinetum mugo* in the southern Julian Alps overlaps with the lower line of occurrence of the stands of the syntaxon *Rhodothamno-Pinetum mugo* var. *Genista radiata*.

Conclusions

The phytosociological analysis of dwarf pine stands in the southern and partly also in the central Julian Alps revealed a group of similar phytocoenoses that are differentiated by thermophilous species which are very rare in the subalpine and in the lower alpine belt. Dwarf pine stands in the Julian Alps that grow on warm aspects in cirques of Alpine valleys or on very steep, eroded dolomite slopes in the belt of montane beech forests can be classified, based on their floristic composition, into the association *Amelanchiero ovalis-Pinetum mugo*. They are a long-term pioneer stage on extreme sites where natural factors, erosion and snow slides, inhibit the development into the beech forest. While they do not comprise all diagnostic species of this association that was described in northern Italy, the frequent occurrence of *Amelanchier ovalis*, *Fraxinus ornus*, *Ostrya carpinifolia*, *Hieracium porrifolium* and *Frangula alnus* clearly differentiates them from the dwarf pine stands from the association *Rhodothamno-Pinetum mugo* that is widely distributed in the Julian Alps, as well as from their most thermophilous form *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata.* Stands of the association *Amelanchiero-Pinetum mugo* have for now been described in the valleys of the Tolminka, Zadlaščica, Možnica and Mala Pišnica, but have also been detected in the Draga valley under Begunjščica in the western Karavanke and in the valleys of Ravenska Kočna and Makekova Kočna in the Jezersko region in the Kamnik Alps. They belong to a habitat type of Community interest (4070*). Their stands comprise also some endemic, protected or rare and endangered species (Anon.

2002, 2004), such as *Centaurea haynaldii* subsp. *julica*, *Aconitum angustifolium*, *Arctostaphyllos uva-ursi*, *Epipactis atrorubens*, *E. helleborine*, *Platanthera bifolia*, *Gymnadenia odoratissima*, *G. conopsea*, *Convallaria majalis*, *Primula wulfeniana* and *Gentiana clusii*. In these stands, dwarf pines sometimes occur as trees (Gnelice in the gable of the Tolminka valley), but are still determined as taxon *Pinus mugo* subsp. *mugo*.

Synsystematic classification of the studied communities into higher units is as follows:

Class: *Erico-Pinetea* Horvat 1959
Order: *Erico-Pinetalia* Horvat 1959
Alliance: *Fraxino orni-Pinion nigrae-sylvestris* Zupančič 2007 (synonym *Fraxino orni-Ericion* Horvat 1959 = *Erico-Fraxinion orni* Horvat 1959)
Suballiance: *Helleboro nigri-Pinenion* (Horvat 1959) Zupančič 2007
Association: *Amelanchiero-Pinetum mugo* Minghetti in Pedrotti 1994
var. geogr. *Rhamnus fallax* var. geogr. nova
var. *Carex firma*
var. *Peucedanum oreoselinum*
Class: *Vaccinio-Piceetea* Br.-Bl. et al. 1939 em. Zupančič (1976) 1980
Order: *Junipero-Pinetalia* Boşcaiu 1971
Alliance: *Erico-Pinion mugo* Leibundgut 1948
Suballiance: *Rhodothamno-Pinenion mugo* Zupančič 2013
Association: *Rhodothamno-Pinetum mugo* Zupančič et Žagar in Zupančič 2013
typicum Zupančič, Žagar et Culiberg 2006
var. *Genista radiata* var. nov.

Alpah uspeva na toplih legah v krnicah alpskih dolin ali na zelo strmih narušenih dolomitnih pobočjih v pasu montanskih bukovih gozdov, lahko na podlagi njegove floristične sestave uvrstimo v asociacijo *Amelanchiero ovalis-Pinetum mugo*. Je dolgotrajen pionirski stadij na skrajnih rastiščih, kjer naravni dejavniki, erozija in snežni plazovi, onemogočajo razvoj v bukov gozd. V njem sicer ne uspevajo vse diagnostične vrste te v severni Italiji opisane asociacije, a pogosta prisotnost vrst *Amelanchier ovalis*, *Fraxinus ornus*, *Ostrya carpinifolia*, *Hieracium porrifolium* in *Frangula alnus* ga dobro razlikuje od v Julijskih Alpah splošno razširjenega ruševja iz asociacije *Rhodothamno-Pinetum mugo*, tudi od njegove najbolj toploljubne oblike *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata*. Sestoje asociacije *Amelanchiero-Pinetum mugo* smo za zdaj popisali v dolinah Tolminke, Zadlaščice, Možnice in Male Pišnice, opazili pa smo jih tudi v dolini Drage pod Begunjščico v zahodnih Karavankah in v Ravenski in Makekovi Kočni na Jezerskem v Kamniških Alpah. Sodijo v prednostni evropsko varstveno pomemben habitatni tip (4070*). V njegovih sestojih uspevajo tudi nekatere endemične, zavarovane ali redke in ogrožene vrste (Anon. 2002, 2004), kot so *Centaurea haynaldii* subsp. *julica*, *Aconitum angustifolium*, *Arctostaphyllos uva-ursi*, *Epipactis atrorubens*, *E. helleborine*, *Platanthera bifolia*, *Gymnadenia odoratissima*, *G. conopsea*, *Convallaria majalis*, *Primula wulfeniana* in *Gentiana clusii*. Rušje ima ponekod v teh sestojih drevesno vzrast (Gnelice v zatrepu doline Tolminke), a ga še vedno uvrščamo v takson *Pinus mugo* subsp. *mugo*.

Povzetek

Fitocenološka analiza ruševja v južnih in deloma osrednjih Julijskih Alpah je pokazala na skupino podobnih fitocenoz, ki jih razlikujejo toploljubne vrste, ki so v subalpinskem in spodnjem alpinskem pasu zelo redke. Ruševje, ki v Julijskih

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Appendix:

Tables 1 to 4

Table 1: *Amelanchiero-Pinetum mugo* var. geogr. *Rhamnus fallax* var. geogr. nova
Preglednica 1: *Amelanchiero-Pinetum mugo* var. geogr. *Rhamnus fallax* var. geogr. nova

Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10
Database number of relevé (Delovna številka popisa)		203375	203376	234425	203381	242273	203380	203382	203405	203406	203407
Elevation in m (Nadmorska višina v m)		1150	1080	930	1230	990	990	800	910	870	770
Aspect (Lega)		N	E	NE	E	S	E	SE	SEE	SE	SE
Slope in degrees (Nagib v stopinjah)		40	45	10	45	45	25	15	20	25	10
Parent material (Matična podlaga)		D	D	Gr	DA	D	Mo	Mo	Mo	Mo	Mo
Soil (Tla)		Re	Re	Li	Re	Re	Re	Re	Re	Re	Re
Stoniness in % (Kamnitost v %)		0	20	20	20	5	0	0	20	40	20
Cover in % (Zastiranje v %):											
Tree layer (Drevesna plast)	E3	10	30	.	.	20	.	20	.	.	.
Shrub layer (Grmovna plast)	E2	80	70	80	70	70	80	70	80	80	70
Herb layer (Zeliščna plast)	E1	50	70	70	60	60	60	60	70	70	70
Moss layer (Mahovna plast)	E0	10	10	10	5	5	10	10	5	5	5
Maximum diameter of trees (Največji prsni premer dreves)	cm	20	25	10	.	7	10	20	.	.	.
Maximum height of tress (Največja drevesna višina)	m	5	10	.	.	.	4	5	.	.	.
Number of species (Število vrst)		49	43	67	54	51	70	57	48	51	53
Relevé area (Velikost popisne ploskve)	m^2	100	100	100	100	100	100	100	100	100	100
Date of taking relevé (Datum popisa)		27.8.1998	27.8.1998	6.9.2004	18.9.1997	25.7.2011	13.9.1999	18.9.1997	16.7.2003	16.7.2003	16.7.2003
Locality (Nahajališče)		Struje nad Zarobarsko grapo	Struje nad Zarobarsko grapo	Možnica, vršaj pod Za Stajo	dolina Tolminke, V Kotu pod Prehodci	Mala Pišnica	dolina Tolminke, Gnelice	dolina Tolminke, Gnelice, pod Vrtiči	olina Tolminke, Gnelice, nad Vrtiči	olina Tolminke, Gnelice, nad Vrtiči	olina Tolminke, Gnelice, nad Vrtiči
Quadrant (Kvadrant)		9748/4	9748/4	9647/1	9748/1	9548/2	9748/1	9748/1	9748/1	9748/1	9748/1
Coordinate GK Y (D-48)	m	406352	406408	388848	400923	406323	400738	401350	401002	401119	401485

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10		
	Coordinate GK X (D-48)	m	5118445	5118484	5138347	5126127	5148545	5125382	5125261	5125362	5125358	5125195		
	Diagnostic species of the association (Diagnostične vrste asociacije)												Pr.	Fr.
EP	*Pinus mugo*	E2b	5	3	4	4	4	4	4	4	4	4	10	100
EP	*Pinus mugo*	E2a	.	+	+	.	.	1	.	.	.	+	4	40
EP	*Amelanchier ovalis*	E2	+	1	1	+	1	+	1	1	+	2	10	100
TR	*Hieracium porrifolium*	E1	.	r	1	+	+	1	+	+	+	r	9	90
QP	*Fraxinus ornus*	E3a	.	.	.	.	1	.	+	.	.	.	2	20
QP	*Fraxinus ornus*	E2b	.	.	+	.	.	1	1	2	2	1	7	70
QP	*Fraxinus ornus*	E2a	.	.	.	.	+	1	1	1	1	1	6	60
QP	*Fraxinus ornus*	E1	.	.	.	.	+	.	.	.	+	1	3	30
QP	*Ostrya carpinifolia*	E3a	.	1	.	.	r	.	+	.	.	.	3	30
QP	*Ostrya carpinifolia*	E2b	r	1	r	+	.	+	.	.	+	+	7	70
QP	*Ostrya carpinifolia*	E2a	.	.	.	+	.	+	+	.	+	+	5	50
QF	*Frangula alnus*	E2	.	.	+	.	+	.	r	.	.	+	4	40
	Differential species of the geographical variant (Razlikovalne vrste geografskih variant)													
AF	*Rhamnus fallax*	E2b	.	.	.	+	.	1	+	.	+	+	5	50
AF	*Rhamnus fallax*	E2a	.	.	.	+	.	+	+	+	.	1	5	50
MuA	*Aconitum angustifolium*	E1	.	.	.	r	.	+	.	.	.	.	2	20
ES	*Centaurea haynaldii* subsp. *julica*	E1	.	.	.	.	.	.	.	+	+	.	2	20
	Differential species of lower units (Razlikovalne vrste nižjih enot)													
ES	*Carex firma*	E1	+	+	2	.	.	.	.	.	.	.	3	30
ML	*Hylocomium splendens*	E0	+	+	+	.	.	.	.	.	.	.	3	30
SCF	*Tofieldia calyculata*	E1	+	.	+	.	.	.	.	.	.	.	2	20
SCF	*Selaginella selaginoides*	E1	r	.	+	.	.	.	.	.	.	.	2	20
BA	*Salix appendiculata*	E2a	+	.	+	.	.	.	.	.	.	.	2	20
FB	*Peucedanum oreoselinum*	E1	.	.	.	.	1	1	1	1	1	1	6	60
TG	*Viola hirta*	E1	.	.	.	.	+	+	+	.	+	+	5	50
ES	*Leucanthemum maximum* agg.	E1	.	.	.	.	.	+	+	+	+	+	5	50
ES	*Carduus crassifolius*	E1	.	.	.	r	+	+	.	+	.	+	5	50
AF	*Helleborus niger*	E1	.	.	.	.	1	+	+	+	.	.	4	40
FB	*Teucrium montanum*	E1	.	.	.	.	1	.	+	+	.	+	4	40
EP	*Carex alba*	E1	.	.	.	.	.	+	.	+	+	.	3	30
TG	*Vincetoxicum hirundinaria*	E1	.	.	.	.	.	.	+	+	.	+	3	30
FB	*Inula ensifolia*	E1	.	.	.	.	.	.	+	.	+	+	3	30
EP	***Erico-Pinetea***													
	Erica carnea	E1	2	2	3	4	4	2	3	4	3	4	10	100
	Calamagrostis varia	E1	1	2	+	1	1	1	+	2	2	1	10	100
	Polygala chamaebuxus	E1	1	1	1	+	1	1	1	1	2	1	10	100
	Asperula aristata	E1	+	+	+	+	+	+	+	+	1	1	10	100
	Rhododendron hirsutum	E2a	1	2	2	1	.	1	r	2	2	.	8	80
	Rubus saxatilis	E1	+	+	.	.	+	1	1	1	1	1	8	80

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	Pr.	Fr.
	Buphthalmum salicifolium	E1	.	+	+	1	+	.	1	1	1	1	8	80
	Molinia arundinacea	E1	.	+	+	.	+	+	3	2	2	1	8	80
	Genista radiata	E2a	.	+	.	1	.	1	1	2	2	2	7	70
	Rhodothamnus chamaecistus	E1	+	+	1	.	+	.	+	.	1	.	6	60
	Allium ericetorum	E1	+	.	+	r	.	+	r	.	.	.	5	50
	Leontodon incanus	E1	.	.	.	+	1	+	+	.	.	+	5	50
	Epipactis atrorubens	E1	.	.	.	+	+	.	+	+	.	+	5	50
	Euphrasia cuspidata	E1	r	r	1	.	.	+	.	.	.	.	4	40
	Arctostaphylos uva-ursi	E1	+	.	.	+	1	.	.	.	.	.	3	30
	Cirsium erisithales	E1	.	+	.	+	.	+	.	.	.	.	3	30
	Cotoneaster tomentosus	E2a	.	.	+	.	r	.	.	+	.	.	3	30
	Pinus sylvestris	E2	.	.	r	.	.	.	.	.	.	+	2	20
	Salix eleagnos	E2b	.	.	+	.	.	.	.	.	.	+	2	20
	Rhamnus saxatilis	E1	.	.	.	+	+	.	.	.	.	.	2	20
	Aster amellus	E1	.	.	.	.	.	+	.	.	.	+	2	20
	Pinus nigra	E2b	.	.	r	.	.	.	.	.	.	.	1	10
	Daphne striata	E1	.	.	.	+	.	.	.	.	.	.	1	10
	Carex ornithopoda	E1	.	.	.	r	.	.	.	.	.	.	1	10
	Crepis slovenica	E1	.	.	.	.	.	+	.	.	.	.	1	10
	Gymnadenia odoratissima	E1	.	.	.	.	.	+	.	.	.	.	1	10
VP	***Vaccinio-Piceetea***													
	Solidago virgaurea	E1	.	.	.	+	.	1	+	1	1	1	6	60
	Picea abies	E2b	.	.	.	.	.	.	r	.	.	.	1	10
	Picea abies	E2a	r	.	+	.	+	r	.	.	.	+	5	50
	Picea abies	E1	.	.	.	r	.	.	.	.	.	.	1	10
	Valeriana tripteris	E1	+	.	.	.	.	.	+	+	+	.	4	40
	Rosa pendulina	E2a	+	.	.	.	.	+	.	.	.	.	2	20
	Clematis alpina	E1	.	+	.	r	.	.	.	.	.	.	2	20
	Hieracium sylvaticum	E1	.	.	.	.	.	.	.	.	+	+	2	20
	Pyrola rotundifolia	E1	.	.	+	.	.	.	.	.	.	.	1	10
	Larix decidua	E2	.	.	r	.	.	.	.	.	.	.	1	10
	Lonicera nigra	E2a	.	.	.	.	.	+	.	.	.	.	1	10
QP	***Quercetalia pubescenti-petraeae***													
	Sorbus aria	E3a	.	.	.	.	.	.	1	.	.		1	10
	Sorbus aria	E2b	+	1	+	1	+	1	1	1	1	+	10	100
	Sorbus aria	E2a	.	.	+	+	.	.	+	.	1		4	40
	Sorbus aria	E1	+	.	.	.	.	.	.	.	+	1	3	30
	Convallaria majalis	E1	1	1	.	+	+	+	+	.	+	+	8	80
	Mercurialis ovata	E1	.	.	.	1	.	.	.	.	.		1	10
	Melittis melissophyllum	E1	.	.	.	.	+	.	.	.	.		1	10
	Sorbus austriaca s. lat.	E2b	.	.	.	.	.	+	.	.	.		1	10
QR	***Quercetalia roboris***													
	Potentilla erecta	E1	.	.	.	.	.	+	+	.	.	+	3	30
	Betula pendula	E2a	.	.	r	.	.	.	.	.	.	.	1	10
AF	***Aremonio-Fagion***													
	Cyclamen purpurascens	E1	+	1	+	+	1	1	+	+	+	.	9	90
	Anemone trifolia	E1	.	+	+	.	.	+	1	.	.	.	4	40
FS	***Fagetalia sylvaticae***													
	Mercurialis perennis	E1	.	+	.	r	.	+	r	+	.	.	5	50
	Melica nutans	E1	.	+	+	.	.	.	+	.	+	.	4	40
	Epipactis helleborine	E1	r	.	.	+	.	+	.	.	.	.	3	30
	Fagus sylvatica	E3a	+	+	.	.	.	.	.	.	.	.	2	20
	Fagus sylvatica	E2	r	+	.	.	.	+	.	.	.	.	3	30
	Laburnum alpinum	E2	.	+	+	.	1	.	.	.	.	.	3	30

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	Pr.	Fr.
	Lonicera alpigena	E2a	.	+	.	.	.	+	.	.	.	.	2	20
	Acer pseudoplatanus	E1	.	.	+	+	.	.	.	.	.	.	2	20
	Daphne mezereum	E2a	.	.	.	+	.	+	.	.	.	.	2	20
	Galium laevigatum	E1	.	.	.	.	.	+	.	.	.	.	1	10
	Viola reichenbachiana	E1	.	.	.	.	.	.	r	.	.	.	1	10
QF	***Querco-Fagetea***													
	Platanthera bifolia	E1	.	.	+	.	.	.	.	.	+	+	3	30
	Cephalanthera longifolia	E1	.	.	.	.	.	.	r	.	.	.	1	10
SSC	***Sambuco-Salicion capreae***													
	Rubus idaeus	E2a	.	.	.	+	.	.	.	.	.	.	1	10
	Sorbus aucuparia	E2b	+	+	+	.	.	.	.	.	+	.	4	40
	Sorbus aucuparia	E2a	.	.	.	+	.	+	+	+	.	.	4	40
	Sorbus aucuparia	E1	+	.	+	.	.	.	.	.	+	.	3	30
BA	***Betulo-Alnetea***													
	Salix glabra	E2	+	1	1	2	r	1	+	1	+	+	10	100
	Sorbus chamaemespilus	E2a	.	.	.	.	.	+	.	.	.	.	1	10
TG	***Trifolio-Geranietea***													
	Laserpitium siler	E1	.	.	+	r	.	.	+	.	+	+	5	50
	Anthericum ramosum	E1	.	.	+	.	+	.	.	.	.	.	2	20
	Polygonatum odoratum	E1	.	.	.	1	+	.	.	.	.	.	2	20
FB	***Festuco-Brometea***													
	Carlina acaulis	E1	.	+	.	.	+	+	+	.	+	+	6	60
	Carex humilis	E1	r	+	.	+	2	.	+	.	.	.	5	50
	Gentianella ciliata	E1	.	.	+	.	.	.	+	.	.	.	2	20
	Linum viscosum	E1	.	.	.	+	.	.	.	+	.	.	2	20
	Teucrium chamaedrys	E1	.	.	.	+	.	.	.	.	.	+	2	20
	Centaurea bracteata	E1	.	.	.	.	.	+	+	.	.	.	2	20
	Gymnadenia conopsea	E1	.	.	.	.	.	.	.	+	.	+	2	20
	Thesium linophyllon	E1	.	+	.	.	.	.	.	.	.	.	1	10
	Linum catharticum	E1	.	.	1	.	.	.	.	.	.	.	1	10
	Galium lucidum	E1	.	.	.	.	+	.	.	.	.	.	1	10
	Hippocrepis comosa	E1	.	.	.	.	.	r	.	.	.	.	1	10
	Prunella grandiflora	E1	.	.	.	.	.	+	.	.	.	.	1	10
	Brachypodium rupestre	E1	.	.	.	.	.	.	.	.	+	.	1	10
	Euphorbia cyparissias	E1	.	.	.	.	.	.	.	.	.	+	1	10
ES	***Elyno-Seslerietea***													
	Laserpitium peucedanoides	E1	1	+	+	1	+	+	+	+	+	+	10	100
	Betonica alopecuros	E1	+	+	+	1	1	1	+	+	+	.	9	90
	Globularia cordifolia	E1	.	.	+	+	1	+	+	+	1	+	8	80
	Sesleria caerulea subsp. *calcaria*	E1	1	2	1	+	.	.	+	1	+	.	7	70
	Dryas octopetala	E1	.	r	1	.	.	+	.	+	+	+	6	60
	Carex mucronata	E1	+	+	+	.	+	.	.	.	.	+	5	50
	Phyteuma orbiculare	E1	+	.	+	+	.	.	.	.	.	+	4	40
	Thesium alpinum	E1	.	.	+	.	.	.	.	.	+	.	2	20
	Thymus praecox subsp. *polytrichus*	E1	.	.	.	.	.	+	.	.	.	+	2	20
	Primula wulfeniana	E1	r	.	.	.	.	.	.	.	.	.	1	10
	Gentiana clusii	E1	r	.	.	.	.	.	.	.	.	.	1	10
	Bartsia alpina	E1	.	.	+	.	.	.	.	.	.	.	1	10
	Linum julicum	E1	.	.	+	.	.	.	.	.	.	.	1	10
	Ranunculus hybridus	E1	.	.	+	.	.	.	.	.	.	.	1	10
	Senecio abrotanifolius	E1	.	.	+	.	.	.	.	.	.	.	1	10
	Euphrasia salisburgensis	E1	.	.	.	+	.	.	.	.	.	.	1	10

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	Pr.	Fr.
	Helianthemum grandiflorum	E1	.	.	.	+	.	.	.	.	.	.	1	10
	Scabiosa lucida subsp. *stricta*	E1	.	.	.	.	+	.	.	.	.	.	1	10
	Acinos alpinus	E1	.	.	.	.	+	.	.	.	.	.	1	10
	Rhinanthus aristatus	E1	.	.	.	.	.	+	.	.	.	.	1	10
	Pimpinella alpina	E1	.	.	.	.	.	.	.	r	.	.	1	10
MA	***Moliniio-Arrhenatheretea***													
	Lotus corniculatus s. lat.	E1	.	.	.	.	+	+	.	1	+	1	5	50
TR	***Thlaspietea rotundifolii***													
	Campanula cespitosa	E1	+	1	1	1	+	+	+	.	+	+	9	90
	Aquilegia einseleana	E1	+	.	1	+	.	+	+	+	.	+	7	70
	Biscutella laevigata	E1	.	.	+	.	+	+	+	+	+	.	6	60
	Petasites paradoxus	E1	.	.	.	r	.	+	.	2	+	+	5	50
	Hieracium bifidum	E1	.	.	+	.	r	+	.	+	.	.	4	40
	Achnatherum calamagrostis	E1	.	.	1	.	.	.	.	.	.	+	2	20
	Valeriana montana	E1	.	.	.	.	.	+	.	.	+	.	2	20
	Adenostyles glabra	E1	r	.	.	.	.	.	.	.	.	.	1	10
	Gypsophila repens	E1	.	.	1	.	.	.	.	.	.	.	1	10
	Astrantia carniolica	E1	.	.	+	.	.	.	.	.	.	.	1	10
	Rumex scutatus	E1	.	.	.	.	.	+	.	.	.	.	1	10
AT	***Asplenietea trichomanis***													
	Valeriana saxatilis	E1	+	+	1	+	.	+	+	+	+	+	9	90
	Potentilla caulescens	E1	r	.	.	.	+	.	.	.	.	.	2	20
	Saxifraga burseriana	E1	.	.	+	.	r	.	.	.	.	.	2	20
	Paederota lutea	E1	+	.	.	.	.	.	.	.	.	.	1	10
	Saxifraga squarrosa	E1	+	.	.	.	.	.	.	.	.	.	1	10
	Saxifraga crustata	E1	.	.	+	.	.	.	.	.	.	.	1	10
	Rhamnus pumilus	E1	.	.	.	.	.	.	.	+	.	.	1	10
O	**Other species (Druge vrste)**													
	Juniperus communis	E2	+	+	.	.	1	.	+	.	.	.	4	40
	Orobanche sp.	E1	.	.	.	.	.	+	.	.	.	.	1	10
ML	**Mosses and lichens (Mahovi in lišaji)**													
	Ctenidium molluscum	E0	+	.	.	+	.	+	+	+	+	+	7	70
	Tortella tortuosa	E0	+	.	.	r	+	+	.	+	+	.	6	60
	Scleropodium purum	E0	.	.	+	.	1	.	+	.	+	.	4	40
	Neckera crispa	E0	+	+	.	.	.	.	.	.	+	.	3	30
	Rhytidiadelphus triquetrus	E0	+	.	+	.	.	.	.	.	.	.	2	20
	Schistidium apocarpum	E0	.	.	+	.	.	+	.	.	.	.	2	20
	Dicranum sp.	E0	+	.	.	.	.	.	.	.	.	.	1	10
	Fissidens dubius	E0	.	+	.	.	.	.	.	.	.	.	1	10

Legend - Legenda
A Limestone - apnenec
D Dolomite - dolomit
Gr Gravel - gruščč
M Moraine (Till) - morena (til)
Re Rendzina - rendzina
Li Lithosols - kamnišče

Table 2: *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata* var. nov.
Preglednica 2: *Rhodothamno-Pinetum mugo typicum* var. *Genista radiata* var. nov.

Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Database number of relevé (Delovna številka popisa)		203066	203067	203308	203378	203101	203107	203104	203068	242058	234424	234460	203070	203435	203436
Elevation in m (Nadmorska višina v m)		1600	1530	1590	1690	1300	1510	1320	1560	1470	1760	1580	1230	1300	1280
Aspect (Lega)		NE	SW	SW	SW	S	SE	S	S	S	SSE	SEE	NE	NW	SW
Slope in degrees (Nagib v stopinjah)		30	35	40	30	40	40	25	35	30	30	30	50	40	40
Parent material (Matična podlaga)		A	A	A	DA	DA	DA	Gr	A	Gr	DA	DA	DA	DA	DA
Soil (Tla)		Re	Re	Re	Re	Li	Re	Li	Re	Re	Re	Re	Re	Re	Re
Stoniness in % (Kamnitost v %)		10	10	50	10	30	40	70	20	20	0	5	40	20	0
Cover in % (Zastiranje v %):															
Tree layer (Drevesna plast)	E3	.	.	.	.	.	.	.	5	.	.	10	10	5	10
Shrub layer (Grmovna plast)	E2	80	80	80	80	80	90	90	90	100	80	80	70	70	80
Herb layer (Zeliščna plast)	E1	50	30	40	60	40	50	40	30	40	60	30	40	50	60
Moss layer (Mahovna plast)	E0	0	10	10	10	5	5	5	10	5	5	10	10	10	5
Maximum diameter of trees (Največji prsni premer dreves)	cm	.	.	.	.	.	.	.	20	.	10	25	25	15	15
Maximum height of tress (Največja drevesna višina)	m	.	.	.	.	.	.	.	4	.	.	8	10	5	5
Number of species (Število vrst)		38	31	53	88	53	52	55	56	38	48	55	58	42	37
Relevé area (Velikost popisne ploskve)	m^2	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Date of taking relevé (Datum popisa)		23.8.1995	23.8.1995	1.7.1999	13.9.1999	21.7.2000	21.7.2000	21.7.2000	26.8.1995	7.7.2011	31.7.2001	13.8.1997	3.8.2000	6.9.1996	6.9.1996
Locality (Nahajališče)		Rodica - Jehlc	Rodica - Grantarski gozd	Žabijki Kuk	Tolminka -Mahavček	Prodi - Mirnik	Prodi - Mirnik	Prodi - Mirnik	Stržiška planina	Rutarski gozd	Predel - Brlogi	Planina nad Sočo	Dravh	Tolminka - Kožljak	Tolminka - Kožljak
Quadrant (Kvadrant)		9749/3	9749/3	9748/4	9748/1	9748/4	9748/4	9748/4	9749/3	9749/3	9547/4	9647/2	9750/3	9748/2	9748/2
Coordinate GK Y (D-48)	m	412687	413080	408022	402802	409714	409512	409671	416045	414893	391892	396661	424819	403894	403866
Coordinate GK X (D-48)	m	5120364	5120436	5120878	5126206	5121866	5122130	5121839	5120836	5120389	5143990	5135310	5121100	5124066	5124028

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Pr.	Fr.
	Diagnostic species of the association (Diagnostične vrste asociacije)																	
EP	*Pinus mugo*	E2b	5	5	5	5	4	4	4	5	5	5	4	4	4	4	14	100
EP	*Rhododendron hirsutum*	E2a	1	2	+	2	+	2	1	+	.	+	+	2	2	.	12	86
ES	*Laserpitium peucedanoides*	E1	+	+	+	1	+	+	.	r	.	1	+	.	.	+	10	71
EP	*Rhodothamnus chamaecistus*	E1	.	+	r	+	.	+	.	.	.	.	.	1	+	.	6	43
	Geographical differential species (Geografske razlikovalne vrste)																	
MuA	*Aconitum angustifolium*	E1	+	.	+	+	+	.	+	.	.	.	.	.	+	+	7	50
ES	*Centaurea haynaldii* subsp. *julica*	E1	.	.	+	+	+	+	+	+	.	.	.	.	.	+	7	50
AF	*Rhamnus fallax*	E2	.	.	.	.	1	r	+	.	1	.	.	.	.	.	4	29
AF	*Anemone trifolia*	E1	.	.	.	.	.	.	.	.	.	1	1	.	.	.	2	14
	Differential species of the variant (Razlikovalne vrste variante)																	
EP	*Genista radiata*	E2a	1	.	+	+	+	+	+	+	.	1	+	.	r	3	11	79
EP	*Amelanchier ovalis*	E2a	.	.	.	.	r	.	.	.	.	.	+	+	.	.	3	21
VP	***Vaccinio-Piceetea***																	
	Picea abies	E3a	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Picea abies	E2b	.	+	+	r	.	+	r	+	.	+	.	+	.	+	9	64
	Rosa pendulina	E2a	.	.	1	+	1	+	+	2	.	+	.	.	.	+	8	57
	Clematis alpina	E2a	.	.	1	.	.	.	+	1	+	+	.	+	1	.	7	50
	Larix decidua	E2	r	r	.	r	.	.	.	.	.	.	.	.	.	+	4	29
	Aposeris foetida	E1	.	.	.	+	.	.	.	+	.	1	1	.	.	.	4	29
	Vaccinium myrtillus	E1	.	.	.	+	.	.	.	.	.	1	1	.	+	.	4	29
	Vaccinium vitis-idaea	E1	.	.	.	+	.	.	.	.	.	+	1	+	.	.	4	29
	Lonicera caerulea	E2a	.	.	.	.	.	.	+	1	1	+	.	.	.	.	4	29
	Maianthemum bifolium	E1	.	.	.	.	+	.	+	.	.	.	+	.	.	.	3	21
	Lonicera nigra	E2a	.	.	.	.	.	.	+	r	+	.	.	.	.	.	3	21
	Valeriana tripteris	E1	.	.	.	.	.	.	+	.	+	+	.	.	.	.	3	21
	Solidago virgaurea	E1	.	.	.	.	.	.	+	.	.	.	.	+	+	.	3	21
	Larix decidua	E3a	.	.	.	.	.	.	.	.	.	.	1	+	.	+	3	21
	Dryopteris expansa	E1	+	.	.	.	.	.	.	.	+	.	.	.	.	.	2	14
	Pyrola rotundifolia	E1	.	.	.	.	.	.	+	.	.	.	+	.	.	.	2	14
	Abies alba	E2a	.	.	.	.	.	.	r	.	.	.	.	+	.	.	2	14
	Homogyne alpina	E1	.	.	.	.	.	.	.	.	.	+	+	.	.	.	2	14
	Luzula sylvatica	E1	.	.	.	.	.	.	.	.	.	+	+	.	.	.	2	14
	Veronica urticifolia	E1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	7
	Polystichum lonchitis	E1	.	.	.	r	.	.	.	.	.	.	.	.	.	.	1	7
	Calamagrostis villosa	E1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	7
	Luzula luzulina	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
	Hieracium murorum	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Huperzia selago	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Lycopodium annotinum	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Melampyrum sylvaticum	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Homogyne sylvestris	E1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	7
	Dryopteris dilatata	E1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	7
EP	***Erico-Pinetea***																	
	Erica carnea	E1	1	2	2	2	2	2	1	+	.	+	+	2	2	3	13	93
	Calamagrostis varia	E1	2	2	1	1	.	1	1	1	1	1	+	+	1	+	13	93
	Rubus saxatilis	E1	.	.	.	1	1	+	1	+	+	1	+	+	1	1	11	79
	Buphthalmum salicifolium	E1	+	.	+	+	+	+	.	+	+	.	.	+	+	+	10	71
	Polygala chamaebuxus	E1	+	.	.	1	+	+	.	+	.	.	.	1	+	1	8	57
	Cirsium erisithales	E1	+	.	1	+	.	.	+	+	+	r	.	.	.	.	7	50

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Pr.	Fr.
	Molinia arundinacea	E1	.	.	.	+	.	.	.	.	.	+	.	.	1	2	4	29
	Allium ericetorum	E1	+	.	.	+	.	.	.	.	.	.	.	.	.	+	3	21
	Chamaecytisus hirsutus subsp. *ciliatus*	E1	+	.	.	.	.	.	.	.	.	+	+	.	.	.	3	21
	Daphne striata	E1	.	.	+	+	.	.	.	.	.	.	.	.	.	.	2	14
	Asperula aristata	E1	.	.	.	.	.	+	.	.	.	.	.	.	.	+	2	14
	Carex ornithopoda	E1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	7
	Carex alba	E1	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	7
	Arctostaphylos uva-ursi	E1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	7
	Peucedanum austriacum subsp. *rablense*	E1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	7
	Gymnadenia odoratissima	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
	Epipactis atrorubens	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Cotoneaster tomentosus	E2a	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	7
	Pinus sylvestris	E3a	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	7
AF	***Aremonio-Fagion***																	
	Cyclamen purpurascens	E1	1	1	1	+	1	+	1	+	1	+	1	1	1	.	13	93
	Cardamine enneaphyllos	E1	.	.	.	.	.	.	+	.	1	.	.	.	.	.	2	14
	Knautia drymeia	E1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	7
FS	***Fagetalia sylvaticae***																	
	Mercurialis perennis	E1	1	+	1	+	1	1	1	1	+	1	.	.	+	+	12	86
	Galeobdolon flavidum	E1	+	.	.	+	+	.	.	1	1	.	.	.	.	.	5	36
	Daphne mezereum	E2a	.	.	.	.	.	.	+	+	+	.	.	+	.	.	4	29
	Lonicera alpigena	E2a	.	.	.	.	+	.	+	+	1	.	.	.	.	.	4	29
	Dryopteris filix-mas	E1	.	.	+	+	.	.	.	+	+	.	.	.	.	.	4	29
	Lilium martagon	E1	.	.	.	+	.	.	.	+	.	.	.	+	.	.	3	21
	Paris quadrifolia	E1	.	.	.	.	+	.	.	+	+	.	.	.	.	.	3	21
	Melica nutans	E1	.	.	.	.	.	.	+	.	.	+	+	.	.	.	3	21
	Galium laevigatum	E1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	2	14
	Laburnum alpinum	E2	.	.	.	.	.	.	.	r	.	.	.	+	.	.	2	14
	Acer pseudoplatanus	E1	.	.	.	r	.	.	.	.	.	.	.	.	.	.	1	7
	Thalictrum aquilegiifolium	E1	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	7
	Polygonatum multiflorum	E1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	7
	Actaea spicata	E1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	7
	Symphytum tuberosum	E1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	7
	Viola reichenbachiana	E1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	7
	Epipactis helleborine	E1	.	.	.	.	.	.	.	.	.	.	.	r	.	.	1	7
	Fagus sylvatica	E3a	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	7
	Fagus sylvatica	E2a	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
QP	***Quercetalia pubescenti-petraeae***																	
	Sorbus aria	E3a	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	7
	Sorbus aria	E2b	.	.	+	.	+	+	1	.	.	.	+	+	1	+	8	57
	Sorbus aria	E1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	7
	Convallaria majalis	E1	.	.	.	.	.	.	1	.	.	.	.	.	.	+	2	14
	Sorbus austriaca s. lat.	E2a	.	.	.	.	.	.	.	.	.	.	.	.	+	r	2	14
QF	***Querco-Fagetea***																	
	Anemone nemorosa	E1	.	.	.	+	.	.	+	+	.	.	.	+	.	.	4	29
	Potentilla erecta	E1	.	.	.	.	.	.	.	.	.	+	+	.	.	.	2	14
	Carex digitata	E1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	7
	Rosa glauca	E2a	.	.	r	.	.	.	.	.	.	.	.	.	.	.	1	7
	Hepatica nobilis	E1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	7
	Listera ovata	E1	.	.	.	.	.	.	.	.	.	r	.	.	.	.	1	7
	Viola riviniana	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
	Corylus avellana	E2a	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Platanthera bifolia	E1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	7
SSC	***Sambuco-Salicetea capreae***																	
	Sorbus aucuparia	E2b	.	.	.	r	+	+	1	r	.	+	+	+	+	.	9	64

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Pr.	Fr.
MuA	***Mulgedio-Aconitetea***																	
	Veratrum album	E1	+	.	+	.	.	.	+	r	.	+	+	.	.	.	6	43
	Aconitum lycoctonum subsp. *ranunculifolium*	E1	.	.	.	r	.	.	+	.	.	+	+	.	.	.	4	29
	Polygonatum verticillatum	E1	.	.	.	+	.	.	+	.	+	+	.	.	.	.	4	29
	Geranium sylvaticum	E1	+	.	.	.	.	.	.	.	.	1	.	.	.	.	2	14
	Viola biflora	E1	.	.	.	r	.	.	.	.	.	+	.	.	.	.	2	14
	Athyrium filix-femina	E1	.	.	.	.	.	.	.	+	+	.	.	.	.	.	2	14
	Senecio ovatus	E1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	7
	Ranunculus platanifolius	E1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	7
	Aconitum degenii subsp. *paniculatum*	E1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	7
	Chaerophyllum villarsii	E1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	7
	Allium victorialis	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
BA	***Betulo-Alnetea***																	
	Salix glabra	E2a	+	+	+	+	.	+	+	+	.	2	.	+	1	.	10	71
	Salix appendiculata	E2b	+	+	+	+	.	+	+	r	+	.	.	+	.	.	9	64
	Juniperus sibirica	E2a	+	+	.	+	.	.	.	r	.	.	.	.	.	.	4	29
	Sorbus chamaemespilus	E2a	.	.	.	+	.	+	.	.	.	+	1	.	.	.	4	29
	Ribes alpinum	E2a	.	.	.	r	.	+	.	+	.	.	.	.	.	.	3	21
	Salix waldsteiniana	E2a	.	.	.	.	.	.	.	r	.	.	.	.	.	.	1	7
ES	***Elyno-Seslerietea***																	
	Betonica alopecuros	E1	1	.	1	1	1	1	1	1	+	+	1	.	1	1	12	86
	Sesleria caerulea subsp. *calcaria*	E1	.	+	1	1	1	+	+	+	.	+	+	2	2	+	12	86
	Carduus crassifolius	E1	1	+	1	+	+	+	1	.	+	.	.	.	.	+	9	64
	Helianthemum grandiflorum	E1	+	+	+	+	.	+	.	+	.	+	+	.	.	+	9	64
	Carex sempervirens	E1	+	+	+	1	.	.	.	+	.	+	+	.	.	+	8	57
	Pimpinella alpina	E1	+	+	+	+	+	+	+	.	.	.	.	.	.	.	7	50
	Thymus praecox subsp. *polytrichus*	E1	.	.	+	+	+	+	.	+	+	.	.	.	.	+	7	50
	Leucanthemum maximum agg.	E1	.	.	+	+	.	.	.	+	.	r	+	.	+	+	7	50
	Phyteuma orbiculare	E1	.	.	+	.	r	+	.	.	.	.	+	+	+	+	7	50
	Pulsatilla alpina	E1	+	.	+	+	.	.	.	.	.	.	+	.	.	.	4	29
	Globularia cordifolia	E1	.	.	+	+	.	+	.	.	.	.	.	+	.	.	4	29
	Senecio abrotanifolius	E1	.	.	+	r	.	+	.	.	.	.	+	.	.	.	4	29
	Carex mucronata	E1	.	.	+	.	+	+	.	.	.	.	.	+	.	.	4	29
	Linum julicum	E1	+	.	+	+	.	.	.	.	.	.	.	.	.	.	3	21
	Galium anisophyllum	E1	.	.	+	.	.	.	.	.	.	+	+	.	.	.	3	21
	Heliosperma alpestre	E1	.	.	.	r	.	+	.	.	.	.	+	.	.	.	3	21
	Bartsia alpina	E1	.	.	.	+	.	.	.	.	.	.	+	.	+	.	3	21
	Scabiosa lucida	E1	+	.	.	+	.	.	.	.	.	.	.	.	.	.	2	14
	Festuca calva	E1	+	.	.	r	.	.	.	.	.	.	.	.	.	.	2	14
	Campanula witasekiana	E1	.	+	.	.	.	.	.	.	.	.	+	.	.	.	2	14
	Gentiana lutea subsp. *symphyandra*	E1	.	.	+	r	.	.	.	.	.	.	.	.	.	.	2	14
	Astrantia bavarica	E1	.	.	.	+	.	.	.	.	.	.	+	.	.	.	2	14
	Aster bellidiastrum	E1	.	.	.	+	.	.	.	.	.	.	.	1	.	.	2	14
	Globularia nudicaulis	E1	.	.	.	+	.	.	.	.	.	r	.	.	.	.	2	14
	Serratula tinctoria subsp. *macrocephala*	E1	.	.	.	+	.	.	.	.	.	.	1	.	.	.	2	14
	Knautia longifolia	E1	.	.	.	+	.	.	.	.	.	.	+	.	.	.	2	14
	Koeleria eriostachya	E1	.	.	.	+	.	.	.	.	.	.	+	.	.	.	2	14
	Achillea clavenae	E1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	7
	Helianthemum alpestre	E1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	7
	Heracleum austriacum subsp. *siifolium*	E1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	7

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Pr.	Fr.
	Leontopodium alpinum	E1	.	.	.	r	.	.	.	.	.	.	.	.	.	.	1	7
	Hieracium villosum	E1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	7
	Primula wulfeniana	E1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	7
	Scorzonera rosea	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
JT	*Soldanella alpina*	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
	Helictotrichon parlatorei	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
	Dryas octopetala	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Euphrasia salisburgensis	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Rhinanthus glacialis	E1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	7
SCF	*Parnassia palustris*	E1													+		1	7
TG	***Trifolio-Geranietea***																	
	Laserpitium siler	E1	.	.	.	.	+	.	+	+	.	.	.	.	.	.	3	21
	Lilium carniolicum	E1	.	.	+	.	+	.	.	.	.	.	.	.	.	.	2	14
	Thalictrum minus	E1	.	.	.	+	.	.	+	.	.	.	.	.	.	.	2	14
	Viola hirta	E1	.	.	.	.	+	.	.	.	.	.	.	.	.	+	2	14
	Anthericum ramosum	E1	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	7
	Stachys recta agg.	E1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	7
	Libanotis sibirica subsp. *montana*	E1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	7
	Polygonatum odoratum	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
	Origanum vulgare	E1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	7
FB	***Festuco-Brometea***																	
	Carlina acaulis	E1	+	+	+	+	+	+	.	.	.	.	.	.	.	+	7	50
	Bromus erectus agg.	E1	.	1	+	.	.	.	.	+	.	.	.	.	.	.	3	21
	Prunella grandiflora	E1	.	.	.	+	r	.	.	.	.	r	.	.	.	.	3	21
	Carex humilis	E1	.	.	.	.	+	.	+	.	.	.	.	.	.	+	3	21
	Hippocrepis comosa	E1	.	.	.	.	+	.	.	r	.	.	.	.	.	.	2	14
	Avenula praeusta	E1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	7
	Euphorbia cyparissias	E1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	7
PaT	***Poo alpinae-Trisetalia***																	
	Campanula scheuchzeri	E1	+	+	.	+	+	+	+	+	.	+	+	.	.	.	9	64
	Trollius europaeus	E1	.	.	.	+	.	.	.	.	.	.	+	.	.	.	2	14
	Polygonum bistorta	E1	.	.	.	r	.	.	.	.	.	.	.	.	.	.	1	7
MA	***Molinio-Arrhenatheretea***																	
	Lotus corniculatus s. lat	E1	+	.	+	+	r	.	.	.	.	r	+	.	+	.	7	50
	Trifolium pratense	E1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	7
EA	***Epilobietea angustifolii***																	
	Rubus idaeus	E2a	+	+	.	+	.	.	.	+	+	.	.	+	+	.	7	50
	Fragaria vesca	E1	.	.	.	.	.	.	.	+	.	.	+	.	.	.	2	14
TR	***Thlaspietea rotundifolii***																	
	Campanula cespitosa	E1	.	+	.	+	+	+	+	.	.	.	.	+	+	1	8	57
	Gymnocarpium robertianum	E1	.	.	+	.	.	.	+	+	+	.	.	.	.	+	5	36
	Adenostyles glabra	E1	.	.	.	.	.	+	+	.	+	.	.	.	.	.	3	21
	Petasites paradoxus	E1	.	.	.	.	.	+	+	.	.	.	.	.	+	.	3	21
	Valeriana montana	E1	.	.	.	.	.	.	+	+	.	+	.	.	.	.	3	21
	Astrantia carniolica	E1	.	.	.	.	.	+	.	.	.	.	.	.	1	.	2	14
	Biscutella laevigata	E1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	7
	Campanula cochleariifolia	E1	.	.	.	r	.	.	.	.	.	.	.	.	.	.	1	7
	Aquilegia bertolonii	E1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	7
	Scrophularia juratensis	E1	.	.	.	.	.	.	.	.	r	.	.	.	.	.	1	7
	Saxifraga caesia	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Aquilegia einseleana	E1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	7
AT	***Asplenietea trichomanis***																	
	Valeriana saxatilis	E1	+	.	+	+	+	+	.	.	.	.	.	1	+	.	7	50
	Asplenium ruta-muraria	E1	.	.	.	r	+	+	.	.	.	.	.	+	.	.	4	29
	Asplenium viride	E1	.	.	.	+	+	+	.	.	.	.	.	+	.	.	4	29
	Paederota lutea	E1	.	.	.	r	.	+	+	.	.	.	.	.	.	.	3	21
	Rhamnus pumilus	E1	.	.	.	r	.	+	.	.	.	.	.	.	.	.	2	14

	Number of relevé (Zaporedna številka popisa)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Pr.	Fr.
	Primula auricula	E1	.	.	.	.	.	+	.	.	.	.	.	+	.	.	2	14
	Hieracium glaucum	E1	.	.	.	r	.	.	.	.	.	.	.	.	.	.	1	7
	Campanula zoysii	E1	.	.	.	.	.	r	.	.	.	.	.	.	.	.	1	7
	Cystopteris fragilis	E1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	7
	Moehringia muscosa	E1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	7
	Carex brachystachys	E1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
O	**Other species (Druge vrste)**																	
	Juniperus communis	E2a	+	.	.	.	r	.	.	.	.	.	.	+	.	.	3	21
ML	**Mosses and lichens (Mahovi in lišaji)**																	
	Tortella tortuosa	E0	.	1	+	+	+	+	+	+	.	+	.	+	.	.	9	64
	Ctenidium molluscum	E0	.	+	.	+	+	+	+	+	+	.	.	1	.	.	8	57
	Fissidens dubius	E0	.	+	.	.	+	+	.	.	+	.	.	+	.	.	5	36
	Dicranum sp.	E0	.	+	+	+	.	.	.	.	.	.	.	.	.	.	3	21
	Hylocomium splendens	E0	.	.	.	+	.	.	.	.	.	.	.	+	+	.	3	21
	Homalothecium philippeanum	E0	.	.	+	.	.	.	.	.	+	.	.	.	.	.	2	14
	Schistidium apocarpum	E0	.	.	.	.	.	.	+	.	+	.	.	.	.	.	2	14
	Dicranum scoparium	E0	.	.	.	.	.	.	.	1	.	.	.	+	.	.	2	14
	Rhytidiadelphus triquetrus	E0	.	.	.	.	.	.	.	.	.	.	.	+	2	.	2	14
	Bazzania trilobata	E0	.	.	.	.	.	.	.	.	.	.	.	+	+	.	2	14
	Pleurozium schreberi	E0	.	.	.	.	.	.	.	.	.	.	.	.	+	+	2	14
	Cladonia sp.	E0	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	7
	Bryum capillare	E0	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	7
	Hypnum cupressiforme	E0	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Neckera crispa	E0	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7
	Orthothecium rufescens	E0	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	7

Legend - Legenda
A Limestone - apnenec
D Dolomite - dolomit
Gr Gravel - grušč
M Moraine (Till) - morena (til)
Re Rendzina - rendzina
Li Lithosols - kamnišče

Table 3: Synoptic table of the associations *Rhodothamno-Pinetum mugo* and *Amelanchiero-Pinetum mugo*
Preglednica 3: Sintezna tabela asociacij *Rhodothamno-Pinetum mugo* in *Amelanchiero-Pinetum mugo*

	Successive number (Zaporedna številka)		1	2	3	4	5
	Number of relevés (Število popisov)		39	14	10	13	9
	Sign for syntaxa (Oznaka sintaksonov)		RPm	RPmgr	APm-JA	APm-Tr	APm-F
	Author (Avtor)		ID	ID	ID	MI	LP
EP	***Erico-Pinetea***						
	Pinus mugo	E2b	100	100	100	100	100
	Rhododendron hirsutum	E2a	97	86	80	69	22
	Rubus saxatilis	E1	74	79	80	85	33
	Erica carnea	E1	69	93	100	100	100
	Calamagrostis varia	E1	62	93	100	54	78
	Rhodothamnus chamaecistus	E1	62	43	60	.	33
	Buphthalmum salicifolium	E1	26	71	80	15	22
	Genista radiata	E1	26	79	70	.	22
	Cirsium erisithales	E1	26	50	30	.	.
	Polygala chamaebuxus	E1	21	57	100	100	100
	Carex ornithopoda	E1	15	7	10	.	.
	Daphne striata	E1	10	14	10	.	.

