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Alpine and subalpine acidophilous vegetation on the eastern side of the Chiprovska Planina Mts.

Alpine und subalpine azidophile Vegetation auf der Ostseite des Chiprovska Planina-Gebirges

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Abstract

The subalpine and alpine vegetation belts are well-developed in Bulgarian mountains, and the alpine biogeographic region covers a large area in Bulgaria. Although alpine and subalpine vegetation is susceptible to climate and land-use changes, the knowledge of this vegetation in Bulgaria is very poor.

The Western Stara Planina Mts. extends from Zlatishki Pass in Bulgaria in the east to Serbia, where it has its westernmost point. In its eastern part, it is composed mainly of limestone, whereas in its highest parts in the Chiprovtska Planina it is composed of acidic rocks, mainly of sandstone, conglomerate, and granite. Most of today's alpine vegetation is secondary due to long-lasting pasturing and fire management; only rock outcrops in high altitudes host primary alpine vegetation.

The alpine and subalpine vegetation in the Western Stara Planina Mts. was systematically studied only on the Serbian territory; the manuscript of Vojislav Mišić which describes this vegetation was published in 1978.

Here, I present vegetation classification of the Bulgarian part of the highest mountain ridge of the Western Stara Planina Mts. and fill gaps in knowledge of the alpine and subalpine vegetation in the northeastern part of the Balkan Peninsula. I recorded 78 phytosociological relevés, based on which I distinguished 12 vegetation classes, 29 associations, and nine informally described local communities. Many of these syntaxa are new to Bulgaria or are newly described according to the International Code of Phytosociological Nomenclature.

A DCA ordination was conducted to display dissimilarities between relevés. Altitude, soil pH, and total cover of plants have significant influence over the sample scores.

Keywords: Alpine, Bulgaria, Midzhur, Phytosociology, Stara Planina, Subalpine, Syntaxonomy, Vegetation classification

Erweitere deutsche Zusammenfassung am Ende des Artikels

1. Introduction

The oldest information on Bulgarian vegetation can be found in studies carried out in the first half of the 20th century, but their main focus was on general botany, phytogeography, and forestry. Systematic research on vegetation was done mainly since the second half of the 20th century (TZONEV et al. 2009). The first study of the alpine and subalpine vegetation

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using the Braun-Blanquet approach in Bulgaria was published by foreigners (HORVAT et al. 1937) in the Rila Mts. Particularly later work of HORVAT et al. (1974), which focused on the whole Balkan Peninsula, had a major impact on vegetation classification in the region. SIMON (1957) studied mainly acidophilous vegetation of the Pirin Mts. The most recent comprehensive work on the alpine vegetation of Bulgaria was done in the Rila Mts. by ROUSSAKOVA (2000), in which most of the high-mountain vegetation types in Bulgaria were described. She focused on the collection of data and vegetation classification of the upper alpine belt. The compilation of TZONEV et al. (2009) corrects some of the mistakes in syntaxa proposed by ROUSSAKOVA (2000) to follow the regulations of the International Code of Phytosociological Nomenclature.

In the Stara Planina Mts., the most notable works regarding non-forest vegetation were performed in its central part by KOCHEV (1967) and in its eastern and central part by MICHALIK (1990, 1992). MESHINEV et al. (2000) described non-forest vegetation types of the Central Stara Planina Mts. using the Russian dominance-based approach. Following these works, no efforts have been made to classify zonal subalpine and alpine plant communities on the Bulgarian side of the Stara Planina Mts. Recently, few studies have been made that deal with a classification of thermophilous grasslands (e.g., VASSILEV et al. 2012, PODASHENKO et al. 2013, VASSILEV et al. 2014) and spring vegetation (HÁJKOVÁ et al. 2006) in the area.

On the Serbian side, the investigation of the plant communities was conducted by MIŠIĆ (1978) for the whole range of vegetation belts. Since then, only a few works containing information about vegetation have been carried out. The revision of syntaxa for the territory of Serbia was done by KOJIĆ et al. (1998), and the revision of scrub and forest vegetation was done by TOMIĆ & RAKONJAC (2011). The Catalog of Habitats of Serbia (BLAŽENČIĆ et al. 2005) defined vegetation types according to the EUNIS classification. Red Data Book of the Republic of Bulgaria (BISERKOV 2015) grouped vegetation types into a few categories, which are divided based on expert opinions.

In this work, I describe the vegetation occurring on the Bulgarian side of the Chiprovska Planina Mts. (i.e., the highest part of the Western Stara Planina Mts.) using the Braun-Blanquet approach, focusing on all vegetation types developing above the timberline.

2. Study area

2.1 Landscape characteristics

The altitude of the Western Stara Planina ranges between ~200 and 2169 m a.s.l. The main ridge (Chiprovska Planina) is oriented in an NW–SE direction. The sandstone and conglomerate rocks in the area are of Permian origin, the metamorphic rocks are of Cambrian-Devonian origin, and the igneous rocks are of Carboniferous origin (EGS 2022). The NE side of the main mountain ridge is rugged. The slopes are steep and contain, especially near Mt. Midzhur, numerous outcrops. The springs are relatively rare, occurring especially at the boundaries between different types of rocks.

The study area is formed of sedimentary rocks (sandstone, conglomerate, and claystone), metamorphic rocks (phyllite), and igneous rocks (granite and granodiorite). Mt. Midzhur is composed mainly of sandstone, Mt. Dupljak of granite, and the area near Mt. Kopren of conglomerates (cf. MIŠIĆ 1978, EGS 2022).

Table 1. Selected climatic approximations for Mt. Midzhur based on the model of Chelsa (KARGER et al. 2017); t mean – monthly mean of daily mean temperature, t min – monthly mean of daily minimum temperature, t max – monthly mean of daily maximum temperature, p mean – monthly mean of precipitation, g m – grand mean.

Tabelle 1. Ausgewählte klimatische Näherungswerte für den Mt. Midzhur basierend auf dem Modell von Chelsa (KARGER et al. 2017); t mean – Monatsmittel der Tagesmitteltemperaturen, t min – Monatsmittel der Tagesminimaltemperaturen, t max – Monatsmittel der Tageshöchsttemperaturen, p mean – Monatsmittel des Niederschlags, g m – Jahres-Gesamtmittelwert.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	g m
t mean [°C]	-9.0	-7.8	-3.6	1.1	6.0	9.6	11.7	11.4	7.1	2.1	-3.5	-7.6	1.45
t min [°C]	-12.8	-12.1	-8.4	-4.0	0.8	4.5	6.5	6.2	2.1	-2.6	-7.5	-11.1	-3.2
t max [°C]	-5.2	-3.5	1.2	6.2	11.1	14.8	17.0	16.6	12.2	6.8	0.5	-4.1	6.13
p mean [mm]	47	51	57	72	95	105	77	56	54	53	70	59	66.3

The most widespread soil types in the study area are brown forest soils (Cambisols; below ~ 1800 m a.s.l.) and dark-colored mountainous forest soils (Cambic Umbrisols; above ~ 1800 m a.s.l.) on meadows likely accompanied by mountainous meadow soils (Umbric Leptosols) and on rocks outcrops and screes by initial soil types and their degraded variants (KOINOV et al. 1968, CHESWORTH et al. 2008, SHISHKOV & KOLEV 2014).

The climatic data are taken from the model of Chelsa (KARGER et al. 2017) based on the measurements from the period of 1979–2013 (Table 1). The mean annual temperature for the summit area of Mt. Midzhur is estimated at 1.5 °C and the annual precipitation at 796 mm, with two precipitation peaks in June and November. However, MILOVANOVIĆ (2010) estimates the mean annual precipitation at the mountain ridges on the Serbian side of the Stara Planina around 1200 mm. The main wind direction is ~ SW (cf. DTU 2022), which causes the accumulation of blown snow mainly on the N and NE sides of the mountains. The snow at the highest parts persists for about six months, at N slopes slightly longer (MILOVANOVIĆ 2010).

Within the Köppen-Geiger climate classification (KOTTEK et al. 2006), the area is classified as Dfb (warm-summer humid continental climate), which is true for most of the mountain range of Stara Planina, except for the highest parts of the Central Stara Planina, the area near the Botev Peak (2376 m a.s.l.), which falls under Dfc (subarctic climate).

2.2 Biogeography and potential vegetation

The study area lies in the alpine biogeographic region (CERVELLINI et al. 2020), within alpine and subalpine vegetation belts (UZUNOV & GUSSEV 2003). Beech forests, which are dominant above ~ 600 m (MICHALIK 1992), create a timberline at ~ 1900 m. Subalpine scrub with *Alnus viridis*, *Salix* spp., and *Sorbus aria* occurs above timberline, together with dwarf scrub, meadows, and scree vegetation. The western part of the Stara Planina Mts. also has a local presence of the spruce forest belt, which lies between ~ 1500 and 1900 m a.s.l. and develops mainly on northern slopes. Above the timberline, *Picea abies* creates subalpine parkland with solitary individuals, rarely also accompanied by stands of *Pinus mugo*.

The study area lies in the northern part of the Balkan phytogeographic region (MEUSEL & JÄGER 1992) and is affected, through the proximity of the mountain systems, mainly by the Carpathian phytogeographic region. In the Bulgarian national classification of floristic regions (BONDEV in JORDANOV 1966, ASSYOV & PETROVA 2012), the area lies in the Western Stara Planina subregion. It has specific floristic composition, connecting the area to a wider context of neighboring mountainous regions such as floristic elements of the Carpathian-Balkan origin, *Veronica baumgartenii,* and *Swertia punctata*.

The map of the natural vegetation of Europe (BOHN et al. 2004) depicts altimontane and partly montane spruce and mixed spruce forests (D.4.2) and subalpine and oro-Mediterranean vegetation (D.3) in the study area. The latter is only shown near the top of Mt. Midzhur. However, the soil conditions near Mt. Dupljak (2033 m a.s.l.), on granodiorite boulder fields above ~1900 m, would likely not support the forest. The subalpine vegetation in its natural state would be, therefore, most likely fragmented, occurring near the peaks and ridges of the highest mountains.

2.3 Traditional management

There are several traditional management systems still preserved in the area. These include communal pastures: herds of goats, cows, and horses can be seen at high altitudes. However, they mostly lack a shepherd and roam freely through the area. In the sites where cattle concentrate, the vegetation is often highly disturbed, with bare soil and sparse vegetation consisting mainly of geophytes and sporadic grasses. Near the seasonal shepherd buildings, where sheep were kept overnight, there are nutrient-rich soils with persisting monodominant tall-herb vegetation of *Rumex alpinus*. This vegetation occurs only sporadically in open patches within forests.

Pasture management was historically more widespread and intense. However, it was also more directly controlled due to the presence of shepherds. Fire is commonly used to maintain the non-forest pastures and to benefit the grass-dominated vegetation types at the expense of shrubs (mainly of *Juniperus communis* subsp. *nana*). Partly due to fire management, the timberline was decreased by ~300 m beneath its natural altitude, and the stands of *Picea abies* were considerably reduced. Some vegetation types show a strong affinity to primary non-forest conditions, such as narrow-leaved grasslands of *Festuca valesiaca* s. l. These vegetation types are most likely remnants of glacial steppe-tundra that have persisted near the upper treeline since the last glacial due to human management (DÚBRAVKOVÁ et al. 2010, CHYTRÝ et al. 2018, MAGNES et al. 2021).

3. Methods

The fieldwork was carried out in August 2020 and July 2021 in the Western Stara Planina (see Fig. 1). In total, 78 phytosociological relevés of standard size (CHYTRÝ & OTÝPKOVÁ 2003) were recorded using the Braun-Blanquet approach (WESTHOFF & VAN DER MAAREL 1980). The relevés were deposited in the Masaryk University's Gap-Filling Database of European Vegetation (EU-00-031; CHYTRÝ & KNOLLOVÁ 2020). The grassland vegetation of rock outcrops was recorded in 7 m^2 plots of triangular shape, the vegetation of rock crevices had various plot sizes, and other vegetation types (e.g., grasslands, tall-herb vegetation) were recorded mainly in 16 m^2 square plots. In each plot, I recorded the total cover, the cover of the shrub, herb, and moss layers, the height of the layers, altitude, inclination of the slope, aspect, and coordinates. The coordinates and altitude were measured using the Garmin Foretrex 601 device. The altitude, if necessary, was corrected using the information from maps.

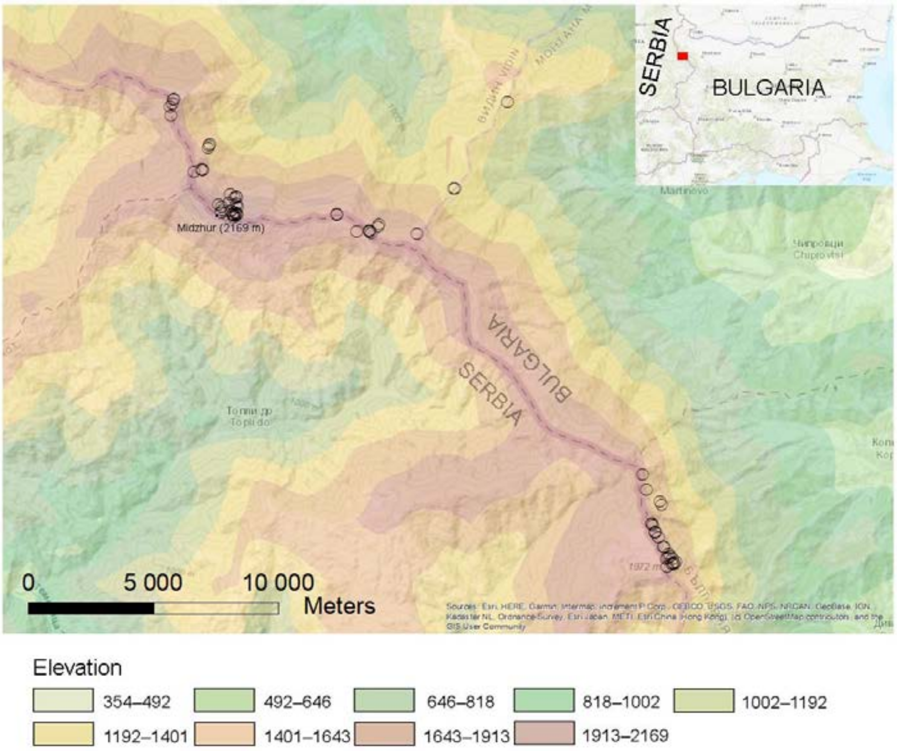

Fig. 1. Location of the recorded relevés.

Abb. 1. Lage der Aufnahmeflächen.

Soil samples were collected from a depth of ~ 10 cm (where the soil was not influenced by the organic matter), if possible, from four places in each plot, mixed, and used to measure soil pH. Plant specimens were collected for later determination and subsequently deposited in the herbarium of BRNU (see https://www.jacq.org/#database). Bryophytes were identified only for a few vegetation plots of rock outcrops, scrub vegetation, springs, and fens.

The nomenclature of vascular plants follows the Euro+Med PlantBase (EURO+MED 2006+). The nomenclature of the higher syntaxa follows MUCINA et al. (2016). The nomenclature of new syntaxonomical units respects the 4th edition of the International Code of Phytosociological Nomenclature (THEURILLAT et al. 2021). New associations were described when the vegetation could not be assigned to any existing one (i.e., the vegetation was physiognomically and floristically unique) and occurred in multiple places. When the vegetation was well distinguishable but was observed only on one site, the association or alliance has the abbreviation "prov." (provisorium) after the name. When the recorded vegetation was unique in the area and inhomogenous, the vegetation was described as "community" without a formal rank within the alliance. Species that were not identified are recorded only on a genus level or grouped into aggregates.

The species grouped into aggregates are *Anthoxanthum odoratum* agg. (including *A. alpinum* and *A. odoratum*), *Campanula rotundifolia* agg. (including *C. rotundifolia* and *C. velebitica*), *Hieracium sparsum* agg. (including *H. sparsum*, *H. transsylvanicum*, and plants of various ploidy levels), *Sedum acre* agg. (including *S. acre* and *S. alpestre*), *Senecio nemorensis* agg. (including *S. hercynicus* and *S. ovatus*) and *Sesleria coerulans* agg. (including *S. coerulans* and *S. comosa*).

The species of unclear taxonomic inclusions are *Caltha palustris* s. l., *Cardamine amara* s. l., *Cerastium alpinum* s. l., *Cystopteris alpina* s. l., *Festuca valesica* s. l. and *Valeriana officinalis* s. l. The nomenclature of bryophytes follows the work of HODGETTS et al. (2020).

The vegetation-plot records were stored in the Turboveg database (HENNEKENS & SCHAMINÉE 2001). First, numerical classifications (cluster analysis, Twinspan, K-means) were applied to the dataset. However, with such a high number of vegetation types and a low number of relevés, these methods did not produce satisfactory results, therefore, the final classification is subjective. The classification was done based on the floristic composition and physiognomy of vegetation types. The set of relevés was divided into classes and then to lower syntaxonomical units. The Juice program (TICHÝ 2002) was used for calculating the fidelity of species to groups of relevés, which was quantified using the phi coefficient of association with standardization of plot group size and accompanied by significance calculation using Fisher's exact test ($p > 0.05$). The fidelity threshold was set at $\Phi > 0.6$ for diagnostic species, and the frequency threshold was set at 60% for constant species. Dominant species were defined as those with a cover of at least 50% in at least one plot. Species with the relatively highest fidelity within the analyzed groups were marked with a "*". There had to be at least two relevés in the distinguished groups to be included in this analysis. In the text, species lists were sorted alphabetically, and dominant species were marked with a bold font style. Species that occurred as dominant but were not classified as diagnostic or constant were indicated by "Do:" after the diagnostic "Dg:" and constant "Co:" species in brackets. Fidelity for the groups of vegetation types (see Supplement 2) was calculated using the same methods and thresholds.

Ordination (DCA, detrended correspondence analysis) was calculated using R (R CORE TEAM 2020) in the R Studio environment (RSTUDIO TEAM 2020). The packages ggplot2 (WICKMAN 2016), ggpubr (KASSAMBARA 2020), and ggrepel (SLOWIKOWSKI 2021) were used to produce graphs. For the DCA analysis, vegan package (OKSANEN et al. 2020) was used and bryophytes were excluded from the analysis. The environmental vectors were fitted onto ordination using "envfit" command (OKSANEN et al. 2020). Weighted species scores were calculated using the command "weights".

Soil pH was measured following the international standard ISO 103905 (Soil, treated biowaste and sludge – Determination of pH, www https://www.iso.org/standard/75243.html). The soil was weighed on the Radwag WPT 2C weighing scale, soil samples were shaken on a Biosan PSU-10i Orbital Shaker, and pH was measured using the Hach HQ40d multi-meter. The pH was measured in a water suspension with a ratio of soil and distilled water of 2:5.

4. Results

The vegetation was classified into 12 phytosociological classes and subordinated orders, alliances, associations, and communities.

4.1 Classification

Cl.: *Asplenietea trichomanis* (Br.-Bl. in Meier et Br.-Bl. 1934) Oberd. 1977

Ord.: *Androsacetalia vandellii* Br.-Bl. in Meier et Br.-Bl. 1934

All.: *Silenion lerchenfeldianae* Simon 1958

Dg: *Silene lerchenfeldiana*

This initial acidophilic vegetation is distributed in the Eastern and Southern Carpathians and the Balkan Peninsula (PREISLEROVÁ et al. 2022). The vegetation is characterized by chasmophytic specialists such as *Symphyandra wanneri* and *Silene lerchenfeldiana*. It can also contain plants more typical of the class *Juncetea trifidi*, such as *Festuca* spp. and *Juncus trifidus* (HORVAT et al. 1937, SIMON 1957, SANDA et al. 2010). In Bulgaria, two association of this alliance occur: *Sileno lerchenfeldianae-Potentilletum haynaldianae* and *Geo-Saxifragetum cymosae* (cf. TZONEV et al. 2009).

***Jovibarbo heuffellii-Silenetum lerchenfeldianae* ass. nov. prov.**

Vegetation plots: 66, 70 in Supplement 2

Dg: *Jovibarba heuffelii*, **Silene lerchenfeldiana*

This vegetation develops in the nutrient-poor environment of conglomerate crevices and rubble at the montane to the subalpine belts. It is characterized primarily by the occurrence of the acidophilic species *Silene lerchenfeldiana*, accompanied by neutrophilous succulent *Jovibarba heuffelii* (see Fig. 3a). The moss layer is sparse and contains mainly lichens. The area in which this vegetation occurs is dependent on the size of the rock crevices, but typically, it does not exceed 1 m^2.

Syntaxonomical remark: The *Jovibarbo heuffelii-Silenetum lerchenfeldianae* is transitional to the vegetation of *Asplenion trichomanis*, which reflects low altitudes in which this vegetation occurs and a low number of vascular plants; however, the species are typical of the alliance *Silenion lerchenfeldianae*.

Distribution: This vegetation occurs on acidophilic conglomerates in the southeastern part of the study area (Mt. Kopren and nearby peaks). It was also observed in diorite crevices on Mt. Dupljak.

***Symphyandro wanneri-Veronicetum baumgartenii* ass. nov. prov.**

Vegetation plot: 60 in Supplement 2

This moderately species-rich vegetation occurs in crevices of sandstone outcrops. The sandstone is finely grained, with deeply eroded layers. Species that occur in this vegetation are *Silene pusilla*, *Symphyandra wanneri*, and *Veronica baumgartenii* (see Fig. 3b). *Asplenium* spp. were also rarely observed there. The moss layer is usually well-developed.

Syntaxonomical remark: This vegetation is related to the alliance of *Silenion lerchenfeldianae* through the occurrence of *Symphynandra wanneri*; however, the association is transitional to the alliance *Asplenion trichomanis*. This vegetation differs from the *Jovibarbo heuffelii-Silenetum lerchenfeldianae* by the occurrence of more nutrient- and moisture-demanding plants and substrate in which the vegetation occurs. The vegetation is somewhat similar to the *Sileno larchenfeldianae-Potentilletum heynaldianae* (cf. SANDA et al. 2008); however, it lacks many species in comparison to the original diagnosis such as *Poa laxa*, *Potentilla heynaldiana*, and *Saxifraga juniperifolia* (cf. HORVAT et al. 1937, SIMON 1957).

Distribution: Sandstone outcrops on Mt. Midzhur.

Cl.: *Koelerio-Corynephoretea* Klika in Klika et Novák 1941

Ord.: *Alysso-Sedetalia* Moravec 1967

All.: *Alysso alyssoidis-Sedion albi* Oberd. et T. Müller in T. Müller 1961

This vegetation of *Sedum* spp. is usually warm-demanding and occurs on calcareous rocks and rubble (MUCINA & KOLBEK 1989, SÁDLO et al. 2007, MUCINA et al. 2016). It contains ephemeral and succulent species and has perialpidic distribution (SÁDLO et al. 2007). It is known in most of Europe (PREISLEROVÁ et al. 2022); in Bulgaria, this alliance is represented by the *Achillea clyptopetala-Verbascum longifolium* community (MUCINA & KOLBEK 1989).

***Sempervivo marmorei-Poetum alpinae* ass. nov.**

Vegetation plot: 45 (holotypus) in Supplement 2

This association occurs on eroded plateaus of sandstone outcrops. The soil is initial with a small amount of accumulated organic matter. The species of this vegetation are adapted to dry conditions mostly by succulency, as is the case of *Sedum annuum* and *Sempervivum marmoreum*, or by scleromorphic features (e.g., *Saxifraga paniculata* and *Scleranthus perennis*). Geophytes such as *Allium carinatum* subsp. *pulchellum* and grasses such as *Festuca airoides* and *Poa alpina* can also be present (see Fig. 3c). The vegetation usually occurs in small patches and has well-developed moss and lichen layers. The moss layer contains *Grimmia* sp., *Hedwigia ciliata*, and *Racomitrium canescens*.

Syntaxonomical remark: This vegetation can hardly be compared to the *Achillea clypeolata-Verbascum longifolium* community described by MUCINA & KOLBEK (1989), because they did their study in relatively low altitudes in southwest Bulgaria. In Romania, the relict vegetation of *Sileno rupestris-Sedetum annuui* contains similarly to *Sempervivo marmorei-Poetum alpinae* acidophilous species such as *Agrostis capillaris*, *Sedum annuum*, and *Rumex acetosella* (SANDA et al. 2008). The *Sempervivo marmorei-Poetum alpinae* is distinguished from other associations of the alliance *Alysso alyssoidis-Sedion albi* by the occurrence of high mountain species such as *Poa alpina* and *Festuca airoides* and the co-occurrence of acidophilous (e.g., *Festuca airoides*, *Sedum annuum*) and calciphilous (e.g., *Saxifraga paniculata*) species.

Distribution: On sandstone outcrops on the mountain ridge (documented near Orlov Kamen peak).

Cl.: *Calluno-Ulicetea* Br.-Bl. et Tx. ex Klika et Hadač 1944

Ord.: *Vaccinio myrtilli-Genistetalia pilosae* Schubert ex Passarge 1964

All.: *Bruckenthalion spiculifoliae* Horvat 1949

Dg: *Avenula versicolor*, *Bruckenthalia spiculifolia*, *Genista pilosa*

Co: *Avenella flexuosa*, *Hieracium sparsum* agg., *Juniperus communis* subsp. *nana*, *Vaccinium myrtillus*, *V. uliginosum*, *V. vitis-idaea*

This alliance is distributed in the Carpathians and the Balkan Peninsula (KOJIĆ et al. 1998, PREISLEROVÁ et al. 2022). It develops in the supramontane and subalpine belts, typically on siliceous substrates (MUCINA et al. 2016). The alliance of *Bruckentalion spiculifoliae* has, in comparison to the alliance of *Genisto pilosae-Vaccinion*, a narrower range of the number of species and soil pH (see Fig. 2); this can be, however, caused by the different number of contained associations.

***Bruckenthalio spiculifoliae-Juniperetum sibiricae* (Horvat 1938) Zupančič 1992**

Vegetation plots: 42, 56, 64, 68 in Supplement 2

Dg: *Avenula versicolor*, *Genista pilosa*

Co: *Avenella flexuosa*, *Bruckenthalia spiculifolia*, *Hieracium sparsum* agg., *Juniperus communis* subsp. *nana*, *Vaccinium myrtillus*, *V. uliginosum*, *V. vitis-idaea*

This vegetation is common in the study area on shallow and nutrient-poor soils. It typically develops in the middle parts of gentle mountain slopes. The vegetation is species-poor, and its dominant species belong to the *Ericaceae* family (mainly *Bruckenthalia spiculifolia*, but also *Vaccinium myrtillus*, *V. vitis-idaea*, and *V. uliginosum*). It can be transitional

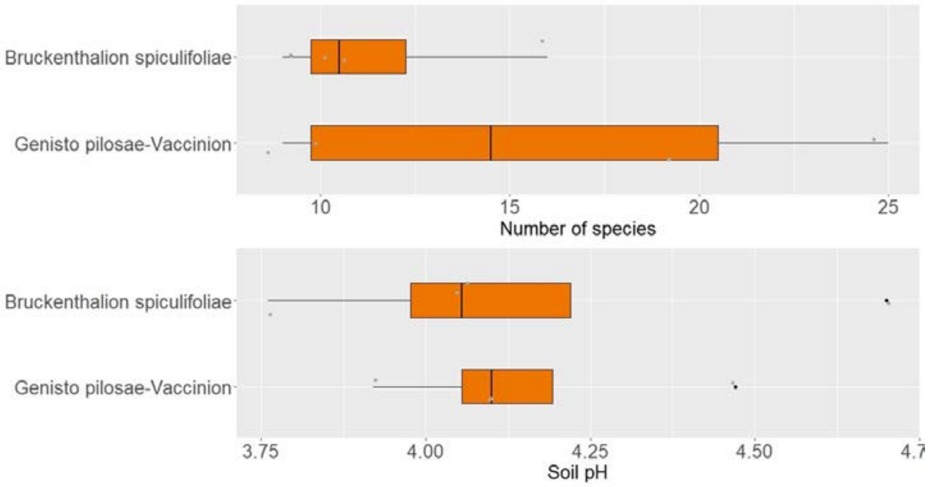

Fig. 2. Comparison of the species number (above) and soil pH (below) between alliances within the class *Calluno-Ulicetea*.

Abb. 2. Vergleich der Artenzahl (oben) und des Boden-pH-Wertes (unten) zwischen den Verbänden der Klasse *Calluno-Ulicetea*.

to the vegetation of the alliance of *Juniperion nanae*, as the competitively stronger *Juniperus communis* subsp. *nana* can replace the *Ericaceae* heathlands unless the vegetation is disturbed by fire. It also contains other species, such as *Hieracium sparsum* agg. And graminoids (such as *Avenella flexuosa* and *Luzula luzuloides*; see Fig. 3d). It is typical of the lower subalpine belt and develops at wind-sheltered sites. The moss layer can be well-developed and, in such cases, contains, among others, *Hylocomium splendens*, *Hypnum cupressiforme*, *Racomitrium canescens*, and *Tortella tortuosa*.

Distribution: This vegetation occurs in the Carpathians and Balkan Peninsula (REXHEPI 1994, SANDA et al. 2010). In Kosovo, it is also accompanied by calciphilic species (cf. REXHEPI 1994). It is also reported from Serbia, but these records may relate to the territory of Kosovo (BLAŽENČIĆ et al. 2005, TOMIĆ & RAKONJAC 2011). Similar vegetation was reported from the central part of the Stara Planina Mts. by KOCHEV (1967) and VELEV & APOSTOLOVA (2008).

All.: *Genisto pilosae-Vaccinion* Br.-Bl. 1926

Co: *Avenella flexuosa*, *Luzula luzuloides*, *Melampyrum sylvaticum*, *Senecio abrotanifolius* subsp. *carpaticus*, *Vaccinium myrtillus*, *V. vitis-idaea*

Heathlands of the alliance *Genisto pilosae-Vaccinion* occur in the montane to subalpine belts in the nemoral mountains (MUCINA et al. 2016). The constant species occurring in this vegetation are *Vaccinium* spp. This vegetation is differentiated from the alpine heathlands of *Loiseleurio procumbentis-Vaccinion* by the absence of dwarf shrubs typical of higher altitudes (KRAHULEC et al. 2007). It is distributed in the mountains of Central Europe and Bosnia and Herzegovina (cf. PREISLEROVÁ et al. 2022).

Fig. 3. – Abb. 3. a) *Jovibarbo heuffelli-Silenetum lerchenfeldianae*, **b)** *Symphyandro wanneri-Veronicetum baumgartenii*, **c)** *Sempervivo marmorei-Poetum alpinae*, **d)** *Bruckenthalio spiculifoliae-Juniperetum sibiricae*, **e)** *Seslerio coerulantis-Vaccinietum myrtilli*, **f)** *Seslerio comosae-Juniperetum sibiricae* (Photos: D. Szokala, a) b) c) d) 2020, e) f) 2021).

Vaccinium myrtillus community

Vegetation plot: 7 in Supplement 2

This vegetation occurs dominantly near the edge of the artificially lowered upper timberline, in stony, dry places. The dominant species which occur in this vegetation belong to the *Ericaceae* family. The high-mountain species such as *Juncus trifidus* are mixed in this vegetation with the montane species such as *Agrostis capillaris* and *Veronica officinalis*. Species that indicate human activity and eutrophication such as *Rumex arifolius* and

Verbascum longifolium occur frequently in this vegetation. It is similar to the *Vaccinio-Callunetum vulgaris* Büker 1942, however the heather shrubs of *Calluna vulgaris* is not present in this vegetation due to its south-eastern distributional border (cf. MEUSEL et al. 1978) and the relative rarity in Bulgaria (cf. PETROVA & VLADIMIROV 2009). It also resembles the vegetation of *Calamagrostio arundinaceae-Vaccinietum myrtilli* through the occurrence of widespread *Ericaceae* species and secondary origin of this vegetation (cf. KRAHULEC et al. 2007).

Syntaxonomical remark: In the study area, this vegetation is related to the alliance *Bruckenthalion spiculifoliae*, however, *Bruckenthalion spiculifoliae* differs in physiognomy and higher number of species typical of higher altitudes such as *Avenula versicolor* and *Gnaphalium supinum*.

Distribution: This vegetation was observed in the whole studied area, recorded at the base of Mt. Midzhur.

Seslerio coerulantis-Vaccinietum myrtilli **ass. nov.**

Vegetation plots: 14 (holotypus), 43, 77 in Supplement 2

Dg: *Senecio abrotanifolius* subsp. *carpaticus*

Co: *Allium victorialis*, *Avenella flexuosa*, *Festuca airoides*, *Gentiana punctata*, *Luzula luzuloides*, *Melampyrum sylvaticum*, *Sesleria coerulans* agg., *Soldanella* sp., *Vaccinium vitis-idaeae*, *V. myrtillus*

(+ **Do**: *Clematis alpina*)

This association represents the natural open vegetation of alpine heaths. It consists of dominant *Vaccinium myrtillus*, *V. uliginosum* and *V. vitis-idaea*, accompanied by *Ligusticum mutellina*, *Sesleria coerulans* agg., *Soldanella* sp., *Pseudorchis albida*, *Allium victorialis*, *Gentiana punctata*, *Festuca airoides*, and *Senecio abrotanifolius* subsp. *carpaticus* (see Fig. 3e). It occurs dominantly at relatively high altitudes, in conditions sheltered from the wind. It can transition into other grass-dominated vegetation types, especially if the stands of *Seslerio coerulantis-Vaccinietum myrtilli* are accessible and the area is grazed. It is typical of north or northeastern middle slopes, which are sheltered, with a high amount of snow cover that also lasts longer due to its exposition. The moss layer is usually well-developed and contains only ubiquitous species such as *Hylocomium splendens*. The measured soil pH was 3.9 and 4.1.

Syntaxonomical remark: This vegetation is vicariant to the *Festuco supinae-Vaccinietum myrtilli*, distributed in the Sudetes and higher parts of the mountains in Germany (KRAHULEC et al. 2007) and *Avenastro versicoloris-Vaccinietum myrtilli* from the Carpathians (KLIMENT & VALACHOVIČ 2007); in the study area, the vegetation contains *Sesleria coerulans* agg. and *Vaccinium uliginosum*, which are not typical of this vegetation. However, *Sesleria coerulans* agg. is partly vicariant to *Festuca airoides*, and *Vaccinium uliginosum* is commonly found at higher altitudes among *V. myrtillus* and *V. vitis-idaea*. Therefore, it is very similar to vegetation found in Sudetes and Germany. Somewhat similar vegetation type was reported from the Serbian part of the Stara Planina Mts. by MIŠIĆ (1978) as *Festuco supinae-Agrostietum rupestris*, however, it differs in species composition and the dominant species, which indicates the relation to the association of *Agrostio rupestris-Seslerietum comosae* (alliance *Seslerion comosae*).

Distribution: Widespread in the whole study area, especially in sheltered places on N and NE sandstone slopes above ~ 1900 m a.s.l.

Cl.: *Loiseleurio-Vaccinietea* Eggler ex Schubert 1960

Ord.: *Vaccinio microphylli-Juniperetalia nanae* Rivas-Mart. et M. Costa 1998

All.: *Juniperion nanae* Br.-Bl. in Br.-Bl. et al. 1939

Dg: **Genista tinctoria*, **Hypochaeris maculata* subsp. *pelivanovicii*, *Thymus vandasii*

Co: *Anemone narcissiflora*, *Antennaria dioica*, *Avenella flexuosa*, *Campanula rotundifolia* agg., *Centaurea uniflora* subsp. *nervosa*, *Festuca airoides*, *F. rubra*, *Juniperus communis* subsp. *nana*, *Sesleria coerulans* agg., *Vaccinium myrtillus*, *V. uliginosum*, *V. vitis-idaea*

Subalpine shrublands of the alliance *Juniperion nanae* are widespread in the mountains of the nemoral zone of Europe (Preislerová et al. 2022). They occur mostly on siliceous bedrock and have chionophobous character (Mucina et al. 2016).

***Seslerio comosae-Juniperetum sibiricae* Roussakova 2000**

Vegetation plots: 2, 4, 55 in Supplement 2

Dg: *Genista tinctoria*, *Hypochaeris maculata* subsp. *pelivanovicii*

Co: *Antennaria dioica*, *Anemone narcissiflora*, *Avenella flexuosa*, *Festuca airoides*, *Centaurea uniflora* subsp. *nervosa*, *Festuca rubra*, *Juniperus communis* subsp. *nana*, *Sesleria coerulans* agg., *Thymus vandasii*, *Vaccinium myrtillus*, *V. uliginosum*, *V. vitis-idaea*

This association represents low scrub vegetation in both human-influenced and natural habitats of the subalpine and alpine belts. It is relatively species-poor usually with ~20 species in 16 m^2. It is common in mesic conditions on acidic rocks between ~1700–1900 m a.s.l., where it is one of the most widespread vegetation types. It is characterized by *Juniperus communis* subsp. *nana*, which forms dense stands. Small shrubs such as *Bruckenthalia spiculifolia*, *Vaccinium myrtillus*, *V. uliginosum*, *V. vitis-idaea*, graminoids *Festuca airoides*, *Sesleria coerulans* agg.; other flowering plants such as *Achillea lingulata*, *Anthemis carpatica*, and *Campanula rotundifolia* agg. occur there as well (see Fig. 3f). Their abundance varies mainly by the total cover of *Juniperus communis* subsp. *nana*. The moss layer is usually poorly developed. The shrubs of *J. communis* subsp. *nana* are very low due to unfavorable climatic conditions, in contrast to the association of *Epilobio angustifolii-Juniperetum nanae*, which also contains more nitrophilous species. The vegetation is natural in origin, although potentially it would be much less common in the absence of human impact. It is largely affected by grazing and small-scale fire management applied on expansively growing *Juniperus communis* subsp. *nana*. Regeneration of vegetation after the management can be quick but depends on the extent and intensity of the fire. The association changes dynamically with grassland vegetation types due to these interventions.

Distribution: This vegetation occurs across the whole study area. It is documented from the Rila, where it was described by Roussakova (2000). It differs from the dwarf *Juniperus* growths of *Campanulos abietinae-Juniperetum sibiricae*, which occur also in the Carpathians, by having a lower number of species that are nutrient-demanding (cf. Roussakova 2000).

Cl.: *Crataego-Prunetea* Tx. 1962

Ord.: *Sambucetalia racemosae* Oberd. ex Doing 1962

All.: *Sambuco-Salicion caprae* Tx. et Neumann ex Oberd. 1957

The shrubs of deciduous mesopilous species (such as *Lonicera xylosteum*, *Rubus idaeus*, and *Sambucus racemosa*) occur in nutrient-rich places in forest clearings of temperate Europe (SÁDLO et al. 2013, MUCINA et al. 2016, PREISLEROVÁ et al. 2022). It can also contain tree species, including coniferous ones, which indicate forest regeneration (SÁDLO et al. 2013).

***Epilobio angustifolii-Juniperetum nanae* ass. nov.**

Vegetation plots: 53 (holotypus), 54 in Supplement 2

Dg: *Epilobium angustifolium*

Co: *Juniperus communis* subsp. *nana, Rubus idaeus, Senecio nemorensis* agg., *Vaccinium myrtillus*

This secondary vegetation develops near the subalpine timberline. It includes advanced successional stages after the abandonment of pastures and indicates their return to woodland. It is typical of the occurrence of the overgrown *Juniperus communis* subsp. *nana* scrub, in which more nutrient-demanding species such as *Senecio nemorensis* agg., *Epilobium angustifolium*, and *Rubus idaeus* grow and can supplant the juniper shrubs (see Fig. 5a). Other higher woody species such as *Acer heldreichii* have also been observed there. It is a relatively stable vegetation type in the medium-long term. The moss layer is usually poorly developed or not present. The measured soil pH was acidic: 4.1 and 4.0.

Syntaxonomical remark: The classification of this association in the alliance of *Sambuco-Salicion caprae* is due to the occurrence of nitrophilous species; however, this alliance does not include vegetation, in which coniferous species are dominant. Therefore, the vegetation of *Epilobio angustifolii-Juniperetum nanae* needs further research to be properly evaluated. It has a relation to the alliance *Juniperion nanae* (class *Loiseleurio-Vaccinietea*), in the area especially to the vegetation *Seslerio comosae-Juniperetum sibiricae* from which it differs by the occurrence of tall nitrophilous species which indicate human-influenced environment (e.g., *Rubus idaeus*, *Epilobium angustifolium*) and physiognomically as the *Epilobio angustifolii-Juniperetum nanae* is tall vegetation developing in less extreme conditions.

Distribution: Abundantly near the timberline in the whole study area.

Cl.: *Juncetea trifidi* Hadač in Klika et Hadač 1944

Ord.: *Caricetalia curvulae* Br.-Bl. in Br.-Bl. et Jenny 1926

All.: *Juncion trifidi* Krajina 1933

Grasslands of the alpine rush develop on siliceous substrates (MUCINA et al. 2016). They are known from the Alps, other Central-European mountains, and the Carpathians (MUCINA et al. 2016, PREISLEROVÁ et al. 2022). They are species-poor and usually occur on the mountain tops and their ridges, where they are exposed to extreme weather (KLIMENT & VALACHOVIČ 2007).

In the comparison of alliances within the class of *Juncetea trifidi* (see Fig. 4), the alliances of *Caricion curvulae* and *Juncion trifidi* have a smaller number of species and more acidic pH than the alliance *Seslerion comosae,* which has a wider range of associations and ecological conditions.

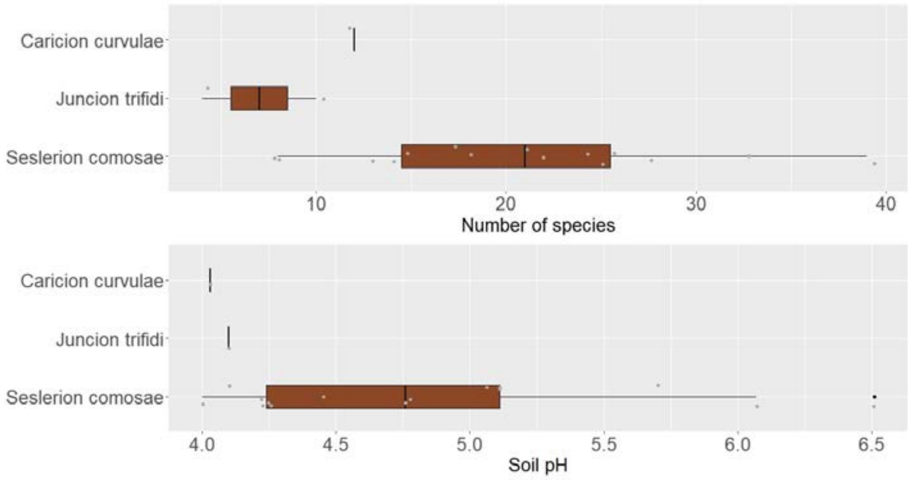

Fig. 4. Comparison of the species number (above) and soil pH (below) between alliances within the class *Juncetea trifidi*.

Abb. 4. Vergleich der Artenzahl (oben) und des Boden-pH-Wertes (unten) zwischen den Verbänden der Klasse *Juncetea trifidi*.

Juncetum trifidi Szafer et al. 1923 em. Klika 1933

Vegetation plots: 1, 78 in Supplement 2
Dg: *Veronica bellidioides*
Co: *Avenella flexuosa*, *Juncus trifidus*, *Juniperus communis* subsp. *nana*

This vegetation occurs in the clefts of boulder fields on nutrient-poor bedrocks like granite. It is affected by winds, which cause its exposure to low temperatures in winter. These conditions are critical for suppressing plants typical of the order of *Seslerietalia comosae*, which occur in less extreme conditions. The dominant species *Juncus trifidus* forms bulky stands with abundant lichens (*Cetraria* sp., *Thamnolia* sp.). The *Juniperus communis* subsp. *nana* occurs in this vegetation as well, but its cover is limited due to unfavorable conditions. Other plants, such as *Avenella flexuosa*, *Sesleria coerulans* agg., and *Veronica bellidioides* are also rarely present (see Fig. 5b).

Distribution: The alliance of *Juncion trifidi* is present in the Alps, Carpathians (Western, Eastern), and the Sudetes, where it grows on siliceous substrates, often at extreme sites. This association is distributed in the Carpathians (GRABHERR 1933, KLIMENT & VALACHOVIČ 2007, SANDA et al. 2008).

This vegetation is in the study area documented only near the peak of Mt. Dupljak at ~ 2000 m a.s.l., where it is well-developed only on the wind-exposed side of the mountain. It was also observed in other parts of the study area, on mountain ridges on conglomerates. The plant composition and cover were, however, different and transitional either to the order *Seslerietalia comosae* or the vegetation types of the class *Calluno-Ulicetea*.

All.: *Caricion curvulae* Br.-Bl. 1925

These alpine sedge grasslands develop on siliceous bedrocks of the Alps and Eastern and Southern Carpathians (GRABHERR 1993, SANDA et al. 2010, MUCINA et al. 2016, PREISLEROVÁ et al. 2022). They occur in the alpine belt, and their physiognomy is characterized by the occurrence of the dominant species *Carex curvula* (GRABHERR 1993, SANDA et al. 2008) or, in some cases, *Festuca airoides* (SANDA et al. 2010).

***Caricetum tricoloris* ass. nov. prov.**

Vegetation plot: 3 in Supplement 2

This vegetation represents the swards of *Carex tricolor* on a crystalline bedrock in the alpine belt. *C. tricolor* is ~20 cm tall sedge that forms short laterally spreading stolons (JORDANOV 1964), which gives it a competitive advantage against other plants. The sedge is, therefore, a determinant of the species composition due to its dense and monodominant stands (see Fig. 5c). It is accompanied only by a small number of species that are either competitively strong or ubiquitous, such as *Avenella flexuosa*, *Campanula rotundifolia* agg., *Juniperus communis* subsp. *nana*, *Sesleria coerulans* agg. and *Vaccinium* spp. These species, however, tend to have lower vitality and flower rarely. The moss layer is poorly developed. The measured soil pH was 4.0.

Syntaxonomical remark: This vegetation was classified within the alliance of *Caricion curvulae* due to the similarity of the sedge-dominated vegetation. However, it also contains species of the *Seslerion comosae*, such as *Campanula rotundifolia* agg. and *Sesleria coerulans* agg. These species, though, occur in other vegetation types, such as the alliance of *Juniperion nanae* (class *Loiseleurio-Vaccinietea*) and *Genisto pilosae-Vaccinion* (class *Calluno-Ulicetea*).

Distribution: Documented only near Mt. Dupljak.

Ord.: *Seslerietalia comosae* Simon 1958

All.: *Seslerion comosae* Horvat et al. 1937

Dg: *Saxifraga paniculata*

Co: *Campanula rotundifolia* agg., *Festuca airoides*

The vegetation of the alpine and subalpine grasslands of the alliance *Seslerion comosae* develops on acidic soils (MUCINA et al. 2016, ROUSSAKOVA 2000). It is distributed in the Balkans (PREISLEROVÁ et al. 2022). It is distinguished mainly by the species endemic to the Balkan Peninsula (HORVAT et al. 1937).

***Agrostio rupestris-Saxifragetum paniculatae* ass. nov.**

Vegetation plots: 17 (holotypus), 19 in Supplement 2

Dg: *Allium carinatum* subsp. *pulchellum*, *Carex kitaibeliana*, *Dianthus giganteus*, *Luzula italica*, *Poa alpina*, **Saxifraga paniculata*, **S. pedemontana* subsp. *cymosa*, *Sempervivum marmoreum*, *Symphyandra wanneri*

Co: *Festuca airoides*

This association represents the vegetation of sandstone rock edges, crevices, screes, and platforms (see Fig. 5d). It contains some chasmophytic species typical of the alliances of *Silenion lerchenfeldianae* or *Saxifragion cymosae* (order *Asplenietea trichomanis*), such as *Jovibarba heuffelii*, *Saxifraga exarata* subsp. *pirinica*, *S. pedemontana* subsp. *cymosa*

Fig. 5. – Abb. 5. a) *Epilobio angustifolii-Juniperetum nanae*, **b)** *Juncetum trifidi*, **c)** *Caricetum tricoloris*, **d)** *Agrostio rupestris-Saxifragetum paniculatae*, **e)** *Veronico baumgartenii-Festucetum airoidis*, **f)** *Agrostio rupestris-Seslerietum comosae* (Photos: b) G. Kunev 2020, all othes D. Szokala c), d), e), f) 2020, a) 2021).

(cf. Amidzic & Stefanović 1996, Roussakova 2000), and other chasmophytic species such as *Luzula italica*, *Saxifraga paniculata*, and *Symphyandra wannerii*. Plants typical of the grasslands, such as *Agrostis rupestris*, *Campanula rotundifolia* agg., *Poa alpina*, *Sesleria coerulans* agg., occur frequently in high abundances. Chionophilous *Primula minima*, basophilous *Carex kitaibeliana*, and neutrophilous *Myosotis alpestris* also occur at high altitudes. The vegetation is relatively species-rich, with ~ 14 species of vascular plants in 7 m^2. The moss layer is well developed, with a typical cover of around 65% containg species such as *Grimmia* sp., *Hedwigia ciliata*, *Hypnum* sp, *Polytrichastrum formosum*, and *Tortella tortuosa*. The measured soil pH was 4.23 and 4.0.

Syntaxonomical remark: This vegetation is similar to the order *Silenion lerchenfeldianae* (class *Asplenietea trichomanis*), with which it shares some grassland species. However, it has relatively well-developed soils (with accumulated organic matter) and different specialists. Therefore, it should be viewed as a grassland with a strong connection to the association of *Agrostio rupestris-Seslerietum comosae*. Compared to the *Veronico baumgartenii-Festucetum airoidis*, it develops on wind-exposed solitary rock outcrops and contains xeromorphic species (e.g., *Allium carinatum* subsp. *pulchellum* and *Sempervivum marmoreum*) which indicates poorly developed soils and thus higher fluctuation of water availability.

Distribution: The vegetation is documented on north-facing sandstone outcrops near the peak of Orlov Kamen and the adjacent ridge.