	Successive number (Zaporedna številka)		1	2	3	4	5
	Allium ericetorum	E1	8	21	50	.	.
	Chamaecytisus hirsutus subsp. *ciliatus*	E1	8	21	.	46	.
	Amelanchier ovalis	E2	5	21	100	100	100
	Asperula aristata	E1	5	14	100	8	44
	Aquilegia nigricans	E1	3	.	.	.	.
	Arctostaphylos uva-ursi	E1	3	7	30	54	44
	Cotoneaster tomentosus	E2a	3	7	30	77	.
	Epipactis atrorubens	E1	3	7	50	23	56
	Gymnadenia odoratissima	E1	3	7	10	8	.
	Pinus sylvestris	E2	3	7	20	15	11
	Carex alba	E1	.	7	30	54	22
	Peucedanum austriacum subsp. *rablense*	E1	.	7	.	.	11
	Euphrasia cuspidata	E1	.	.	40	23	11
	Leontodon incanus	E1	.	.	50	.	11
	Aster amellus	E1	.	.	20	.	.
SP	*Salix eleagnos*	E2	.	.	20	.	.
	Crepis slovenica	E1	.	.	10	23	11
	Pinus nigra	E2	.	.	10	.	22
	Rhamnus saxatilis	E2	.	.	20	23	11
	Chamaecytisus purpureus	E1	.	.	.	77	56
	Daphne cneorum	E1	.	.	.	62	33
	Aquilegia atrata	E1	.	.	.	15	.
	Polygala nicaeensis subsp. *forojulensis*	E1	.	.	.	.	44
	Knautia ressmanii	E1	.	.	.	.	33
	Bupleurum ranunculoides	E1	.	.	.	.	11
	Galium purpureum	E1	.	.	.	.	11
VP	***Vaccinio-Piceetea***						
	Rosa pendulina	E2a	79	57	20	8	.
	Clematis alpina	E1	72	50	20	8	.
	Vaccinium myrtillus	E1	72	29	.	.	11
	Vaccinium vitis-idaea	E1	69	29	.	31	9
	Picea abies	E2	62	64	70	8	.
	Lonicera caerulea	E2a	59	29	.	.	.
	Homogyne alpina	E1	54	14	.	.	.
	Valeriana tripteris	E1	51	21	40	62	.
	Solidago virgaurea	E1	49	21	60	31	11
	Lycopodium annotinum	E1	46	7	.	.	.
	Calamagrostis villosa	E1	41	7	.	.	.
	Larix decidua	E2	41	43	10	8	11
	Luzula sylvatica	E1	36	14	.	.	.
	Gymnocarpium dryopteris	E1	36	.	.	.	.
	Polystichum lonchitis	E1	36	7	.	.	.
	Oxalis acetosella	E1	33	.	.	.	.
	Aposeris foetida	E1	31	29	.	.	.
	Dryopteris expansa	E1	28	14	.	.	.
	Huperzia selago	E1	28	7	.	.	.
	Homogyne sylvestris	E1	26	7	.	.	.
	Dryopteris dilatata	E1	26	7	.	.	.
	Lonicera nigra	E2a	23	21	10	.	.
	Maianthemum bifolium	E1	23	21	.	.	.
	Phegopteris connectilis	E1	23	.	.	.	.
	Abies alba	E2	18	14	.	.	.
	Gentiana asclepiadea	E1	15	.	.	.	.
	Calamagrostis arundinacea	E1	13	.	.	.	.
	Hieracium sylvaticum	E1	13	7	20	54	.
	Luzula luzulina	E1	10	7	.	.	.
	Saxifraga cuneifolia	E1	8	.	.	.	.
	Melampyrum sylvaticum	E1	5	7	.	.	11
	Veronica urticifolia	E1	5	7	.	.	.

	Successive number (Zaporedna številka)		1	2	3	4	5
	Listera cordata	E1	5	.	.	.	.
	Luzula luzuloides	E1	5	.	.	.	.
	Laserpitium krapfii	E1	3	.	.	.	.
	Luzula pilosa	E1	3	.	.	.	.
	Rhododendron ferrugineum	E2a	3	.	.	.	.
	Goodyera repens	E1	.	.	.	8	.
QP	***Quercetalia pubescenti-petraeae***						
	Sorbus aria	E2	26	57	100	85	67
	Convallaria majalis	E1	13	14	80	62	.
	Sorbus austriaca	E2b	5	14	10	.	.
	Ostrya carpinifolia	E2	.	.	90	85	44
	Fraxinus ornus	E2	.	.	70	92	44
	Mercurialis ovata	E1	.	.	10	.	.
	Melittis melissophyllum	E1	.	.	10	.	.
	Coronilla emerus s. lat.	E2	.	.	.	54	11
	Hierochloë australis	E1	.	.	.	54	11
	Carex flacca	E1	.	.	.	23	.
	Cotynus coggygria	E2	.	.	.	23	.
	Quercus pubescens	E2	.	.	.	15	.
QR	***Quercetalia roboris***						
	Potentilla erecta	E1	10	14	30	46	33
	Melampyrum pratense s. lat.	E1	3	.	.	.	33
	Betula pendula	E2		.	10	.	.
	Quercus petraea	E2	.	.	.	.	11
AF	***Aremonio-Fagion***						
	Cyclamen purpurascens	E1	46	93	90	85	67
	Cardamine enneaphyllos	E1	36	14	.	.	.
	Anemone trifolia	E1	15	14	40	15	33
	Rhamnus fallax	E2b	15	29	60	.	.
	Knautia drymeia	E1	8	7	.	.	.
	Cardamine trifolia	E1	8	.	.	.	.
	Helleborus niger	E1	3	.	40	.	.
AI	***Alnion incanae***						
	Chrysosplenium alternifolium	E1	8	.	.	.	.
	Frangula alnus	E2	.	.	40	31	44
TA	***Tilio-Acerion***						
	Acer pseudoplatanus	E3a	5	.	.	.	.
	Acer pseudoplatanus	E1	8	7	20	.	11
	Thalictrum aquilegiifolium	E1	5	7	.	.	.
	Polystichum aculeatum	E1	5	.	.	.	.
	Adoxa moschatellina	E1	3	.	.	.	.
FS	***Fagetalia sylvaticae***						
	Mercurialis perennis	E1	44	86	50	8	.
	Melica nutans	E1	33	21	40	.	11
	Galeobdolon flavidum	E1	31	36	.	.	.
	Daphne mezereum	E2a	26	29	20	.	.
	Dryopteris filix-mas	E1	26	29	.	.	.
	Lonicera alpigena	E2a	23	29	20	8	.
	Paris quadrifolia	E1	21	21	.	.	.
	Lilium martagon	E1	18	21	.	.	.
	Prenanthes purpurea	E1	18	.	.	8	.
	Epilobium montanum	E1	13	.	.	.	.
	Galium laevigatum	E1	13	14	10	.	.
	Actaea spicata	E1	10	7	.	.	.
	Fagus sylvatica	E3a	5	7	20	.	.
	Fagus sylvatica	E2	10	7	30	8	.
	Laburnum alpinum	E2b	8	14	40	.	11
	Symphytum tuberosum	E1	8	7	.	.	.
	Carex sylvatica	E1	3	.	.	.	.

	Successive number (Zaporedna številka)		1	2	3	4	5
	Luzula nivea	E1	3	.	.	.	.
	Myosotis sylvatica	E1	3	.	.	.	.
	Scrophularia nodosa	E1	3	.	.	.	.
	Viola reichenbachiana	E1	3	7	10	23	.
	Polygonatum multiflorum	E1	.	7	.	.	.
	Neottia nidus-avis	E1	.	.	.	8	.
QF	***Querco-Fagetea***						
	Anemone nemorosa	E1	38	29	.	.	.
	Hepatica nobilis	E1	5	7	.	8	11
	Carex digitata	E1	3	7	.	46	.
	Corylus avellana	E2a	3	7	.	15	.
	Listera ovata	E1	3	7	.	8	.
	Platanthera bifolia	E1	3	7	30	23	11
	Ranunculus auricomus agg.	E1	3	.	.	.	.
	Viola riviniana	E1	3	7	.	.	.
	Cephalanthera longifolia	E1	.	.	10	15	.
	Lonicera xylosteum	E2a	.	.	.	15	.
	Carex montana	E1	.	.	.	15	.
SSC	***Sambuco-Salicion capreae, Epilobietea angustifolii***						
	Sorbus aucuparia	E2	69	64	80	15	22
EA	*Rubus idaeus*	E2a	31	50	10	.	.
EA	*Fragaria vesca*	E1	10	14	.	.	.
EA	*Hypericum hirsutum*	E1	3	.	.	.	.
	Salix caprea	E2	.	.	.	23	.
RP	***Rhamno-Prunetea***						
	Rosa canina agg.	E2a	3	.	.	8	.
	Rosa glauca	E2a	3	7	.	.	.
	Viburnum lantana	E2	.	.	.	85	33
	Berberis vulgaris	E2	.	.	.	77	44
	Prunus spinosa	E2	.	.	.	15	.
	Rhamnus catharticus	E2	.	.	.	.	11
MuA	***Mulgedio-Aconitetea***						
	Veratrum album	E1	59	43	.	.	.
	Polygonatum verticillatum	E1	51	29	.	.	.
	Viola biflora	E1	51	14	.	8	.
	Aconitum lycoctonum subsp. *ranunculifolium*	E1	38	29	.	.	.
	Geranium sylvaticum	E1	38	14	.	.	.
	Athyrium filix-femina	E1	31	14	.	.	.
	Aconitum angustifolium	E1	26	50	20	.	.
	Ranunculus platanifolius	E1	18	7	.	.	.
	Adenostyles alliariae	E1	15	.	.	.	.
	Saxifraga rotundifolia	E1	13	.	.	.	.
	Senecio cacaliaster	E1	13	.	.	.	.
	Allium victorialis	E1	10	7	.	.	.
	Chaerophyllum hirsutum	E1	10	.	.	.	.
	Chaerophyllum villarsii	E1	8	7	.	.	.
	Senecio ovatus	E1	5	7	.	.	.
	Heracleum montanum	E1	8	.	.	.	.
	Hypericum maculatum	E1	8	.	.	.	.
	Carduus personata	E1	5	.	.	.	.
	Cicerbita alpina	E1	5	.	.	.	.
	Doronicum austriacum	E1	5	.	.	.	.
	Geum rivale	E1	5	.	.	.	.
	Phyteuma ovatum	E1	5	.	.	.	.
	Crepis paludosa	E1	3	.	.	.	.
	Crepis pyrenaica	E1	3	.	.	.	.

	Successive number (Zaporedna številka)		1	2	3	4	5
	Eryngium alpinum	E1	3	.	.	.	.
	Lathyrus occidentalis var. montanus	E1	3	.	.	.	.
	Myrrhis odorata	E1	3	.	.	.	.
	Peucedanum ostruthium	E1	3	.	.	.	.
	Pleurospermum austriacum	E1	3	.	.	.	.
	Poa hybrida agg.	E1	3	.	.	.	.
	Stellaria nemorum	E1	3	.	.	.	.
	Streptopus amplexifolius	E1	3	.	.	.	.
BA	***Betulo-Alnetea***						
	Salix glabra	E2a	79	71	100	.	56
	Salix appendiculata	E2	74	64	20	.	.
	Sorbus chamaemespilus	E2	54	29	10	.	22
	Juniperus sibirica	E2a	36	29	.	.	11
	Salix waldsteiniana	E2a	31	7	.	.	.
	Alnus viridis	E2	28	.	.	.	.
	Ribes alpinum	E2a	13	21	.	.	.
TG	***Trifolio-Geranietea***						
	Laserpitium siler	E1	5	21	50	.	.
	Thalictrum minus	E1	5	14	.	.	.
	Libanotis sibirica subsp. *montana*	E1	3	7	.	.	.
	Lilium carniolicum	E1	3	14	.	.	.
	Origanum vulgare	E1	3	7	.	.	.
	Polygonatum odoratum	E1	3	7	20	54	11
	Viola hirta	E1	3	14	50	8	44
	Anthericum ramosum	E1	.	7	20	46	11
	Stachys recta agg.	E1	.	7	.	.	.
	Vincetoxicum hirundinaria	E1	.	.	30	15	33
	Lilium bulbiferum	E1	.	.	.	8	.
FB	***Festuco-Brometea***						
	Carlina acaulis	E1	21	50	60	.	.
	Bromus erectus agg.	E1	8	21	.	.	.
	Carex humilis	E1	5	21	50	85	33
	Prunella grandiflora	E1	5	21	10	.	.
	Avenula praeusta	E1	3	7	.	.	.
	Euphorbia cyparissias	E1	3	7	10	.	.
	Gentianella ciliata	E1	3	.	20	.	.
	Hippocrepis comosa	E1	3	14	10	8	.
	Koeleria pyramidata	E1	3	.	.	.	.
	Linum catharticum	E1	3	.	10	.	33
	Peucedanum oreoselinum	E1	.	.	60	69	33
	Inula ensifolia	E1	.	.	30	.	.
	Teucrium montanum	E1	.	.	40	8	22
	Centaurea jacea agg. *(C. bracteata)*	E1	.	.	20	.	22
	Gymnadenia conopsea	E1	.	.	20	.	44
	Linum viscosum	E1	.	.	20	.	.
	Teucrium chamaedrys	E1	.	.	20	15	.
	Thesium linophyllon	E1	.	.	10	15	.
	Brachypodium rupestre	E1	.	.	10	.	11
	Galium lucidum	E1	.	.	10	31	22
	Galium verum	E1	.	.	.	23	44
	Serratula nudicaulis	E1	.	.	.	15	.
	Dianthus monspessulanus	E1	.	.	.	.	11
	Genista sericea	E1	.	.	.	.	11
ES	***Elyno-Seslerietea***						
	Sesleria caerulea subsp. *calcaria*	E1	69	86	70	100	100
	Laserpitium peucedanoides	E1	59	71	100	.	22
	Betonica alopecuros	E1	54	86	90	23	22
	Carex sempervirens	E1	36	57	.	.	.
	Helianthemum grandiflorum	E1	36	64	10	15	.

	Successive number (Zaporedna številka)		1	2	3	4	5
	Aster bellidiastrum	E1	31	14	.	46	.
	Carduus crassifolius (inc. C. defloratus)	E1	31	64	50	8	11
	Thymus praecox subsp. *polytrichus*	E1	28	50	20	.	.
	Phyteuma orbiculare	E1	26	50	40	46	33
	Leucanthemum maximum agg.	E1	23	50	50	.	22
	Pimpinella alpina	E1	23	50	10	.	.
	Pulsatilla alpina	E1	23	29	.	.	.
	Bartsia alpina	E1	21	7	10	.	11
	Heliosperma alpestre	E1	21	21	.	.	.
	Campanula witasekiana	E1	18	14	.	.	.
	Galium anisophyllum	E1	18	21	.	.	.
	Achillea clavenae	E1	15	7	.	.	.
	Centaurea haynaldii subsp. *julica*	E1	15	50	20	.	.
	Koeleria eriostachya	E1	15	14	.	.	.
	Linum julicum	E1	15	21	10	.	.
	Polygonum viviparum	E1	15	.	.	.	.
	Senecio abrotanifolius	E1	15	29	10	.	11
	Festuca calva	E1	13	14	.	.	.
	Globularia cordifolia	E1	13	29	80	38	67
	Carex ferruginea	E1	10	.	.	31	.
	Carex mucronata	E1	10	29	50	.	22
	Heracleum austriacum subsp. *siifolium*	E1	10	7	.	.	.
	Hieracium villosum	E1	10	7	.	.	.
	Juncus monanthos	E1	10	.	.	.	.
	Globularia nudicaulis	E1	8	14	.	.	.
	Helianthemum alpestre	E1	8	7	.	.	.
	Knautia longifolia	E1	8	14	.	.	.
	Leontopodium alpinum	E1	8	7	.	.	.
	Scabiosa lucida subsp. *lucida*	E1	8	14	.	.	.
	Serratula macrocephala	E1	8	14	.	.	.
	Gentiana lutea subsp. *symphyandra*	E1	5	14	.	.	.
	Dryas octopetala	E1	5	7	60	.	22
	Euphrasia salisburgensis	E1	5	7	10	.	.
	Helictotrichon parlatorei	E1	5	7	.	.	.
	Carex firma	E1	5	.	30	.	33
	Polygala alpestris	E1	5	.	.	.	.
	Potentilla crantzii	E1	5	.	.	.	.
	Ranunculus carinthiacus	E1	5	.	.	.	.
	Primula wulfeniana	E1	3	7	10	.	.
	Rhinanthus aristatus	E1	3	7	10	.	.
	Ranunculus hybridus	E1	3	.	10	.	.
	Scorzonera rosea	E1	3	7	.	.	.
	Alchemilla alpigena	E1	3	.	.	.	.
	Anemone narcissiflora	E1	3	.	.	.	.
	Cerastium strictum	E1	3	.	.	.	.
	Salix alpina	E1	3	.	.	.	.
	Thesium alpinum	E1	.	.	20	.	.
	Gentiana clusii	E1	.	.	10	.	11
	Acinos alpinus	E1	.	.	10	.	.
	Scabiosa lucida subsp. *stricta*	E1	.	.	10	.	.
	Primula glaucescens	E1	.	.	.	8	.
	Ranunculus montanus	E1	.	.	.	.	11
JT	***Junctea trifidi, Loiseleurio-Vaccinietea***						
	Soldanella alpina	E1	21	7	.	.	.
	Gentiana pannonica	E1	5	.	.	.	.
LV	*Empetrum hermaphroditum*	E1	5	.	.	.	.
LV	*Arctostaphylos alpinus*	E1	5	.	.	.	.
LV	*Vaccinium gaultherioides*	E1	3	.	.	.	.
OE	*Carex atrata*	E1	3	.	.	.	.