***Veronico baumgartenii-Festucetum airoidis* ass. nov.**

Vegetation plots: 8 (holotypus), 11, 48, 49, 50, 51 in Supplement 2

Dg: **Asplenium viride*, **Galium anisophyllon*, **Ranunculus montanus*, *Saxifraga bryoides*, **S. exarata* subsp. *pirinica*, *Symphyandra wanneri*, *Veronica baumgartenii*

Co: *Cerastium alpinum* s. l., *Festuca airoides*, *Juncus trifidus*, *Luzula italica*, *Saxifraga paniculata*, *Sesleria coerulans* agg., *Silene pusilla*

The vegetation of *Veronico baumgartenii-Festucetum airoidis* occurs on poorly developed, barely stabilized sandstone screes and rock outcrops on the northern and north-eastern leeward slopes of the mountains, on large rock formations above ~ 1900 m a.s.l., where snow remains for a long time. The vegetation is often sparse due to gravel movement, which permits the occurrence of less competitive species. It is moderately species-rich, with ~ 25 species of vascular plants in 7 m^2, typically with no distinctive dominants. Species of rock crevices and screes such as *Cerastium alpinum* s. l., *Luzula italica*, and *Symphyandra wanneri* occur in open places. Moisture-demanding plants such as *Silene pusilla* occur especially in the most shaded conditions. The open, slightly wet parts are occupied by species such as *Huperzia selago*, *Primula minima*, saxifrages (*Saxifraga bryoides*, *S. exarata* subsp. *pirinica*, *S. pedemontana* subsp. *cymosa*), and *Soldanella* sp. Other sporadically occurring species of screes and rock crevices include *Galium anisophyllon*, *Minuartia verna* agg., *Pedicularis comosa*, and *P. verticillata*. Rarely occurring plants of more stabilized places include *Anemone narcissiflora*. Ubiquitous species such as *Campanula rotundifolia* agg., graminoids (*Carex atrata*, *Festuca airoides*, *F. rubra* agg. and *Sesleria coerulans* agg.), and *Ranunculus montanus* are abundant there (see Fig. 5e). The vegetation also rarely contains species not typically bound to acidic conditions, such as *Asplenium viride*.

The moss layer is well developed, with total cover ranging typically between 10 and 20%. The occurring species include *Amphidium mougeotii*, *Distichium capillaceum, Polytrichum juniperinum*, *Tortella tortuosa*, and *Trilophozia quinquedentata*. The vegetation has a pronounced relict character and occupies extreme places. Even though the vegetation belts were greatly altered, it is possible that rock formations that host this association were historically never covered by any forest or scrub vegetation.

Syntaxonomical remark: High cover of graminoids is caused by progressing stabilization of the screes, favorable properties of soil, its substrate, and climatic conditions. Therefore, this association is related to the vegetation of the class *Seslerietalia comosae*. It resembles some associations of the order *Veronicion baumgartenii* (cf. SANDA et al. 2010); however, the vegetation of *Veronicion baumgartenii* develops as the initial vegetation of screes in the Carpathians. It is also related to the alliance of *Silenion lerchenfeldianae*; however, the *Veronico baumgartenii-Festucetum airoidis* is not typically vegetation of bare rocks and needs an accumulated organic matter to develop. Apart from the mentioned differences, the vegetation has a chionophilous character with species such as *Primula minima*, *Saxifraga bryoides*, and *Soldanella* sp., much of which have high coverage and optimum occurrence in this vegetation. Vegetation captured by SIMON (1957) in the Pirin Mts. has a somewhat similar floristic composition as vegetation recorded in the study area. It has a high number of chionophilous species and differs from the original diagnoses provided by HORVAT et al. (1937). However, it contains several species not occurring in the study area (e.g., *Alopecurus gerardii*, *Carex curvula*, *Dianthus microlepsis*, *Festuca riloensis*, *Leontodon riloensis*; cf. SIMON 1957); it is more related to the alliance *Caricion curvulae*.

Distribution: This association occurs on the sandstone outcrops of Mt. Midzhur. It has a strong connection to the alliance *Silenion lerchenfeldianae* (order *Asplenietea trichomanis*), namely *Sileno lerchenfeldianae-Potentilletum haynaldianae*; however, it lacks some high-mountain species such as *Dianthus microlepis* and *Rhodiola rosea*. It is dominated by grasses, and the soil is relatively well-developed. Consequently, it should be considered grassland vegetation.

***Agrostio rupestris-Seslerietum comosae* Horvat et al. 1937**

Vegetation plots: 18, 59 in Supplement 2

Dg: ***Agrostis rupestris***, **Festuca nigrescens*, *Senecio abrotanifolius* subsp. *carpaticus*, **Scleranthus perennis*

Co: *Campanula rotundifolia* agg., *Hieracium sparsum* agg., *Ligusticum mutellina*, *Potentilla ternata*

This vegetation is common at the highest altitudes on shallow soils. If the soils are relatively well-developed, intensive grazing must be present for this vegetation to occur. It is short vegetation consisting predominantly of graminoids (*Agrostis rupestris*, *Carex* spp., *Festuca nigrescens*) and other plants such as *Centaurea uniflora* subsp. *nervosa* and *Senecio abrotanifolius* subsp. *carpaticus* (see Fig. 5f). It can be found in either sheltered or open spaces. The snow cover and its duration differ between sites. In places where the snow cover remains for a long time, chionophilic species such as *Gnaphalium supinum* can occur.

Distribution: *Agrostio rupestris-Seslerietum comosae* is distributed across the whole study area in exposed places on shallow soils. It is known from the Rila and Pirin Mts. (HORVAT et al. 1937, 1974, ROUSSAKOVA 2000).

***Thesio alpini-Avenelletum flexuosae* ass. nov.**

Vegetation plots: 61, 63, 71 (holotypus), 72 in Supplement 2

Dg: *Achillea millefolium*, *Bupleurum falcatum*, **Chamaecytisus supinus*, *Crepis conyzifolia*, **Luzula campestris*, *Thesium alpinum*

Co: *Anthoxanthum odoratum* agg., *Avenella flexuosa*, *Campanula rotundifolia* agg., *Calamagrostis arundinacea*, *Gentiana asclepiadea*, *Hypericum maculatum*, *Luzula luzuloides*, *Solidago virgaurea*, *Thymus vandasii*

These meadows occur in relatively nutrient-rich places. They are typical of moderately tall herbs such as *Bupleurum falcatum*, *Gentiana asclepiadea*, *Scabiosa columbaria*, and *Solidago virgaurea* (see Fig. 7a). The sites are usually not grazed and have a strong connection to meadows at mid- altitudes; however, they also contain species typical of the subalpine belt. They usually develop in natural habitats, although they can also occur in anthropically affected places, such as ruins of buildings or at the edges of roads and trails.

Hemi-parasitic and parasitic species such as *Thesium alpinum* and *Orobanche* spp. occur in this vegetation regularly. The dominant grasses are either *Avenella flexuosa* or *Nardus stricta,* and through the dominance of matgrass it resembles the vegetation of *Nardion strictae* and *Potentillo ternatae-Nardion strictae* (cf. SIMON 1957, KLIMENT & VALACHOVIČ 2007, GRABHERR 1993). The measured soil pH was 4.1, 4.3, and 5.1.

Distribution: This vegetation can be found in the lower part of the subalpine belt and in places where the subalpine belt was artificially reduced. This vegetation was found mainly on conglomerate bedrock.

***Sesleria coerulans-Vaccinium myrtillus* community**

Vegetation plot: 10 in Supplement 2

This vegetation occurs in places of bed layers of avalanches. It is characterized by a high number of vascular plant species. The vegetation is transitional between alpine heaths and alpine grasslands and has no distinct dominants. It contains *Vaccinium* spp. and other species typical of grasslands, such as *Alchemilla* spp., *Anemone narcissiflora*, *Crepis viscidula*, *Sesleria coerulans* agg., and *Solidago virgaurea*. There have been recorded 39 species of vascular plants in 16 m^2. The measured soil pH was 4.5.

Distribution: This vegetation was recorded on the NE slope of Mt. Midzhur ~ 2000 m a.s.l., in the place of likely origin of avalanches. The main ecological characteristic is its natural disturbance regime which enables the coexistence of species that are not typically found in regularly disturbed places, such as *Vaccinium* spp. It is also possible that this vegetation developed after the partial abandonment of pasture and is undergoing succession from grassland to heathland. As such, it contains species of both habitats. The vegetation was present only in one place in an area of ~ 200 m^2.

Cl.: *Roso pendulinae-Pinetea mugo* Theurillat in Theurillat et al. 1995

Ord.: *Junipero-Pinetalia mugo* Boşcaiu 1971

All.: *Pinion mugo* Pawłowski et al. 1928

This alliance of the subalpine scrub of *Pinus mugo* develops on siliceous bedrock in Central Europe, the Carpathians, and the Balkans (MUCINA et al. 2016, PREISLEROVÁ et al. 2022). It is usually species-poor (CHYTRÝ 2013). In Bulgaria, it is represented only by the association of *Avenello flexuosae-Pinetum mugo* (ROUSSAKOVA 2000).

***Avenello flexuosae-Pinetum mugo Bondev* ex Roussakova in Tzonev et al. 2009 nom. corr.**

Synonym: *Lerchenfeldio-Pinetum mugo* Bondev ex Roussakova in Tzonev et al. 2009 (original diagnosis in TZONEV et al. 2009, p. 226, with reference to a table in ROUSSAKOVA 2000, p. 117)

Avenella flexuosa (L.) Drejer [nom. illeg. *Lerchenfeldia flexuosa* (L.) Schur]

Vegetation plots: 65, 67 in Supplement 2

Dg: ***Pinus mugo***

Co: *Calamagrostis arundinacea*, *Juniperus communis* subsp. *nana*, *Vaccinium myrtillus*

This vegetation occupies a large portion of the subalpine belt on conglomerates. It is distinct by the dominant *Pinus mugo*, which creates impenetrable vegetation (see Fig. 7b), and low shrub *Juniperus communis* subsp. *nana*, which often fills the gaps in *Pinus mugo* stands. The herb layer is poorly developed, which is partially caused by the accumulation of dead biomass and shade of shrubs. It contains only edaphically indifferent or acidophilic species such as *Calamagrostis arundinacea* and *Vaccinium* spp. The moss layer is either poorly developed or absent. The measured soil pH was 4.1 and 4.4.

Distribution: This vegetation was recorded by ROUSSAKOVA (2000) in the Rila Mts. In the studied part of the Stara Planina, it is distributed on acidic bedrocks and documented near Mt. Kopren and observed near Mt. Dupljak.

Cl. *Mulgedio-Aconitetea* Hadač et Klika in Klika et Hadač 1944

Ord. *Adenostyletalia alliariae* Br.-Bl. 1930

All. *Cirsion appendiculati* Horvat et al. 1937

This tall-herb vegetation of the Balkan Peninsula (PREISLEROVÁ et al. 2022) develops near streams and springs on acidic soils (ROUSSAKOVA 2000, MUCINA et al. 2016). It is distinguished by the occurrence of *Cirsium appendiculatum* and other species typical of the Balkan Peninsula (HORVAT et al. 1937). The comparison of alliances within the class of *Mulgedio-Aconitetea* (see Fig. 6) shows that the alliance of *Cirsion appendiculati* has a low number of species but relatively high soil pH. The broadest range between the variables can be seen within the alliances of *Dryopterido filicis-maris-Athyrion distentifolii* (in both the number of species and soil pH) and *Scabioso-Doronicion columnae*, which has a wide range of species number; however, the soil pH in the alliance of *Scabioso-Doronicion columnae* has the narrowest range of values.

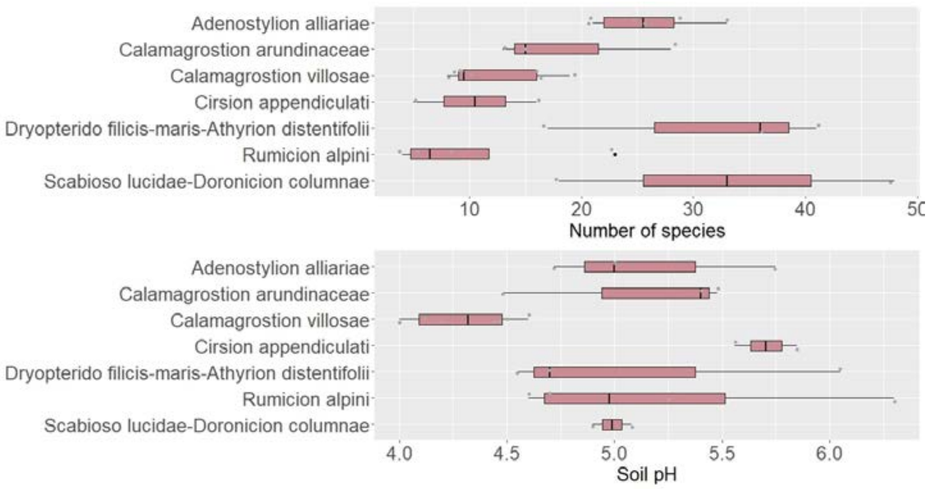

Fig. 6. Comparison of the species number (above) and soil pH (below) between alliances within the class *Mulgedio-Aconitetea*.

Abb. 6. Vergleich der Artenzahl (oben) und des Boden-pH-Wertes (unten) zwischen den Verbänden der Klasse *Mulgedio-Aconitetea*.

***Angelico sylvestris-Heracleetum verticillati* Horvat et al. 1937 mut. Szokala 2023**

(synonym: *Angelico pancicii-Heracleetum verticillati* Horvat et al. 1937)
Angelica sylvestris L. (synonym: *Angelica pancicii* VANDAS in VELENOVSKÝ 1891, Flora Bulgarica I.: 200. Fr. Řivnáč, Praha. CANNON in TUTIN et al. (1968): Flora Europaea II. – Cambride University Press. Cambridge: 469 pp. [Cannon synonymised *Angelica pancicii* Vandas with *Angelica sylvestris* L.]. DIHORU, G., PAUCĂ-COMĂNESCU, M. et ION, R. (2011): Analysis of the characters on some *Angelica* taxa. – Rom. J. Biol. – Plant Biol., 56: 79–89 [No morphometric evidence was found based on mericarps and fruits to support the existence of *Angelica pancicii* and it is synonymised with *A. sylvestris* subsp. *montana*].)
Vegetation plots: 6, 29 in Supplement 2
Dg: *Epilobium alpestre* Co: *Adenostyles alliariae*, ***Rumex alpinus***, *Senecio nemorensis* agg.

This tall-herb vegetation occurs near mountain streams. The dominant plants can attain around 2 m in height; the most prevalent species are *Heracleum sphondylium* subsp. *verticillatum*, and in some cases, where the vegetation is affected by human activity, *Angelica sylvestris* and *Rumex alpinus* can also attain dominance (see Fig. 7c), which indicates the transition to the alliance of *Rumicion alpini*. The vegetation develops on gentle or steep slopes (with an inclination of ~25–30°). The measured pH was 5.6 and 5.9.

Syntaxonomical remark: *Cirsium appendiculatum* was not recorded in this vegetation in the study area, which can indicate the geographic border of the alliance *Cirsion appendiculati* and the transition of this vegetation to the alliance of *Adenostylion alliariae.* Species that occur in the documented vegetation and are not present in the originally described relevés (cf. HORVAT et al. 1937) are *Adenostyles alliariae* and *Epilobium alpestre*. However, the presence of *Heracleum sphondylium* subsp. *verticillatum* together with ecological preferences relates this vegetation to the alliance *Cirsion appendiculati*. Recorded vegetation is species-poor in comparison with vegetation that occurs in the Rila Mts. (cf. HORVAT et al. 1937, ROUSSAKOVA 2000). This difference can be caused by a stronger effect of human activities and eutrophication in the study area.

Distribution: This vegetation is documented near the streams on Mt. Midzhur. The association was also documented in the Rila Mts. (HORVAT et al. 1937, 1974, ROUSSAKOVA 2000) and Central Stara Planina (MICHALIK 1990).

All.: *Adenostylion alliariae* Br.-Bl. 1926

Dg: *Trollius europaeus*

Co: *Adenostyles alliariae*, *Anemone narcissiflora*, *Alchemilla* sp., *Bistorta major*, *Doronicum columnae*, *Geranium sylvaticum*, *Heracleum sphondylium*, *Hypericum maculatum*, *Ligusticum mutellina*, *Myosotis nemorosa*, *Primula elatior*, *Rumex arifolius*, *Silene vulgaris*, *Soldanella* sp., *Valeriana tripteris*

This high mountain alliance associates tall-herb vegetation with a siliceous substrate (MUCINA et al. 2016). In comparison with the alliance of *Cirsion appendiculati*, it contains species such as *Adenostyles alliariae*, *Cicerbita alpina*, and *Epilobium alpestre* (cf. HORVAT et al. 1937). It is distributed in most parts of temperate Europe and has an expected occurrence in Bulgaria according to PREISLEROVÁ et al. (2022).

Fig. 7. – Abb. 7. a) *Thesio alpini-Avenelletum flexuosae*, **b)** *Avenello flexuosae-Pinetum mugo*, **c)** *Angelico sylvestris-Heracleetum verticillati*, d) *Ranunculo platanifolii-Adenostyletum alliariae*, **e)** *Anemono narcissiflorae-Trollietum europaei*, **f)** *Cystopterido alpinae-Athyrietum filicis-feminae* (Photos: D. Szokala, 2021).

Ranunculo platanifolii-Adenostyletum alliariae **Dúbravcová et Hadač ex Kočí 2001**

Vegetation plots: 9, 12, 25, 33 in Supplement 2

Dg: *Doronicum columnae*, *Geranium sylvaticum*, *Myosotis sylvatica*, *Primula elatior*, **Trollius europaeus*

Co: ***Adenostyles alliariae***, *Anemone narcissiflora*, *Alchemilla* sp., *Bistorta major*, *Heracleum sphondylium*, *Hypericum maculatum*, *Ligusticum mutellina*, *Rumex arifolius*, *Saxifraga rotundifolia*, *Silene vulgaris*, *Soldanella* sp., *Valeriana tripteris*

Tall-herb vegetation that develops in wet places on soil-filled screes or in terrain depressions. The vegetation is constituted of the dominant *Adenostyles alliariae* and other plants with higher stature, such as *Trollius europaeus* and *Ranunculus platanifolius* (see Fig. 7d). The dominants, however, differ among sites, depending on soil conditions. The moss layer is usually poorly developed. This vegetation is relatively species-rich, with ~ 20–30 species in 16 m^2. The measured soil pH was 5 and 4.7.

Syntaxonomical remark: There have been documented occurrences of species not typically found in this association such as *Doronicum columnae*, *Geranium sylvaticum* and *Trollius europaeus*. Further studies will be needed to determine whether there should be distinguished separate vegetation types in the area.

Distribution: Documented from multiple places on sandstone bedrock, especially near Mt. Midzhur. The association is known from the Carpathians (KLIMENT & VALACHOVIČ 2007) and Sudetes (KOČÍ 2007).

***Veratrum lobelianum-Chenopodium bonus-henricus* community**

Vegetation plot: 26 in Supplement 2

This vegetation develops on disturbed, partly soil-filled sandstone screes. It is distinguished from the *Ranunculo nemorosi-Adenostyletum alliariae* by the occurrence of ruderal species such as *Chenopodium bonus-henricus* and *Taraxacum* sp. The location of the habitat suggests that the surrounding area of this vegetation served as a resting place for cattle. It is also accompanied by the nitrophilous *Rubus idaeus* with a high cover, which is unusual for the class of *Mulgedio-Aconitetea*. The soil has a higher concentration of rubble than the soils of *Ranunculo nemorosi-Adenostyletum alliariae*, which can be caused by previous soil erosion. A single recorded vegetation plot contained 21 species in 16 m^2. This vegetation is very similar to the *Poo supinae-Chenopodietum boni-henrici* (Br.-Bl. 1949) Kopecký in Hejný et al. 1979 which is known from the Alps and accompanies pastures in the supramontane and subalpine vegetation belts. In the recorded plot however, there is a lack of some differential taxa such as *Poa angustifolia*, *P*. *supina*, *Lamium album*, and *Urtica dioica*. The ecology of the recorded community suggests its relation to this vegetation (cf. BRAUN-BLANQUET 1949, 1972, HEJNÝ et al. 1979). More data are needed to evaluate this vegetation type properly.

Distribution: Recorded at one locality near the peak of Martinova Čuka.

***Anemono narcissiflorae-Trollietum europaei* ass. nov.**

Vegetation plot: 46 (holotypus)

This vegetation develops in the middle part of Mt. Midzhur, in wet soil-filled sandstone screes, which were previously grazed and later abandoned. The herb layer usually has two layers: the higher layer contains relatively tall herbs such as *Anemone narcissiflora*, *Geranium sylvaticum*, *Tephroseris aucheri,* and *Trollius europaeus* (see Fig. 7e). Species of a smaller stature such as graminoids *Luzula luzuloides*, *L. sylvatica*, and other plants such as *Alchemilla* sp., *Ligusticum mutellina*, and *Primula elatior*, indicate previous meadow-like conditions and create lower herb layer, which is very sparse. The vegetation of *Anemono narcissiflorae-Trollietum europaei* grows on steep slopes (~ 45° inclination). The moss layer is usually restrained by the densely growing herbs and contains ubiquitous species such as *Hypnum cupressiforme* and *Mnium marginatum*. The sampled vegetation plot had 28 species in 16 m^2. The measured soil pH was 5.8.

Syntaxonomical remark: The most similar to this vegetation is the association of *Trollio altissimi-Geranietum sylvatici*, which has similar species and physiognomy (cf. JENÍK et al. 1980). However, this association differs from the *Trollio altissimi-Geranietum sylvatici* in site preferences, as it grows in wet places near streams of cirques. The main factor for this vegetation is, however, wet conditions (KOČÍ 2007). Moreover, some of the species that accompany the *Anemono narcissiflorae-Trollietum europaei* such as *Centaurea uniflora* subsp. *nervosa*, *Festuca balcanica*, *Silene roemeri* and *Tephroseris aucheri* do not grow in the Sudetes. It was speculated that the association of *Trollio altissimi-Geranietum sylvatici* has been influenced by previous grazing (KOČÍ 2007). The presented vegetation shows that cattle keeping can have a significant influence on this kind of communities, as it also occurs in the complexes of abandoned pastures.

Distribution: This vegetation was documented on the middle slope of Mt. Midzhur, near sandstone outcrops. In Europe, similar vegetation of *Trollio altissimi-Geranietum sylvatici* can only be found in the Sudetes, in the Hrubý Jeseník Mts. (KOČÍ 2007).

All.: *Dryopterido filicis-maris-Athyrion distentifolii* (Holub ex Sýkora et Štursa 1973) Jeník et al. 1980

Dg: *Cystopteris alpina* s. l., *Gymnocarpium dryopteris*, *Ranunculus platanifolius*, *Sedum acre* agg., *Solidago virgaurea*

Co: *Adenostyles alliariae*, *Athyrium filix-femina*, *Allium victorialis*, *Bistorta major*, *Campanula rotundifolia* agg., *Calamagrostis arundinacea*, *C. villosa*, *Festuca rubra*, *Geranium sylvaticum*, *Gentiana asclepiadea*, *Geum montanum*, *Heracleum sphondylium*, *Hypericum maculatum*, *Ligusticum mutellina*, *Myosotis nemorosa*, *Phleum alpinum*, *Poa alpina*, *Saxifraga rotundifolia*, *Senecio nemorensis* agg., *Silene vulgaris*, *Rumex arifolius*, *Valeriana tripteris*, *Veratrum lobelianum*

This alliance of fern-dominated high-mountain springs is distributed in Central Europe and Scandinavia (MUCINA et al. 2016, PREISLEROVÁ et al. 2022). It typically develops on soil-filled screes and boulder fields near the timberline (KOČÍ 2007).

***Cystopterido alpinae-Athyrietum filicis-feminae* ass. nov.**

Vegetation plots: 27 (holotypus), 30, 37 in Supplement 2

Dg: *Cystopteris alpina* s. l., *Gymnocarpium dryopteris*, *Phleum alpinum*, *Silene vulgaris*

Co: *Adenostyles alliariae*, *Athyrium filix-femina*, *Allium victorialis*, *Bistorta major*, *Campanula rotundifolia* agg., *Calamagrostis arundinacea*, *C. villosa*, *Festuca rubra*, *Geranium sylvaticum*, *Gentiana asclepiadea*, *Geum montanum*, *Heracleum sphondylium*, *Hypericum maculatum*, *Ligusticum mutellina*, *Myosotis nemorosa*, *Poa alpina*, *Saxifraga rotundifolia*, *Sedum acre* agg., *Senecio nemorensis* agg., *Ranunculus platanifolius*, *Rumex arifolius*, *Solidago virgaurea*, *Valeriana tripteris*, *Veratrum lobelianum*

This tall-herb vegetation develops in periodical streams in places with high content of exposed rocks or on shallow soils. The vegetation is species-rich and has no distinct dominants. It consists of relatively tall species, such as *Athyrium distentifolium*, *A. filix-femina*, *Heracleum sphondylium* subsp. *verticillatum*, and *Veratrum lobelianum* (see Fig. 7f). Other lower plants of wet places, such as *Bistorta major*, *Myosotis nemorosa*, and *Saxifraga rotundifolia* occur there as well. Meadow species such as *Geum montanum*, *Ligusticum mutellina*, *Phleum alpinum*, and *Silene vulgaris* are mixed in this vegetation due to dry summer periods. At lower altitudes, where the rocks are covered by a shallow layer of soil, the vegetation is less species-rich and dominated by *Athyrium filix-femina* and *Calamagrostis* spp. The moss layer usually develops only near large stones and contains ubiquitous species such as *Hylocomium splendens* and *Pleurozium schreberi*.