	Successive number (Zaporedna številka)		1	2	3	4	5
	Parnassia palustris	E1	21	7	.	8	22
	Selaginella selaginoides	E1	10	.	20	.	11
	Pinguicula alpina	E1	8	.	.	.	.
	Tofieldia calyculata	E1	5	.	20	23	11
	Carex capillaris	E1	3	.	.	.	.
	Pinguicula vulgaris	E1	.	.	.	.	22
CU	***Calluno-Ulicetea***						
	Anthoxanthum odoratum	E1	8	.	.	.	.
	Genista germanica	E1	.	.	.	15	11
	Anntenaria dioica	E1	.	.	.	.	11
PaT	***Poo alpinae-Trisetalia***						
	Campanula scheuchzeri	E1	59	14	.	.	.
	Poa alpina	E1	10	.	.	.	.
	Trollius europaeus	E1	10	14	.	.	.
	Festuca nigrescens	E1	5	.	.	.	.
	Cerastium fontanum	E1	3	.	.	.	.
	Crocus albiflorus	E1	3	.	.	.	.
	Polygonum bistorta	E1	3	.	.	.	.
	Ranunculus nemorosus	E1	3	.	.	.	.
MA	***Molinio-Arrhenatheretea***						
	Lotus corniculatus s. lat.	E1	23	50	50	.	11
	Angelica sylvestris	E1	5	.	.	.	.
	Deschampsia cespitosa	E1	5	.	.	.	.
	Trifolium pratense	E1	5	.	.	.	.
	Dactylis glomerata	E1	3	.	.	.	.
	Festuca rubra agg.	E1	3	.	.	.	.
	Galium mollugo agg.	E1	3	.	.	.	.
TR	***Thlaspietea rotundifolii***						
	Adenostyles glabra	E1	33	21	10	.	.
	Dryopteris villarii	E1	21	.	.	.	.
	Gymnocarpium robertianum	E1	21	36	.	15	.
	Campanula cespitosa	E1	18	57	90	.	44
	Festuca nitida	E1	18	.	.	.	.
	Valeriana montana	E1	15	21	20	8	.
	Campanula cochleariifolia	E1	13	7	.	.	.
	Astrantia carniolica	E1	10	14	10	.	.
	Petasites paradoxus	E1	10	21	50	.	33
	Rhodiola rosea	E1	10	.	.	.	.
	Biscutella laevigata	E1	5	7	60	23	33
	Saxifraga aizoides	E1	5	.	.	.	.
	Aquilegia einseleana	E1	3	7	70	.	33
	Saxifraga caesia	E1	3	7	.	.	.
	Rumex scutatus	E1	3	.	10	.	.
	Homogyne discolor	E1	3	.	.	.	.
	Salix retusa	E1	3	.	.	.	.
	Festuca laxa	E1	3	.	.	.	.
	Molopospermum peloponnesiacum subsp. *bauhinii*	E1	3	.	.	.	.
	Trisetum argenteum	E1	3	.	.	.	.
	Cystopteris montana	E1	3	.	.	.	.
	Aquilegia bertolonii	E1		7	.	.	.
	Scrophularia juratensis	E1	.	7	.	.	.
	Hieracium porrifolium	E1	.	.	90	.	33
	Achnatherum calamagrostis	E1	.	.	20	.	.
	Hieracium bifidum	E1	.	.	40	.	.
	Gypsophila repens	E1	.	.	10	.	.
	Euphorbia triflora subsp. *kerneri*	E1	.	.	.	.	44
	Thesium rostratum	E1	.	.	.	.	44
	Centaurea dichroantha	E1	.	.	.	.	11

	Successive number (Zaporedna številka)		1	2	3	4	5
	Asplenium viride	E1	51	29	.	.	.
	Valeriana saxatilis	E1	46	50	90	8	44
	Paederota lutea	E1	36	21	10	.	.
	Asplenium ruta-muraria	E1	10	29	.	.	.
	Cystopteris fragilis	E1	10	7	.	.	.
	Primula auricula	E1	8	14	.	.	.
	Saxifraga crustata	E1	5	.	10	.	.
	Campanula zoysii	E1	3	7	.	.	.
	Carex brachystachys	E1	3	7	.	.	.
	Hieracium glaucum	E1	3	7	.	.	.
	Moehringia muscosa	E1	3	7	.	.	.
	Potentilla caulescens	E1	3	.	20	.	.
	Cystopteris regia	E1	3	.	.	.	.
	Festuca stenantha	E1	3	.	.	.	.
	Saxifraga squarrosa	E1		.	10	.	.
	Saxifraga burseriana	E1	.	.	20	.	.
O	**Other species (Druge vrste)**						
	Juniperus communis	E2b	8	21	40	31	44
	Alchemilla sp.	E1	5	.	.	.	.
	Festuca sp.	E1	5	.	.	.	.
	Agrostis sp.	E1	3	.	.	.	.
	Ranunculus sp.	E1	3	.	.	.	.
	Saxifraga sp.	E1	3	.	.	.	.
	Hieracium sp.	E1	3	.	.	.	.
	Juglans regia	E1	.	.	.	.	.
	Orobanche sp.	E1	.	.	10	.	.
ML	**Mosses and lichens (Mahovi in lišaji)**						
	Tortella tortuosa	E0	74	64	60	.	.
	Ctenidium molluscum	E0	54	57	70	54	.
	Rhytidiadelphus triquetrus	E0	49	14	20	54	.
	Dicranum scoparium	E0	38	14	.	8	.
	Hylocomium splendens	E0	36	21	30	15	.
	Fissidens dubius	E0	26	36	10	.	.
	Rhytidiadelphus loreus	E0	26	.	.	.	.
	Polytrichum formosum	E0	26	.	.	.	.
	Dicranum sp.	E0	21	21	10	.	.
	Orthothecium rufescens	E0	18	7	.	.	.
	Schistidium apocarpum	E0	13	14	20	.	.
	Cladonia sp.	E0	13	7	.	.	11
	Bazzania trilobata	E0	10	.	.	.	.
	Pleurozium schreberi	E0	10	14	.	38	.
	Rhizomnium punctatum	E0	8	.	.	.	.
	Peltigera canina	E0	8	.	.	.	.
	Peltigera leucophlebia	E0	8	.	.	.	.
	Cladonia pyxidata	E0	5	.	.	8	.
	Conocephalum conicum	E0	5	.	.	.	.
	Mnium sp.	E0	5	.	.	.	.
	Sphagnum sp.	E0	5	.	.	.	.
	Homalothecium philippeanum	E0	3	14	.	.	.
	Neckera crispa	E0	3	7	30	.	.
	Hypnum cupressiforme	E0	3	7	.	8	.
	Scleropodium purum	E0	3	.	40	85	.
	Dicranum majus	E0	3	.	.	.	.
	Distichium capillaceum	E0	3	.	.	.	.
	Encalypta sp.	E0	3	.	.	.	.
	Mnium thomsonii	E0	3	.	.	.	.
	Plagiochila asplenioides	E0	3	.	.	.	.
	Plagiochila porelloides	E0	3	.	.	.	.
	Plagiothecium undulatum	E0	3	.	.	.	.

Successive number (Zaporedna številka)		1	2	3	4	5
Sanionia uncinata	E0	3	.	.	.	.
Bryum capillare	E0	.	7	.	.	.

RPm *Rhodothamno-Pinetum mugo*, the Julian Alps (Julijske Alpe), Dakskobler (in litt.)
RPmgr *Rhodothamno-Pinetum mugo* var. *Genista radiata*, the Julian Alps (Julijske Alpe) (Table 2, this article)
APm-JA *Amelanchiero-Pinetum mugo*, the Julian Alps (Julijske Alpe) (Table 1, this article)
APm-Tr *Amelanchiero-Pinetum mugo*, Trentino, northern Italy (Minghetti 1996, Table 1)
APm-F *Amelanchiero-Pinetum mugo*, Friuli, northeastern Italy (Poldini and Vidali 1999, Table 3)

Table 4: Groups of diagnostic species in the stands of the associations *Rhodothamno-Pinetum mugo* and *Amelanchiero-Pinetum mugo* (relative frequencies)
Preglednica 4: Skupine diagnostičnih vrst v sestojih asociacij *Rhodothamno-Pinetum mugo* in *Amelanchiero-Pinetum mugo* (relativne frekvence)

Successive number (Zaporedna številka)	1	2	3	4	5
Number of relevés (Število popisov)	39	14	10	13	9
Sign for syntaxa (Oznaka sintaksonov)	RPm	RPmgr	APm-JA	APm-Tr	APm-F
Author (Avtor)	ID	ID	ID	MI	LP
Erico-Pinetea	11,51	**19,07**	**27,34**	**32,51**	**35,62**
Vaccinio-Piceetea	**21,69**	**11,11**	4,77	6,02	1,74
Quercetalia pubescenti-petraeae	0,82	1,75	**6,79**	**13,62**	**5,81**
Aremonio-Fagion	2,45	3,23	4,22	2,76	3,28
Quercetalia roboris	0,24	0,29	0,73	1,27	2,53
Fagetalia sylvaticae	**6,51**	**7,47**	**5,32**	1,74	1,08
Querco-Fagetea	1,25	1,46	1,47	**4,86**	2,17
Sambuco-Salicion capreae	2,12	2,63	1,65	1,05	0,72
Rhamno-Prunetea	0,10	0,14	0	**5,11**	2,89
Mulgedio-Aconitetea	**8,58**	**4,55**	0,37	0,22	0
Betulo-Alnetea	5,91	4,55	2,39	0	2,92
Trifolio-Geranietea	0,43	2,02	**3,12**	**3,62**	**3,25**
Festuco-Brometea	1,01	2,90	**7,52**	**7,43**	**9,39**
Elyno-Seslerietea	**16,00**	**22,24**	**14,68**	**8,70**	**13,07**
Junctea trifidi, Loiseleurio-Vaccinietea	0,77	0,14	0	0	0
Scheuchzerio-Caricetea fuscae	0,87	0,14	0,73	0,86	2,17
Calluno-Ulicetea	0,14	0	0	0,41	0,72
Poo alpinae-Trisetalia	1,78	0,58	0	0	0
Molinio-Arrhenatheretea	0,87	1,03	0,92	0	0,36
Thlaspietea rotundifolii	3,81	4,36	**8,81**	1,27	**9,03**
Asplenietea trichomanis	3,47	3,66	2,94	0,22	1,44
Other species (Druge vrste)	0,53	0,43	0,92	0,86	1,44
Mosses and lichens (Mahovi in lišaji)	9,15	6,25	5,32	7,46	0,36
Total (Skupaj)	100,00	100	100	100	100

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Characteristics of centipede (Chilopoda) assemblies in Dinaric frost hollows in Velika gora (Slovenia)

Značilnosti združbe strig (Chilopoda) v dinarskih mraziščih na Veliki gori (Slovenija)

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Abstract: Current study is preliminary research of centipedes (Chilopoda) assemblies in Slovenian frost hollows. With two sampling methods in three series (June, August and November) in year 2010, 834 individuals were caught and indentified to 30 species. Most collected species had middle Europe distribution, 6 species were endemic for southeast Alps and northwest Balkan region, 3 of them are probably new for science. Five species had paleartic distribution. Maximum number of species found in one location was 28. Average density of centipedes was from 218 ind./m^2 to 552 ind./m^2. The alfa diversity of the centipede assemblies is medium compared to other locations in Dinaric part of Slovenia and evidently higher compare to other European forest. The same applies for average density and species richness. Overall centipede assemblies were more similar in one location during the season than to assemblies from different locations in the same month.

Keywords: Chilopoda, frost hollow, assemblies, seasonal characteristic, Dinaric region

Izvleček: Preučevali smo sezonsko dinamiko strig v nekaterih mraziščih na Veliki gori, J Slovenija. Z dvema vzorčevalnima metodama v treh vzorčenjih (junija, avgusta in novembra) v letu 2010 smo dobili 834 osebkov, ki smo jih uvrstili v 30 vrst. Največ vrst je imelo srednje evropsko razširjenost, kar 6 vrst je bilo endemnih za območje jugovzhodnih Alp ali severozahodnega Balkana, od tega so 3 vrste najverjetneje nove za znanost. Največje število dobljenih vrst v enem mrazišču je bilo 28. Povprečna gostota osebkov na posameznem vzorčenju je bila od 218 os./m^2 do 552 os./m^2. Glede na alfa diverziteto združbi strig v mraziščih sodita med srednje bogate na območju Slovenije in med zelo bogate v primerjavi z drugimi evropskimi gozdnimi združbami. Enako velja za vrstno bogastvo in povprečno gostoto. Združbe strig so si bile bolj podobne na posamezni lokaciji skozi sezono, kot združbe različnih lokacij v istem mesecu.

Ključne besede: strige, mrazišče, združba, sezonske značilnosti, dinarsko območje

Introduction

According final revision of data (Ravnjak 2012) there are 98 species of Chilopoda known in Slovenia, more than one third of them (35 species) being endemic in southeast Alps or northwest Balkan (Kos 2001). But Slovenia area is not evenly studied. We have still very little information for

the southeast and northeast part of Slovenia, part of the southwest and surroundings of the Ljubljana basin (Ravnjak 2012).

One of unique characteristic of Slovenia is also karst terrain and karst phenomena such as frost hollows. In Slovenia frost hollows are present in the Julian Alps, Karavanke and all Dinaric area. There were many topological and geological studies conducted in the hollows (Gams 1972, 1974, Trošt 2008, Stepišnik 2006, 2010), but few biological studies. Authors who made studies of vegetation in frost hollows in Slovenia were Martinčič (1977), Zupančič (1980, 1999), Wraber M. (1969), Wraber T. (1963) and Zavadlav (1974). There were only few studies of the fauna in frost hollows, confined to the particular animal groups: Collembola (Červek 1967, 1968), Gastropoda (Bole 1976) and Acarina (Tarman 1975). Chilopoda in frost hollows have been only partially sampled (Kos et al. unpublished) and collected data have not yet been analyzed. This survey is therefore first preliminary study of centipedes' assemblies in frost hollows in Slovenia. Our expectations were as follows: (i) rare or new species for centipede fauna of Slovenia will be found, (ii) the majority of species found will be species with middle European and paleartic distribution, iii) species with boreal and alpine character will be present, iv) there will be season differences in densities of centipedes, v) individual species will have different densities during the season.

Materials and methods

Sampling took place in Velika gora hills in Dinaric region in southern of Slovenia, west of city Ribnica (Fig. 1). Bedrock in this area is mostly calcareous, dominated by limestone and dolomites of different ages. Area is mountainous but does not reach great heights, while the terrain is very diverse due to karst phenomena (Bole and Slapnik 1997). Dominant natural vegetation in the area is the fir – beech forest (*Omphalodes - fagetum*) (Bole and Zupančič 1992). First selected frost hollow was **Smrekov žleb** (GKX: 5061900, GKY: 5476404). Most numerous tree species in the valley are common spruce (*Picea abies*) and fir (*Abies alba*). The topmost layer of the soil in the frost hollow was acidic and covered with rich undergrowth. Second frost hollow was near **Kragulovec** (GKX: 5062821, GKY: 5474681). Common spruce was also most present tree species there, ground were also covered with rich, acidophilic undergrowth.

Sampling took place on the 1st of June, 17th of July and 17th of November in year 2010, between 8 am and 15 pm. Nine (9) soil sample units (SU), representing one sample, on each location were collected with metal cylinder. The sample units dimensions was Ø21cm x 15cm (appr. 5.2 dm^3 of soil). Both organic (litter) as well as the fermentation horizon were covered. Samples were taken randomly in single location, but minimum 10 m apart. Samples were then placed on Tullgren funnels, modified so that the lower parts of fun-

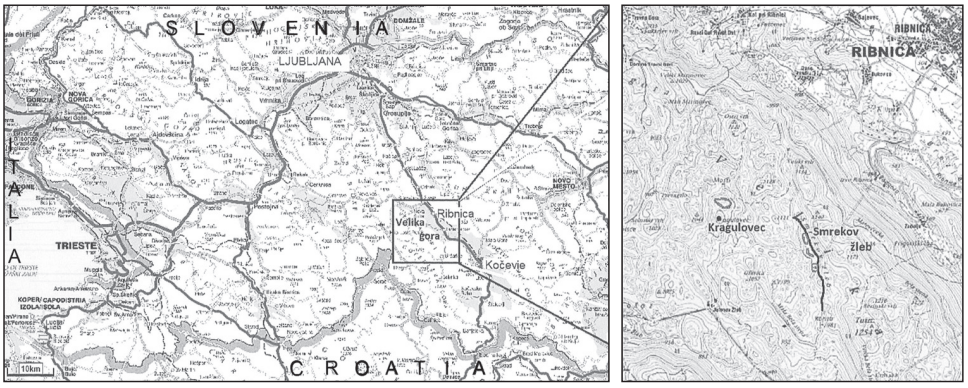

Figure 1: Left: The location of Velika gora plateau in south of Slovenia. Right: Frost hollows Kragulovec and Smrekov žleb.

Slika 1: Levo: Položaj planote Velika gora v Sloveniji. Desno: Mrazišči Kragulovec in Smrekov žleb.

nels were in the dark and cooled. Animals were intercepted in vessels filled with ethylene glycol. The extraction lasted 20-30 days, depended of the humidity of the sample. We also collected animals under the dead wood plants material and stones. In single location we have searched for 20 – 30 min in all area. Captured animals were directly put in 70% alcohol.

All statistical analysis was made following Krebs (1989). For estimation of species richness we used Jackknife for diversity Shanon-Wiener index and Evenness index. For calculation of similarity among centipede assemblies Percentage similarity (Renkonen index) was used (Krebs 1989, p.304). For this we used only relative share of species (without juvenile lithobids and undetermined individuals) from each soil sampling. Dendrogram of similarity was made with program PAST (http://folk.uio.no/ohammer/past/) using minimum-linkage method of clustering. Centipedes were determined following published literature by Eason (1964), Koren (1986, 1992), Matic (1966, 1972), Verhoef (1931, 1937) and other. All collected material is kept in Biotehnical faculty in Department of biology.

Results

Review of the species

Order Geophilomorpha was recently fully reviewed and amended by Bonato and Minelli (2014). New species names are therefore used in the article, but to allow comparison with earlier data, the previous valid names and/or names that were used in past Slovenian literature are given in parentheses in list 1. For general distribution of species we followed Stoev (1997), Kos (2012) and data from Fauna europaea and Chilobase.

List 1: A list of all taxa collected with hand sampling (*) and with soil sampling method (+) in both locations. Currently known distribution (C.D.): pa – paleartic, il – Illyric, en – endemic, Ev – european, miE - middle european, sE - south european, seE- southeast european, eE – east european, Me –Mediterranean

Seznam 1: Seznam vseh taksonov. Vrste, ki smo jih dobili pri ročnem pobiranju * in vrste, ki smo jih dobili pri talnem vzorčenju +. Splošna razširjenost (C.D.): pa – palearktična, il – ilirska, en – endemit, Ev – evropska, miE – srednjeevropska, sE – južnoevropska, seE - jugovzhodnoevropska, eE – vzhodno evropska, Me – mediteranska

C.D	o. GEOPHILOMORPHA	
	f. Geophilidae Leach, 1815	
ili	*Clinopodes carinthiacus* (Latzel, 1880) +	*(Clinopodes trebevicensis* (Verfoeff, 1898))
En	*Eurygeophilus pinguis* (Brölemann, 1898) +	*(Chalandea scherpeltzi* Attems, 1952)
miE	*Geophilus alpinus* Meinert, 1870 +	*(Geophilus (Orinophilus) insculptus* Attems, 1895)
En	*Geophilus n.*sp. +	*(Geophilus* (*Orinophilus)* n.sp.)
sE	*Stenotenia sorrentina* (Attems, 1903) +	
	f.Linotaeniidae Cook, 1899	
Ev	*Strigamia acuminata* (Leach, 1815) +	
miE	*Strigamia transsilvanica* (Verhoeff, 1928) + *	
	f. Mecistocephalidae Bollman, 1893	
ili	*Dicellophilus carniolensis* (C.L.Koch), 1847 + *	
	f. Schendylidae Cook, 1896	
Al-ka	*Schendyla tyrolensis* (Meinert, 1870) + *	*(Schendyla montana* Attems, 1895)
Ili	*Schendyla carniolensis* (Verhoef, 1902) +	
Pa	*Schendyla nemorensis* (C. L. Koch, 1837) +	

	o. LITHOBIOMORPHA	
	f. Lithobiidae	
sE	*Eupolybothrus (Leptopolybothrus) tridentinus* (Fanzago, 1874) *	
En	*Harpolithobius* cf. *gottscheensis* (Verhoeff, 1937) +	
	Harpolithobius sp. + *	
	Lithobius juv + *	
	Lithobius sp. +	
Pa	*Lithobus borealis* Meinert, 1868 *	
Me	*Lithobius castaneus* Newport, 1844 +	
Pa	*Lithobius forficatus* (Linnaeus, 1758) *	
miE	*Lithobius latro* Meinert, 1872 +	
miE	*Lithobius nodulipes* Latzel, 1880 + *	
miE	*Lithobius pelidnus* Haase, 1880 +	
miE	*Lithobius pygmaeus* Latzel, 1880 +	
Ev	*Lithobius tenebrosus* Meinert, 1872 + *	
miE	*Lithobius punctulatus* C.L. Koch, 1847 + *	(*Lithobius validus* Meinert, 1872)
miE	*L. (Monotarsobius) aeruginosus C.* L. Koch, 1862 +	
En ?	*L. (M.)* n.sp. + *	
En	*L. (Sigibius) burzenlandicus carinthiacus* (Koren, 1992) + *	
En ?	*L. (Sigibius)* n. sp. «anici« +	
	o. SCOLOPENDROMORPHA	
	f. Cryptopidae	
Pa	*Cryptops anomalans* Newport, 1844 *	
Pa	*Cryptos hortensis* Leach, 1815 +	
Ev	*Cryptos parisi* Brolemann, 1920 + *	
seE	*Cryptos rucneri* Matic & Teodoreanu, 1966 +	

All species that were found in this study have been already found in area of Slovenia. Four species were found only by hand collecting method, 17 species only with soil sampling method. Nine species were found with both sampling methods (List 1). Most collected species had middle European distribution (8), followed by endemic species (6) and paleartic species (5). We found 3 Illiric species and 3 species with european distribution (List 1). One Mediterranean (*Lithobius castaneus*), one alpine-karpatian (*Schendyla tyrolensis*) and one species with southeast distribution (*Cryptops rucneri*) were also found.

Table 1: N- number of centipedes collected with hand collecting method.
Tabela 1: N- število ulovljenih osebkov pri ročnem nabiranju. Vrste označene "odebeljeno", so bile najdene le s to metodo

	Sampling date	1. 6. 2010		17. 8. 2010		17. 11. 2010	
o.	Species/Vrste	Kragulovec	Smrekov žleb	Kragulovec	Smrekov žleb	Kragulovec	Smrekov žleb
geo	*D. carniolensis*		3		5		
geo	*S. tyrolensis*	1					
geo	*S. transsilvanica*			1		1	
lit	***E. tridentinus***	**1**			**5**		
lit	***L. borealis***					**4**	
lit	*L. burzenlandicus carinthiacus*				1		
lit	*L. castaneus*			1	1		
lit	***L. forficatus***		**1**				
lit	*L. nodulipes*				1		
lit	*L. pelidnus*					1	
lit	*L. punctulatus*			1	1	1	
lit	*L. tenebrosus*	1	2	1	1	1	17
lit	*L. (M.)* n.sp.				1		
sco	***C. anomalans***			**3**	**1**		
sco	*C. parisi*			6	1	2	
lit	*Harpolithobius*.sp.				1		
lit	*Lithobius* juv			1			
	N	3	6	14	19	10	17

Average density and species richness

Juvenile Lithobiidae had the highest density in location **Kragulovec** in summer and autumn followed by species *Lithobius pygmaeus, Clinopodes carinthiacus* and *Cryptops parisi*. The last two had highest densities in the spring and then progressively lower. *Schendyla carniolensis*, *S. tyrolensis* and *Stenotaenia sorerentina* on the other hand had the lowest densities in the summer and the highest in the autumn.

In **Smrekov žleb** species with very high density in all three samplings were *Lithobius (Sigibius*) n.sp. »anici«, followed by L. *pygmaeus* and again *C. parisi*. Juvenile Lithobiidae also had very high density, but lower than in Kragulovec. In this location *L. pygmaeus, Cryptops hortensis* and *C. parisi* had highest densities in the summer. Opposite had *Eurygeophilus pinguis*, *Lithobius (Monotarsobius*) n. sp. and *L. (S.*) n. sp. "anici" lowest densities in the summer.

Average density of centipedes was from 218 ind./m^2 to 552 ind./m^2 (Tab. 2,Tab. 3). In location **Smrekov žleb** the density was higher in all three samplings comparing to samplings in location **Kragulovec**. The number of species caught with square soil sampling method at one sampling was between 12 in 20 (Tab. 2,Tab. 3). Total number of species (soil sampling and hand collecting method in all three samplings) was 22 in location Kragulovec and 28 in location Smrekov žleb.

Diversity index, evenness and Similarity of the assemblies

Shannon – Wiener diversity index was between 1.9 and 2.47 and the Evenness index was between 0.77 and 0.86 (Tab. 2, Tab. 3). In both locations the highest S-W index and Evenness was in August.

Calculation of percentage similarity (Renkonen index) showed the greatest similarity between the centipedes assemblies in June and August on loca-

Table 2: Location Kragulovec, soil sampling method. n – the number of collected centipedes belonging to single species, D - dominance, ind/m^2 (min, max) - density estimation with 95% confidence. N- the number of all individuals in one sampling, densities (ind/m^2) on each location, Jackknife – species richness (max. number estimation), S-W -Shannon-Wiener diversity index, E - Evenness.

Tabela 2: Lokacija Kragulovec, talon vzorčenje. n -Število ulovljenih osebkov določene vrste pri posameznem vzorčenju, D - dominanca, ind/m^2 - povprečna gostota osebkov z 95% intervalom zaupanja, N –celotno število osebkov pri posameznem vzorčenju, average.ind/m^2 - povprečna gostota osebkov na posamezni lokaciji, Jackknife – ocena vrstnega bogastva, S-W - Shannon-Wiener indeks, (E) - parameter stalnosti.