Syntaxonomical remark: This vegetation is most similar to the *Adenostylo alliariae-Athyrietum distentifolii*, which is relatively species-poor and develops near timber-line, in places where snow accumulates during winter (KLIMENT & VALACHOVIČ 2007, KOČÍ 2007). It is, therefore, not bound to periodical streams, which disturb vegetation and allow the coexistence of expansive species such as *Athyrium* spp. with other plants.

Distribution: This vegetation was documented along a periodical stream of Mt. Midzhur. Fragmentary stands also occur on stony streams near Mt. Kopren.

***Scabioso lucidae-Doronicion columnae* all. nov. prov.**

Dg: *Doronicum columnae*, *Festuca pratensis*, *Geranium macrorrhizum*, *Poa media*

Co: *Anemone narcissiflora*, *Alchemilla* sp., *Bistorta major*, *Campanula rotundifolia* agg., *Festuca rubra*, *Primula elatior*, *Saxifraga rotundifolia*, *Sesleria coerulans* agg., *Valeriana tripteris*, *Veratrum lobelianum*

This alliance represents species-rich vegetation of screes of sedimentary rocks in the alpine vegetation belt. It is distinguished from other alliances of the class *Mulgedio-Aconitetea* by the notable occurrence of scree specialists such as *Geranium macrorrhizum* and *Doronicum columnae*. It resembles the alliance of *Calamagrostion arundinaceae*, which is also species-rich and develops on stony soils, however, it differs floristically. It also resembles the alliance *Dryopterido filicis-maris-Athyrion distentifolii* (association *Cystopterido alpinae-Athyrietum filicis-feminae*), however, it prefers drier conditions.

***Scabioso lucidae-Doronicetum columnae* ass. nov. prov.**

Vegetation plot: 13 in Supplement 2

This vegetation develops on relatively stabilized screes. These screes occur in large open gaps between rock outcrops. The vegetation is species-rich, containing 50 vascular plant species in 16 m^2, with no distinct dominants. It contains mesophilous species such as *Anemone narcissiflora*, *Phleum alpinum*, *Poa alpina*, *Senecio carpaticus*, *Solidago virgaurea* and *Tephroseris aucheri*, species of nutrient-rich places such as *Heracleum sphondylium* and *Rumex alpinus* (see Fig. 8a). Competitively weak and light-demanding species such as *Jovibarba heuffelii* and *Noccaea ochroleuca* grow in more open places. *Saxifraga rotundifolia* occurs in shaded wet places. Typical species of rock screes such as *Doronicum columnae* and *Valeriana tripteris* occur throughout the vegetation. There are present also species of lower elevations such as *Hypericum maculatum*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Silene vulgaris*, and *Trifolium badium*. Acidophilic specialists such as *Vaccinium myrtillus* and *Juncus trifidus* grow in stable spots and at the edges of the rock screes. Calciphilous *Scabiosa lucida* sporadically occurs throughout the vegetation. Rarely occurring tall-herb species such as *Adenostyles alliariae*, *Geranium sylvaticum*, and *Veratrum lobelianum* indicate transitional stages to the alliance of *Adenostylion alliariae*. The measured soil pH was 5.1. The moss layer is poorly developed, mainly occupying spaces near larger rocks that are not covered by vascular plants; 48 vascular plants have been recorded there in a 16 m^2 plot.

Distribution: Documented near Mt. Midzhur.

***Geranio macrorrhizi-Doronicetum columnae* ass. nov. prov.**

Vegetation plot: 44 in Supplement 2

This vegetation develops on partially soil-filled sandstone screes. It is usually relatively small-scale vegetation that contains scree specialists such as *Doronicum columnae*, *Geranium macrorrhizum*, and *Valeriana tripteris*, which occur abundantly (see Fig. 8b). Other plants that indicate later stages of scree stabilization such as grasses (e.g., *Festuca balcanica*, *Poa nemoralis*) or species typical to the alliance of *Adenostylion alliariae* (e.g., *Veratrum lobelianum*, *Ranunculus platanifolius*) occur there as well. The occurrence of tall herbs indicates a transition of this vegetation to more productive and moisture-demanding vegetation types. The moss layer is poorly developed. It differs from the *Scabioso lucidae-Doronicetum columnae* by the occurrence of purely acidophilic species and progressed stabilization of the screes. The measured soil pH was 4.9.

Distribution: In shaded parts of sandstone outcrops. It is documented only near the peak of Martinova Čuka.

Ord.: *Calamagrostietalia villosae* Pawłowski et al. 1928

All.: *Calamagrostion arundinaceae* (Luquet 1926) Oberd. 1957

Co: *Allium victorialis*, *Bistorta major*, *Calamagrostis arundinacea*, *Festuca balcanica*, *Geranium sylvaticum*, *Heracleum sphondylium*, *Luzula luzuloides*, *Primula elatior*, *Rumex arifolius*, *Senecio nemorensis* agg., *Silene vulgaris*, *Vaccinium myrtillus*, *Veratrum lobelianum*

This alliance comprises tall-grass vegetation types of upper montane to the subalpine belts. It is distributed mainly in the oceanic mountains of Europe (Mucina et al. 2016), with expected occurrence in Bulgaria (Preislerová et al. 2022). In the mountains of Central Europe, this vegetation is usually found at dry sites and is species-rich (Karner & Mucina 1993, Kliment & Valachovič 2007, Kočí 2007), however, it is not always the case in the study area.

***Geranium sylvaticum-Calamagrostis arundinacea* community**

Vegetation plot: 15 in Supplement 2

This vegetation develops in wet, nutrient-rich, shallow terrain depressions. It is characterized by the dominant *Calamagrostis arundinacea* (see Fig. 8c). The vegetation is species-poor, and the species that occur there are mostly generalists such as *Allium victorialis*, *Gentiana asclepiadea*, and *Veratrum lobelianum*, or nitrophytes such as *Adenostyles alliariae*, *Rumex arifolius*, *Senecio nemorensis* agg. The vegetation develops on medium-steep slopes (inclination ~ 30°). The measured soil pH was 5.4.

Syntaxonomical remark: The described vegetation is related to the *Roso pendulinae-Calamagrostietum arundinaceae*, as it shares some generalist species such as *Allium victorialis* and *Geranium sylvaticum*, however, it differs in moisture, nutrient, and soil conditions; it develops in more stony and drier places near rock outcrops. The *Geranium sylvaticum-Calamagrostis arundinacea* community occurs in small areas, typically within the vegetation of the alliances *Genisto pilosae-Vaccinion* (class *Calluno-Ulicetea*) or *Seslerion comosae* (class *Juncetea trifidi*) which are exposed to grazing; therefore, it could have been affected by pasture.

Distribution: Documented near Mt. Midzhur in 1970 m a.s.l.

Fig. 8. – Abb. 8. a) *Scabioso lucidae-Doronicetum columnae*, **b)** *Geranio macrorrhizi-Doronicetum columnae*, **c)** *Geranium sylvaticum-Calamagrostis arundinacea* community, **d)** *Roso pendulinae-Calamagrostietum arundinaceae*, **e)** *Crepido conyzifoliae-Calamagrostietum villosae*, **f)** *Sphagno compacti-Molinietum caeruleae* (Photos: D. Szokala, a), c) 2020, b), d), e), f) 2021).

***Roso pendulinae-Calamagrostietum arundinaceae* ass. nov.**

Vegetation plot: 47 (holotypus) in Supplement 2

Moderately species-rich vegetation that occurs mainly at the edges of rock terraces on stony nutrient-rich soils. The vegetation is relatively tall. It comprises herbaceous dominants such as *Allium victorialis* and *Calamagrostis arundinacea* and woody species *Rosa pendulina* (see Fig. 8d). Other species such as *Festuca balcanica*, *Geranium sylvaticum*, and *Veratrum lobelianum* occur there as well. It is poor to moderately rich in species. The moss layer is poorly developed or missing. It occurs at the edges of rock terraces on relatively steep slopes, on soils with a high gravel content. The measured soil pH was 4.5.

Syntaxonomical remark: The occurrence of *Rosa pendulina* and species of the *Ericaceae* family indicate the relation of this vegetation to the scrub vegetation of the classes of *Roso pendulinae-Pinetea mugo* and *Loiseleurio procumbentis-Vaccinietea*, by which it is distinguished from other vegetation types of the alliance *Calamagrostion arundinaceae*. However, the dominant species typical of the class *Mulgedio-Aconitetea*, such as *Allium victorialis*, *Bistorta major*, *Calamagrostis arundinacea*, *Geranium sylvaticum*, and *Valeriana tripteris* define this vegetation type as tall herb vegetation.

Distribution: Documented by one vegetation plot recorded near Mt. Midzhur. It was dominant on multiple stone plateaus. This vegetation was most likely never directly influenced by human activities because of the extreme sites in which it occurs.

Trifolium medium subsp. *balcanicum* community

Vegetation plot: 28 in Supplement 2

This subalpine grassland vegetation develops in nutrient-rich places. It comprises typical grassland species such as *Campanula moesiaca*, *Trifolium medium* subsp. *balcanicum* and *Silene vulgaris* and species more typical for tall-herb vegetation such as *Valeriana officinalis* s. l., *Crepis viscidula*, and *Veratrum lobelianum*. It develops in the middle part of the slopes, in slightly wet conditions. The vegetation is medium-tall and medium species-rich, as there have been recorded 28 species in 16 m^2. The measured pH was 5.5.

Distribution: This vegetation was recorded on the NE side of Midzhur Mt., in the middle part of its slope at ~2000 m a.s.l. It was observed in a few other places, however, always near abandoned road tracks. This vegetation could thus naturally occur either in suitable habitats at higher altitudes, where soils are well developed, or more likely on soils created by deluvial sediments keeping the organic matter in places of accumulation. Alternatively, it can be human-influenced, e.g., by historical pasture and occurence of animals in geomorphologically favorable parts of slopes and near tracks and later by the eutrophication of soil.

All.: *Calamagrostion villosae* Pawłowski et al. 1928

Dg: **Carex echinata*, *C. nigra*, *Molinia caerulea*, **Pinguicula balcanica*, *Potentilla erecta*

Co: *Calamagrostis villosa*, *Nardus stricta*, *Veratrum lobelianum*

The alliance of *Calamagrostion villosae* is distributed in the subalpine belt of the mountains of most of temperate Europe, and its occurrence is expected in Bulgaria (MUCINA et al. 2016, PREISLEROVÁ et al. 2022). It develops on acidic soils and can contain both a high or small number of species (KARNER & MUCINA 1993, KOČÍ 2007, MUCINA et al. 2016). The dominant species in this vegetation are grasses, usually *Calamagrostis villosa*, *Molinia caerulea*, or *Deschampsia cespitosa* (KOČÍ 2007). The distributional center of this alliance lies in the Carpathians and Sudetes (KARNER & MUCINA 1993).

Crepido conyzifoliae-Calamagrostietum villosae (Zlatník 1925) Jeník 1961

Vegetation plots: 36, 41, 62, 69 in Supplement 2

Co: ***Calamagrostis villosa***, *Gentiana asclepiadea*, *Potentilla erecta*, *Veratrum lobelianum*

This vegetation is dominated by the acidophilous grass *Calamagrostis villosa*, which forms 30–40 cm high stands (see Fig. 8e). It is accompanied by other species such as *Gentiana asclepiadea*, *Potentilla erecta*, *Rubus* ser. *Glandulosi*, and *Veratrum lobelianum*, which typically occur with low cover. The moss layer is poorly developed or missing. The vegetation typically occurs in the lower subalpine belt, near the timberline, on medium-steep slopes. The measured soil pH was 4.5, 4.4, 4.2, and 4.0.

Syntaxonomical remark: The association is known from Central Europe (KOČÍ 2007), however, in the study area, it lacks some species such as *Homogyne alpina* and *Trientalis europaea*. In the current syntaxonomical revision of Austria, similar species-poor growths of *Calamagrostis villosa* are classified within the association of *Campanulo scheuchzeri-Calamagrostietum arundinaceae* (cf. KARNER & MUCINA 1993) and in the Carpathians within the *Vaccinio myrtilli-Calamagrostietum villosae* (KLIMENT & VALACHOVIČ 2007). However, both contain species that do not occur in the study area. The recorded plots on wet sites contain *Polytrichum commune*, *Sphagnum fallax* and *S. papillosum* in the moss layer.

Distribution: In the study area, this vegetation can be commonly found in the lower part of the subalpine belt on conglomerates.

Sphagno compacti-Molinietum caeruleae Wagnerová in Berciková 1976

Vegetation plots: 38, 39 in Supplement 2

Dg: *Carex echinata*, **C. nigra*, *C. pallescens*, **Eriophorum latifolium*, *Juncus conglomeratus*, ****Molinia caerulea***, *Pinguicula balcanica*

Co: *Nardus stricta*, *Potentilla erecta*, *Veratrum lobelianum*

This vegetation occurs on a flat slope in ~ 1900 m a.s.l., in wet places near streams. It creates an extensive stand with dominant *Molinia caerulea* (see Fig. 8f), accompanied by other moisture-demanding plants such as *Carex echinata*, *C. nigra*, *Eriophorum latifolium*, and ubiquitous species such as *Potentilla erecta* and *Nardus stricta*. The moss layer is usually well-developed and contains only *Sphagnum* spp. (*S. capillifolium*, *S. papillosum*, and *S. russowii* were collected in the plots). The soils have a thick organic layer due to the accumulation of poorly degradable moss peat. The soil is strongly acidic; the measured pH was 4.1 and 4.6.

Syntaxonomical remark: The vegetation of *Sphagno compacti-Molinietum coeruleae* is species poorer than the vegetation of *Junco effusi-Molinietum caeruleae*. Moreover, it is linked to the primary non-forest conditions and contains tall-herb species typical of higher altitudes such as *Veratrum lobelianum* (HÁJKOVÁ et al. 2007, KOČÍ 2007).

Distribution: A large stand was found near Mt. Kopren. This association is known from the Sudetes (KOČÍ 2007), and there is also an uncertain record in the Carpathians (BUDZHAK et al. 2016).

Pinguicula balcanica-Nardus stricta community

Vegetation plots: 73, 74 in Supplement 2

Dg: *Carex echinata*, *Pinguicula balcanica*

Co: ***Nardus stricta***, *Potentilla erecta*

This vegetation occurs in sheltered wet places of bed layers of avalanches. The vegetation is sparse and occurs in patches on a bare surface or in places where avalanches do not disturb the vegetation only moderately. It is a species-poor and short vegetation dominated by *Nardus stricta*. It contains moisture-demanding plants such as *Carex echinata* and *Pinguicula balcanica* (see Fig. 9a). The moss layer is present and usually well-developed, containing *Sphagnum* spp. The measured soil pH was 4.0 and 4.5.

Syntaxonomical remark: The most similar communities to this vegetation type are *Carici nigrae-Nardetum strictae* (class *Nardetea strictae*), with which it shares the dominant *Nardus stricta* and some moisture-demanding species such as *Carex echinata* and *C. nigra* (cf. KLIMENT & VALACHOVIČ 2007). It also resembles some vegetation types of the alliance *Caricion fuscae* and *Caricion canescenti-nigrae* (both Cl. *Scheuchzerio palustris-Caricetea nigrae*; cf. HÁJEK et al. 2005, HÁJEK & HÁJKOVÁ 2011). In the Serbian part of the Stara Planina, MIŠIĆ (1978) reported the vegetation of *Hygronardetum*, which is somewhat similar but more species-rich and contains plants typical of wet meadows. Furthermore, *Pinguicula balcanica-Nardus stricta* community contains species of tall-herb vegetation such as *Calamagrostis villosa*, *Molinia caerulea* and *Veratrum lobelianum*. These species, along with the unique ecological properties of the habitats, indicate the relation of this vegetation to the class of *Mulgedio-Aconitetea*.

Distribution: This vegetation was found at few localities near Mt. Kopren.

Ord.: *Senecioni rupestris-Rumicetalia alpini* Mucina et Karner in Mucina et al. 2016

All.: *Rumicion alpini* Scharfetter 1938

Dg: *Doronicum austriacum*, *Stellaria nemorum*, *Urtica dioica*
Co: *Rumex alpinus*

This alliance of synanthropic high mountain tall-herb vegetation occurs in nemoral mountain ranges of Europe (MUCINA et al. 2016, PREISLEROVÁ et al. 2022). In Bulgaria, there is one known association of this alliance, *Senecioni rupestri-Rumicetum alpini* reported from the Rila Mts. (ROUSSAKOVA 2000).

***Rumicetum alpini* Beger 1922**

Vegetation plots: 21, 22 in Supplement 2
Dg: *Carduus personata*, *Festuca gigantea*, *Milium effusum*, *Urtica dioica*
Co: ***Rumex alpinus***

This vegetation develops in nutrient-rich places near abandoned shepherd houses. It is typical for places where sheep were kept overnight, and strong eutrophication took place. The herb layer is dominated by *Rumex alpinus* (see Fig. 9b), which can be accompanied by other nutrient-demanding species such as *Carduus personata*, *Milium effusum*, and *Urtica dioica*. As this vegetation typically develops near the forests, it can contain woodland species such as *Festuca gigantea*. The moss layer is poorly developed or can be missing. The soil properties are variable as they can be greatly influenced by human activity. The measured soil pH was 6.3 and 4.7.

Distribution: The association is known from the Czech Republic (LÁNÍKOVÁ et al. 2009), Carpathians (KLIMENT & VALACHOVIČ 2007) and reported for Serbia (BLAŽENČIĆ et al. 2005). In Romania, this vegetation is most likely classified to the association of *Urtico dioicae-Rumicetum alpini* (cf. SANDA et al. 2008). In Chiprovska Planina, *Rumicetum alpine* was found in one large stand at the edge of the forest.

***Rumici alpini-Doronicetum austriaci* ass. nov.**

Vegetation plots: 32, 40 (holotypus) in Supplement 2
Dg: **Doronicum austriacum*, *Geum urbanum*
Co: *Gentiana asclepiadea*, *Rubus idaeus*, *Rumex alpinus*, *R. arifolius*, *Veratrum lobelianum*

This vegetation occurs in nutrient-rich places in the supra-montane to the lower part of the subalpine belts. There are only a few species that create this vegetation, and most of them are co-dominant. The most abundant are *Doronicum austriacum* and ferns (*Athyrium distentifolium*, *Dryopteris filix-mas*), accompanied by other species typical of the alliance *Rumicion alpini*: *Geum urbanum*, *Rubus idaeus*, and *Rumex alpinus* (see Fig. 9c). The moss layer is usually poorly developed and containg ubiquitous species such as *Mnium* sp. The measured soil pH in this association was 4.6 and 5.3.

Syntaxonomical remark: Several species are characteristic of other vegetation types of the class *Mulgedio-Aconitetea*: *Veratrum lobelianum* and *Gentiana asclepiadea*. It is distinguished from the association *Rumicetum alpini* by the dominants *Doronicum austriacum* and fern species. Ecologically it differs by the range of occurrence: *Rumicetum alpini* typically occurs at lower altitudes than *Rumici alpini-Doronicetum austriaci*, although both associations indicate anthropogenic alteration of the environment.

Distribution: This vegetation is distributed throughout the whole study area. It was documented on Mt. Midzhur, where, at the base of the mountain, creates a dominant vegetation type, and near Mt. Kopren, where it grows sporadically in wet and nutrient-rich places.

Cl.: *Betulo carpaticae-Alnetea viridis* Rejmánek ex Bœuf, Theurillat, Willner, Mucina et Simler in Bœuf et al. 2014

Ord.: *Alnetalia viridis* Rübel ex Karner et Willner in Willner et Grabherr 2007

All.: *Alnion viridis* Schnyder 1930

This vegetation of subalpine alder and willow scrub is distributed in the Apennines, Central Europe, the Carpathians, and the Balkans (Mucina et al. 2016, Preislerová et al. 2022). The associations are sometimes classified within the tall-herb vegetation (Kliment & Valachovič 2007, Sanda et al. 2008) because of their similarity in the herb layer in which tall-herb species occur.

***Salici-Alnetum viridis* Colić et al. 1962**

Vegetation plots: 23, 24, 31, 34, 35 in Supplement 2
Dg: ****Alnus viridis***, *Dryopteris dilatata*
Co: *Calamagrostis arundinacea*, *Rumex arifolius*, ***Rubus idaeus***, *Senecio nemorensis* agg.
(+ Do: ***Calamagrostis villosa*, *Salix caprea*, *Salix silesiaca***)

This subalpine scrub vegetation occurs in the lower part of the subalpine belt on steep slopes (typically with an inclination of ~45°). In places, where the vegetation is occasionally disturbed by avalanches, the vegetation is relatively species-rich, with 26 species in 24 m^2. In contrast, in places where the vegetation is not disturbed, the number of species is somewhat reduced, and the herb layer contains only a few dominant herbs. The species in the shrub layer are *Alnus viridis* and *Salix* spp., which create dense growths. The herb layer is affected by the amount of light that can penetrate the shrub layer and typically consists of relatively nutrient-demanding plants such as *Calamagrostis arundinacea*, *Rubus idaeus*, *Rumex arifolius*, and *Senecio nemorensis* agg. In places where the vegetation is not disturbed, *Calamagrostis villosa* can become dominant. The soil is acidic, with measured pH values of 3.7, 4.2, 4.2, 4.5, and 5.2.

Distribution: Abundantly at lower altitudes across the study area (documented on Mt. Midzhur, near the peak of Orlov Kamen and Mt. Kopren). It was recorded by Roussakova (2000) in the Rila Mts.

Fig. 9. – Abb. 9. a) *Pinguicula balcanica-Nardus stricta* community, **b)** *Rumicetum alpini*, **c)** *Rumici alpini-Doronicetum austriaci*, **d)** *Brachythecio rivularis-Cardaminetum balcanicae*, **e)** S*axifragetum stellaris*, **f)** *Angelico sylvestris-Calthetum laetae* (Photos: D. Szokala, 2021).

Cl.: *Scheuchzerio-Caricetea fuscae* Tx. 1937

Ord.: *Caricetalia fuscae* Koch 1926

All.: *Narthecion scardici* Horvat ex Lakušić 1968

This alliance of permanently wet fen vegetation develops in places saturated with underground water, which is slightly acidic to alkaline; it is distributed in Balkan Peninsula (PREISLEROVÁ et al. 2022).

Dactylorhiza cordigera-Parnassia palustris **communities**

Vegetation plots: 5, 52 in Supplement 2

Dg: *Agrostis stolonifera*, *Carex ovalis*, *C. sylvatica*, **Dactylorhiza cordigera*, *Juncus articulatus*, *J. thomasii*, *Leontodon hispidus*, *Parnassia palustris*, *Petasites hybridus*, *Swertia punctata*, *Valeriana officinalis* s. l.

Co: *Angelica sylvestris*, *Deschampsia cespitosa*, *Silene pusilla*, *Veratrum lobelianum*

This relatively species-rich vegetation occurs near springs with cold mesotrophic water on sandstone and phyllite bedrock. The vegetation consists of moisture-demanding species such as *Angelica sylvestris*, *Dactylorhiza cordigera*, *Deschampsia cespitosa*, and *Parnassia palustris*, and species that indicate slight transitions to meadows, such as *Leontodon hispidus*. The vegetation has no dominants. The moss layer is well-developed and contains *Ptychostomum pseudotriquetrum* and *Rhytiadelphus triquetrus*. The measured soil pH was 5.8 and 6.6.

Distribution: Documented on two sites near Mt. Midzhur.

Cl.: *Montio-Cardaminetea* Br.-Bl. et Tx. ex Klika et Hadač 1944

Ord.: *Montio-Cardaminetalia* Pawłowski et al. 1928

All.: *Swertio perennis-Anisothecion squarrosi* Hadač 1983

Dg: *Cardamine amara* s. l., *Epilobium alsinifolium*

Co: *Angelica sylvestris*, *Saxifraga rotundifolia*, *Silene pusilla*

The vegetation of this alliance develops near cold oligotrophic springs with acidic to neutral pH in high mountains of Central Europe, the Carpathians, and the Balkans (Zechmeister 1993, Mucina et al. 2016, Preislerová et al. 2022). It is characteristic of a well-developed moss layer and the occurrence of low-productive vascular plants (Zechmeister 1993, Hájková & Hájek 2011).