	Sampling date	1.6.2010					17.8.2010					17.11.2010				
o.	Species (vrste)	n	D (%)	ind/m^2	min	max	n	D (%)	ind/m^2	min	max	n	D (%)	ind/m^2	min	max
geo	*C. carinthiacus*	34	24.8	109.1	17.1	135.7	7	10.3	22.5	9.9	35.0	1	0.8	3.2	0.0	7.4
geo	*E. pinguis*	3	2.2	9.6	0.2	19.1	2	2.9	6.4	0.0	12.6					
geo	*G. (O.)* n.sp.											1	0.8	3.2	0.0	7.4
geo	*S. carniolensis*	8	5.8	25.7	1.8	38.6	6	8.8	19.3	0.0	29.3	28	22.8	89.9	25.6	154.1
geo	*S. nemorensis*						1	1.5	3.2	0.0	7.4	1	0.8	3.2	0.0	7.4
geo	*S. tyrolensis*	7	5.1	22.5	1.8	43.1						8	6.5	25.7	5.8	45.6
geo	*S. sorrentina*	2	1.5	6.4	0.0	12.3	1	1.5	3.2	0.0	7.4	13	10.6	41.7	14.8	68.6
geo	*S. acuminata*	2	1.5	6.4	0.0	12.6	3	4.4	9.6	0.0	17.1	3	2.4	9.6	0.2	19.1
geo	*S. transsilvanica*	2	1.5	6.4	0.0	12.3	1	1.5	3.2	0.0	7.4	3	2.4	9.6	0.2	19.1
lit	*L. burzenlandicus carinthiacus*	3	2.2	9.6	0.2	19.1										
lit	*L. castaneus*	1	0.7	3.2	0.0	7.4										
Lit	*L. latro*	4	2.9	12.8	0.0	26.5	2	2.9	6.4	0.0	12.3	1	0.8	3.2	0.0	7.4
lit	*L. nodulipes*						4	5.9	12.8	0.0	21.7	2	1.6	6.4	0.0	12.3
lit	*L. pelidnus*	1	0.7	3.2	0.0	7.4										
lit	*L. pygmaeus*	22	16.1	70.6	29.4	111.8	13	19.1	41.7	7.6	75.9	15	12.2	48.1	11.6	84.7
lit	*L. (M.)* n.sp.	1	0.7	3.2	0.0	7.4										
sco	*C. hortensis*	1	0.7	3.2	0.0	7.4	1	1.5	3.2	0.0	7.4					
sco	*C. parisi*	13	9.5	41.7	7.6	75.9	6	8.8	19.3	2.9	35.6	3	2.4	9.6	0.2	19.1
sco	*C. rucneri*	3	2.2	9.6	0.0	17.1										
lit	*Harpolithobius* sp.											3	2.4			
lit	*Lithobius* juv	27	19.7	89.9	36.1	143.6	19	27.9	61.0	20.5	101.5	41	33.3	131.6	34.4	228.7
lit	*Lithobius* sp.	3	2.2				2	2.9								
N		137					68					123				
Aver. ind./m^2 (min-max)		343,4 (158,4-528,6)					218.3 (100.6-332.6)					394.8 (257.3-532.1)				
Species No.		16					12					12				
Jackknife		20 (17-24)					16 (12-21)					16 (12-19)				
S – W		2.14					2.15					1.89				
E		0.77					0.86					0.76				

Table 3: Location Smrekov žleb, soil sampling method. n – the number of collected centipedes belonging to single species, D - dominance, ind/m² (min, max) - density estimation with 95% confidence. N- the number of all individuals in one sampling, densities (ind/m²) on each location, Jackknife – species richness (max.number estimation), S - W – Shanon-wiener indeks, E – parameter stalnosti

Tabela 3: Lokacija Smrekov žleb, talno vzorčenje. n -Število ulovljenih osebkov določene vrste pri posameznem vzorčenju, D - dominanca, ind/m² - povprečna gostota osebkov z 95% intervalom zaupanja, *N*–celotno število osebkov pri posameznem vzorčenju, average.ind/m² - povprečna gostota osebkov na posamezni lokaciji, Jackknife – ocena vrstnega bogastva, S - W – Shannon-wiener diversity index, E – Evenness

	Sampling date	1.6.2010					17.8.2010					17.11.2010				
	Species (vrsta)	n	D (%)	ind/m²	min	max	n	D (%)	ind/m²	min	max	n	D (%)	ind/m²	min	max
geo	*C. carinthiacus*	4	2.5	12.8	0.0	21.2	5	4.8	16.0	2.3	29.8					
geo	*D. carniolensis*	2	1.3	6.4	0.0	12.3	4	3.8	12.8	0.0	21.2					
geo	*E. pinguis*	11	6.9	35.3	4.3	66.3	5	4.8	16.0	6.1	26.0	7	4.1	22.5	0.0	32.7
geo	*G. (O.)alpinus*						3	2.9	9.6	0.0	17.1	6	3.5	19.3	2.9	35.6
geo	*G. (O.)* n.sp.	4	2.5	12.8	0.0	20.2	1	1.0	3.2	0.0	7.4	7	4.1	6.4	0.0	32.4
geo	*S. carniolensis*	6	3.8	19.3	0.0	25.9	1	1.0	3.2	0.0	7.4	13	7.6	41.7	8.9	74.5
geo	*S. tyrolensis*	3	1.9	9.6	0.2	19.1						21	12.2	67.4	29.9	93.2
geo	*S. sorrentina*	4	2.5	12.8	0.0	26.5	1	1.0	3.2	0.0	7.4					
geo	*S. acuminata*	2	1.3	6.4	0.0	12.3	2	1.9	6.4	0.0	12.3	3	1.7	9.6	0.0	17.1
geo	*S. transsilvanica*	1	0.6	3.2	0.0	7.4	1	1.0	3.2	0.0	7.4	1	0.6	3.2	0.0	7.4
lit	*H. gottscheensis*											1	0.6	3.2	0.0	7.4
lit	*L. burzenlandicus carinthiacus*	4	2.5	12.8	0.0	21.7	3	2.9	9.6	0.0	17.1	3	1.7	9.6	0.2	19.1
lit	*L. castaneus*	2	1.3	6.4	0.0	12.3										
lit	*L. latro*	2	1.3	6.4	0.0	12.3	1	1.0	3.2	0.0	7.4	2	1.2	6.4	0.0	12.3
lit	*L. nodulipes*						1	1.0	3.2	0.0	7.4					
lit	*L. pelidnus*						2	1.9	6.4	0.0	12.6					
lit	*L. pygmaeus*	9	5.6	28.9	3.9	53.8	22	21.0	70.6	21.5	119.7	14	8.1	44.9	13.5	76.4
lit	*L. punctulatus*						1	1.0	3.2	0.0	7.4					
lit	*L. tenebrosus*	2	1.3	6.4	0.0	12.6						1	0.6	3.2	0.0	7.4
lit	*L.(M.)aeruginosus*											1	0.6	3.2	0.0	7.4
lit	*L. (M.)* n.sp.	14	8.8	44.9	9.5	80.4	1	1.0	3.2	0.0	7.4	6	3.5	19.3	0.4	38.1
lit	*L. (S.)* n.sp.*"anici"*	49	30.6	157.3	52.6	261.9	12	11.4	38.5	4.8	54.9	23	13.4	134.8	24.1	105.2
sco	*C. hortensis*	5	3.1	16.0	2.3	29.8	10	9.5	32.1	3.1	61.1	3	1.7	9.6	0.0	17.1
sco	*C. parisi*	16	10.0	51.4	24.9	70.8	10	9.5	32.1	1.9	46.6	13	7.6	41.7	18.4	65.0
sco	*C. rucneri*	5	3.1	16.0	2.3	29.8	2	1.9	6.4	0.0	12.3	3	1.7	9.6	0.2	19.1
lit	*Harpolithobius* sp.	1	0.6													
lit	*Lithobius* juv	12	7.5	41.7	18.4	65.0	17	16.2	54.6	20.0	89.1	42	24.4	134.8	38.0	192.0
lit	*Lithobius* sp.	2	1.3									2	1.2			
N		160					105					172				
Average. ind./m² (min-max)		513.5 (335.7-691.1)					337.0 (267.6-406.3)					552.1 (427.7-676.2)				
Species No.		19					20					18				
Jackknife		22 (19 - 25)					28 (21-34)					22 (18 - 26)				
S - W		2.37					2.47					2.45				
E		0.81					0.83					0.85				

tion Kragulovec (68.2%), followed by assemblies in Smrekov žleb in June and November (64.7%) (Tab.4). Overall centipede assemblies were more similar in one location during the season than assemblies from different locations in the same month (Fig. 2).

Table 4: Matrix of similarity coefficients (Renkonen index) for all samples. K1 - Kragulovec 1.6.2010, K2 - Kragulovec 17.8.2010, K3 – Kragulovec 17.11.2010; SmZ1 – Smrekov žleb 1.6.2010, SmZ2 – Smrekov žleb 17.8.2010, SmZ3 – Smrekov žleb 17.11.2010

Tabela 4: Matrica podobnosti (Rankonenov indeks) med posameznimi vzorčenji. K1 – Kragulovec 1.6.2010, K2 - Kragulovec 17.8.2010, K3 – Kragulovec 17.11.2010; SmZ1 – Smrekov žleb 1.6.2010, SmZ2 – Smrekov žleb 17.8.2010, SmZ3 – Smrekov žleb 17.11.2010

	K1	K2	K3	SmZ1	SmZ2	SmZ3
K1						
K2	0,682					
K3	0,449	0,499				
SmZ1	0,427	0,361	0,248			
SmZ2	0,547	0,564	0,331	0,569		
SmZ3	0,487	0,423	0,407	0,647	0,582	

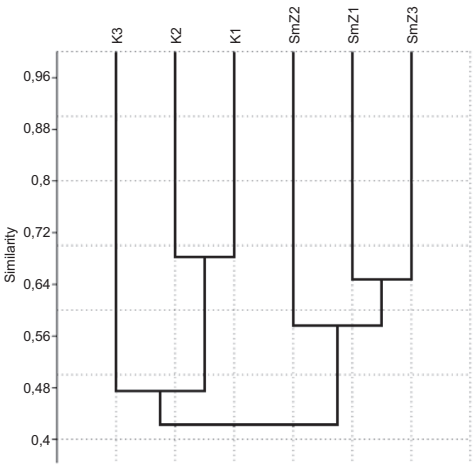

Figure 2: Dendrogram of similarity using Renkonen index of similarity) between locations (soil sampling method). Key: K1 - Kragulovec 1.6.2010, K2 - Kragulovec 17.8.2010, K3 – Kragulovec 17.11.2010; SmZ1 – Smrekov žleb 1.6.2010, SmZ2 – Smrekov žleb 17.8.2010, SmZ3 – Smrekov žleb 17.11.2010

Slika 2: Dendrogram podobnosti med posameznimi lokacijami (talni vzorci) po Renkonenovemu indeksu podobnosti. Legenda: K1 – Kragulovec 1.6.2010, K2 - Kragulovec 17.8.2010, K3 – Kragulovec 17.11.2010; SmZ1 – Smrekov žleb 1.6.2010, SmZ2 – Smrekov žleb 17.8.2010, SmZ3 – Smrekov žleb 17.11.2010

Discussion

Presentation of species

Many studies was made stating that for most representative faunistic studies combination of quantitative and qualitative sampling methods should be used (Kos, 1988a, Fründ et al. 1997, Leśniewska 2000, Grgič 2005). Much smaller number of individuals obtained with hand collecting method is the result of lower effort compared with soil sampling method. Nevertheless according to the given estimation of species richness repeated sampling would result in 2 (in location Kragulovec) to 6 (location Smrekov žleb) additional species at most. We can therefore conclude that our sampling was sufficiently intense and that most of the species present in frost hollows were captured. Below are in more detail presented 4 species which are endemic to the southeast Alps or/and the northwest Balkan region, one species with alpine character and two species with boreal character (in alphabetical order).

Eurygeophilus pinguis Brolemann, 1898

In Slovenia there were 36 individuals found in the Dinaric and alpine region (Kos 1988a, Kos unpublished) and 28 more individuals in frost hollows (Vode & Kos this research). They were first determined as *Chalandea scheerpeltzi* Attems, 1952, following Attems (1952) and Koren (1986) with reference to their physical characteristics and number of legs. All male individuals had 33 and all female indivividuals had 35 pairs of leg namely. After the revision (Bonato et al. 2006) *C. scheerpeltzi* was put in the synonimics with *E. pinguis*.

Individuals of ***Geophilus ("Orinophilus")* n. sp.** were found in Kočevska reka (Kos and Praprotnik 2000), Mala gora near Kočevje (Grgič 2002), near Ribnica (Kos 1988a) in the valley Iška (Grgič 2005), in Cerkno (Pagon 2006) and in the

frost hollows near Velika gora (Vode & Kos, this research). Altogether 60 individuals were found and identification key for thee potentially new species is in preparation.

We found one individual of the species ***Harpolithobius gottscheensis*** Verhoef, 1937. Till now several individuals were found in the Karst Edge (Kos 1990), Kočevski Rog (Kos & Grgič 2001), valley Iška (Grgič 2005) and Boč plateau (Ravnjak 2006). According to current knowledge this species is rare in Slovenia and it is considered endemic in northern Dinarides and southeast Alps (Kos, 2012).

Lithobius borealis Meinert, 1868 is paleartic species, common in boreal forests in northern Eurasian area. It was found sparsely in Slovenian Alps (Kos et al. 2000), valley Iška (Grgič 2005) and Dinaric region (Kos 1988a, 1995a, b; Vode & Kos this research). Altogether there have been only 17 individuals found in Slovenia so far.

Lithobius tenebrosus Meinert, 1872 is widespread in boreal forests in Northern and Central Europe and the Carpathian Mountains (Chilobase, Kos 1995b). With its unique metabolism it is adapted to the environments with low temperature (Kos unpublished). It was found in alpine, sub alpine and Dinaric region of Slovenia (Kos 1988b, Kos et al. 2000, Pagon 2006, Grgič 2002, 2005, respectively) almost exclusively with hand collecting method. Its colder preferences were confirmed with this study as it was most abundant species found in frost hollows with hand collecting method.

There were 38 individuals of the species ***Lithobius* (*Monotarsobius*) n. sp.** found in Kočevski Rog (Kos 1995b), Kočevje area (Kos and Praprotnik 2000), the valley Iška (Grgič 2005), Cerkno (Pagon 2006) and Kras (Kos et al. unpublished). In this study 23 more individuals were found, which is noticeable contribution to facilitate the description of this potentially new species.

***Lithobius (Sigibius*) n. sp. "anici"** is new species for science and was fist found in Kočevje area, where it was one of the most abundant species (Kos 1988a). Later it was also found in Bosnia (Kos 1992), Slovenian Karst (Kos 1995a), in the valley Iška (Grgič 2005), Kočevje area (Kos in Praprotnik 2000, Vode & Kos this research). Altogether there were almost 800 individuals found which makes this species one of the most numerous species of Dinaric region in Slovenia.

Centipede assemblies' characteristics

Comparing to other locations in Dinaric region in Slovenia (where densities and species number were as high as 44 species and 892 ind./m^2 (Grgič 2005)) average density of centipedes from 218 ind./m^2 to 552 ind./m^2 and number of species 22 to 28 defines centipede assemblies in frost hollows as medium rich. But when comparing to forest assemblies in Europe can be defined as (very) rich. In Poland for instance Leśniewska (2000) found up to 19 species with average density 181 ind./m^2 in *Querco-Carpinetum* forest with two sampling methods. Tuf (2000) found 2 - 9 species (max. aver. density 250 ind./m^2 with soil sampling method) in different successional stages of *Querco-Ulmetum* association and Wytwer (2000) found 6 – 9 species (max. aver. density 40 ind/m^2 with Barber' pitfall traps) in 5 different forests types. Studies made in Germany by Albert (1982) and Fründ (1987) also reviled smaller numbers of species (4 – 9) and lower densities (up to 171 ind/m^2) as have studies in England (Roberts 1957: 7 species, 150 ind./m^2) and in Hungary (Loksa, 1979: 7-9 species, up to 234 ind./m^2). Jet we must point out that all densities made by Slovenian authors were determined on the basis of sampling the unoccupied ("free") surface. The data are therefore not fully compatible with other authors who used different combination of sampling methods and statistical analysis.

Seasonal depended centipede assemblies changes

According to the temperature of the soil and air in the frost hollows made in previous studies (see "Introduction") we presume that evaporation in the frost hollows is smaller and soil retains more moisture than in the surroundings. Knowing that centipedes actively choose the most optimal locations available (Grgič and Kos 2001) and that they are capable of relatively long distance migra-

tion (referring to larger epidaphic species) (Kos 1995a, Grgič 2005) we were anticipating there will be seasonal migration to frost hollows from the surrounding area in the summer, meaning that centipede densities in the frost hollows would be higher in the summer months. Our results reject this theory as the average centipede density was in the summer in both locations lower than in spring or in autumn. Our presumptions are therefore that in summer months when the temperatures were higher, larger more mobile species migrated out of frost hollows, while smaller less mobile species moved deeper in the soil. The disclosure of reasons for this migration as well as the confirmation of our migrational theory still have to be done.

Diversity, evenness and similarity

Although the average densities were in the summer the lowest, the S – W diversity index and the evenness index were in the summer the highest in both frost hollows. Interpretation of the dominance tells us why. In every sampling 2 - 3 species and juvenile Lithobiidae had very high dominance. In location Kragulovec they were presenting 57 – 77% of all captured individuals. In spring species *Clinopodes carinthiacus* had 24.8% dominance. Increased evenness rate in summer in Kragulovec can be attributed to more balanced proportions of species present while *C. carinthiacus* dominance declined to 10.3%. Again lower evenness rate and S – W index in autumn are due to the increased dominance of *Schendyla carniolensis, Stenotaenia sorrentina* and *Lithobius pygmaeus*. In location Smrekov žleb S – W diversity index and evenness rate were higher comparing to Kragulovec as three most dominant taxa represent "only" 48 – 49% of all species found. In this location *Lithobius (Sigibius)* n.sp. "anici" was most dominant species in all samplings followed by one more species (*C. parisi* in the spring, *L. pygmaeus* in the summer and *S. tyrolensis* in the autumn) and juvenile Lithobiidae. Whereas the total dominance of the 3 most dominant species did not change during the season so did not the S – W and evenness index.

Dendrogram of similarity show distinct difference between frost hollows. The assemblies were more similar in the same location during the season, than to assemblies in the same month in other location. We assume that species composition of centipede assembly therefore depends more with respect to the surroundings rather than by environmental conditions in the frost hollows.

Conclusions

According to results we can confirm all hypotheses. We found 6 species that are endemic for northeren Dinarides or southeasteren Alps, 3 of them are probably new to science. Species with middle European distribution were far most numerous frost hollows, followed by species with palearctic distribution. We found *Eurygeophilus pinguis* which is alpine species and two species with boreal character: *Lithobius borealis* and *Lithobius tenebrosus*, last being the most numerous species obtained with hand collecting method. There were statistical differences in species composition and densities during the season. From the results we predict that there is an active season migration between frost hollows and surroundings. We assume that frost hollows in Dinaric region are "refugia" of local populations of certain species thus having an important role when concerning maintaining population viability and biodiversity of the area. Due to this features we believe that frost hollows are suitable sampling sites for monitoring of impact of climatic changes on centipedes. To confirm our theories more comprehensive seasonal sampling with additional sampling methods should be carried out.

Povzetek

Namen raziskave je bil ugotoviti vrstno sestavo in gostoto strig v mraziščih, ter kako se tekom vegetacijske sezone spreminjata. Predvidevali smo, da bomo našli redke ali nove vrste za slovensko favno strig, da bomo poleg vrst s srednjeevropskim in palearktičnim arealom razširjenosti našli vrste z alpskim in borealnim značajem, kar smo potrdili. Našli smo 6 endemnih vrst, od katerega so 3 najverjetneje nove za znanost, vrsto *Eurygeophilus pinguis*,ki ima alpski značaj in dve vrsti z borealnim značajem, *Lithobius tenebrosus* in *Lithobius borealis*. Skupno smo dobili 22 in 28 vrst v posameznem mrazišču, povprečna gostota

je bila od 218 os./m^2 do 552 os./m^2, kar uvršča združbo strig v mraziščih med srednje bogate združbe v primerjavi z drugimi lokacijami v slovenski dinarski regiji oziroma med zelo bogate v primerjavi z drugimi evropskimi gozdnimi lokacijami. Povprečna gostota je bila poleti na obeh lokacijah najmanjša, kar je v nasprotju z našimi predvidevanji, da strige poleti migrirajo v mrazišča zaradi nižjih temperatur in posledično večje vlažnosti. Zato predvidevamo, da se strige poleti ali umaknejo ven iz mrazišč ali pa se pomaknejo globlje v tla, kar pa s to študijo nismo uspeli potrditi. Prav tako ostaja nepojasnjeno, kateri parametri so glavni razlog za sezonske spremembe v združbi strig v mraziščih, saj temperatura sama očitno nima glavnega vpliva. Vrstna pestrost v izbranih mraziščih je primerljiva z vrstno pestrostjo dinarskih bukovo-jelovih gozdov in je višja od mezofilnih gozdov srednje in severne Evrope. V obeh mraziščih sta bila vrednost Shannon – Wienerjevega indeksa ter indeksa stalnosti najvišja v avgustovskem vzorčenju. To lahko razložimo s stopnjo dominance treh najštevilčnejših taksonov. Poleti so bile vrste bolj enakomerno zastopane kot spomladi ali jeseni, ko so dominirali juvenilni litobidi in vrste *Clinopodes carinthiacus, Lithobius pygmeus, Schendyla carniolensis* in *Stenoteania sorrentina* v lokaciji Kragulovec, oziroma juvenilni litobidi in vrste *Schendyla tyrolensis*, *Lithobius (Sigibius)* n.sp. »anici« in *Cryptops parisi* v lokaciji Smrekov žleb. Ocena podobnosti po Renkonenu je pokazala, da so bile združbe strig v posameznem mrazišču tekom sezone bolj podobne med sabo, kot z združbo v drugem mrazišču vzorčeno v istem obdobju, kar pomeni, da je vrstna sestava združbe strig bolj odvisna od vrstne sestave okolice, kot od okoljskih značilnosti mrazišča. Ta preliminarna raziskava združb strig v mraziščih utemeljuje potrebo po sezonskem vzorčenju z dodatnimi metodami, da bomo lahko potrdili naše domneve glede sezonske migracije strig med mraziščem in okolico in o refugialnem pomenu mrazišč za določene vrste. Že sedaj pa lahko predvidevamo, da so mrazišča primerna vzorčna mesta za spremljanje vplivov klimatskih sprememb na združbe strig.

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Skull modularity of the European ground squirrel *Spermophilus citellus* (Linnaeus, 1766)

Modularnost lobanje evropske tekunice *Spermophilus citellus* (Linnaeus, 1766)

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Abstract: The skull is a complex structure that has frequently been studied for the patterns of morphological integration and modularity. The ventral side of the skull can be divided into two functional modules, the neurocranium composed of the braincase, eyes and ears, and the viscerocranium composed of the jaw apparatus. The aim of this study was to test the ventral cranium of the European ground squirrel *Spermophilus citellus* (Linnaeus, 1766) for this partitioning as sciurid skull is believed to be highly integrated without clear divisions into subunits. Additionally, I compared the degree of modularity between juveniles and adults. Hypothesized modularity was tested on 159 (43 juveniles and 116 adults) skulls by applying geometric morphometric method based on Escoufier RV coefficient. In adults, the results yielded strong support to the hypothesis that the viscerocranium and neurocranium are separate modules. In juveniles, two-module organization of the skull was also confirmed, but the hypothesized modules were much more integrated with each other. Although allometry can be a strong integrating factor, it had very little influence on the hypothesized modularity of the *S. citellus* skull. A permutation test for the difference in the degree of modularity between juveniles and adults was marginally significant. The change in the strength of integration between the viscerocranium and neurocranium in the *S. citellus* skull during ontogeny, with the higher level of modularity in adults than in juveniles, is probably a consequence of the transition from suckling to gnawing of food and greater specialisation of the two functional modules.