Brachythecio rivularis-Cardaminetum balcanicae **Marhold et Valachovič 1998**

Vegetation plots: 57, 58 in Supplement 2

Dg: **Cardamine amara* s. l., *Chrysosplenium alternifolium*, **Epilobium alsinifolium*

Co: *Silene pusilla*, *Saxifraga rotundifolia*, *Angelica sylvestris*

This vegetation of subalpine springs develops near stable springs of mesotrophic or oligotrophic water (see Fig. 9d). It contains a small number of species such *as Epilobium alsinifolium* and *Silene pusilla*, which indicate a low concentration of nutrients. Other species, such as *Angelica pancicii*, *Cardamine amara* s. l., and *Chrysosplenium alternifolium*, can indicate slight degradation and successional changes within the vegetation towards the tall-herb vegetation of the class *Mulgedio-Aconitetea*. The moss layer is well-developed and contains *Cratoneuron filicinum*, *Palustriella commutata*, and rarely *Ptychostomum weigelii*.

Distribution: Found at one stream in the middle slope of Mt. Midzhur. It is distributed in Bulgaria (Marhold et Valachovič 1998).

Cystopteris fragilis-Saxifraga stellaris **community**

Vegetation plot: 16 in Supplement 2

This vegetation develops on permanently wet, shaded sandstone outcrops. It is distinguishable by the co-occurrence of species of stony places at high altitudes such as

Cerastium alpinum s. l., *Poa alpina*, and *Saxifraga exarata* subsp. *pirinica*, species of stony places not bound to the alpine belt, such as *Cystopteris fragilis*, and species of alpine springs, such as *Primula minima*, *Saxifraga stellaris*, and *Silene pusilla*. Due to the small-scale occurrence of this vegetation, meadow species such as *Festuca airoides* and *Ligusticum mutellina* are present due to the spatial mass effect. The moss layer is well-developed. This vegetation needs further research to be properly classified.

Distribution: Found on one sandstone outcrop near Mt. Midzhur at 1970 m a.s.l.

***Saxifragetum stellaris* Deyl 1940**

Vegetation plot: 76 in Supplement 2

This vegetation develops in wet places of steep inclination on nutrient-poor soils. In its distributional range, it typically grows in mineral-poorest and acidic springs and has the widest range of altitudinal distribution of springs in the high mountains of Bulgaria (HÁJKOVÁ et al. 2006). The vegetation is species-poor, usually dominated by *Philonotis seriata* and *Saxifraga stellaris* (HÁJEK et al. 2005, HÁJKOVÁ et al. 2006). In the studied area, the recorded vegetation consists of dominant *Saxifraga stellaris* (see Fig. 9e) and other species, namely *Myosotis nemorosa*, *Moehringia muscosa*, *Deschampsia cespitosa*, and *Angelica sylvestris*, all of which occurred in the vegetation very sporadically. Mosses that are occurring there are *Philonotis serriata* and *Scapania undulata*.

Distribution: Documented near Mt. Kopren on a wet rock wall (inclination ~ 90°), on a nutrient-poor conglomerate bedrock. It was developed on the whole rock wall, which was approx. 3 m high.

***Angelico sylvestris-Calthetum laetae* Hájek et al. 2005 mut. Szokala 2023**

(synonym: *Angelico pancicii-Calthetum laetae* Hájek et al. 2005)

Angelica sylvestris L. (synonym: *Angelica pancicii* Vandas in Velenovský 1891 [VELENOVSKÝ, J. (1891): Flora Bulgarica I. – Fr. Řivnáč, Praha: 200.])
CANNON in TUTIN et al. (1968): Flora Europaea II. – Cambridge University Press, Cambridge: 469 pp. [Cannon synonymised *Angelica pancicii* Vandas with *Angelica sylvestris* L.].
DIHORU, G., PAUCĂ-COMĂNESCU, M. et ION, R. (2011): Analysis of the characters on some *Angelica* taxa. – Rom. J. Biol. – Plant Biol. 56, p. 79–89 [No morphometric evidence was found based on mericarps and fruits to support the existence of *Angelica pancicii* and it is synonymised with *A. sylvestris* subsp. *montana*].

Vegetation plot: 75 in Supplement 2

This relatively high-productive spring community is typical of lower altitudes of high mountains (HÁJKOVÁ et al. 2006) and usually has only a few dominant herb species (HÁJEK et al. 2005, HÁJKOVÁ et al. 2006). In the study area, the recorded species *Caltha palustris* s. l., *Crepis paludosa*, and *Juncus thomasii* play the most crucial role and have the greatest abundance (see Fig. 9f). However, due to the openness of the recorded vegetation, other species are present such as *Pinguicula balcanica*, *Epilobium nutans*, and *Saxifraga stellaris*, which indicate their transition to less productive vegetation types. The vegetation of *Angelico pancicii-Calthetum laetae* is most likely affected by the nutrient enrichment due to pasture, as suggested by HÁJEK et al. (2005). The vegetation in the studied area neighbors more productive anthropogenic vegetation of *Rumicetum alpini*; therefore, it supports the presumption of the human-conditioned origin of this association. The moss layer in the recorded vegetation is poorly developed, and the measured soil pH was 5.3.

Distribution: The vegetation was found near Mt. Kopren on a disturbed site with a steep inclination (~70°). The association was originally described in Bulgaria (HÁJEK et al. 2005) and has the vicariant association of *Calthetum laetae* in the Carpathians (VALACHOVIČ 2001, HÁJEK et al. 2005), although *Calthetum laetae* is perhaps less influenced by human activities.

Cl.: *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947

Ord.: *Festucetalia valesiacae* Soó 1947

All.: *Festucion valesiacae* Klika 1931

This alliance represents fescue grasslands dominated by *Carex humilis*, *Festuca valesiaca*, or *Stipa* spp. It usually develops on calcareous soils in subcontinental areas (CHYTRÝ et al. 2007, MUCINA et al. 2016). It is distributed in Central and (South-)Eastern Europe (PREISLEROVÁ et al. 2022). Communities with steppic character are known from the alpine belt of the continental and Mediterranean areas of the Balkans (cf. KOCHEV 1967, DUCHOŇ 2018), however, their classification differs.

***Festuca valesiaca* s. l. community**

Vegetation plot: 20 in Supplement 2

This vegetation occurs near the upper treeline. It is similar to the *Bromo-Festucetum valesiaceae* Blaženčić in Mišić 1978 which was described from the Serbian part of the Stara Planina Mts. at altitudes around 800 m a.s.l. on limestone bedrock. In the recorded vegetation, the dominant species *Festuca valesiaca* s. l. (see Fig. 10a) is accompanied by mesophilous species such as *Bupleurum falcatum* and *Verbascum longifolium* and xerophilous *Galium verum*. The recorded vegetation was burned, and therefore some nitrophilous species such as *Rumex acetosella* and *Trifolium repens* are present. Species more typical for acidophilous vegetation, such as *Avenella flexuosa*, occur there as well. The recorded vegetation develops in stony places on gentle slopes (15° inclination) and the measured pH was 4.6, although it could have been influenced by the recent fire.

The vegetation described in MIŠIĆ (1978) contains a higher number of thermophilous species (such as *Bromus squarrosus*, *Thalictrum minus*, and *Trifolium alpestre*), which are missing in the recorded relevé due to higher altitudes in which the vegetation was recorded. In one vegetation plot ruderal and wet-demanding species, (such as *Convolvulus arvensis*, *Ranunculus arvensis*, and *Sanguisorba officinalis*) were documented (MIŠIĆ 1978), which indicate the human-influenced processes and the relation to more mesophilous vegetation. As the *Festuca valesiaca* s. l. is a poorly studied taxon and potential cryptic species can have different ecological requirements in the Balkans, this vegetation needs a more detailed study.

Distribution: Found abundantly near the upper treeline near the peak of Gorno Âzovo in the matrix with dry and mesophilic meadows. There was evidence of cattle grazing and fire management at this site.

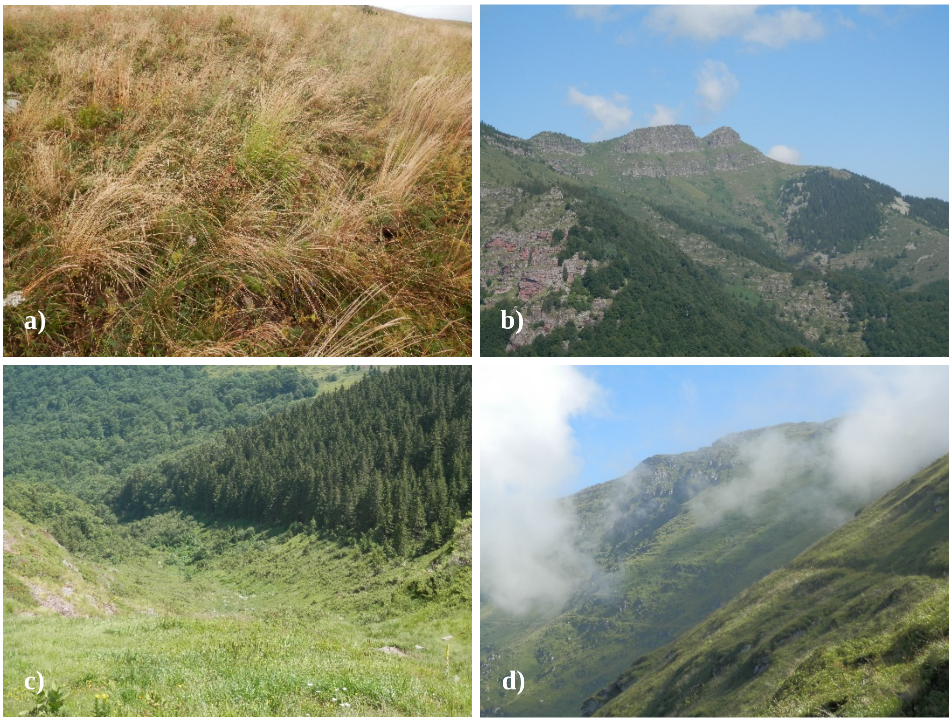

Fig. 10. a) *Festuca valesiaca* s. l. community, **b)** View on the Mt. Tri Čuke with steep slopes and rock outcrops, where scrub vegetation of *Pinus mugo* persists, **c)** Avalanche track near Mt. Kopren: *Picea abies* forests usually develop on the northern slopes, whereas *Fagus sylvatica* dominates on southern slopes, **d)** Steep slopes of Mt. Midzhur with rock outcrops (Photos: D. Szokala, a), d) 2020, b), c) 2021).

Abb. 10. a) *Festuca valesiaca* s. l.-Gesellschaft, **b)** Blick auf den Mt. Tri Čuke mit steilen Hängen und Felsvorsprüngen, wo Krummholzvegetation aus *Pinus mugo* überdauert, **c)** Lawinenbahn neben dem Mt. Kopren: *Picea abies*-Wälder entwickeln sich normalerweise auf den nordexponierten Hängen, während *Fagus sylvatica* auf den südexponierten Hängen dominiert, **d)** Steile Hänge des Mt. Midzhur mit Felsvorsprüngen (Fotos: D. Szokala, a), d) 2020, b), c) 2021).

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Fig. 11. a) Result of DCA ordination (projected are sample scores): ● *Asplenietea trichomanis*, ● *Betulo carpaticae-Alnetea viridis*, ● *Calluno-Ulicetea*, ● *Crataego-Prunetea*, ● *Festuco-Brometea*, ● *Juncetea trifidi*, ● *Koelerio-Corynephoretea*, ● *Loiseleurio-Vaccinietea*, ● *Montio-Cardaminetea*, ● *Mulgedio-Aconitetea*, ● *Roso pendulinae-Pinetea mugo*, ● *Scheuchzerio-Caricetea*; the effect of environmental factors on the site scores (brighter colors indicate higher concentrations): **b)** Altitude (1440–2120 m a. s. l.), **c)** Soil pH (3.9–6.7), **d)** Total cover (5–100%); the variables were significant ($p < 0.001$); in the graphs: A – *Adenostylion alliariae*, B – *Alnion viridis*, C – *Alysso alysoidis-Sedion albi*, D – *Bruckenthalion spiculifoliae*, E – *Calamagrostion arundinaceae*, F – *Calamagrostion villosae*, G – *Caricion curvulae*, H – *Narthecion scardici*, I – *Cirsion appendiculati*, J – *Dryopterido filicis-maris-Athyrion distentifolii*, K – *Festucion valesiacae*, L – *Genisto pilosae-Vaccinion*, M – *Juncion trifidi*, N – *Juniperion nanae*, O – *Pinion mugo*, P – *Rumicion alpini*, Q – *Sambuco-Salicion caprae*, R – *Scabioso lucidae-Doronicion columnae*, S – *Seslerion comosae*, T – *Silenion lerchenfeldianae*, U – *Swertio perennis-Anisothecion squarrosi*.

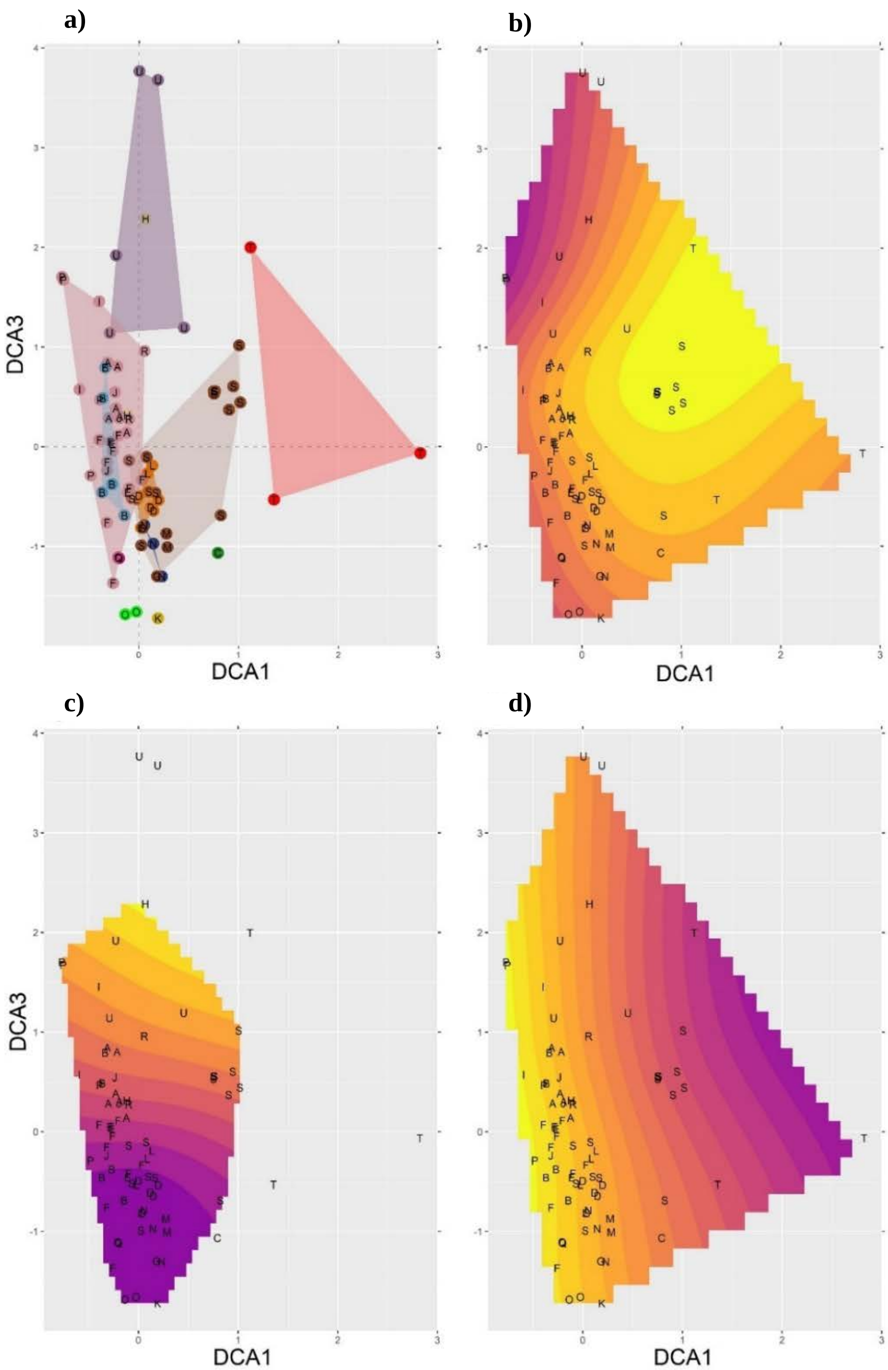

Abb. 11. a) Ergebnis der DCA-Ordination (projiziert werden die Stichprobenpunkte – Legende s. o.); die Auswirkung von Umweltfaktoren auf die Standortwerte (hellere Farben bedeuten höhere Konzentrationen): **b)** Höhenlage (1440–2120 m ü.d.M.), **c)** Boden-pH-Wert (3,9–6,7), **d)** Gesamtbedeckung (5–100 %); die Variablen waren signifikant ($p < 0,001$); Abkürzungen in den Graphiken s. o.

4.2 Analysis

The results of the DCA ordination (see Fig. 11) display the arbitrarily classified groups. The eigenvalues for the first four axes are in turn 0.67, 0.46, 0.44, and 0.34. The 1st axis reflects the total cover of plants, the 2nd axis reflects the pH gradient. The total cover is influenced, among others, by the availability of nutrients and water in the environment, and it is also related to productivity. The species with the highest weighted scores are *Avenella flexuosa*, *Calamagrostis arundinacea*, *C. villosa*, *Campanula rotundifolia* agg., *Festuca airoides*, *F. rubra*, *Gentiana asclepiadea*, *Juncus trifidus*, *Juniperus communis* subsp. *nana*, *Luzula luzuloides*, *Sesleria coerunals* agg., *Vaccinium myrtillus*, *V. uliginosum*, *V. vitis-idaea*, and *Veratrum lobelianum* (see Fig. 12).

The classes of *Mulgedio-Aconitetea* and *Betulo carpaticae-Alnetea viridis* overlap considerably in the ordination diagram. The classes of *Juncetea trifidi*, *Calluno-Ulicetea*, and *Loiseleurio-Vaccinietea* are also considerably overlapping since they contain many shared species.

Soil pH was generally acidic to neutral (see Fig. 13). The most acidic soils were in the vegetation of subalpine heathlands (class *Calluno-Ulicetea* and *Loiseleurio-Vaccinietea*) and subalpine scrub (class *Betulo carpaticae-Alnetea viridis*). The class of *Juncetea trifidi* has a broad range of pH, which is caused by heterogeneous vegetation types that occupy different habitats. The class *Mulgedio-Aconitetea* also had a broad range of pH, which in this case indicates that pH is a less important factor for this vegetation type than soil moisture. The class *Scheuchzerio-Caricetea* had a higher pH value because of the influence of freshwater enriched by calcium from bedrock.

The number of species differs considerably between and inside the vegetation types. The plots with the most species were recorded in the classes *Mulgedio-Aconitetea* and *Scheuchzerio-Caricetea*.

5. Discussion

This first phytosociological study of alpine and subalpine vegetation in the Bulgarian part of the Western Stara Planina Mts. classifies the vegetation into 12 classes, 29 associations and nine communities. A DCA graph was created to display the dissimilarities between the recorded plots. Environmental factors have been tested for significance over the distribution of sample scores.

This work presents alliances not previously known in Bulgaria according to PREISLEROVÁ et al. (2022). These include *Adenostylion alliariae*, *Calamagrostion arundinaceae*, *Calamagrostion villosae*, *Caricion curvulae*, *Dryopterido filicis-maris-Athyrion distentifolii*, *Genisto pilosae-Vaccinion*, and *Juncion trifidi*, and one newly described alliance *Scabioso lucidae-Doronicion columnae*. Many of the associations in this work were newly described. The reasons are mainly that in Bulgaria, Braun-Blanquet school was not historically used (cf. TZONEV et al. 2009), and the alpine vegetation there is understudied in comparison to West and Central Europe, with only a few publications (e.g., HORVAT et al. 1937, ROUSSAKOVA 2000). Moreover, there are no available relevés of the alpine and subalpine vegetation in the study area, and there is a lack of comparative studies performed in similar environmental conditions in a broader area around the Western Stara Planina Mts. The Balkans are also one of the plant biodiversity (cf. MUTKE et al. 2010, SABATINI et al. 2022) and endemism (cf. EEA 2022) hotspots in Europe. A higher concentration of species

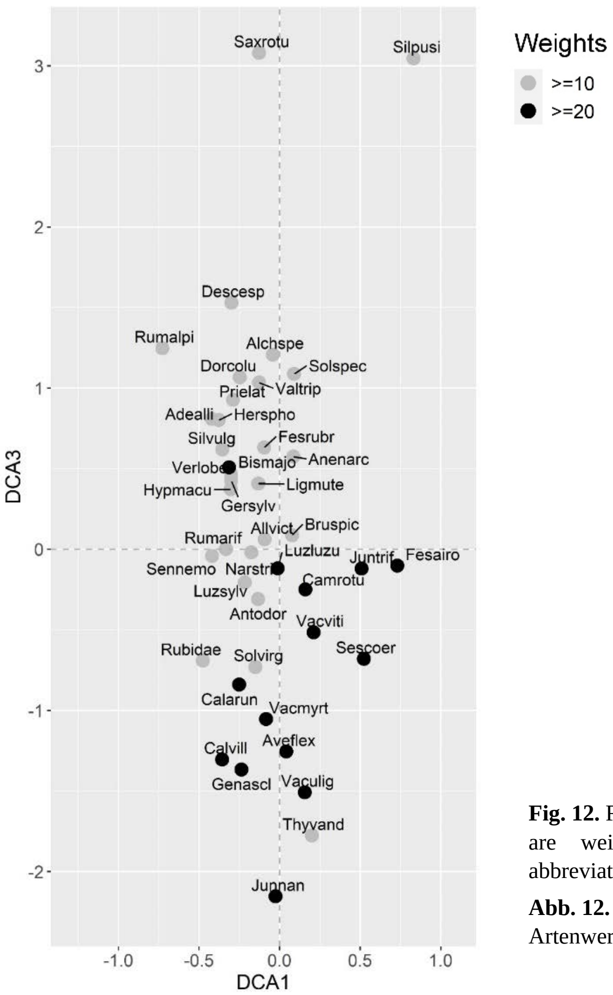

Fig. 12. Result of DCA ordination, projected are weighted species scores; for the abbreviations see Supplement 1.

Abb. 12. DCA-Ordination mit gewichteten Artenwerten; Abkürzungen siehe Anhang 1.

in an area can lead to a greater niche differentiation (cf. CHESSON 2000, LEVINE & HILLE-RISLAMBERS 2009) and thus possibly produce a greater number of narrowly specialized plant communities (JIMÉNEZ-ALFARO et al. 2014). Although there has been an attempt to define new associations, some of them may be rejected in future comparative studies performed on a larger scale. However, the unique species composition in the study area implies that the vegetation types developing there should be well distinguishable.

5.1 Comparison with other studies and classifications

MIŠIĆ (1978) provided a comprehensive study of vegetation types across all vegetation belts in the Serbian part of the Western Stara Planina. Although his work described both forest and non-forest vegetation, it contains only a few vegetation plots. In the case of subalpine and alpine vegetation, the plots were recorded at relatively low altitudes; therefore, they are not representative of this vegetation. MICHALIK (1990) described in the Central

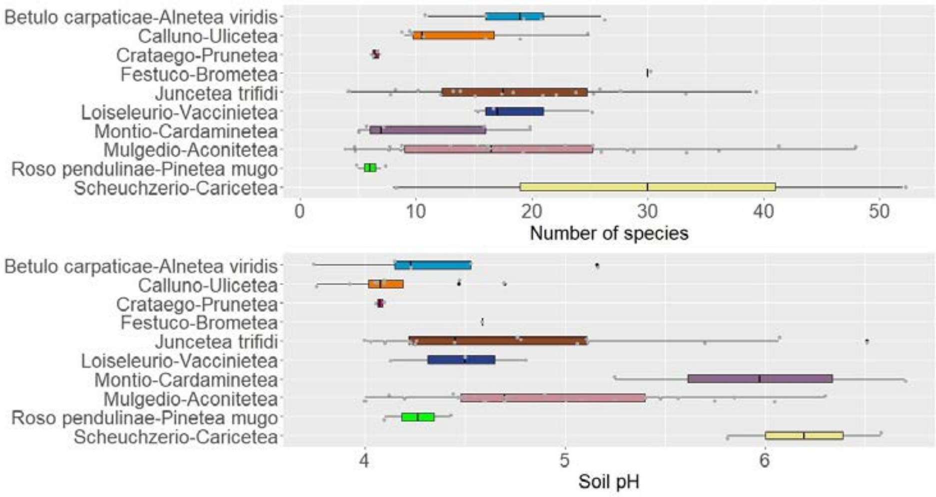

Fig. 13. Comparison of species number (above) and soil pH (below) between the vegetation classes.

Abb. 13. Vergleich der Artenzahl (oben) und des Boden-pH-Wertes (unten) zwischen den Vegetationsklassen.

Stara Planina numerous vegetation types. Some of them, like *Juncus trifidus-Sesleria comosa* community are very similar to the vegetation in Western Stara Planina (ass. *Veronico baumgartenii-Festucetum airoidis*). There are also vegetation types that differ as he recorded relevés with dominant *Cirsium appendiculatum* in the ass. *Heracleo verticillati-Cirsietum appendicutali*. This association is also recognised in presented paper, however, *C. appendiculatum* was not recorded or observed in Chiprovska Planina. His work does not contain any validly described syntaxa.

ROUSSAKOVA (2000) studied the vegetation in Rila Mts., where the vegetation survey was also performed by HORVAT et al. (1937). These mountains are composed mainly of acidic siliceous rocks and rarely of calcareous rocks. She described many alpine vegetation types now recognized in Bulgaria. The main difference between the study area and the Rila Mts., besides the geological structure, is altitude (the highest peak in the Rila Mts., Musala, has 2926 m a.s.l.), and geographical position (the Rila Mts. are more connected to southern mountain ranges). Therefore, in the Rila Mts., there is a higher portion of relic and endemic species. The vegetation types which were accepted in the present study are those which are widespread.

SIMON (1957) performed a vegetation survey in the Pirin Mts., which also contains calciphilous vegetation types; however, the described vegetation is similar to that of HORVAT et al. (1937) and ROUSSAKOVA (2000).

The work of TZONEV et al. (2009) is only a list of syntaxonomical units of Bulgaria, in which the high-mountain vegetation types mostly derive from the work of ROUSSAKOVA (2000).

5.2 Vegetation types

The alliance of *Pinion mugo* (class *Roso pendulinae-Pinetea mugo*), in Bulgaria represented by the association *Avenello flexuosae-Pinetum mugo*, is divided in the literature into several subassociations (cf. TZONEV et al. 2009). This vegetation type includes phyto-coenoses which, following my field experience, could be divided into separate associations as they differ floristically and physiognomically and need further research. However, as I only recorded two plots of this vegetation, I did not attempt to further differentiate other vegetation types from this association.

To some extent, the classification of the vegetation of *Thesio alpini-Avenelletum flexuosae* (class *Juncetea trifidi*) and *Pinguicula balcanica-Nardus stricta* community (class *Mulgedio-Aconitetea*) is problematic. Their classification is uncertain, and they could be classified as the alliance of oligotrophic mat-grass swards of *Potentillo ternatae-Nardion strictae* (class *Juncetea trifidi*; MUCINA et al. 2016). However, they do not show, in the study area, any attributes which would justify their assignment to this alliance. In the case of *Thesio alpini-Avenelletum flexuosae*, there are only species that also occur in the alliance of *Seslerion comosae*, while *Nardus stricta* is rarely present in this vegetation. The community of *Pinguicula balcanica-Nardus stricta* could be classified into this alliance based only on the dominance of *Nardus stricta*, however, other species of the alliance *Calamagrostion villosae* would need to be excluded from the consideration. It also resembles vegetation of *Scheuchzerio palustris-Caricetea nigrae* (cf. HÁJEK & HÁJKOVÁ 2011). Moreover, species that ROUSSAKOVA (2000) considers as characteristic of the alliance *Potentillo ternatae-Nardion strictae* do not grow in the study area. Thus, the distinction of the alliance *Potentillo ternatae-Nardion strictae* from the vegetation of *Seslerion comosae* is impossible.

The newly proposed alliance of *Scabioso lucidae-Doronicion columnae* is defined based on the presence of scree species such as *Geranium macrorrhizum* and *Doronicum columnae*, which indicate a relic, mesic, and in some respects stable conditions (e.g., in the case of pH and microclimate). No vegetation type similar to this vegetation has been described so far. The alliance of *Scabioso lucidae-Doronicion columnae* has the closest relation to the alliance of *Adenostylion alliariae*, which likely replaces it in later successional stages (indicated by a few species that sporadically occur in the *Scabioso lucidae-Doronicion columnae* such as *Adenostyles alliariae* and *Ranunculus platanifolius*). This relationship is, however, very weak and should be further studied if this vegetation was assigned to this alliance. It also has a slight relation to the alliances *Calamagrostion arundinacae* (class *Mulgedio-Aconitetea*) and *Seslerion comosae* (class *Juncetea trifidi*). In granite boulder fields near Mt. Dupljak, I observed vegetation containing only *Geranium macrorrhizum*. This vegetation was very similar to the vegetation described by DUCHOŇ (2018) and classified into the alliance *Silenion caesiae* (class *Thlaspietea rotundifolii*). The observed vegetation, however, shows that the vegetation dominated by *Geranium macrorrhizum* is not bound to carbonate rocks, on which this vegetation was observed by DUCHOŇ (2018), and would also be most likely classified within the *Scabioso lucidae-Doronicion columnae*. In Chiprovska Planina, the slight relationship of this vegetation to the class of *Thlaspietea rotundifolii* is indicated by the calciphilous *Scabiosa lucida*.

The vegetation of the subalpine alder scrub of the association *Salici-Alnetum viridis* (alliance *Alnion viridis*) was classified considering the distribution range of the association. This association is reported in the Romanian Carpathians (SANDA et al. 2008), the Serbian part of the Stara Planina Mts. (KOJIĆ 1998), and Bulgaria (ROUSSAKOVA 2000). However, the vegetation captured in the sampled plots does not show any specific relationship to the vegetation captured by ROUSSAKOVA (2000). The vegetation that occurs in the Rila Mts. contains species not typical for the Western Stara Planina Mts., e.g., *Aquilegia aurea*, *Cirsium appendiculatum*, *Geum bulgaricum*, *Luzula alpino-pilosa*, *Pinus peuce*, *Rhodiola rosea*, and *Telekia speciosa* (cf. ROUSSAKOVA 2000), some of these species are endemic to the Rila Mts. It is uncertain if the subalpine alder scrub in this part of the Stara Planina Mts. (and Romanian Carpathians) belongs to the alliance *Salicion silesiacae* (class *Betulo carpaticae-Alnetea viridis*), from which it only differs by the absence of *Betula carpatica* but contains the same species in the herb layer (cf. KLIMENT & VALACHOVIČ 2007). The specific species composition of the *Salici-Alnetum viridis* in the study area also opens the question if the differentiation of the alliance *Alnion viridis*, at least at the NE edge of the Balkan Peninsula, is justified.

A surprising connection has been found between the vegetation of central Europe, the Carpathians, and the study area of the Western Stara Planina Mts. through the vegetation types of *Juncetum trifidi*, *Ranunculo platanifolii-Adenostyletum alliariae*, *Anemono narcissi-florae-Trollietum europaei*, *Crepido conyzifoliae-Calamagrostietum villosae* and *Sphagno compacti-Molinietum caeruleae*. This can be due to a lack of publications on some vegetation types from the Carpathians and other mountain systems (mainly of *Mulgedio-Aconitetea*). It can be assumed that some vegetation types (at least on the alliance level) may not be strictly bound to central Europe or the Carpathians but are more widespread than previously anticipated.

5.3 The effect of bedrock types

An interesting aspect of species composition in the study area is the occurrence of calciphilous species on acidic sedimentary rocks, such as *Asplenium viride*, *Carex kitaibeliana*, *Galium anisophyllon*, and *Saxifraga paniculata*, which is the only diagnostic species in the usually acidophilic class of *Seslerion comosae*. There can be several explanations for their occurrence. The first is through the properties of the substrate: sandstone can contain some amount of calcium, from which these chasmophytic plants can benefit. The second is environmental extremeness: for the occurrence of *Carici rupestris-Kobresietea bellardii* (and species characteristic of this vegetation), the role of pH is not crucial, and extreme climatic conditions can play a more important role (PETRÍK et al. 2005).

A clear difference between vegetation occurring on sandstone and conglomerate was observed (see Fig. 14 and 15). The vegetation occurring on sandstone seems to be more neutrophilous and nutrient-demanding. The vegetation types that occur only on sandstone are those that develop on shallow soils, such as *Symphyandro wanneri-Veronicetum baumgarteni*i and *Veronico baumgartenii-Festucetum airoidis*. Other vegetation types recorded only near Mt. Midzhur (mainly from the class *Mulgedio-Aconitetea*) are limited by the occurrence of suitable habitats. Vegetation types that develop on the nutrient-poorer conglomerate bedrock are *Jovibarbo heuffelii-Silenetum lerchenfeldianae* and *Thesio alpini-Avenelletum flexuosae*. The change in the occurrence is, however, also influenced by different altitudes and the slightly different slope aspects of the areas.

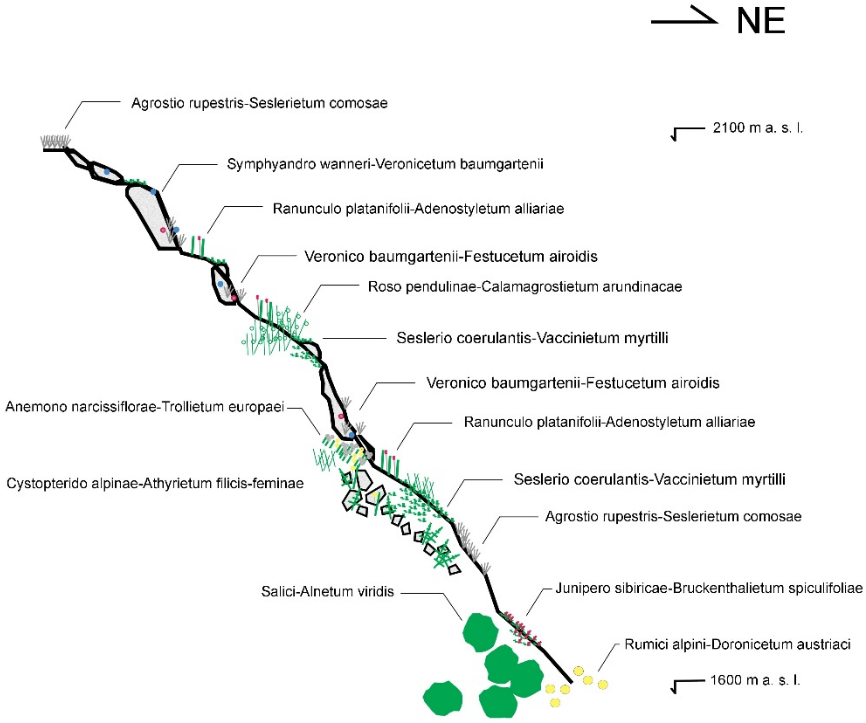

Fig. 14. Vegetation of Mt. Midzhur: it is strongly influenced by sandstone outcrops occurring abundantly above 1900 m a. s. l. and by avalanches.

Abb. 14. Die Vegetation des Mt. Midzhur: Sie wird stark von Sandsteinaufschlüssen, die oberhalb von 1900 m ü. M. reichlich vorkommen, und von Lawinen beeinflusst.

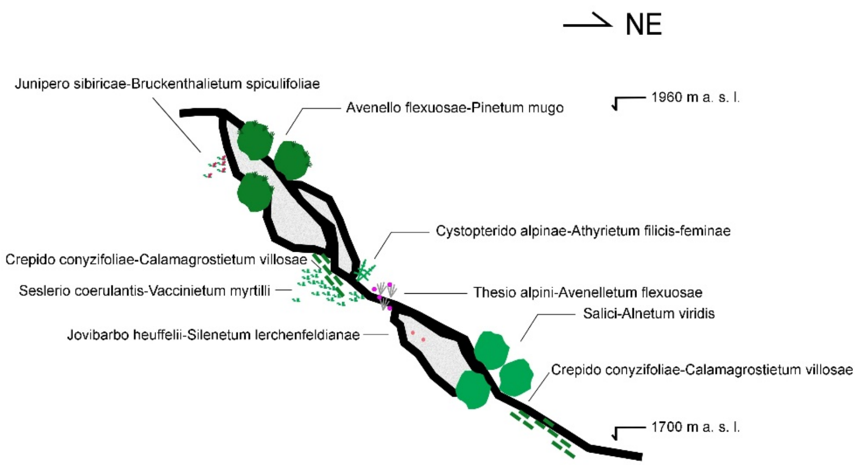

Fig. 15. Vegetation of Mt. Kopren: it develops on conglomerates and was extensively influenced by pasture which permitted the preservation of *Pinus mugo* stands only in the most extreme sites.

Abb. 15. Die Vegetation des Kopren: Sie entwickelt sich auf Konglomeraten und wurde stark von Beweidung beeinflusst, was die Erhaltung von Pinus mugo-Beständen nur an den extremsten Standorten ermöglichte.

Erweiterte deutsche Zusammenfassung

Einleitung – Die erste Untersuchung alpiner und subalpiner Pflanzengesellschaften in Bulgarien nach dem Braun-Blanquet-Konzept wurde von HORVAT et al. (1937) im Rila-Gebirge durchgeführt. Seitdem haben SIMON (1957) diese Vegetation im Pirin-Gebirge, und ROUSSAKOVA (2000) im Rila-Gebirge untersucht. TZONEV et al. (2009) korrigierten mehrere von ROUSSAKOVA (2000) veröffentlichte Assoziationen. Im zentralen Stara-Planina-Gebirge haben MESCHINEV et al. (2000) die wichtigste Arbeit zur Vegetationsklassifizierung unter Verwendung des russischen dominanzbasierten Ansatzes durchgeführt. Seitdem folgten im Stara-Planina-Gebirge nur wenige Arbeiten, die sich auf verschiedene Aspekte der Offenlandvegetation konzentrierten, wie z. B. die Klassifizierung von thermophilem Grasland (VASSILEV et al. 2012, PODASHENKO et al. 2013, VASSILEV et al. 2014) oder nicht-zonaler subalpiner Quellvegetation (HÁJKOVÁ et al. 2006). Auf der serbischen Seite des Stara-Planina-Gebirges wurde die Vegetationsklassifizierung von MIŠIĆ et al. (1978) für die gesamte Bandbreite der Vegetationsstufen vorgenommen. Die alpine und subalpine Vegetation auf der bulgarischen Seite des höchsten Teils des westlichen Stara-Planina-Gebirges (d. h. des Chiprovska-Planina-Gebirges) wurde bisher jedoch noch nicht untersucht.

Das westliche Stara-Planina-Gebirge reicht von ca. 200 bis 2169 m ü. d. M. und ist von Nordwest nach Südost ausgerichtet. Das Chiprovska-Planina-Gebirge besteht hauptsächlich aus Sedimentgesteinen (Sandstein, Konglomerat und Tonstein) und Eruptivgesteinen (Granit und Granodiorit; vgl. EGS 2022). Die mittlere Jahrestemperatur des Mt. Midzhur wird auf 1,5 °C und der Jahresniederschlag auf 796 mm geschätzt (KARGER et al. 2017); möglicherweise kann der Niederschlag in seinem höchsten Teil bis zu 1200 mm pro Jahr erreichen (MILANOVIĆ 2010). Das Gebiet liegt in der Balkanischen phytogeografischen Region (MEUSEL & JÄGER 1992) und wird durch die Nähe zu den Karpaten beeinflusst, was sich in der Artenzusammensetzung zeigt. Im natürlichen Zustand würde das Untersuchungsgebiet kleinere Flächen der alpinen und subalpinen Zonen enthalten (BOHN et al. 2004), während heute die noch erhaltene traditionelle Bewirtschaftung (hauptsächlich Weide und damit verbundene Praktiken) die Waldgrenze um ca. 300 m reduzierte und nicht nur den Wald, sondern auch die Krummholzvegetation unterdrückte.

In der vorliegenden Arbeit stelle ich die erste Studie zur Klassifizierung der alpinen und subalpinen Vegetation des bulgarischen Teils des Chiprovska-Planina-Gebirges vor.

Methoden – Die Feldarbeit wurde im August 2020 und Juli 2021 durchgeführt. Insgesamt wurden 78 Vegetationsaufnahmen nach der Braun-Blanquet-Methode (WESTHOFF & VAN DER MAAREL 1980) erfasst und in der „Gap-Filling Database of European“ der Masaryk-Universität (EU-00-031; CHYTRÝ & KNOLLOVÁ 2020) hinterlegt. Die Nomenklatur der Gefäßpflanzen folgt Euro+Med PlantBase (EURO+MED 2022), die Nomenklatur der Moose folgt der Arbeit von HODGETTS et al. (2020) und die Nomenklatur der höheren Syntaxa folgt der Arbeit von MUCINA et al. (2016). Neue syntaxonomische Einheiten wurden in Übereinstimmung mit dem Internationalen Code der phytosoziologischen Nomenklatur (THEURILLAT et al. 2021) aufgestellt.

Zunächst wurden numerische Klassifizierungsmethoden (Clusteranalyse, Twinspan, K-means) auf den Datensatz angewandt, die jedoch bei einer so geringen Anzahl relevanter Arten keine aussagekräftigen Ergebnisse lieferte; daher ist die endgültige Klassifizierung subjektiv. Das Programm Juice (TICHÝ 2002) wurde verwendet, um die Treue der Arten zu den relevanten Gruppen zu berechnen, wobei eine Standardisierung der Parzellengruppengrößen vorgenommen und ein exakter Test nach Fisher ($p > 0,05$) durchgeführt wurde. Der Schwellenwert für die Treue wurde für diagnostische Arten auf $\Phi > 0,6$ und für konstante Arten auf 60 % festgelegt. Es mussten mindestens zwei relevante Arten in den unterschiedenen Gruppen vorhanden sein, um in diese Analyse einbezogen zu werden. Die Ordination (DCA) wurde in der R Studio-Umgebung (RSTUDIO TEAM 2020) berechnet. Der pH-Wert des Bodens wurde nach der internationalen Norm ISO 103905 gemessen.

Ergebnisse und Diskussion – Im Ergebnis dieser Arbeit wurde im Chiprovska-Planina-Gebirge 29 Assoziationen und neun informell beschriebene Gesellschaften aus 12 Klassen gefunden. Sieben der Verbände waren bisher aus Bulgarien noch nicht bekannt (vgl. PREISLEROVÁ et al. 2022): *Adenostylion* *alliariae*, *Calamagrostion arundinaceae*, *Calamagrostion villosae*, *Caricion curvulae*, *Dryopterido filicis-maris-Athyrion distentifolii*, *Genisto pilosae-Vaccinion* und *Juncion trifidi*. Ein vorläufig beschriebener Verband *Scabioso lucidae-Doronicion columnae* wird vorgestellt; er unterscheidet sich von anderen Verbänden der Klasse *Mulgedio-Aconitetea* durch das auffällige Vorkommen von Blockhalden-Spezialisten. Viele Assoziationen in dieser Arbeit sind neu beschrieben. Der Grund dafür ist das Fehlen vergleichbarer Arbeiten und die relative geographische Isolierung des Untersuchungsgebiets vom Rila- und Pirin-Gebirge, wo HORVAT (1937), SIMON (1957) und ROUSSAKOVA (2000) ihre Studien durchführten. Außerdem wurde in Bulgarien der Braun-Blanquet-Ansatz in der Vergangenheit nicht verwendet (TZONEV et al. 2009). Die Arbeit von MIŠIĆ (1978) enthält nur wenige Vegetationstypen der alpinen und subalpinen Zone, und die entsprechenden Aufnahmen wurden in relativ niedrigen Höhenlagen gemacht; daher ist die Vegetation in der Regel schwach entwickelt oder tendiert zu weit verbreiteten Vegetationstypen. Ein interessanter Aspekt der Artenzusammensetzung war das gemeinsame Vorkommen von azidophilen und calziphilen Arten (wie *Asplenium viride*, *Carex kitaibeliana*, *Galium anisophyllon* und *Saxifraga paniculata*) in den eher säureliebenden Gesellschaften des Verbandes *Seslerion comosae*. Dieses gemeinsame Vorkommen kann durch die Eigenschaften des Sandsteins beeinflusst werden, der eine gewisse Menge an Kalzium enthalten kann, das für diese chasmophytischen Pflanzen zugänglich ist.

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Supplements

Additional supporting information may be found in the online version of this article.

Zusätzliche unterstützende Information ist in der Online-Version dieses Artikels zu finden.

Supplement E1. Abbreviations used for species.

Anhang E1. Für die Arten verwendete Abkürzungen.

Supplement E2. Phytosociological tables.

Anhang E2. Pflanzensoziologische Tabellen.

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Supplement E1. Abbreviations used for species.

Anhang E1. Für die Arten verwendete Abkürzungen.

Adealli – *Adenostyles alliariae*, Alchspe – *Alchemilla* species, Allvict – *Allium victorialis*, Anenarc – *Anemone narcissiflora*, Antodor – *Anthoxanthum odoratum*, Bismajo – *Bistorta major*, Bruspic – *Bruckenthalia spiculifolia*, Calarun – *Calamagrostis arundinacea*, Calvill – *Calamagrostis villosa*, Camrotu – *Campanula rotundifolia* agg., Descesp – *Deschampsia caespitosa*, Dorcolu – *Doronicum columnae*, Fesairo – *Festuca airoides*, Fesrubr – *Festuca rubra*, Genascl – *Gentiana asclepiadea*, Gersylv – *Geranium sylvaticum*, Herspho – *Heracleum sphondylium*, Hypmacu – *Hypericum maculatum*, Juntrif – *Juncus trifidus*, Junnan – *Juniperus communis* subsp. *nana*, Aveflex – *Lerchenfeldia flexuosa*, Ligmute – *Ligusticum mutellina*, Luzluzu – *Luzula luzuloides*, Luzsylv – *Luzula sylvatica*, Narstri – *Nardus stricta*, Prielat – *Primula elatior*, Rubidae – *Rubus idaeus*, Rumalpi – *Rumex alpinus*, Rumarif – *Rumex arifolius*, Saxrotu – *Saxifraga rotundifolia*, Sennemo – *Senecio nemorensis* agg., Sescoer – *Sesleria coerulans* agg., Silpusi – *Silene pusilla*, Silvulg – *Silene vulgaris*, Solspec – *Soldanella* species, Solvirg – *Solidago virgaurea*, Thyvand – *Thymus vandasii*, Vacmyrt – *Vaccinium myrtillus*, Vaculig – *Vaccinium uliginosum*, Vacviti – *Vaccinium vitis-idaea*, Valtrip – *Valeriana tripteris*, Verlobe – *Veratrum lobelianum*

Supplement E2. Phytosociological tables.

Anhang E2. Pflanzensoziologische Tabellen.

The tables were analyzed firstly between the associations within a table (excluded those with only one relevé; *phi* > 0.60 indicated by a frame) and then between the alliances (*phi* > .60 indicated by grey shading). Relevés and species in grey color did not enter the analysis because of the low number of relevés (taken into consideration were those with at least two relevés for either association or alliance). The shapes of the relevés are indicated by images: ■ – square shape, ▬ – rectangular shape, ▲ – triangular shape. The layers are indicated after the species name with a letter: L – lichen layer, M – moss layer, H – herb layer, S – shrub layer.

Die Tabellen wurden zunächst zwischen den Assoziationen innerhalb einer Tabelle (mit Ausnahme derjenigen mit nur einer Vegetationsaufnahme; *phi* > 0,60 durch einen Rahmen angezeigt) und dann zwischen den Verbänden (*phi* > 0,60 durch graue Schattierung angezeigt) analysiert. Aufnahmen und Arten in grauer Farbe wurden aufgrund der geringen Anzahl von Aufnahmen nicht in die Analyse einbezogen (berücksichtigt wurden solche mit mindestens zwei Aufnahmen für entweder Assoziation oder Verband). Die Formen der Aufnahmen werden durch Bilder angedeutet: ■ – quadratische Form, ▬ – rechteckige Form, ▲ – dreieckige Form. Die Schichten werden hinter dem Artnamen mit einem Buchstaben angegeben: L – Flechtenschicht, M – Moosschicht, H – Krautschicht, S – Strauchschicht.

Relevé not included in the comparative tables because of a lack of similar vegetation types:

Vegetationsaufnahme, die aufgrund eines Mangels ähnlicher Vegetationstypen nicht in den vergleichenden Tabellen enthalten ist:

Relevé no. 20; vegetation type: *Festuca valesiaca* s. l. community; relevé shape: ■; relevé area 16 m^2; altitude 1440 m a. s. l.; number of species: 30; aspect: WSW; slope: 15°. – E1: *Bupleurum falcatum* 2b, *Festuca valesiaca* s. l. 2b, *Chamaecytisus eriocarpus* 2b, *Genista sagittalis* 2a, *Silene roemeri* 1, *Poa pratensis* 1, *Cerastium arvense* 1, *Avenella flexuosa* 1, *Luzula luzuloides* 1, *Hypochaeris maculata* +, *Thymus vandasii* +, *Allium carinatum* subsp. *pulchellum* +, *Agrostis capillaris* +, *Arrhenatherum elatius* +, *Achillea millefolium* +, *Carex caryophyllea* +, *Rumex acetosella* +, *Galium verum* +, *Hieracium pilosella* agg. +, *Dianthus giganteus* +, *Scabiosa columbaria* +, *Trifolium repens* +, *Lotus corniculatus* +, *Verbascum longifolium* +, *Hypericum calycinum* +, *Campanula rotundifolia* agg. +, *Leontodon hispidus* r, *Scleranthus perennis* r, *Koeleria* sp. r, *Trifolium pratense* r.

Supplement E2.1. Initial vegetation.
Silenion lerchenfeldianae : 1 – *Jovibarbo heuffelii-Silenetum lerchenfeldianae* , 2 – *Symphyandro wanneri-Veronicetum baumgartenii; Alysso-Sedion* : Sempervivo marmorei-*Poetum alpinae*

Anhang E2.1. Pioniervegetation.