Keywords: neurocranium, viscerocranium, ontogeny, allometry, Escoufier RV, morphological integration, geometric morphometrics

Izvleček: Lobanja je kompleksna struktura, pri kateri se pogosto preučujejo vzorci morfološke modularnosti in integracije. Ventralno stran lobanje lahko razdelimo v dve funkcionalni podenoti; nevrokranij, ki ga sestavljajo kosti možganskega dela lobanje, oči in ušes, in viscerokranij, ki je iz kosti čeljustnega aparata. Cilj raziskave je bil preveriti prisotnost te delitve na ventralni strani lobanje evropske tekunice *Spermophilus citellus* (Linnaeus, 1766), saj za lobanje veveric velja, da imajo visoko stopnjo integracije brez jasnih delitev na podenote. Primerjala sem tudi stopnjo modularnosti med mladimi in odraslimi osebki. Hipotetično modularnost sem testirala na 159 (43 mladih in 116 odraslih) lobanjah z metodami geometrijske morfometrije na osnovi

Escoufierjevega RV koeficienta. Pri odraslih osebkih so rezultati podprli hipotezo o delitvi lobanje na viscerokranij in nevrokranij. Hipotezo o modularnosti sem potrdila tudi pri mladih osebkih, le da sta bila modula med seboj veliko bolj povezana. Čeprav je alometrija lahko močan integracijski faktor, je imela na hipotetično modularnost lobanje *S. citellus* zelo majhen vpliv. Permutacijski test, s katerim sem testirala razliko v stopnji modularnosti med mladimi in odraslimi osebki, je bil na meji signifikantnosti. Sprememba v stopnji povezanosti med viscerokranijem in nevrokranijem pri lobanji *S. citellus* med ontogenijo, z višjim nivojem modularnosti pri odraslih kot pri mladih, je verjetno posledica prehoda s sesanja na glodanje hrane ter večje specializacije obeh funkcionalnih modulov.

Ključne besede: nevrokranij, viscerokranij, ontogenija, alometrija, Escoufier RV, morfološka integracija, geometrijska morfometrija

Introduction

The skull is a complex structure composed of many parts that have different embryonic origins and functions (Klingenberg et al. 2004). To function as a whole, the parts of the skull are integrated (Olson and Miller 1958). The integration is not evenly distributed, but rather structured into modules (Klingenberg et al. 2004) that are internally tightly correlated and relatively independent from other modules (Klingenberg 2008). Integration and modularity of a structure can be studied by analyzing the covariation among its traits (Drake and Klingenberg 2010). In morphometrics, traits are usually measured by the use of lenghts or landmarks. It has been shown that in studies of integration and modularity the two methodologies, i. e. traditional, using linear measurements, and geometric, using landmarks, give similar results (Goswami and Polly 2010, Jojić et al. 2012). Goswami and Polly (2010) also compared different exploratory and confirmatory approaches for studying integration and modularity and did not find statistically distinguishable differences among them.

Integration and modularity of the skull have been the most frequently studied in primates, whereas in rodents, analyses of the mandible modularity have been more popular (e. g. Klingenberg and Leamy 2001, Jojić et al. 2007, Klingenberg 2009, Swiderski and Zelditch 2010, Jojić et al. 2012). The ventral side of the skull can be divided into two functional components, the neurocranium composed of the braincase, eyes and ears, and the viscerocranium composed of the jaw apparatus (Emerson and Bramble 1993). However, different analyses of the rodent skull showed that patterns of modularity can be inconsistent and sometimes unclear (Klingenberg 2013). Among rodents, modularity and integration in sciurid skulls are, especially compared to murid skulls, poorly investigated. Olson and Miller (1958) studied the fox squirrel *Sciurus niger* and discovered that its skull is well integrated without clear subdivisions into subunits. Moreover, Roth (1996) suggested that high integration of the sciurid skull is a general feature of the family; probabaly because of its conservative evolution.

European ground squirrel, *Spermophilus citellus* (Linnaeus, 1766), inhabits dry grasslands and open woodland throughout central and southeastern Europe (Ramos-Lara et al. in press). It is a relatively well-studied species with clear phylogenetic stucturing and reasonably well-known ecology and life history (ibid.). Because of its longevity and well defined age stages, *S. citellus* is also a good organism for studying changes in the strength of integration over postnatal ontogeny, a process that has been previously investigated in some rodent skulls (Willmore et al. 2006, Zelditch et al. 2006, Gonzalez et al. 2011, Klingenberg 2013).

In this study, I applied geometric morphometric methods to test the *S. citellus* ventral cranium for hypothetical partitioning to two functional modules, the viscerocranium and neurocranium, despite the previous findings that the sciurid skull is highly integrated (Olson and Miller 1958, Roth 1996). Additionally, based on prediction that the shift in diet during ontogeny could influence the strength of integration between modules, I compared the level of modularity between juveniles and adults.

Material and Methods

I studied 159 skulls of *S. citellus* from Burgenland (Austria) and Banat (Serbia). Specimens are deposited in the Slovenian Museum of Natural History (Ljubljana, Slovenia), the Museum of Natural History (Vienna, Austria), and the Zoological Research Museum Alexander Koenig (Bonn, Germany). Individuals were categorized either as juveniles (1 - 5 months old, caught after natal emergence to the end of September) or adults (> 5 months old, caught just before or after the first hibernation). Age was estimated on the basis of molar tooth wear (Ružić 1966) and the date of collection. Very old individuals (after the fourth hibernation) were excluded. The sample comprised 24 juveniles and 70 adults from Burgenland, and 19 juveniles and 46 adults from Banat. Adults from different seasons were pooled because a previous study of the *S. citellus* skull ontogeny (Klenovšek and Kryštufek 2013) showed that the skull shape does not change after the age of five months, which means that the majority of shape changes during growth are correlated with the shift from a liquid to a solid diet that takes place before the first hibernation.

The ventral side of the skulls was photographed under constant conditions, following Cardini and Tongiorgi (2003). Twenty-two two-dimensional landmarks were digitized on the left side of the skull (Fig. 1), using the tpsDig program (Rohlf 2010). Landmark precision was tested for digitizing error as described in Klenovšek and Kryštufek (2013). The digitizing error was low.

Landmark coordinates were superimposed using the generalized Procrustes analysis (GPA) (Rohlf and Slice 1990) to standardize size and remove the differences in landmark configurations due to position and orientation. With GPA, I obtained centroid sizes (CS) and Procrustes coordinates for all skulls. The CS is a geometric measure of size calculated as the square root of the sum of squared distances between each landmark and the centroid of the landmark configuration

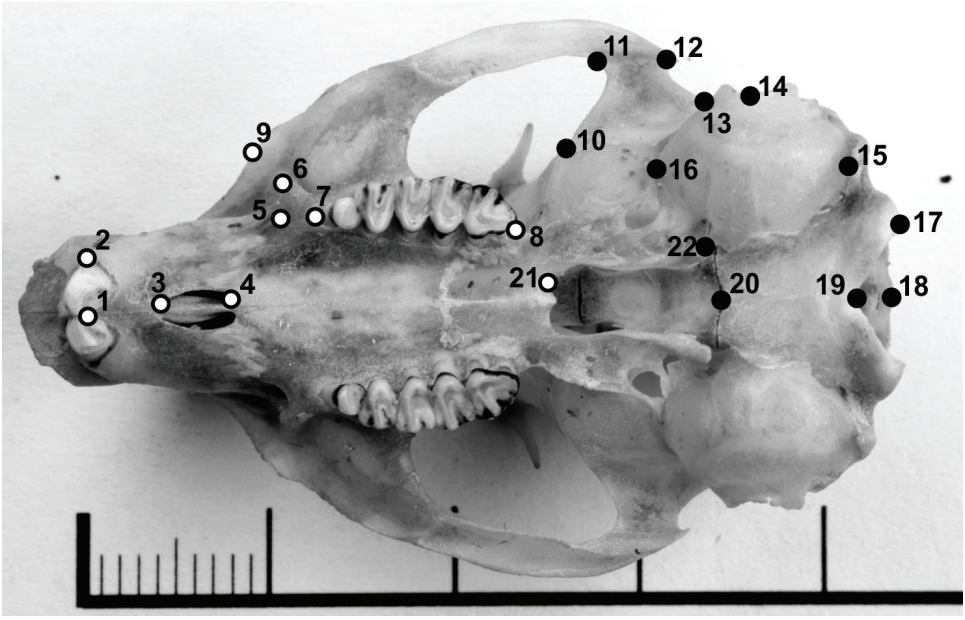

Figure 1: Ventral side of the cranium of *S. citellus* with 22 landmarks divided into two hypothesized modules (white dots – viscerocranium, black dots – neurocranium). For definitions of landmarks see Klenovšek and Kryštufek 2013

Slika 1: Ventralna stran lobanje *S. citellus* z 22 oslonilnimi točkami razdeljenimi na dva hipotetična modula (bele pike – viscerokranij, črne pike – nevrokranij). Za opis točk glej Klenovšek and Kryštufek 2013

(Bookstein 1991). Procrustes coordinates are shape variables containing the complete information on shape variation after superimposition.

A previous study of the ventral side of the skull of *S. citellus* (Klenovšek and Kryštufek 2013), performed on the same material, detected sexual dimorphism (SD) in the size of the skull in adults. Because there was no SD in the skull shape, the sexes were pooled in the current study. Population differences between Burgenland and Banat were also significant in skull size as well as shape (for results see Klenovšek and Kryštufek 2013). Nevertheless, morphometric distances between populations at different ages showed that differences between juveniles and adults exceeded the differences between populations (ibid.). I therefore pooled juveniles and adults from Burgenland and Banat.

To evaluate the hypothesis that in *S. citellus* the anterior part of the ventral cranium (the upper jaw bones with the palate or the viscerocranium) and the posterior part (the skull base or the neurocranium) are modules, the configuration of 22 landmarks was divided into subsets of 10 (viscerocranium) and 12 (neurocranium) landmarks (Fig. 1).

I compared the degree of covariation between the hypothesized modules to alternative spatially contiguous partitions with the same number of landmarks as in the hypothesized modules (Klingenberg 2009).

The strength of association between the sets of landmarks was estimated with the RV coefficient, a multivariate generalization of the Pearson correlation coefficient (Escoufier 1973), which represented the amount of covariation scaled by the amount of variation within the two sets of variables. If the two sets of variables are completely uncorrelated, the RV coefficient takes the value of zero, and the value of one, if the two sets of variables are completely interdependent (Klingenberg 2009). If the hypothesis of modularity holds, the RV coefficient for the selected partition should be the lowest value, or at least near the lower extreme of the distribution of RV coefficients of all partitions (Klingenberg 2009). I separately computed RV coefficients for the hypothesized modules for juveniles and adults. Because allometry can have a major effect on detection of modularity (e. g. Hallgrímsson et al. 2006, Klingenberg 2009), I afterwards corrected the data for allometry and repeated the analyses of modularity with the residuals from the multivariate regression of shape on the centroid size for each age group. Because the value of RV coefficient can depend on the sample size as well as on the difference in sample size between groups (Fruciano et al. 2013), I computed the Escoufier RV coefficients (Escoufier, 1973) for both age classes, and performed a permutation test of the null hypothesis of no difference in the RV coefficient between juveniles and adults (Fruciano et al. 2013).

Statistical analyses were performed using the IBM SPSS Statistics (2008), and analyses of morphological modularity with the MorphoJ software (Klingenberg 2011) and RVComparison 1.0 (Fruciano et al. 2013).

Results

In juveniles, 294 (or 3.9 %) of the 7460 partitions had a lower RV coefficient than the partition into the hypothesized modules, and in adults, none of the 7460 alternative partitions had a lower RV coefficient (Fig. 2). Both age groups had similar minimal RV values (juveniles: RV = 0.282, adults: RV = 0.212). In adults, the RV coefficient for the hypothesized subdivision was clearly in the lower extreme of the distribution of RV coefficients, which was consistent with the hypothesis that viscerocranium and neurocranium of the *S. citellus* ventral side of the skull are distinct modules. A higher RV coefficient in juveniles (RV = 0.330) for the hypothesized partition, and the percent of partitions with lower RV coefficients, indicated that juveniles, compared to adults, are characterized by a lower level of modularity.

Regressions of shape variables onto CS showed statistically significant effect of size on shape in both age groups. In juveniles, the allometry accounted for 10.77 % of shape variation, and in adults, for 4.82 %. After the correction for allometry, the values of RV coefficients between the viscero- and neurocranium were in both age groups higher than before the correction (Fig. 3). In both age groups, the range of the distribution of RV coefficients for all alternative partitions broadened mainly to the right side, towards the higher values of RV coefficients. In juveniles, the P-value slightly lowered.

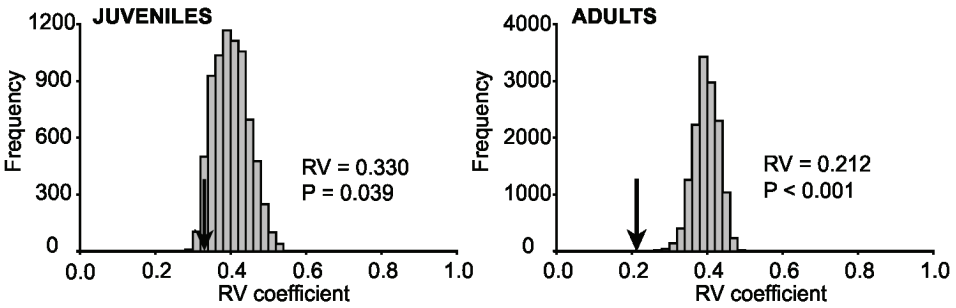

Figure 2: Histograms of the RV coefficients of all spatially contiguous partitions of the ventral skull landmark configurations for juveniles and adults. The arrows indicate the values of RV coefficients beween the hypothesized modules (viscerocranium vs. neurocranium). The P value is the proportion of partitions with lower RV than observed for the hypothesized modules

Slika 2: Histograma RV koeficientov vseh prostorsko sosednjih delitev konfiguracije oslonilnih točk ventralne strani lobanje za mlade in odrasle osebke. Puščice označujejo vrednosti RV koeficientov med hipotetičnima moduloma (viscerokranijem in nevrokranijem). P-vrednost je delež delitev z nižjim RV koeficientom kot tistim za hipotetična modula

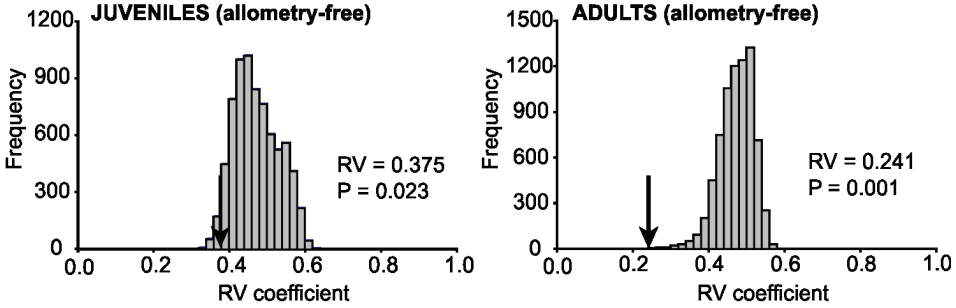

Figure 3: Histograms of the RV coefficients of all spatially contiguous partitions of the ventral skull landmark configurations for juveniles and adults after the correction for allometry. The arrows indicate the values of RV coefficients beween the hypothesized modules (viscerocranium vs. neurocranium). The P value is the proportion of partitions with lower RV than observed for the hypothesized modules

Slika 3: Histograma RV koeficientov vseh prostorsko sosednjih delitev konfiguracije oslonilnih točk ventralne strani lobanje za mlade in odrasle osebke po izločitvi vpliva alometrije. Puščice označujejo vrednosti RV koeficientov med hipotetičnima moduloma (viscerokranijem in nevrokranijem). P-vrednost je delež delitev z nižjim RV koeficientom kot tistim za hipotetična modula

Finally, the Escoufier RV coefficients of juveniles and adults were 0.331 and 0.158, respectively. Permutation test for the difference in modularity between *a priori* defined groups disclosed that the difference in RV coefficient between juveniles and adults (0.173) was marginally significant (P = 0.050).

Discussion

The ventral skull is a complex structure that can be divided into two functional components, the neurocranium and the viscerocranium (Emerson and Bramble 1993). Olson and Miller (1958) and Roth (1996), on the other hand, discovered that squirrels have a highly integrated skull without clear subdivisions into subunits. Nevertheless, in

the current study, the analysis of the covariation among landmarks in the ventral cranium yielded strong support to the hypothesis that in *S. citellus* the viscerocranium and neurocranium are separate modules. I also analyzed the strength of integration between the hypothesized modules of the *S. citellus* ventral cranium during ontogeny and observed that the level of modularity was higher in adults than in juveniles, i.e. the hypothesized modules in the juvenile skull were more integrated with each other. In adults, the partition to viscerocranium and neurocranium had the lowest RV value from all alterative partitions and therefore the lowest degree of covariation. In juveniles, the RV of the hypothesized modules was near the lower extreme of the distribution of RV coefficients. Nevertheless, both age groups had similar minimal RV values. Minimal RV value applies minimal covariation between sets of landmarks and was in adults congruent with the partition to viscerocranium and neurocranium. In juveniles, a pattern of modularity emerged that did not match the subdivision into functional modules. A further study might discover a model of association between cranial traits different from conventional modules. Allometry can be a strong integrating factor (Klingenberg 2009), but it had little influence on the hypothesized modularity of the *S. citellus* skull in juveniles as well as in adults, probably because the amount of shape variation explained by allometry was low. Although marginally significant, observed difference in RV coefficients between the two age classes also suggests that in *S. citellus* the strength of association between viscerocranium and neurocranium was higher in juvenile than in adult skull.

The relationship between the developmental determinants of integration and phenotypic covariance is very complicated, therefore the integration cannot be studied through phenotypic covariance patterns alone (Hallgrímsson et al. 2009). Nevertheless, it is commonly known that functionally and developmentally related traits are more integrated than traits that do not share functional and developmental influences (Leamy et al. 1999, Willmore et al. 2006). Most studies of morphological integration showed high covariation patterns between functionally related traits (e. g. Cheverud 1995, Marroig and Cheverud 2001, Klingenberg et al. 2004, Ivanović and Kalezić 2010, Jojić et al. 2012). In skulls, modularity is well studied and defined in primates (e. g. Marriog and Cheverud 2001, González-José et al. 2008), whereas in rodents the correlations between functionally and developmentally related structures are less consistent and obvious (Willmore et al. 2006, Klingenberg 2013). For instance, Monteiro et al. (1999) discovered that the orofacial region of the *Thrichomys apereoides* (Lund, 1839) skull is less integrated than the basicranium. Willmore et al. (2006), on the other hand, found out that the facial regions of mice are weakly but significantly integrated, while no integration was found for the cranial vault. Jojić et al. (2011), who used the same methods as the present study, confirmed the hypothesis of a face-basicranium organization of the *Apodemus flavicollis* (Melchior, 1834) skull. Tests of integration and modularity can yield mixed results also because of the differences in methodology (Jojić et al. 2012, Klingenberg 2013). Olson and Miller (1958) studied morphological integration of the cranium and mandible of the fox squirrel using linear measurements and methods based on statistical correlation. Roth (1996) studied the lateral view of the cranium of several squirrel species using landmark based geometric morphometric methods and preseneted only descriptive preliminary results with no statistical analyses of morphological integration. Therefore, it is possible that support for the two-module organization of the ventral cranium observed herein or for a highly integrated sciurid skull reported in previous studies (Olson and Miller 1958, Roth 1996) could depend upon the methodology.

Because the shape of bones is influenced by the mechanical forces during ontogeny (Sun et al. 2004, Young and Badyaev 2007) and the bones of the viscerocranium are directly involved in the mechanics of feeding, they undergo prominent shape transformations after weaning when juveniles change their diet form suckling to gnawing. Based on the results, I suppose that modularity in the *S. citellus* ventral cranium is largely driven by masticatory forces that apply to the bones of the viscerocranium and form a functional module that is in weak covariation with the neurocranium, which grows relatively slow during postnatal ontogeny (Herring 1993, Monteiro et al. 1999). For a better understanding of modularity, variability and development of the skull of *S. citellus* more research is needed, ideally on bigger samples and

postnatal longitudinal data including the study of fluctuating asymmetry, which can be a useful tool for determination of the boundaries of developmental modules (Klingenberg and Zaklan 2000, Klingenberg et al. 2001).

Conclusions

1. Unlike previous studies of sciurid skulls, the analysis of the covariation among landmarks in the ventral cranium yielded strong support to the hypothesis that in *S. citellus* the viscerocranium and neurocranium are separate modules.

2. The level of modularity was higher in adults than in juveniles, i.e. the hypothesized modules in the juvenile skull were more integrated with each other.

3. Although allometry can be a strong integrating factor, it had very little influence on the hypothesized modularity of the *S. citellus* skull.

4. The change in the strength of integration between the viscerocranium and neurocranium in the *S. citellus* skull during ontogeny is probably a consequence of the change in diet, from liquid to solid food.

Povzetek

Članek obravnava morfološko integracijo in modularnost lobanje evropske tekunice *Spermophilus citellus* in primerja stopnjo modularnosti med mladimi in odraslimi osebki vrste. Moduli so notranje tesno povezani deli strukture, ki so med seboj relativno neodvisni. Integracijo in modularnost morfoloških struktur analiziramo z ugotavljanjem stopnje povezanosti med posameznimi deli strukture. Ventralno stran lobanje lahko razdelimo v dve funkcionalni podenoti; nevrokranij, ki ga sestavljajo kosti možganskega dela lobanje, oči in ušes, in viscerokranij, ki je iz kosti čeljustnega aparata. Cilj raziskave je bil preveriti prisotnost te delitve na ventralni strani lobanje evropske tekunice, saj je za lobanje veveric znano, da imajo visoko stopnjo integracije brez jasnih delitev na podenote (Olson and Miller 1958, Roth 1996). Testirala sem 159 lobanj, od tega 43 mladih in 116 odraslih osebkov. Obliko ventralne strani lobanje sem opisala z 22 oslonilnimi točkami. Konfiguracije koordinat oslonilnih točk vseh lobanj sem poravnala s posplošeno Procrustovo analizo (GPA), ki konfiguracije koordinat premakne, zavrti in skalira, tako da je vsota kvadratov razlik na koncu v vzorcu minimalna. Nato sem z delitvijo oslonilnih točk na viscerokranij in nevrokranij postavila hipotezo o modularni zgradbi lobanje. Hipotezo testiramo s izračunom stopnje kovariabilnosti med hipotetičnimi moduli, ki jo nato primerjamo z vsemi alternativnimi delitvami točk na podskupine z enakim številom točk, kot jih imajo hipotetični moduli. Hipoteza o modularnosti drži, če je kovariabilnost med hipotetičnimi moduli izrazito nižja kot med vsemi ostalimi alternativnimi delitvami točk na module. Stopnjo integracije med moduli sem ovrednotila z metodami, ki temeljijo na RV koeficientu. Primerjala sem tudi stopnjo modularnosti in integracije med mladimi in odraslimi osebki. Tako pri mladih kot odraslih osebkih so rezultati podprli hipotezo o delitvi lobanje *S. citellus* na viscerokranij in nevrokranij, le da je bila lobanja mladih osebkov izraziteje integrirana. Razliko v stopnji integracije in modularnosti lobanje med mladimi in odraslimi osebki je potrdil tudi permutacijski test. Čeprav je alometrija lahko močan integracijski faktor, je imela majhen vpliv na vzorec modularnosti in integracije. Sprememba v stopnji modularnosti pri lobanji evropske tekunice med ontogenetskim razvojem je najverjetneje posledica spremembe v prehrani, t. j. prehoda s tekoče na trdo hrano, in večje specializacije obeh funkcionalnih modulov.

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Methodological weaknesses regarding the use of PEF-meters when assessing physiological effects of air pollution risk factors

Metodološke pomanjkljivosti uporabe PEF-metrov za oceno fizioloških učinkov zračnih polutantov

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Abstract: The manuscript discusses the applicability of self-administered monitoring of respiratory function in asthma patients in order to discern between negative health effects of different air pollutants on respiratory function. Thirteen asthma patients measured their respiratory function twice daily over a one month winter period. They used PEF-meters to monitor peak expiratory flow (PEF; L/min) and forced expiratory volume in the first second of expiration (FEV_1; L). Subjects' vital capacity (VC; L) was measured in a laboratory setting at the end of the measuring period. Respiratory data were evaluated in respect to the ambient concentrations of NO_2, NOx , SO_2 , O_3 , and PM_{10}, which were monitored during the same period. The concentrations of some air pollutants (PM_{10} and NO_x) exceeded the critical levels on several days during the study. PEF-meter data (PEF, FEV_1 and FEV_1/VC), however, did not respond significantly to the ambient conditions ($P>0.05$). The results speak against the use of self-administered PEF-meter monitoring for the recognition and investigation of air pollutant related negative health effects. Limitations and delimitations of the method are presented.

Keywords: respiratory function; asthma; self-administered respiratory monitoring; particulate matter; PM_{10}; PEF; FEV_1

Izvleček: Prispevek analizira uporabnost samo-apliciranega spremljanja dihalne funkcije pri astmatikih, uporabljenega z namenom razločiti med negativnimi zdravstvenimi učinki različnih zračnih onesnaževalcev na dihalno funkcijo. Trinajst astmatikov je dvakrat dnevno v obdobju enega meseca v zimskem času spremljalo svojo dihalno funkcijo. Maksimalni pretoka zraka ob izdihu (PEF; L/min) in prisiljen ekspiratorni volumen v prvi sekundi izdiha (FEV_1; L) so spremljali s PEF-metri. Vitalna kapaciteta preiskovancev (VC; L) je bila izmerjena v laboratoriju ob koncu raziskovalnega obdobja. Respiratorni podatki so bili analizirani glede na okoljske koncentracije onesnaževalcev NO_2, NOx, SO_2, O_3 in PM_{10}, ki so bili spremljani v istem časovnem obobju. Koncentracije nekaterih zračnih onesnaževalcev (PM_{10} in NO_x) so presegle kritično mejo v več dnevih raziskovalnega obdobja. Kljub temu, s podatki s PEF-metrov (PEF, FEV_1 in FEV_1/VC) ni bilo mogoče pokazati statistično značilnih odzivov dihalne funkcije na okoljske razmere ($P>0.05$). Rezultati raziskave izpostavljajo problematičnost uporabe samo-apliciranega spremljanja dihalne funkcije s PEF-metri za prepoznavo in raziskave negativnih zdravstvenih učinkov, povezanih z zračnimi onesnaževalci. V besedilu so podrobneje prikazane prednosti in slabosti predstavljene metodologije.

Ključne besede: respiratorna funkcija; astma; samo-aplicirano spremljanje dihalne funkcije; PM_{10}; PEF; FEV_1

Introduction

Respiratory tract is an organic system that is maximally exposed to air pollution. People with respiratory diseases are thus one of the most susceptible population groups to different air pollutants. Indeed, studies suggest that the quality of air in the environment can affect the respiratory function in humans (Rios et al. 2004), and that respiratory conditions, such as asthma, can be aggravated in a polluted environment (Heinrich et al. 1999).

Asthma is a chronic disease that severely affects the respiratory function. Asthma associated inflammation of the airways constricts the bronchia, which increases resistance and decreases the airflow through the respiratory system. It is generally accepted that the prevalence of asthma has increased significantly over the last years. It has been suggested that an increase in the number of asthmatic conditions is most likely related to environmental factors, as the period in which the changes have been observed is too short for genetic mutations to occur (Joseph et al. 1996). Epidemiological and controlled exposure studies of human volunteers have indeed demonstrated that exposure to a variety of pollutants induces asthma exacerbations (Peden 1996).

The intensity of asthma symptoms and signs varies in time and the aggravation of health status has been related to several factors, such as pollen, ambient temperature and viral infections (Gent et al. 2003). Furthermore, studies have demonstrated that the aggravation of disease is related to several air pollutants, although, the relation between asthma outbreaks and any particular air substance has not yet been determined unequivocally (Gent et al. 2003). Different studies suggest that particulate matter (PM) and NO_2 can be pointed out as air pollutants that cause the most negative health effects in individuals with already impaired respiratory function, namely, in COPD and asthma patients (Lagorio et al. 2006).

As air pollutants cause negative health effects worldwide, this topic has gained an increasing interest. Epidemiological approach has most often been used when the effects of air pollutants on health have been studied. In contrast, physiological data on this matter are rather scarce or even non-existent. Thus rather surprisingly, data on the effects of different air pollutants on a day to day respiratory function of both, healthy people and people with respiratory diseases, are limited, although they can provide vital information about the detection and consequent prevention against the environmental risk factors. In one of the few studies, for example, Linn and co-workers (Linn et al. 1996) reported that in healthy schoolchildren forced vital capacity measured in the morning decreases significantly with increase in particulate air pollution or NO_2 measured over the preceding 24 hours, and that morning-to-afternoon change in FEV_1 becomes significantly affected with increase in particulate matter, NO_2, or O_3 on the same day. Daily assessment of respiratory function can therefore serve as a fast and non-subjective tool, which is able to discern critical environmental factors.

It is likely that one of the reasons for the lack of data about the effects of different air pollutants on a day to day respiratory function is logistical, as daily ambulatory measurements of respiratory function are expensive and rather difficult to be organized. The availability and development of new techniques, which allow self-administered monitoring of respiratory function at home, thus provide promising new research opportunities and the use of peak expiratory flow meters (PEF-meters) has been suggested as a potentially useful methodological approach to address this issue (Bellia et al. 2003).

To monitor the respiratory state of asthma patients, pneumotachs or spirometers are usually used in ambulatory monitoring, and portable peak expiratory flow-meters (PEF-meters) by patients themselves. Peak expiratory flow (PEF, L/min) is the maximal flow of air during a forced expiration. PEF measurements are used in outpatient monitoring of asthma and in emergencies (Cross and Nelson 1991). PEF measurements, however, have been criticized for use with chronic obstructive pulmonary disease patients (COPD) due to unreliability, poor reproducibility, and unavailable reference values (Pauwels et al. 2001). To improve

the monitoring, the measurements of forced expiratory volume in the first second of expiration (FEV_1, L) have therefore become regularly used and have also become available with newer portable PEF-meters. It has to be noted, that PEF and FEV_1 measurements provide different information, since PEF reflects flows in the large airways, and FEV_1 reflects obstruction in different parts of the airways (Paggiaro et al. 1997).

As data about the application of portable PEF-meters for a daily respiratory monitoring for the assessment of the effects of air pollutants on respiratory function are limited (Bellia et al. 2003), the present study aimed to assess the feasibility, sensitivity and applicability of self-administered monitoring of respiratory function by PEF-meters for the detection of environmental conditions that have previously been demonstrated to negatively affect respiratory function in humans. Should the negative effects of air pollutants be reflected in diminished respiratory function as self-assessed by PEF meters, asthma patients would gain a simple tool to recognize the environmental risk and consequently decrease it by modifying their behavior, i.e. by modifying the time or location of their outdoor exposure. We hypothesized that self-administered PEF-meter monitoring will be able to detect changes in respiratory function of asthma patients in relation to the concentrations of specific air pollutants in an urban area.

Methods

Asthma patients were selected for the study, because they, being respiratory disease patients, are one of the most sensitive groups to air pollution. Daily monitoring of the respiratory function of 13 asthma patients was performed over a period of one month. The study was performed in wintertime, as this is the period in which the likelihood for temperature inversion and thus the high concentrations of air pollutants in the selected urban area is the highest. Furthermore, the concentration of pollen, which can considerably worsen the respiratory function of asthmatic patients, and can thus interfere with the respiratory measurements, is smallest in winter. If the study was, for example, performed during seasons change, when the temperature fluctuation are highest and the pollen concentration increases, this two influential factors could severely interfere with the study results (Gent et al. 2003).

Ethical clearance

The study was conducted in accordance with the Declaration of Helsinki and the protocol of the study gained approval by the Ethics Committee of the Republic of Slovenia (approval number 110/12/04). Each subject provided written informed consent before participating.

Subjects

Asthma patients were asked to voluntarily participate in the study and were recruited by their attending pulmologist. The subjects with emphysema, chronic bronchitis, and heart failure could not participate in the study. Also, the subjects with acute upper respiratory infections could not be recruited. The main inclusion criteria for the subjects was a settled medical asthmatic condition, for which large alterations in regular medications were not expected to occur, as a substantial change in medication during the course of the study would likely interfere with the study results. Furthermore, as air pollution is affected by geographical features, the study aimed to minimize this effect by recruiting only the subjects living in an area within approximately 1.5 km of air radius around the measuring station of Environmental Agency of the Republic of Slovenia. Thus, only the subjects permanently living in the strict town area of Ljubljana were included in the study.

Protocol and instrumentation

The information about the daily concentrations of pollutants in the air of the town of Ljubljana was obtained from the Environmental Agency of the Republic of Slovenia, an official body that monitors air pollution in Slovenia. The data about the following pollutants were obtained: particulate matter of less than 10 micrometers in diameter (PM_{10}; $\mu g/m^3$); ozone (O_3; $\mu g/m^3$); sulphur dioxide (SO_2; $\mu g/m^3$); nitrogen dioxide (NO_2; $\mu g/m^3$), and nitrogen oxides (NO_x; $\mu g/m^3$).

Peak expiratory flow-meters (Piko-1 Ferraris Respiratory Europe Ltd., Great Britain) were

used in the study to monitor the respiratory state of asthma patients. These PEF meters determine both, peak expiratory flow (PEF, L/min), thus the maximal flow of air during forced expiration, as well as the forced expiratory volume in the first second of expiration (FEV_1, L). According to manufacturers' recommendations, the PEF and FEV_1 values measured by PiKo-1 PEF meter correlate well at all flows with those measured by a pneumotach. The devices used correspond both, to the American Thoracic Society standards and to standards of the European Union.

Prior to the study, all subjects were given thorough instructions about the functioning of the PEF meters and aims of the study. A correct procedure of the measurement was demonstrated to them**.** To perform the measurement, the subjects were asked to stand up, hold a PEF-meter horizontally and be careful not to cover the expiratory outlets. They were instructed to blow as much air as they could through the mouthpiece of the PEF-meter after an audible signal. They were asked to perform the measurement three times at each occasion and to write down the obtained values of PEF and FEV_1 into the suitable tables after each measurement. The subjects performed the measurements in the morning, immediately when they got up, and in the evening, just prior they went to sleep. Apart from providing the values of PEF and FEV_1, all subjects were asked to daily fulfill the questionnaire with any remarks they thought might be relevant to the measurements, such as: their state of health, fever, cold, a change in measurement place (if they would be absent from home), and a change in medication. For each subject, the data acquisition tables were prepared in advance and were collected at the end of a one-month period.

Vital capacity (VC, L), i.e. the maximum volume of air that can be exhaled after a maximum inhalation, was also measured in a laboratory setting with a spirometer (Cosmed K4b2, Rome, Italy) at the end of the study period. The subjects' age was recorded and their height and weight were determined on a certified scale (Vita Libela Elsi, Celje, Slovenia). The spirometer was first calibrated with a 3-litre calibrating syringe (Cosmed, Rome, Italy), then the subjects were fitted with a nose clip. The standing subjects first breathed normally

Table 1: Subjects characteristics, including gender, with individual and average age, height, mass and smoking status presented

Tabela 1: Značilnost preiskovancev. Predstavljeni so spol ter posamezni in povprečni podatki za starost, višino, maso in kadilski status.

Subjects' characteristics
Lastnosti preiskovancev

Subject number Številka preiskovanca	Gender (male/female) Spol (moški/ženska)	Age (years) Starost (leta)	Height (cm) Višina (cm)	Mass (kg) Masa (kg)	Smoker (yes/ex/no) Kadilec (da/bivši/ne)
1	male / moški	56	177	84	Yes / Da
2	male / moški	58	189	97	Yes / Da
3	male / moški	31	186	81	Yes / Da
4	male / moški	70	164	52	No / Ne
5	male / moški	39	183	80	Ex / Bivši
6	female / ženska	26	166	54	Yes / Da
7	female / ženska	85	159	67	Ex / Bivši
8	female / ženska	41	175	60	No / Ne
9	female / ženska	40	166	61	No / Ne
10	female / ženska	64	163	76	Ex / Bivši
11	female / ženska	59	166	94	Yes / Da
12	female / ženska	59	155	92	Ex / Bivši
13	female / ženska	45	173	83	Ex / Bivši
AVG±SD	/	**52±17**	**171±11**	**75±15**	/

through a spirometer and then took a maximally deep breath, after which they blew through the mouthpiece as strongly and as for as long as they could. The whole procedure was repeated three times and the maximal measured volume of expired air was taken as representative for the subjects' vital capacity. No broncho-dilatators were used for the vital capacity determination.

Statistical analysis

For each pollutant, a day with its minimum and maximum measured concentration was selected. Then, PEF and FEV_1 values of all subjects measured for these two days were compared with a two tailed paired Student T-test. Both, the absolute and relative values of PEF and FEV_1 were analysed.

Table 2: The maximum hourly concentrations of fine particles (PM_{10}; µg/m^3) and nitrogen oxides (NOx; µg/m^3) in the air in the town of Ljubljana during the experimental period. The two experimental days with the maximum and minimum concentrations of the two air polutants are presented in bold. The shaded areas denote days in which the legislative boundary concentrations of PM_{10} or NOx were exceeded

Tabela 2: Največji urni koncentraciji finih delcev (PM_{10}; µg/m^3) in dušikovih oksidov (NOx; µg/m^3) v zraku v mestu Ljubljana med potekom raziskave. Dneva z največjima in najmanjšima koncentracijama obeh onesnaževalcev sta prikazana odebeljeno. Osenčena polja označujejo dneve, v katerih so bile zakonsko določene največje koncentracije PM_{10} ali NOx presežene

The maximum hourly concentrations of pollutants in the experimental days
Največja urna koncentracija onesnaževalcev v raziskovalnih dneh

Experimental Day Raziskovalni dan	PM_{10} (µg/m^3)	Experimental Day Raziskovalni dan	NO_x (µg/m^3)
4	**207.45**	**4**	**208.55**
3	181.47	5	200.55
5	155.19	6	170.30
25	133.18	25	162.35
6	126.29	12	138.90
2	121.15	3	136.80
27	115.01	11	132.35
28	102.92	18	119.35
1	95.42	27	112.75
12	90.02	1	102.85
24	88.35	17	94.10
26	84.01	13	93.50
11	75.33	8	92.30
17	70.00	26	91.25
13	69.75	28	91.15
18	67.60	2	90.70
19	59.27	22	87.05
16	55.49	24	86.70
14	52.45	23	78.65
23	52.14	16	75.15
20	50.90	19	75.10
21	46.38	9	57.70
8	44.08	20	48.75
15	42.22	10	40.80
10	39.70	15	31.65
22	38.32	7	30.10
9	37.32	14	22.70
7	**29.20**	**21**	**15.30**

To enable inter-individual comparisons, FEV_1/VC ratio was calculated for each subject and compared between the days with minimal and maximal concentrations of air pollutants. A P-value of less than 0.05 was adopted as statistically significant. All the following results are presented as average±SD.

Results

Subjects characteristics

The average age of the subjects was 52±17 years, height 171±11 cm and mass 75±15 kg. Eight of the subjects were females (two smokers, four ex-smokers, two non-smokers) and five of them males (three smokers, one ex-smoker, one non-smoker) (Table 1). During the study the subjects pursued their regular daily activities and reported no changes in their day-to-day medication. During the period of the study, none of the asthmatics required any emergency medical treatment, medicine alterations, or hospitalization.

Concentrations of pollutants

During the course of the study, the concentrations of PM_{10} and NO_x exceeded the legislatively determined critical values, i.e. the boundary daily value of 50 μg/m^3 for PM_{10} and the hourly boundary value of 200 μg/m^3 for NO_x, on several occasions (Table 2). The concentrations of ozone, SO_2 and NO_2 remained below the legislatively determined critical values for a particular substance throughout the course of the present study. The concentrations of air pollutants at the measuring location are presented on Figure 1.

Respiratory function measurements

Maximal evening values of PEF and FEV_1, both absolute and relative data, were used for the analysis.

On a day with maximal (207.5 μg/m^3) PM_{10} concentration, the PEF of the subjects was 342.5±146.7 L/min, and on a day with a minimal (29.2 μg/m^3) PM_{10} concentration 352.3±124.9 L/min (P=0.55). PEF, relative to the first day of measurements was 90±23 % on the day of the maximal, and 97±12 % on the day of the minimal PM_{10} concentration (P=0.26). The differences were thus not statistically significant (P>0.05).

FEV_1 of the subjects (Figure 2) was similar at 2.5± 0.9 L on a day with maximal and minimal PM_{10} concentration (P=0.67). FEV_1, relative to the first day of measurements was 90±22 % on the day of the maximal, and 94±21 % on the day of the minimal PM_{10} concentration (P=0.40). The differences were thus not statistically significant (P>0.05).

The ratio of FEV_1/VC of the subjects was 69±23 % on a day with maximal, and 71±19 % on a day with minimal PM_{10} concentration, with no significant differences (P=0.58>0.05) between the two days.

On a day with maximal (208.6 μg/m^3) NO_X concentration, the PEF of the subjects was 342.5±146.7 L/min, and on a day with minimal (15.3 μg/m^3) NO_X concentration 355.0±148.2 L/min (P=0.64). PEF, relative to the first day of measurements was 90±23 % on the day of the maximal, and 96±28 % on the day of the minimal NO_X concentration (P=0.41). The differences were thus not statistically significant (P>0.05).

FEV_1 of the subjects (Figure 2) was 2.5±0.9 L on a day with maximal NO_X concentration, and 2.9±1.0 L on a day with minimal NO_X concentration (P=0.18). FEV_1, relative to the first day of measurements was 90±22 % on the day of the maximal, and 105±28 % on the day of the minimal NO_X concentration (P=0.12). The differences were thus not statistically significant (P>0.05).

The ratio of FEV_1/VC of the subjects was 69±23 % on a day with maximal, and 78±26 % on a day with minimal NO_x concentration, with no significant differences (P=0.15>0.05) between the two days.

The concentrations of other air pollutants (ozone, NO_2, SO_2) did not exceed the legislatively determined critical levels during the course of the study. PEF, FEV_1 and PEF/FEV_1 were nevertheless compared with respect to the maximal and minimal concentrations of these pollutants and no significant differences between the conditions were observed (P>0.05).

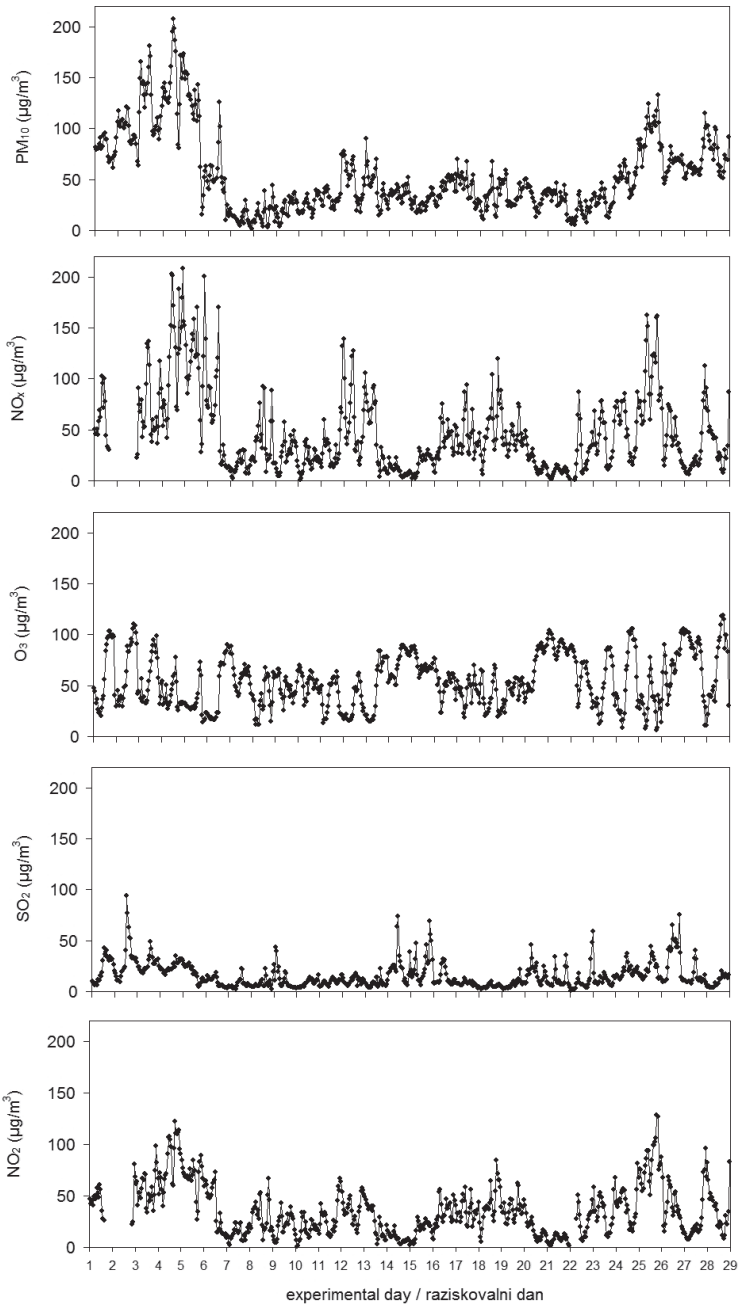

Figure 1: Measured concentrations of PM_{10}, NO_x, O_3, SO_2 and NO_2, all measured in µg/m^3 in ambient air, during the course of the study

Slika 1: Izmerjene koncentracije PM_{10}, NO_x, O_3, SO_2 in NO_2 v okoljskem zraku med potekom raziskave, vse izražene v µg/m^3

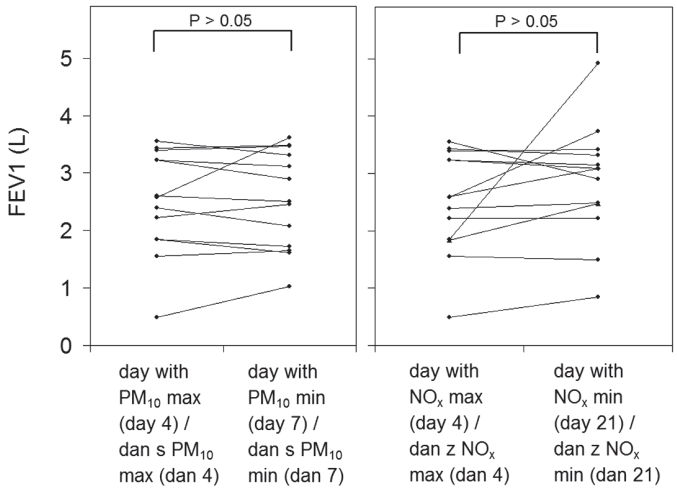

Figure 2: Individual values of forced expiratory volume in the first second of expiration (FEV_1, L) measured in the days with maximal and minimal ambient concentrations of PM_{10} (μg/m^3) and NOx (μg/m^3). For any of the pollutants, no significant differences in FEV_1, as assessed by self-administered PEF-meter monitoring, were found between the two days (P>0.05). The individual data also demonstrate that no consistent trend or pattern in the FEV_1 responses was evident

Slika 2: Posamezne vrednosti prisiljenega ekspiratornega volumna zraka v prvi sekundi izdiha (FEV_1, L), izmerjene v dneh z največjima in najmanjšima okoljskima koncentracijama PM_{10} (μg/m^3) in NOx (μg/m^3). Za nobenega od onesnaževalcev se FEV_1 vrednosti, izmerjene s samo-apliciranim spremljanjem dihalne funkcije s PEF-metrom, med obema dnevoma niso značilno (P>0.05) razlikovale. Posamezni podatki kažejo tudi na odsotnost kakršnegakoli trenda ali vzorca v izmerjenih FEV_1 vrednostih

Discussion

The present study investigated whether self-administered monitoring of respiratory function by PEF-meters can be used for the recognition of critical environmental conditions that have been demonstrated to aggravate the severity of asthma symptoms. Although the exact levels of air pollutants, as well as time of outdoor exposure cannot be standardised for a field study, both, the concentrations of PM_{10} and NO_x were elevated above the legislatively determined critical levels in several days during the selected study period, and were above the concentrations that have been proven to affect the respiratory function in asthmatics (Pope, III and Kanner 1993).