Syntaxon		*Silenion lerchenfeldianae*			*Alysso-Sedion*
		1		2	
Relevé number		66	70	60	45
Relevé shape		■	—	■	—
Relevé area (m^2)		0.16	0.15	0.25	3
Altitude (m a. s. l.)		1860	1706	2050	1950
Number of species		1	6	3	10
Aspect		E	SE	NE	E
Slope (degrees)		90	90	90	10
Allium carinatum subsp. *pulchellum*	H	.	.	.	+
Festuca airoides	H	.	+	.	+
Grimmia sp.	M	.	.	.	2a
Hedwigia ciliata	M	.	.	.	1
Jovibarba heuffelii	H	.	2b	.	.
Luzula italica	H	.	+	.	.
Poa alpina	H	.	.	.	1
Racomitrium canescens	M	.	.	.	2a
Rumex acetosella	H	.	+	.	.
Saxifraga paniculata	H	.	.	.	2a
Scleranthus perennis	H	.	.	.	2a
Sedum annuum	H	.	1	.	2a
Sempervivum marmoreum	H	.	.	.	2a
Silene lerchenfeldiana	H	3	2b	.	.
Silene pusilla	H	.	.	+	.
Symphyandra wanneri	H	.	.	+	.
Veronica baumgartenii	H	.	.	+	.

Supplement E2.2. Montane and subalpine heathlands and Juniper scrub.
Bruckenthalion spiculifoliae: Junipero (sibiricae)-Bruckenthalietum (spiculifoliae); Juniperion nanae: Seslerio comosae-Juniperetum sibiricae; Genisto pilosae-Vaccinion: 1 – *Seslerio coerulantis-Vaccinietum myrtilli,* 2 – *Vaccinio-Callunetum vulgaris; Sambuco-Salicion caprae: Epilobio angustifolii-Juniperetum nanae*

Anhang E2.2. Montane und subalpine Heiden und Wacholdergebüsche.

Syntaxon		*Bruckenthalion spiculifoliae*				*Juniperion nanae*			*Genisto pilosae-Vaccinion*				*Sambuco-Salicion*	
									1			2		
Relevé number		42	56	64	68	2	4	55	14	43	77	7	53	54
Relevé shape		■	■	■	■	■	■	■	■	■	■	■	■	■
Relevé area (m^2)		16	16	16	16	16	16	16	16	1	16	16	16	16
Altitude (m a. s. l.)		1753	1850	1900	1800	1990	1865	1910	1945	1950	1850	1770	1600	1600
Number of species		16	19	11	10	15	25	17	19	10	9	25	6	7
Aspect		E	NE	SW	E	SSE	S	E	N	NE	SE	NW	E	E
Slope (degrees)		20	40	5	25	15	8	20	30	45	60	25	10	10
Bruckenthalia spiculifolia	H	4	2b	3	4	.	+	.	.	.	.	+	.	.
Thymus vandasii	H	.	.	.	.	+	1	+	.	.	.	+	.	.
Genista tinctoria	H	.	.	.	.	+	1	.	.	.	.	.	.	.
Hypochaeris maculata subsp. *pelivanovicii*	H	.	.	.	.	+	1	.	.	.	.	.	.	.
Centaurea uniflora subsp. *nervosa*	H	.	.	.	.	r	+	.	.	.	.	.	.	.
Festuca rubra	H	.	.	.	.	.	1	+	.	.	.	.	.	.
Anemone narcissiflora	H	.	.	.	.	r	r	.	.	.	.	.	.	.
Senecio abrotanifolius subsp. *carpaticus*	H	.	.	.	.	.	.	+	1	1	+	.	.	.
Soldanella sp.	H	.	.	.	.	.	.	.	2a	.	1	.	.	.
Allium victorialis	H	.	.	.	.	.	.	.	2a	r	.	.	.	.
Rubus idaeus	S	.	.	.	.	.	.	.	.	.	.	.	2b	2a
Senecio nemorensis agg.	H	.	.	.	.	.	.	1	.	.	.	.	1	2a
Antennaria dioica	H	+	.	.	.	+	+	.	.	.	.	.	.	.
Alchemilla flabellata	H	.	.	.	.	.	+	.	.	.	.	.	.	.
Alchemilla sp.	H	.	.	.	.	.	+	.	.	.	.	.	.	.
Carex sempervirens	H	.	.	+	.	.	.	.	.	.	.	.	.	.
Calamagrostis arundinacea	H	.	.	.	1	.	+	.	.	.	.	+	.	+
Genista pilosa	H	.	.	+	+	.	.	.	.	.	.	.	.	.
Calamagrostis villosa	H	.	.	.	.	.	.	.	.	.	1	.	.	.
Euphrasia sp.	H	.	.	.	.	.	+	.	.	.	.	+	.	.
Anthemis carpatica	H	.	.	.	.	+	.	.	.	.	.	.	.	.
Epilobium angustifolium	H	.	.	.	.	.	.	.	.	.	.	.	2b	.
Festuca airoides	H	1	.	1	.	1	1	+	2a	1	.	.	.	.
Festuca balcanica	H	.	.	.	.	.	.	+	.	.	.	.	.	.
Crocus sp.	H	.	.	.	r	.	.	.	.	.	.	.	.	.
Gentiana asclepiadea	H	.	.	.	.	.	.	+	.	.	.	+	.	+
Gentiana lutea	H	.	.	.	.	.	r	.	.	.	.	.	.	.
Clematis alpina	H	.	.	.	.	.	.	.	.	5	.	.	.	.
Gentiana punctata	H	r	.	.	.	.	.	.	+	.	1	.	.	.
Gentianella germanica	H	.	.	.	.	.	+	.	.	.	.	.	.	.
Geum montanum	H	.	.	.	.	.	.	.	+	.	.	.	.	.
Campanula rotundifolia agg.	H	+	+	.	.	+	+	.	.	+	.	+	.	.
Luzula luzuloides	H	+	.	.	+	.	.	.	2a	2b	.	2a	+	.
Avenella flexuosa	H	1	+	2b	1	1	1	1	2a	.	+	1	.	+
Juncus trifidus	H	.	1	1	.	.	.	1	+	.	.	.	.	.
Rhinanthus angustifolius	H	.	.	.	.	.	.	.	+	.	.	.	.	.
Gnaphalium supinum	H	.	+	.	.	.	.	.	.	.	.	.	.	.
Ligusticum mutellina	H	.	.	.	.	.	.	.	2a	.	.	.	.	.
Juniperus communis subsp. *nana*	H	1	.	+	+	4	3	4	.	.	.	.	.	.
Juniperus communis subsp. *nana*	S	.	.	.	.	.	.	.	.	.	.	.	4	3
Leucanthemum vulgare	H	.	.	.	.	.	+	.	.	.	.	.	.	.
Melampyrum sylvaticum	H	+	+	.	.	.	.	.	+	.	+	2a	.	.
Luzula sylvatica	H	.	.	.	.	.	.	.	.	.	1	.	.	.
Pseudorchis albida	H	r	.	.	.	.	.	.	+	.	.	.	.	.
Poa nemoralis	H	.	.	.	.	.	.	.	.	+	.	.	.	.
Potentilla ternata	H	.	.	.	.	.	+	.	+	.	.	r	.	.
Sesleria coerulans agg.	H	+	.	.	.	3	3	1	2a	1	.	.	.	.
Rosa pendulina	H	.	.	.	.	.	.	+	.	.	.	.	.	.
Hieracium sparsum agg.	H	+	.	+	+	+	.	.	.	.	.	2a	.	.
Avenula versicolor	H	+	.	+	.	.	.	.	.	.	.	.	.	.
Carex caryophyllea	H	.	.	.	.	.	+	.	.	.	.	.	.	.
Rumex arifolius	H	.	.	.	.	.	.	r	.	.	.	1	.	.
Veratrum lobelianum	H	.	.	.	.	.	.	.	+	.	.	.	.	.
Vaccinium myrtillus	H	+	2a	.	+	.	+	2a	2b	2b	4	2b	1	2b
Vaccinium uliginosum	H	3	2a	2b	.	2b	1	2a	2b	.	.	1	.	.
Vaccinium vitis-idaea	H	+	1	1	1	1	+	1	1	1	2b	1	.	.
Agrostis capillaris	H	.	.	.	.	.	.	.	.	.	.	2a	.	.
Anthoxanthum odoratum agg.	H	.	.	.	.	.	.	.	.	.	.	1	.	.
Chamaecytisus pygmeus	H	.	.	.	.	.	.	.	.	.	.	+	.	.
Dicranum scoparium	M	+	.	.	.	.	.	.	.	.	.	.	.	.
Grimmia ovalis	M	1	.	.	.	.	.	.	.	.	.	.	.	.
Grimmia unicolor	M	1	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium pilosella agg.	H	.	.	.	.	.	.	.	.	.	.	+	.	.
Hylocomium splendens	M	2b	.	.	.	.	.	.	3	.	.	.	.	.
Hypnum cupressiforme	M	1	.	.	.	.	.	.	.	.	.	.	.	.
Hypochaeris maculata	H	.	.	.	.	.	.	.	.	.	.	1	.	.
Polytrichastrum alpinum	M	1	.	.	.	.	.	.	.	.	.	.	.	.
Racomitrium canescens	M	1	.	.	.	.	.	.	.	.	.	.	.	.
Sedum anuum	H	.	.	.	.	.	.	.	.	.	.	r	.	.
Solidago virgaurea	H	.	.	.	.	.	.	.	.	.	.	+	.	.
Syntrichia ruralis	M	1	.	.	.	.	.	.	.	.	.	.	.	.
Tortella tortuosa	M	1	.	.	.	.	.	.	.	.	.	.	.	.
Tritomaria quinquedentata	M	+	.	.	.	.	.	.	.	.	.	.	.	.
Valeriana tripteris	H	.	.	.	.	.	.	r	.	.	.	.	.	.

Supplement E2.3. Acidophilous grasslands of the class *Juncetea trifidi* .
Bruckenthalion spiculifoliae: Juncion trifidi: Avenello flexuosae-Juncetum trifidi; Caricion curvulae: Caricetum tricoloris; Seslerion comosae: 1 – *Agrostio rupestris-Saxifragetum paniculatae,* 2 – *Veronico baumgartenii-Festucetum airoidis,* 3 – *Agrostio rupestris-Seslerietum comosae,* 4 – *Thesio alpini-Avenelletum flexuosae,* 5 – *Community of Sesleria coerulans and Vaccinium myrtillus*

Anhang E2.3. Bodensaure Grasländer der Klasse *Juncetea trifidi* .

Syntaxon		*Juncion trifidi*		*Caricion curvulae*	*Seslerion comosae*														
					1		2						3		4				5
Relevé number		1	78	3	17	19	8	11	48	49	50	51	18	59	61	63	71	72	10
Relevé shape		■	■	■	▲	▲	▲	▲	■	■	■	■	■	▬	■	■	■	■	■
Relevé area (m^2)		16	4	16	7	7	7	7	4	9	9	9	16	6	16	16	16	16	16
Altitude (m a. s. l.)		1990	1950	1923	1985	1915	1958	1980	2100	2075	2080	2080	1970	1800	1805	1897	1810	1800	1940
Number of species		10	4	12	23	13	50	22	8	14	18	12	21	24	17	26	33	25	39
Aspect		S	NE	SSW	NW	NNE	N	NE	NE	NE	NE	NE	WSW	NE	NE	E	SE	SE	NE
Slope (degrees)		14	60	8	60	50	80	80	90	90	75	90	5	80	20	40	35	5	20
Poa alpina	H	.	.	.	r	+	.	.	.	.	.	.	1	.	.	.	.	.	.
Saxifraga exarata subsp. *pirinica*	H	.	.	.	.	.	+	1	1	+	+	.	.	.	.	.	.	.	.
Galium anisophyllon	H	.	.	.	.	.	+	.	.	2a	+	+	.	.	.	.	.	.	.
Ranunculus montanus	H	.	.	.	.	.	+	r	.	+	+	.	.	.	.	.	.	.	.
Asplenium viride	H	.	.	.	.	.	r	r	.	+	+	.	.	.	.	.	.	.	.
Silene pusilla	H	.	.	.	+	.	+	1	2a	+	1	2a	.	.	.	.	.	.	.
Saxifraga bryoides	H	.	.	.	.	.	+	+	2b	.	.	.	.	.	.	.	.	.	.
Anemone narcissiflora	H	.	.	.	.	.	r	r	.	.	+	.	.	.	.	.	.	.	1
Soldanella sp.	H	.	.	.	.	.	+	+	.	.	1	.	.	.	.	.	.	.	.
Veronica baumgartenii	H	.	.	.	.	.	1	+	.	.	1	.	.	.	.	.	.	.	.
Symphyandra wanneri	H	.	.	.	+	+	+	+	+	2a	+	2a	.	.	.	.	.	.	.
Juniperus communis subsp. *nana*	H	2b	1	1	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Ligusticum mutellina	H	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+
Senecio abrotanifolius subsp. *carpaticus*	H	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Potentilla ternata	H	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	+	.	+
Calamagrostis arundinacea	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	r
Chamaecytisus supinus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	.	.
Hypericum maculatum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2a	1	2b
Luzula campestris	H	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	1	.
Thymus vandasii	H	.	.	.	.	1	.	.	.	.	.	.	.	.	2a	1	2a	2b	.
Luzula luzuloides	H	+	.	.	.	.	r	.	.	.	.	.	.	.	1	+	2a	+	1
Gentiana asclepiadea	H	.	.	+	.	.	.	.	.	.	.	.	.	+	+	+	1	.	+
Anthoxanthum odoratum agg.	H	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	+	.	1
Solidago virgaurea	H	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	+	.	2a
Avenella flexuosa	H	+	+	2b	.	.	.	.	.	.	.	.	+	.	2a	1	2a	1	1
Nardus stricta	H	.	.	.	.	.	.	.	.	.	.	.	.	1	2a	+	.	.	.
Minuartia verna agg.	H	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.
Pedicularis verticillata	H	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.
Melampyrum sylvaticum	H	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1
Primula minima	H	.	.	.	+	.	1	1	.	.	+	.	.	.	.	.	.	.	.
Carex atrata	H	.	.	.	2a	.	+	+	1	.	.	.	.	.	.	.	.	.	.
Aconogonon alpinum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Rumex arifolius	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+
Ornithogalum umbellatum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Gnaphalium supinum	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Polygonatum verticillatum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Vaccinium uliginosum	H	3	.	+	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Pedicularis comosa	H	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Vaccinium myrtillus	H	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	1
Orobanche sp.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Veratrum lobelianum	H	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	+	.	+
Valeriana tripteris	H	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	+
Sempervivum marmoreum	H	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula rotundifolia agg.	H	.	.	+	.	.	+	+	.	.	+	.	+	+	1	+	1	1	+
Myosotis alpestris	H	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.
Luzula italica	H	.	.	.	1	+	+	r	1	.	.	+	.	.	.	.	.	1	.
Veronica bellidioides	H	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Verbascum longifolium	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	r	.	.
Noccaea ochroleuca	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Sedum annuum	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Veronica chamaedrys	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Trifolium pratense	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Sedum acre agg.	H	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Seseli libanotis	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.
Stellaria graminea	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Rhinanthus minor	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Rhinanthus sp.	H	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Vaccinium vitis-idaea	H	+	.	+	.	.	+	+	.	.	+	.	.	.	.	.	+	.	.
Carex caryophyllea	H	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sesleria coerulans agg.	H	1	.	1	.	1	2a	2a	.	2a	3	2b	.	2a	.	+	.	.	2b
Silene roemeri	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
Campanula patula subsp. *abietina*	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+
Luzula sylvatica	H	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.	+
Scleranthus perennis	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Allium victorialis	H	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+
Antennaria dioica	H	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea lingulata	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	1	.	+
Chamaespartium sagittale	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Bistorta major	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Calamagrostis villosa	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Carex kitaibeliana	H	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Centaurea uniflora subsp. *nervosa*	H	.	.	r	.	.	.	.	.	.	.	.	2b	.	+	2a	.	.	1
Alchemilla sp.	H	.	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.	.	+
Allium carinatum subsp. *pulchellum*	H	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex sempervirens	H	.	.	.	+	.	.	.	.	.	.	.	.	2b	2a	.	.	.	.
Agrostis rupestris	H	.	+	.	1	.	.	.	.	.	.	.	4	2a	.	.	.	.	.
Thesium alpinum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.
Cerastium alpinum s. l.	H	.	.	.	+	.	1	+	.	+	1	.	.	.	.	.	.	.	.
Hieracium sparsum agg.	H	.	.	.	.	.	.	.	.	.	.	.	+	r	2a	.	+	.	.
Saxifraga paniculata	H	.	.	.	+	2a	1	1	.	1	1	2b	.	.	.	.	.	.	.
Bupleurum falcatum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.
Rumex acetosella	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.
Achillea millefolium	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.
Agrostis capillaris	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.
Saxifraga pedemontana subsp. *cymosa*	H	.	.	.	+	r	+	.	.	.	.	1	.	.	.	.	.	.	.
Scabiosa columbaria	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2b	.
Geum montanum	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+
Crocus sp.	H	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Pilosella officinarum agg.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Festuca nigrescens	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Cruciata laevipes	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Crepis conyzifolia	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2a
Chamaecytisus pygmaeus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Gnaphalium sylvaticum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Juncus trifidus	H	3	3	.	+	.	+	+	1	2a	1	.	+	.	.	.	.	1	.
Huperzia selago	H	.	.	.	.	.	+	r	.	.	+	.	.	+	.	.	.	.	.
Koeleria eriostachya	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Deschampsia cespitosa	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Crepis viscidula	H	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.
Alchemilla flabellata	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.
Festuca airoides	H	1	.	+	1	2a	1	2a	2b	1	2b	2a	.	2b	.	1	.	+	.
Botrychium lunaria	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Allium vineale	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Euphrasia sp.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+
Dianthus giganteus	H	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
Digitalis grandiflora	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Gentiana punctata	H	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Festuca rubra	H	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	1	3	1
Amphidium mougeotii	M	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Brachythecium cf. *cirrosum*	M	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Bryum sp.	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Carex tricolor	H	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cephaloziella sp.	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Cetraria sp.	L	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Distichium capillaceum	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Distichium sp.	M	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Doronicum columnae	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
Festuca balcanica	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Genista tinctoria	H	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium sylvaticum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Grimmia sp.	M	.	.	.	2a	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Hedwigia ciliata	M	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hylocomnium splendens	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Hymenostylium sp.	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Hypnum cupressiforme var. *subjulaceum*	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Hypnum sp.	M	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Hypochaeris illyrica	H	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lejeunea cavifolia	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Leucanthemum vulgare	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Lotus corniculatus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Metzgernia pubescens	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Mnium marginatum	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Myurella julracea	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Nardia sp.	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Phleum alpinum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Plagiochilla porelloides	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Pleurotzium schreberi	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Pohlia nutans	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichastrum formosum	M	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichum juniperinum	M	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Pseudorchis albida	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Ranunculus nemorosus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Ranunculus platanifolius	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Rhinanthus angustifolius	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Rhytiadelphus triquetrus	M	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Sanionia uncinata	M	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Thamnolia sp.	L	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tortella tortuosa	M	.	.	.	1	.	1	.	.	.	.	1	.	.	.	.	.	.	.
Trilophozia quinquedentata	M	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Trollius europaeus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+

Supplement E2.4. Montane and subalpine heathlands and Juniper scrub.
Bruckenthalion spiculifoliae: Junipero sibiricae-Bruckenthalietum spiculifoliae; Juniperion nanae: Seslerio comosae-Juniperetum sibiricae; Genisto pilosae-Vaccinion: 1 – *Seslerio coerulantis-Vaccinietum myrtilli,* 2 – *Vaccinio-Callunetum vulgaris; Sambuco-Salicion caprae: Epilobio angustifolii-Juniperetum nanae*

Anahng E2.4. Montane und subalpine Heiden und Wacholdergebüsche.

Syntaxon		*Pinion mugo*		*Cirsion appendiculati*		*Adenostylion alliariae*						*Dryopterido-Athyrion*			*Scabioso-Doronicion*		*Calamagrostion arundinaceae*			*Calamagrostion villosae*								*Rumicion alpini*				*Alnion viridis*				
						1				2	3				1	2	1	2	3	1				2		3		1		2						
Relevé number		65	67	6	29	9	12	25	33	26	46	27	30	37	13	44	15	47	28	36	41	62	69	38	39	73	74	21	22	32	40	23	24	31	34	35
Relevé shape		■	■	■	■	■	■	■	■	■	■	■	■	■	■	—	■	■	■	■	■	—	—	■	■	■	■	■	■	■	■	■	■	—	■	■
Relevé area (m^2)		16	16	16	16	16	16	16	16	16	16	16	16	16	16	8	16	16	16	16	16	8	6	16	16	16	16	16	16	16	16	16	16	24	16	16
Altitude (m a. s. l.)		1860	1850	1750	1880	1934	2010	1950	2120	1950	2000	1980	1820	1830	2010	1950	1970	2000	1950	1650	1800	1882	1630	1770	1760	1786	1774	1441	1441	1660	1770	1800	1800	1725	1800	1610
Number of species		4	6	16	5	29	33	25	21	21	28	43	36	17	48	18	13	15	28	8	9	19	12	18	13	9	16	5	4	23	8	16	11	25	18	20
Aspect		E	E	SE	N	NWW	N	NE	NE	NE	NE	N	N	NE	NE	NE	N	NE	N	E	NE	NE	SE	NE	NE	NE	NE	S	S	NE	E	NE	NE	N	NE	E
Slope (degrees)		25	30	30	25	15	30	45	45	35	20	45	45	45	45	45	30	25	40	25	35	70	20	35	45	45	35	5	5	45	35	35	45	45	40	50
Pinus mugo	S	4	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epilobium alpestre	H	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Anemone narcissiflora	H	.	.	.	.	.	+	+	+	.	4	.	.	.	+	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trollius europaeus	H	.	.	.	.	1	+	.	+	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Primula elatior	H	.	.	.	.	1	1	1	1	1	1	+	.	.	1	1	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium sylvaticum	H	.	.	.	.	+	1	+	+	.	1	1	+	.	r	.	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Myosotis sylvatica	H	.	.	.	.	r	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Doronicum columnae	H	.	.	.	.	.	1	+	2b	2b	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bistorta major	H	.	.	.	.	+	+	1	2b	1	1	+	.	1	+	+	.	1	2a	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Soldanella sp.	H	.	.	.	.	1	1	1	1	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	+
Solidago virgaurea	H	.	.	.	.	.	+	.	.	.	.	+	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Cystopteris alpina s. l.	H	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gymnocarpium dryopteris	H	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula rotundifolia agg.	H	.	.	.	.	.	.	.	.	.	.	+	+	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Sedum acre agg.	H	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Geum montanum	H	.	.	.	.	.	+	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phleum alpinum	H	.	.	.	.	.	.	.	+	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa alpina	H	.	.	.	.	.	.	+	.	1	+	+	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eriophorum latifolium	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.
Carex nigra	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	2a	.	.	.	.	.	.	.	.	.	.
Molinia caerulea	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	5	.	+	.	.	.	.	.	.	.	.	.
Carex pallescens	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.
Urtica dioica	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.
Doronicum austriacum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	.	.	.	.
Alnus viridis	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Alnus viridis	S	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	2b	4	.	1
Dryopteris dilatata	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1
Carex echinata	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	+	+	+	.	.	.	.	.	.	.	.	.
Nardus stricta	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	+	3	4	.	.	.	.	.	.	.	.	.
Pinguicula balcanica	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	+	+	2m	+	.	.	.	.	.	.	.	.	.
Senecio nemorensis agg.	H	.	.	2a	1	.	.	1	.	.	.	.	+	2a	.	.	r	.	2b	+	+	.	.	.	.	.	.	.	.	.	.	1	1	2a	+	1
Rubus idaeus	H	.	.	.	.	+	.	+	.	2b	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	1	1	4	2b	.	1
Silene vulgaris	H	.	.	.	.	+	1	.	2a	.	+	+	1	1	+	.	.	+	2a	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.
Ranunculus platanifolius	H	.	.	.	.	+	.	1	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Allium victorialis	H	.	.	.	.	+	+	.	.	.	1	1	+	.	.	.	2a	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leucanthemum vulgare	H	.	.	.	.	.	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epilobium montanum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Dryopteris filix-mas	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	1	2b	.	.
Poa pratensis	H	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Athyrium filix-femina	H	.	.	+	.	.	.	.	.	.	.	2a	3	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	1
Oxalis acetosella	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	1
Myosotis scorpioides	H	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salix silesiaca	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Salix silesiaca	S	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.
Angelica sylvestris	H	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	+
Poa nemoralis	H	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.
Rhinanthus sp.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.
Prenanthes purpurea	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Avenella flexuosa	H	.	.	.	.	.	.	+	.	+	.	r	.	.	2a	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	+	.	.	1	.
Scrophularia scopolii	H	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula patula subsp. *abietina*	H	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veratrum lobelianum	H	.	.	r	.	1	.	+	.	2b	.	2a	+	2a	+	+	1	.	2a	.	+	+	r	+	+	.	+	.	.	+	1	+	.	.	+	+
Vaccinium vitis-idaea	H	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	1	.
Luzula luzuloides	H	.	.	.	.	.	.	+	.	.	2a	.	+	.	.	1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.
Myosotis nemorosa	H	.	.	.	.	.	.	+	+	+	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Ranunculus nemorosus	H	.	.	.	.	.	+	.	.	1	.	+	.	.	r	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stellaria nemorum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.
Scabiosa columbaria	H	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rubus ser. *Glandulosi*	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Rumex alpinus	H	.	.	4	3	2b	.	.	.	1	.	.	.	.	+	.	.	.	+	.	+	.	.	.	.	.	.	5	5	1	2a	.	.	.	.	.
Vaccinium myrtillus	H	2a	+	.	.	.	+	+	.	.	+	.	.	.	.	.	.	2b	1	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	1	+
Salix caprea	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Salix caprea	S	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
Sorbus aria	S	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Milium effusum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Symphytum tuberosum	H	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla ternata	H	.	.	.	.	.	r	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga stellaris	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Athyrium distentifolium	H	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.
Thalictrum aquilegiifolium	H	.	.	+	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.
Carduus kerneri	H	.	.	.	.	.	.	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Taraxacum sp.	H	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium uliginosum	H	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	r	.	.	.	2b	.	.	.	.	.	.	.	.	.
Juncus conglomeratus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Tephroseris aucheri	H	.	.	.	.	.	.	.	1	.	2a	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scrophularia nodosa	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.
Chaerophyllum aureum	H	.	.	.	.	+	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aconitum burnatii	H	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lilium jankae	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Festuca balcanica	H	.	.	.	.	.	.	.	+	+	+	+	.	.	r	.	.	2b	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crepis paludosa	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Caltha palustris s. l.	H	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Crepis viscidula	H	.	.	.	.	.	+	.	.	1	.	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ligusticum mutellina	H	.	.	.	.	+	1	.	+	+	1	+	1	.	+	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Crocus sp.	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.
Dactylis glomerata	H	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Melampyrum sylvaticum	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Carex sempervirens	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Carduus personata	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Heracleum sphondilium	H	.	.	.	.	2a	1	.	2a	2a	+	1	+	.	+	.	1	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.
Avenula pubescens	H	.	.	.	.	.	1	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cystopteris fragilis	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Adenostyles alliariae	H	.	.	r	+	3	4	5	3	2a	.	1	.	+	+	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Alchemilla obtusa	H	.	.	.	.	1	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla sp.	H	.	.	r	.	+	+	.	+	.	+	1	.	.	+	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga rotundifolia	H	.	.	.	.	1	.	1	+	.	.	+	+	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Valeriana tripteris	H	.	.	.	.	.	+	+	1	.	+	1	1	.	+	2b	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Calamagrostis villosa	H	.	.	.	.	.	.	+	.	+	.	.	+	1	.	.	.	.	2a	5	5	2a	2a	.	+	1	.	.	.	.	.	.	.	.	4	2b
Rumex arifolius	H	.	.	.	.	1	+	+	+	.	+	+	+	1	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	.	+
Chrysosplenium alternifolium	H	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Daphne mezereum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Chaerophyllum hirsutum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Cicerbita alpina	H	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Asplenium sp.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Acer heldreichii	S	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Aconitum lycoctonum subsp. *neapolitanum*	H	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula moesiaca	H	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geum urbanum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Festuca gigantea	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Acer pseudoplatanus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Huperzia selago	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypericum maculatum	H	.	.	+	.	+	+	+	.	1	.	+	.	1	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.
Juniperus communis subsp. *nana*	H	2a	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	r	.	.	.	r	.	.	+	.	.	.	.	+	.
Juniperus communis subsp. *nana*	S	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.
Agrostis rupestris	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fagus sylvatica	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Juncus effusus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus trifidus	H	.	.	.	.	.	.	.	.	.	+	.	.	.	r	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cirsium oleraceum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Gentiana lutea	H	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca rubra	H	.	.	.	.	+	+	.	.	.	.	+	1	.	r	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Geum rivale	H	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Heracleum sphondylium subsp. *verticillatum*	H	.	.	.	3	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Centaurea uniflora subsp. *nervosa*	H	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Deschampsia cespitosa	H	.	.	+	.	+	+	.	.	.	.	.	.	2a	.	.	.	.	.	.	+	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
Galium sp.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Gentiana punctata	H	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.	.	r	.	.	.	.	.	.	.	+	.
Luzula sylvatica	H	.	.	.	.	.	1	.	.	.	2a	.	.	+	+	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	+	.	.	2a	.
Calamagrostis arundinacea	H	3	1	+	.	.	+	.	.	.	.	.	+	2a	.	.	5	2b	2a	+	.	.	.	.	.	.	.	.	.	2a	.	2a	1	2a	+	.
Potentilla erecta	H	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	+	.	+	+	1	+	+	+	.	.	.	.	.	.	.	+	.
Bruckenthalia spiculifolia	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.
Blechnum spicant	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a
Gentiana asclepiadea	H	.	.	.	.	.	+	+	.	.	+	+	1	1	.	.	+	.	.	+	.	+	+	.	.	.	.	.	.	+	+	+	1	.	.	.
Festuca airoides	H	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthoxanthum odoratum agg.	H	.	.	.	.	.	r	.	.	.	.	.	+	.	+	+	.	.	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.
Pedicularis verticillata	H	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium sparsum agg.	H	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	+	.	.	.	+	.	.
Arrhenatherum elatius	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Asplenium viride	H	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calliergon stramineum	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium bonus-henricus	H	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crepis conyzifolia	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca pratensis	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium macrorhizum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Heracleum sibiricum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hylocomium splendens	M											2a																								
Hypnum cupressiforme	M	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypochaeris maculata	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Knautia drymeja	H	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mnium marginatum	M	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mnium sp.	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Noccaea ochroleuca	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pleurozium schreberi	M											+																								
Poa media	H	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa nemoralis	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichum commune	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2b	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus montanus	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rosa pendulina	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scabiosa lucida	H	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sedum annuum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sempervivum marmoreum	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio abrotanifolius subsp. *carpaticus*	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sesleria coerulans agg.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene pusilla	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene roemeri	H	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphagnum capillifolium	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Sphagnum fallax	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphagnum papillosum	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a.	.	2a	.	.	.	.	.	.	.	.	.	.	.
Sphagnum russowii	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	.	.	.	.	.	.	.	.	.	.	.
Sphagnum sp.	M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
Traunsteinera globosa	H	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium medium subsp. *balcanicum*	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium pratense	H	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Valeriana officinalis s. l.	H	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica chamaedrys	H	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Supplement E2.5. Vegetation of fens and springs.
Narthecion scardici: Communities of Dactylorhiza cordigera and Parnassia palustris; Swertio perennis-Anisothecion squarrosi: 1 – Brachythecio rivularis-Cardaminetum balcanicae, 2 – Community of Cystopteris fragilis and Saxifraga stellaris, 3 – Saxifragetum stellaris, 4 – Angelico sylvestris-Calthetum laetae

Anhang E2.5. Vegetation der Moore und Quellen.

Syntaxon		*Narthecion scardici*		*Swertio perennis-Anisothecion squarrosi*				
				1		2	3	4
Relevé number		5	52	57	58	16	76	75
Relevé shape		■	▬	▬	▬	■	■	■
Relevé area (m^2)		16	10	6	6	4	1	16
Altitude (m a. s. l.)		1754	1608	1706	1710	1970	1770	1770
Number of species		52	10	8	9	16	7	24
Aspect		NE	E	NE	NE	N	NE	NE
Slope (degrees)		30	10	80	70	90	90	70
Dactylorhiza cordigera	H	1	2a	.	.	.	.	.
Agrostis capillaris	H	2a	.	.	.	.	.	.
Agrostis stolonifera	H	1	.	.	.	.	.	+
Alchemilla obtusa	H	+	.	.	.	.	.	.
Alchemilla sp.	H	+	.	.	.	+	.	.
Anemone narcissiflora	H	r	.	.	.	.	.	.
Angelica pancicii	H	1	1	r	+	.	+	+
Anthoxanthum odoratum agg.	H	+	.	.	.	.	.	.
Athyrium filix-femina	H	+	.	.	.	.	.	.
Bistorta major	H	r	.	.	.	.	.	.
Bruckenthalia spiculifolia	H	+	.	.	.	.	.	.
Calamagrostis arundinacea	H	+	.	.	.	r	.	.
Caltha palustris s. l.	H	1	.	.	.	.	.	2a
Campanula rotundifolia agg.	H	+	.	.	.	.	.	.
Cardamine amara s. l.	H	.	.	1	2a	.	.	.
Carex echinata	H	.	.	.	.	.	.	1
Carex ovalis	H	r	.	.	.	.	.	.
Carex pallescens	H	1	.	.	.	.	.	.
Carex sempervirens	H	.	.	.	.	+	.	.
Carex sylvatica	H	r	.	.	.	.	.	.
Centaurea uniflora subsp. *nervosa*	H	+	.	.	.	.	.	.
Cerastium alpinum s. l.	H	.	.	.	.	+	.	.
Cratoneuron filicinum	M	.	.	3	.	.	.	.
Crepis paludosa	H	.	.	.	.	.	.	2a
Crepis viscidula	H	1	.	.	.	.	.	.
Cystopteris fragilis	H	.	.	.	.	1	.	.
Deschampsia cespitosa	H	2a	2a	.	.	.	+	1
Epilobium alpestre	H	+	.	.	.	.	.	.
Epilobium alsinifolium	H	.	.	1	2a	.	.	.
Epilobium nutans	H	.	.	.	.	.	.	+
Epilobium obscurum	H	.	.	.	.	.	.	+
Euphrasia sp.	H	+	.	.	.	.	.	.
Festuca airoides	H	.	.	.	.	r	.	.
Festuca rubra	H	+	.	.	.	.	.	+
Gentiana asclepiadea	H	+	.	.	.	.	.	.
Geum coccineum	H	.	.	.	.	.	.	1
Geum rivale	H	1	.	.	.	.	.	.
Hypericum maculatum	H	+	.	.	.	.	.	.
Chaerophyllum hirsutum	H	+	.	.	.	.	.	1
Chrysosplenium alternifolium	H	.	.	1	1	.	.	.
Juncus articulatus	H	.	+	.	.	.	.	.
Juncus thomasii	H	+	.	.	.	.	.	2a
Juncus trifidus	H	+	.	.	.	.	.	.
Juniperus communis subsp. *nana*	H	1	.	.	.	.	.	.
Leontodon hispidus	H	+	.	.	.	.	.	.
Ligusticum mutellina	H	.	.	.	.	r	.	.
Luzula luzuloides	H	+	.	.	.	.	.	.
Luzula sylvatica	H	+	.	.	.	.	.	.
Moehringia muscosa	H	.	.	.	.	.	+	.
Myosotis nemorosa	H	.	.	.	.	.	1	.
Myosotis scorpioides	H	+	.	.	.	.	.	1
Nardus stricta	H	2a	.	.	.	.	.	+
Palustriella commutata	M	.	.	3	4	.	.	.
Parnassia palustrs	H	2a	.	.	.	.	.	.
Pedicularis verticillata	H	.	.	.	.	r	.	.
Pellia sp.	M	.	.	.	.	.	.	+
Petasites hybridus	H	.	+	.	.	.	.	.
Philonotis seriata	M	.	.	.	.	.	3	1
Pinguicula balcanica	H	.	.	.	.	.	.	+
Poa alpina	H	.	.	.	.	r	.	.
Potentilla ternata	H	+	.	.	.	.	.	.
Primula elatior	H	1	.	.	.	.	.	.
Primula minima	H	.	.	.	.	r	.	.
Pseudorchis albida	H	.	.	.	.	.	.	+
Ptychostomum pseudotriquetrum	M	.	4	.	.	.	.	.
Ptychostomum weigelii	M	.	.	.	+	.	.	.
Ranunculus montanus	H	.	.	.	.	+	.	.
Rhinanthus angustifolius	H	+	.	.	.	.	.	.
Rhizomnium punctatum	M	.	.	.	.	.	.	1
Rhytiadelphus triquetrus	M	.	1	.	.	.	.	.
Rumex alpinus	H	.	.	.	.	.	.	r
Saxifraga exarata subsp. *pirinica*	H	.	.	.	.	+	.	.
Saxifraga rotundifolia	H	.	.	+	+	+	.	.
Saxifraga stellaris	H	.	1	.	.	+	5	1
Scabiosa columbaria	H	1	.	.	.	.	.	.
Scapania undulata	M	.	.	.	.	.	1	.
Senecio nemorensis agg.	H	+	.	.	.	.	.	.
Silene pusilla	H	+	2b	2a	1	2a	.	.
Soldanella sp.	H	+	.	.	.	+	.	+
Sphagnum sp.	M	.	.	.	.	.	.	1
Swertia punctata	H	2a	.	.	.	.	.	.
Thalictrum aquilegiifolium	H	+	.	.	.	.	.	.
Thymus vandasii	H	+	.	.	.	.	.	.
Trifolium sp.	H	r	.	.	.	.	.	.
Urtica dioica	H	.	.	.	+	.	.	.
Vaccinium myrtillus	H	+	.	.	.	.	.	.
Vaccinium uliginosum	H	+	.	.	.	.	.	.
Vaccinium vitis-idaea	H	+	.	.	.	.	.	.
Valeriana officinalis s. l.	H	+	.	.	.	.	.	.
Veratrum lobelianum	H	1	r	.	.	.	.	+

Supplement E2.6. Localities of the relevés.

Anhang E2.6. Lokalitäten der Vegetationsaufnahmen.

Relevé no.	Date	Latitude	Longitude	Locality	Cover (%)			
					E_2	E_1	E_0	Total
1	21.08.2020	43°25'32.8"	22°39'38.8"	Boulder filed near Mt. Dupljak	.	70	60	75
2	21.08.2020	43°25'28.9"	22°39'37.5"	Grassland ca 140 m SSW of Mt. Dupljak	.	95	5	95
3	21.08.2020	43°25'26.3"	22°39'34.8"	Grassland ca 250 m SSW of Mt. Dupljak	.	95	.	95
4	21.08.2020	43°25'17.6"	22°39'35.7"	Grassland ca 500 m SSW of Mt. Dupljak	.	70	25	80
5	22.08.2020	43°24'26.6"	22°40'15.9"	Wet grassland ca 1.45 km NNW of Mt. Midzhur	.	90	15	98
6	22.08.2020	43°24'27.2"	22°40'16"	Tall herb vegetation near the stream ca 1.45 km NNW of Mt. Midzhur	.	90	20	95
7	22.08.2020	43°24'26.8"	22°40'14.4"	Heathland ca 1.45 km NNW of Mt. Midzhur	.	55	10	60
8	22.08.2020	43°23'48"	22°40'53.6"	Rock outcrops ca 360 m ENE of Mt. Midzhur	.	15	20	30
9	22.08.2020	43°23'48.6"	22°40'52.2"	Tall herb vegetation ca 350 m ENE of Mt. Midzhur	.	60	15	70
10	22.08.2020	43°23'51.7"	22°40'40.6"	Grassland ca 280 m NNE of Mt. Midzhur	.	95	40	95
11	23.08.2020	43°23'49.1"	22°40'42.1"	Rock outcrop ca 210 m NNE of Mt. Midzhur	.	20	30	40
12	23.08.2020	43°23'47.1"	22°40'41"	Tall herb vegetation ca 140 m NNE of Mt. Midzhur	.	95	5	95
13	23.08.2020	43°23'46.6"	22°40'40.1"	Sandstone screes ca 120 m NNE of Mt. Midzhur	.	55	35	70
14	23.08.2020	43°23'46.1"	22°41'00.2"	Heathland ca 490 m WNW of Mt. Midzhur	.	98	30	100
15	23.08.2020	43°23'45.2"	22°41'00.2"	Tall herb vegetation ca 480 m WNW of Mt. Midzhur	.	95	10	100
16	23.08.2020	43°23'44.7"	22°41'00.4"	Spring ca 480 m WNW of Mt. Midzhur	.	20	30	40
17	24.08.2020	43°23'44.9"	22°43'09.4"	Rock outcrop ca 250 m WWN of Mt. Orlov Kamen	.	30	40	60
18	24.08.2020	43°23'45.2"	22°43'09.8"	Grassland ca 260 m WWN of Mt. Orlov Kamen	.	65	10	70
19	24.08.2020	43°23'29.5"	22°43'51.7"	Rock outcrop ca 810 m SE of Mt. Orlov Kamen	.	30	60	70
20	25.08.2020	43°25'30.8"	22°46'50.1"	Grassland ca 470 m SW of Mt. Gorno Âzovo	.	70	.	70
21	13.07.2021	43°24'09.1"	22°45'42.4"	Tall herb vegetation ca 2 km NW of Mt. Martinova Čuka	.	100	.	100
22	13.07.2021	43°24'09.1"	22°45'40.9"	Tall herb vegetation ca 2 km NW of Mt. Martinova Čuka	.	100	.	100
23	14.07.2021	43°23'33.2"	22°44'03.4"	Scrub vegetation ca 1 km EES of Mt. Orlov Kamen	95	70	.	95
24	14.07.2021	43°23'35.5"	22°44'04.2"	Scrub vegetation ca 1 km EES of Mt. Orlov Kamen	30	85	.	100
25	14.07.2021	43°23'29.4"	22°43'52"	Sandstone scree ca 820 m SE of Mt. Orlov Kamen	.	100	10	100
26	14.07.2021	43°23'28.8"	22°43'36"	Sandstone scree ca 820 m SE of Mt. Orlov Kamen	.	90	1	90
27	15.07.2021	43°23'46.8"	22°40'58.5"	Periodical stream ca 450 m NE of Mt. Midzhur	.	40	10	50
28	17.07.2021	43°23'54.6"	22°40'37.1"	Tall herb vegetation ca 370 m NNW of Mt. Midzhur	.	100	.	100
29	17.07.2021	43°23'51.8"	22°41'01.3"	Spring ca 570 m NE of Mt. Midzhur	.	80	5	80
30	17.07.2021	43°23'55.1"	22°41'00.1"	Tall herb vegetation ca 600 m NE of Mt. Midzhur	.	70	10	80
31	17.07.2021	43°23'59.9"	22°40'57.3"	Scrub vegetation ca 670 m NE of Mt. Midzhur	80	80	1	80
32	17.07.2021	43°24'03.9"	22°40'52.4"	Tall herb vegetation ca 710 m NE of Mt. Midzhur	.	95	.	95
33	17.07.2021	43°23'42.2"	22°40'56.2"	Tall herb vegetation ca 380 E of Mt. Midzhur	.	100	.	100
34	25.07.2021	43°18'23.3"	22°50'20.8"	Scrub vegetation ca 250 m NNE of Mt. Kopren	80	90	5	100
35	26.07.2021	43°19'12.1"	22°50'09.5"	Scrub vegetation ca 1.8 km NNW of Mt. Kopren	90	50	5	100
36	26.07.2021	43°19'10.6"	22°50'07.3"	Tall herb vegetation ca 1.7 km NNW of Mt. Kopren	.	80	.	80
37	27.07.2021	43°18'32.8"	22°50'11.6"	Scree ca 550 m NNE of Mt. Kopren	.	70	.	70
38	27.07.2021	43°18'46.1"	22°50'01.5"	Tall herb vegetation ca 1 km NNW of Mt. Kopren	.	80	20	90
39	27.07.2021	43°18'46.9"	22°50'01.3"	Tall herb vegetation ca 1 km NNW of Mt. Kopren	.	80	20	90
40	27.07.2021	43°18'52.5"	22°49'58.5"	Tall herb vegetation ca 1.2 km NNW of Mt. Kopren	.	100	1	100
41	27.07.2021	43°18'33"	22°50'13.1"	Heathland ca 550 m NNW of Mt. Kopren	.	95	.	95
42	14.07.2021	43°23'26.3"	22°44'53.9"	Rock outcrop ca 390 m NNE of Mt. Martinova Čuka	.	80	40	100
43	14.07.2021	43°23'29.5"	22°43'52.1"	Sandstone scree ca 820 m SE of Mt. Orlov Kamen	.	90	50	95
44	14.07.2021	43°23'29.1"	22°43'52.3"	Sandstone scree ca 820 m SE of Mt. Orlov Kamen	.	95	10	95
45	14.07.2021	43°23'27.1"	22°43'54.1"	Tall herb vegetation ca 900 m SE of Mt. Orlov Kamen	.	20	30	50
46	15.07.2021	43°23'46.6"	22°40'58.7"	Tall herb vegetation ca 450 m ENE of Mt. Midzhur	.	95	1	95
47	15.07.2021	43°23'45.3"	22°40'55.6"	Rock outcrop ca 370 m ENE of Mt. Midzhur	.	90	.	90
48	15.07.2021	43°23'44"	22°40'57.8"	Rock outcrop ca 420 m ENE of Mt. Midzhur	.	20	20	40
49	16.07.2021	43°23'43.8"	22°40'57.7"	Rock outcrop ca 420 m ENE of Mt. Midzhur	.	30	10	40
50	16.07.2021	43°23'43.8"	22°40'57.5"	Rock outcrop ca 410 m ENE of Mt. Midzhur	.	70	15	80
51	16.07.2021	43°23'43.7"	22°40'57.4"	Rock outcrop ca 410 m ENE of Mt. Midzhur	.	40	10	50
52	16.07.2021	43°24'47.2"	22°40'23.7"	Spring ca 2 km NNW of Mt. Midzhur	.	20	75	90
53	16.07.2021	43°24'49.4"	22°40'25"	Tall herb/Scrub vegetation ca 2 km NNW of Mt. Midzhur	95	10	.	95
54	16.07.2021	43°24'50.7"	22°40'25.9"	Tall herb/Scrub vegetation ca 2 km NNW of Mt. Midzhur	95	10	.	98
55	17.07.2021	43°24'24.6"	22°40'05.6"	Scrub vegetation ca 1.5 km NNW of Mt. Midzhur	.	100	.	100
56	17.07.2021	43°23'53.8"	22°40'59.6"	Heathland ca 560 m NE of Mt. Midzhur	.	40	50	80
57	17.07.2021	43°24'01.7"	22°40'59.7"	Spring ca 750 m NE of Mt. Midzhur	.	20	60	60
58	17.07.2021	43°24'01.2"	22°41'00.2"	Spring ca 750 m NE of Mt. Midzhur	.	30	70	80
59	17.07.2021	43°23'55.9"	22°40'50.6"	Grassland ca 480 m NE of Mt. Midzhur	.	70	30	90
60	17.07.2021	43°23'44.7"	22°40'55.8"	Rock outcrop ca 380 m ENE of Mt. Midzhur	.	5	5	10
61	25.07.2021	43°18'26"	22°50'19.1"	Grassland ca 320 m NNE of Mt. Kopren	.	80	1	80
62	25.07.2021	43°18'22.2"	22°50'17.8"	Rock outcrop ca 210 NE of Mt. Kopren	.	30	40	50
63	25.07.2021	43°18'21.5"	22°50'15.9"	Grassland ca 200 m N of Mt. Kopren	.	60	.	60
64	25.07.2021	43°18'13.7"	22°50'16.7"	Heathland near Mt. Kopren	.	70	20	80
65	25.07.2021	43°18'16.6"	22°50'23.5"	Scrub vegetation ca 130 m E of Mt. Kopren	70	70	.	90
66	25.07.2021	43°18'16.3"	22°50'24.5"	Rock outcrop ca 150 m E of Mt. Kopren	.	50	.	50
67	25.07.2021	43°18'17.6"	22°50'25.4"	Scrub vegetation ca 170 m ENE of Mt. Kopren	95	10	.	100
68	25.07.2021	43°18'17"	22°50'26.5"	Heathland ca 200 m E of Mt. Kopren	.	60	10	70
69	26.07.2021	43°19'15.2"	22°50'07.3"	Tall herb vegetation ca 1.8 km N of Mt. Kopren	.	60	40	70
70	26.07.2021	43°19'26.4"	22°49'50"	Rock outcrop ca 2.2 km NNW of Mt. Kopren	.	50	.	50
71	26.07.2021	43°19'40.4"	22°49'45.2"	Grassland ca 2.7 km NNE of Mt. Kopren	.	90	.	90
72	27.07.2021	43°18'18.2"	22°50'28.5"	Grassland ca 260 m NNE of Mt. Kopren	.	90	5	95
73	27.07.2021	43°18'41.4"	22°50'05.9"	Grassland ca 790 m NNE of Mt. Kopren	.	40	15	50
74	27.07.2021	43°18'45.7"	22°50'01.3"	Grassland ca 1 km NNE of Mt. Kopren	.	80	40	95
75	27.07.2021	43°18'54.6"	22°49'57.1"	Fen vegetation ca 1.3 km NNE of Mt. Kopren	.	50	10	60
76	27.07.2021	43°18'54.5"	22°49'56.8"	Rock outcrop ca 2. 6 km NNE of Mt. Kopren	.	50	50	95
77	27.07.2021	43°18'21.5"	22°50'23.5"	Heathland ca 200 m NE of Mt. Kopren	.	95	20	100
78	24.08.2020	43°25'33.4"	22°39'39.8"	Grassland near Mt. Dupljak	.	30	20	40