The respiratory values of PEF, FEV_1, and FEV_1/VC were investigated in the view of minimal and maximal concentrations of air pollutants detected in a one-month winter period. In contrast to the expectations, the elevated concentrations of the selected air pollutants were not significantly reflected in the monitored respiratory parameters of the subjects as self-assessed by PEF-meters. The lack of the observed effect might result either from the actual lack of a physiological effect, or from the inappropriateness of the used method to detect the effect – the two options are discussed below.

To a certain extent, the absence of effect can be explained by the fact that during the course of the present study, the concentrations of the majority of monitored air pollutants did not exceed the legislatively determined critical values. This might suggest that the actual respiratory function of asthma patients was indeed not affected by air pollutants. However, both, PM_{10} and nitrogen oxides did exceed the critical values for several days and therefore the absence of any significant effects of PM_{10} on the respiratory function as determined by PEF-meters should be seriously questioned.

The fact that exposure to particulate matter affects respiratory function in asthmatics has been demonstrated several times. In asthmatic children, an increase in particulate matter (PM_{10}) elevates the incidence of lower respiratory symptoms and cough (Aekplakorn et al. 2003). Similarly, small airway function significantly decreases, and oxidative stress significantly increases in relation to $PM_{2,5}$ (as well as to SO_2 and NO_2) concentrations in ambient air (Liu et al. 2009). Studies have also demonstrated that acute increases in PM_{10} result in a greater use of asthma medications and increased hospital admissions due to asthma (Lipsett et al. 1997). Even more, Pope and Dockery (Pope and Dockery 1999) noticed an average of 2 % increase in hospitalizations and related health care visits, and an approximate 3 % increase in asthma symptoms for each 10 $\mu g/m^3$ rise in PM_{10}.

Furthermore, Pope and Kanner (1993) reported that in smokers with mild to moderate chronic obstructive pulmonary disease PM_{10} of approximately 100 $\mu g/m^3$ was associated with a significant decline in FEV_1. The PM_{10} level of 100 $\mu g/m^3$ was exceeded in several days during the course of the present study, but nevertheless no significant diminishment in PEF or FEV_1 as self-assessed by PEF-meters has been detected. It therefore seems more reasonably to believe that the self-administered respiratory monitoring by PEF-meters failed to detect the actual physiological effect of air pollutants, rather than to believe in the absence of the actual physiological effect. The reasons for such conclusions are several and are presented in details below.

A potential difference between personal exposures and ambient pollution may be a source of variation. However, Janssen and co-workers (Janssen et al. 1998) demonstrated that personal PM_{10} concentrations are well correlated with ambient PM_{10} concentrations over time, which provided support for using fixed site outdoor measurements of air pollutants for studies aiming to link day-to-day variations in respiratory function with ambient conditions. In the present study, as PM_{10} concentrations were one of the crucial pollutants, the failure of self-administered PEF-meter monitoring to detect negative effects of air pollutants on respiratory function as being due to the difference between indoor and outdoor conditions, is therefore excluded.

One may also argue that the failure of self-administered PEF-meter monitoring to detect negative effects of air pollutants on respiratory function might be due to the number of subjects included in the study. However, as evident from the results, in the present study the calculated P values were far from statistical significance, although the inter-individual variability was accounted for by a repeated-measures design. Furthermore, no consistent changes were observed in the individual responses, thus no pattern or trend in the PEF or FEV_1 as related to the air pollutant concentrations was detected, rather the responses were chaotic (Figure 2). It is therefore rather unlikely that simply increasing the sample size would yield any significant response. Furthermore, the present study was designed on the basis of published studies, which used similar methodological approach, and found significant results with similar sample sizes (Chalmers et al. 2002; Kim et al. 2007; Fujimura et al. 2003). Kim et al. (2007), for example, investigated the effects of on-site ozone concentrations on peak expiratory flow in 17 asthmatics by the use of pocket PEF-meters. Kim et al. (2007) found that although the degree of asthma symptoms was influenced significantly by the ozone concentration, no significant correlation between PEF as self determined by pocket PEF-meters and ozone concentration was found. The results of Kim et al. (2007) provide further support to the present study, suggesting that it is highly unlikely to expect different performance assessment of PEF-meters, should indoor instead of outdoor measuring sites be used in the present study.

Furthermore, although the PEF-meters used to determine the respiratory function of the subjects in the present study have been assessed as reliable (Rodriguez-Pascual et al. 2006), self-administered PEF-meter monitoring still largely depends on the compliance of the subjects and should be therefore closely scrutinized. As usual with any self-administered monitoring, a certain percentage of the subjects will not follow the suggested protocol precisely, therefore, individual data have to be carefully examined. In the present study, for example, 20 subjects were enrolled, but data from 13 subjects satisfied the criteria for the final analysis, namely, three subjects did not perform the measurements regularly, as evident from the

post-hoc memory recall of the PEF meters, one of the subjects experienced some problems with handling the PEF meter and therefore the respiratory data were not recorded, one of the subjects did not consent to vital capacity monitoring, and two of the PEF meters were broken due to misuse during the measuring period, which the subjects failed to report. It is therefore suggested that the subjects should be very thoroughly instructed about the proper use of PEF-meters. Ideally, a short test period of several days prior to the actual beginning of the study with repeated self-administered PEF-meter monitoring may prove beneficial in improving the reliability of measurements. During such a test period, subjects should follow a similar protocol as planned for the study, and data from the test period should be screened by the investigators. Subjects, who would fail to produce reliable self-administered PEF-meter measurements during the test period, should be further instructed, and, if no progress made, they should be excluded from the actual study. Finally, an insufficient compliance with long-term monitoring and falsified measurements will diminish the reliability of data; the option of automatic saving of the results provided by some PEF-meters, such as the one used in the present study, help to identify the falsified reports. In longer longitudinal studies, loss of PEF-meter accuracy over time (Irvin et al. 1997) should also be considered, as this will play a crucial role in the final success or failure of a study.

Povzetek

Kakovost zraka vpliva na dihalno funkcijo ljudi in zdravstveno stanje respiratornih bolnikov, denimo astmatikov, se v onesnaženem ozračju poslabša. Kljub temu obstaja znatno pomanjkanje podatkov o učinkih različnih onesnaževalcev na vsakodnevno dihalno funkcijo ljudi, saj, tudi zaradi različnih metodoloških pristopov, ustreznih rezultatov še nismo pridobili. Namen raziskave je bil zato oceniti uporabnost samo-apliciranega spremljanja dihalne funkcije pri astmatikih, uporabljenega z namenom razločiti med negativnimi zdravstvenimi učinki različnih zračnih onesnaževalcev na dihalno funkcijo.

Trinajst astmatikov je dvakrat dnevno v obdobju enega meseca v zimskem času spremljalo svojo dihalno funkcijo. Maksimalni pretoka zraka ob izdihu (PEF; L/min) in prisiljeni ekspiratorni volumen v prvi sekundi izdiha (FEV_1; L) smo spremljali s PEF-metri. Vitalna kapaciteta preiskovancev (VC; L) je bila izmerjena v laboratoriju ob koncu raziskovalnega obdobja. Respiratorni podatki so bili analizirani glede na okoljske koncentracije NO_2, NOx, SO_2 , O_3 , in PM_{10}, ki so bili spremljani v istem časovnem obdobju. Koncentracije nekaterih zračnih onesnaževalcev (PM_{10} in NO_x) so presegle kritično mejo v več dnevih raziskovalnega obdobja. Kljub temu s podatki s PEF-metrov (PEF, FEV_1 in FEV_1/VC), ni bilo mogoče pokazati statistično značilnih odzivov dihalne funkcije na okoljske razmere ($P>0.05$).

Rezultati pričujoče raziskave kažejo, da samo-aplicirana uporaba PEF-metrov ne omogoča razločevanja med negativnimi učinki različnih zračnih onesnaževalcev na dihalno funkcijo niti pri najbolj občutljivih skupinah ljudi, niti v okolju, v katerem so koncentracije zračnih onesnaževalcev dovolj velike, da po obstoječih podatkih povečajo število hospitalizacij, in niti ob tako povečanih koncentracijah zračnih onesnaževalcev (trdnih delcev), da dokazano negativno učinkujejo na dihalno funkcijo človeka. Nadalje, rezultati raziskave kažejo, da ostaja ambulantno spremljanje dihalne funkcije, čeprav je logistično zahtevno, eden redkih, če ne edini zanesljivi vir podatkov o negativnih učinkih zračnih onesnaževalcev na dihalno funkcijo, tako pri zdravih posameznikih, kot pri respiratornih bolnikih.

Conclusions

Quality of air affects respiratory function in humans, and respiratory conditions such as asthma are aggravated in a polluted environment. Nevertheless, data on the effects of different air pollutants on a day-to-day respiratory function are lacking, as due to different methodological approaches the issue in question has not been adequately addressed yet. The aim of this study was therefore to assess the applicability of self-administered monitoring of respiratory function in asthma patients in order to discern between negative health effects of different air pollutants

on respiratory function. Thirteen asthma patients measured their respiratory function twice daily over a one month winter period. They used PEF-meters to monitor peak expiratory flow (PEF; L/min) and forced expiratory volume in the first second of expiration (FEV_1; L). Subjects' vital capacity (VC; L) was measured in a laboratory setting at the end of the measuring period. Respiratory data were evaluated in respect to the ambient concentrations of NO_2, NOx , SO_2 , O_3 , and PM_{10}, which were monitored during the same period. The concentrations of some air pollutants (PM_{10} and NO_x) exceeded the critical levels on several days during the study. PEF-meter data (PEF, FEV_1 and FEV_1/VC), however, did not respond significantly to the ambient conditions ($P>0.05$).

The novel findings of the present study are that the self-administered PEF-meter monitoring can not discern between the negative health effects of different air pollutants even in the most susceptible groups of population, even in the environments where the concentrations of air pollutants are high enough to induce increased level of hospitalizations, and even with increased levels of the air pollutant (particulate matter) that seems to cause the largest negative effects on human respiratory health. Furthermore, the results of the present study suggest that, although logistically demanding, ambulatory monitoring of respiratory function may be one of the few, if not the only reliable non-subjective source of information on the negative effects of air pollutants on respiratory function in both healthy individuals and respiratory patients.

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4. slovenski entomološki simpozij z mednarodno udeležbo, 9. in 10. maj 2014

Četrti slovenski entomološki simpozij z mednarodno udeležbo so organizirali Slovensko entomološko društvo Štefana Michielija, zoologi Oddelka za biologijo Fakultete za naravoslovje in matematiko (FNM) Univerze v Mariboru ter Inštitut za biologijo, ekologijo in varstvo narave FNM. To entomološko srečanje je potekalo na FNM Univerze v Mariboru, obiskalo ga je več kot 50 udeležencev iz Slovenije, Bosne, Srbije, Avstrije, Italije, Nizozemske in Velike Britanije. Simpozija so se udeležili tudi akademik prof. dr. Matija Gogala, dr. Andrej Gogala, urednik revije Acta entomologica slovenica in dr. Werner Holzinger, predsednik Avstrijskega entomološkega društva. Uradna jezika srečanja sta bila slovenski in angleški jezik. Večina predavanj je bila v angleškem jeziku, prav tako diskusije.

Ob otvoritvi simpozija so udeležence nagovorili dekanica FNM prof. dr. Nataša Vaupotič, organizator simpozija prof. dr. Dušan Devetak in predsednik Slovenskega entomološkega društva Štefana Michielija mag. Slavko Polak, tudi organizator tega srečanja.

Vabljena predavatelja prvega dne simpozija sta bila dr. Gerd Leitinger (Medical University Graz) in prof. dr. Predrag Jakšić (Univerzitet u Nišu, Prirodno matematički fakultet). Gerd Leitinger je predstavil uporabo vrstične elektronske mikroskopije pri raziskavah živčnega sistema žuželk, Predrag Jakšić zoogeografijo metuljev Panonske nižine. Sledilo je šestnajst predavanj strokovnjakov in raziskovalcev s področja entomologije. Predavanja so bila s področij biologije, ekologije, fiziologije, morfologije in vedenja žuželk. V odmorih je potekala predstavitev posterjev.

Vabljeni predavatelj drugega dne simpozija je bil prof. dr. Mirza Dautbašić (Univerzitet u Sarajevu, Šumarski fakultet), ki je govoril o ksilofagnih škodljivih žuželkah na bosanskem boru *Pinus heldreichii*. Njegovemu predavanju je sledilo še trinajst predavanj. Predavanja drugega dne simpozija so bila s področij naravovarstva, ekologije, sistematike, favnistike žuželk in aplikativne entomologije. V času odmorov smo si ogledali posterje. Simpozij je bil zaključen v popoldanskih urah.

Srečanje entomologov je potekalo v prijetnem vzdušju. V obeh dneh smo imeli priložnost prisluhniti zanimivim in slikovitim prispevkom iz sveta in življenja žuželk. Izvedena so bila vsa načrtovana predavanja razen dveh in predstavljeni so bili vsi najavljeni posterji. Vsem udeležencem se iskreno zahvaljujemo za prisotnost, prispevke, diskusije in ideje za nadaljnje delo.

Na spletni strani simpozija (http://4ses.fnm.uni-mb.si/) je dostopna knjiga povzetkov prispevkov Četrtega slovenskega entomološkega simpozija z mednarodno udeležbo.

Saška Lipovšek

INSTRUCTIONS FOR AUTHORS

1. Types of Articles

SCIENTIFIC ARTICLES are comprehensive descriptions of original research and include a theoretical survey of the topic, a detailed presentation of results with discussion and conclusion, and a bibliography according to the IMRAD outline (Introduction, Methods, Results, and Discussion). In this category ABS also publishes methodological articles, in so far as they present an original method, which was not previously published elsewhere, or they present a new and original usage of an established method. The originality is judged by the editorial board if necessary after a consultation with the referees. The recommended length of an article including tables, graphs, and illustrations is up to fifteen (15) pages; lines must be double-spaced. Scientific articles shall be subject to peer review by two experts in the field.

REVIEW ARTICLES will be published in the journal after consultation between the editorial board and the author. Review articles may be longer than fifteen (15) pages.

BRIEF NOTES are original articles from various biological fields (systematics, biochemistry, genetics, physiology, microbiology, ecology, etc.) that do not include a detailed theoretical discussion. Their aim is to acquaint readers with preliminary or partial results of research. They should not be longer than five (5) pages. Brief note articles shall be subject to peer review by one expert in the field.

CONGRESS NEWS acquaints readers with the content and conclusions of important congresses and seminars at home and abroad.

ASSOCIATION NEWS reports on the work of Slovene biology associations.

2. Originality of Articles

Manuscripts submitted for publication in *Acta Biologica Slovenica* should not contain previously published material and should not be under consideration for publication elsewhere.

3. Language

Articles and notes should be submitted in English, or as an exception in Slovene if the topic is very local. As a rule, congress and association news will appear in Slovene.

4. Titles of Articles

Title must be short, informative, and understandable. It must be written in English and in Slovene language. The title should be followed by the name and full address of the authors (and if possible, fax number and/or e-mail address). The affiliation and address of each author should be clearly marked as well as who is the corresponding author.

5. Abstract

The abstract must give concise information about the objective, the methods used, the results obtained, and the conclusions. The suitable length for scientific articles is up to 250 words, and for brief note articles, 100 words. Article must have an abstract in both English and Slovene.

6. Keywords

There should be no more than ten (10) keywords; they must reflect the field of research covered in the article. Authors must add keywords in English to articles written in Slovene.

7. Running title

This is a shorter version of the title that should contain no more than 60 characters with spaces.

8. Introduction
The introduction must refer only to topics presented in the article or brief note.

9. Illustrations and Tables
Articles should not contain more than ten (10) illustrations (graphs, dendrograms, pictures, photos etc.) and tables, and their positions in the article should be clearly indicated. All illustrative material should be provided in electronic form. Tables should be submitted on separate pages (only horizontal lines should be used in tables). Titles of tables and illustrations and their legends should be in both Slovene and English. Tables and illustrations should be cited shortly in the text (Tab. 1 or Tabs. 1-2, Fig. 1 or Figs. 1-2; Tab. 1 and Sl. 1). A full name is used in the legend title (e.g. Figure 1, Table 2 etc.), written bold, followed by a short title of the figure or table, also in bold. Subpanels of a figure have to be unambiguously indicated with capital letters (A, B, …). Explanations associated with subpanels are given alphabetically, each starting with bold capital letter (**A**), a hyphen and followed by the text.

10. The quality of graphic material
All the figures have to be submitted in the electronic form. The ABS publishes figures either in pure black and white or in halftones. Authors are kindly asked to prepare their figures in the correct form to avoid unnecessary delays in preparation for print, especially due to problems with insufficient contrast and resolution. Clarity and resolution of the information presented in graphical form is the responsibility of the author. Editors reserve the right to reject unclear and poorly readable pictures and graphical depictions. The resolution should be 300 d.p.i. minimum for halftones and 600 d.p.i. for pure black and white. The smallest numbers and lettering on the figure should not be smaller than 8 points (2 mm height). The thickness of lines should not be smaller than 0.5 points. The permitted font families are Times, Times New Roman, Helvetica and Arial, whereby all figures in the same article should have the same font type. The figures should be prepared in TIFF, EPS or PDF format, whereby TIFF (ending *.tif) is the preferred type. When saving figures in TIFF format we recommend the use of LZW or ZIP compression in order to reduce the file sizes. The photographs can be submitted in JPEG format (ending *.jpg) with low compression ratio. Editors reserve the right to reject the photos of poor quality. Before submitting a figure in EPS format make sure first, that all the characters are rendered correctly (e.g. by opening the file first in the programs Ghostview or GSview – depending on the operation system or in Adobe Photoshop). With PDF format make sure that lossless compression (LZW or ZIP) was used in the creation of the *.pdf file (JPEG, the default setting, is not suitable). Figures created in Microsoft Word, Excel, PowerPoint etc. will not be accepted without the conversion into one of the before mentioned formats. The same goes for graphics from other graphical programs (CorelDraw, Adobe Illustrator, etc.). The figures should be prepared in final size, published in the magazine. The dimensions are 12.5 cm maximum width and 19 cm maximum height (width and height of the text on a page).

11. Conclusions
Articles shall end with a summary of the main findings which may be written in point form.

12. Summary
Articles written in Slovene must contain a more extensive English summary. The reverse also applies.

13. Literature
References shall be cited in the text. If a reference work by one author is cited, we write Allan (1995) or (Allan 1995); if a work by two authors is cited, (Trinajstić and Franjić 1994); if a work by three or more authors is cited, (Pullin et al. 1995); and if the reference appears in several works, (Honsig-Erlenburg et al. 1992, Ward 1994a, Allan 1995, Pullin et al. 1995). If several works by the same author

published in the same year are cited, the individual works are indicated with the added letters a, b, c, etc.: (Ward 1994a,b). If direct quotations are used, the page numbers should be included: Toman (1992: 5) or (Toman 1992: 5–6).The bibliography shall be arranged in alphabetical order beginning with the surname of the first author, comma, the initials of the name(s) and continued in the same way with the rest of the authors, separated by commas. The names are followed by the year of publication, the title of the article, the international abbreviation for the journal (periodical), the volume, the number in parenthesis (optional), and the pages. Example:

Mielke, M.S., Almeida, A.A.F., Gomes, F.P., Aguilar, M.A.G., Mangabeira, P.A.O., 2003. Leaf gas exchange, chlorophyll fluorescence and growth responses of Genipa americana seedlings to soil flooding. Experimental Botany, 50 (1), 221–231.

Books, chapters from books, reports, and congress anthologies use the following forms:

Allan, J.D., 1995. Stream Ecology. Structure and Function of Running Waters, 1st ed. Chapman & Hall, London, 388 pp.

Pullin, A.S., McLean, I.F.G., Webb, M.R., 1995. Ecology and Conservation of *Lycaena dispar*: British and European Perspectives. In: Pullin A. S. (ed.): Ecology and Conservation of Butterflies, 1st ed. Chapman & Hall, London, pp. 150-164.

Toman, M.J., 1992. Mikrobiološke značilnosti bioloških čistilnih naprav. Zbornik referatov s posvetovanja DZVS, Gozd Martuljek, pp. 1-7.

14. Format and Form of Articles

The manuscripts should be sent exclusively in electronic form. The format should be Microsoft Word (*.doc) or Rich text format (*.rtf) using Times New Roman 12 font with double spacing, align left only and margins of 3 cm on all sides on A4 pages. Paragraphs should be separated by an empty line. The title and chapters should be written bold in font size 14, also Times New Roman. Possible sub-chapter titles should be written in italic. All scientific names must be properly italicized. Used nomenclature source should be cited in the Methods section. The text and graphic material should be sent to the editor-in-chief as an e-mail attachment. For the purpose of review the main *.doc or *.rtf file should contain figures and tables included (each on its own page). However, when submitting the manuscript the figures also have to be sent as separate attached files in the form described under paragraph 10. All the pages (including tables and figures) have to be numbered. All articles must be proofread for professional and language errors before submission.

A manuscript element checklist (For a manuscript in Slovene language the same checklist is appropriately applied with a mirroring sequence of Slovene and English parts):
English title – (Times New Roman 14, bold)
Slovene title – (Times New Roman 14, bold)

Names of authors with clearly indicated addresses, affiliations and the name of the corresponding author – (Times New Roman 12)
Author(s) address(es) / institutional addresses – (Times New Roman 12)
Fax and/or e-mail of the corresponding author – (Times New Roman 12)
Keywords in English – (Times New Roman 12)
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Abstract in English (Times New Roman 12, title – Times New Roman 14 bold)

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Introduction – (Times New Roman 12, title – Times New Roman 14 bold)
Material and methods – (Times New Roman 12, title – Times New Roman 14 bold)
Results – (Times New Roman 12, title – Times New Roman 14 bold)
Discussion – (Times New Roman 12, title – Times New Roman 14 bold)
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Figure legends; each in English and in Slovene – (Times New Roman 12, title – Times New Roman 14 bold, figure designation and figure title – Times New Roman 12 bold)
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Literature – (Times New Roman 12, title – Times New Roman 14 bold)
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Page numbering – bottom right – (Times New Roman 12)

15. Peer Review

All Scientific Articles shall be subject to peer review by two experts in the field (one Slovene and one foreign) and Brief Note articles by one Slovene expert in the field. With articles written in Slovene and dealing with a very local topic, both reviewers will be Slovene. In the compulsory accompanying letter to the editor the authors must nominate one foreign and one Slovene reviewer. However, the final choice of referees is at the discretion of the Editorial Board. The referees will remain anonymous to the author. The possible outcomes of the review are: 1. Fully acceptable in its present form, 2. Basically acceptable, but requires minor revision, 3. Basically acceptable, but requires important revision, 4. May be acceptable, but only after major revision, 5. Unacceptable in anything like its present form. In the case of marks 3 and 4 the reviewers that have requested revisions have to accept the suitability of the corrections made. In case of rejection the corresponding author will receive a written negative decision of the editor-in-chief. The original material will be erased from the ABS archives and can be returned to the submitting author on special request. After publication the corresponding author will receive the *.pdf version of the paper.