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Comparative assessment of Western Podolia meadow steppes (Ukraine) based on the synphytoindication method

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Ključne besede: klimatski in edafski dejavniki, travniška stepa, ordinacija, planota Podolija, fitoindikacija, sintaksonomija, TWINSPAN, vegetacija.

Abstract

The aim of our study is to establish the determinant ecological factors that have the greatest differential impact on the distribution of meadow steppe plant communities of Western Podolia (Ukraine) on the base of a synphytoindication analysis. There were 8 study sites within the study area in the L'viv and Ivano-Frankivsk regions. To determine the coenotic affinity of the studied species, 48 relevés were analyzed. Numerical classification based on the Modified TWINSPAN algorithm divided the dataset into five clusters, which have been identified as the associations *Pastinaco sativae-Arrhenatheretum elatioris*, *Geranio sanguinei-Trifolietum alpestris*, *Inuletum ensifoliae*, *Jurineo calcareae-Stipetum capillatae* and *Lembotropio nigricans-Potentilletum arenariae*. The results of gradient analyses indicate that the distribution of meadow steppe communities in the Podolia Upland closely correlates with a number of climatic (thermoregime and continentality of climate) and especially edaphic (soil humidity, soil acidity and carbonate content) ecological factors.

Izvleček

Namen naše raziskave je ugotoviti odločilne ekološke dejavnike, ki imajo največji vpliv na razširjenost travniških stepskih rastlinskih združb Zahodne Podolije s sinfitoindikacijsko analizo. V regijah L'viv in Ivano-Frankivsk smo vzorčili na 8 raziskovanih območjih. Za določitev cenotske pripadnosti preučevanih vrst, smo analizirali 48 vegetacijskih popisov. Z numerično klasifikacijo z modificiranim TWINSPAN algoritmom smo podatkovni niz razdelili na 5 klastrov, ki smo jih opredelili kot asociacije *Pastinaco sativae-Arrhenatheretum elatioris*, *Geranio sanguinei-Trifolietum alpestris*, *Inuletum ensifoliae*, *Jurineo calcareae-Stipetum capillatae* in *Lembotropio nigricans-Potentilletum arenariae*. Rezultati gradientne analize kažejo, da je razširjenost travniških stepskih združb na planoti Podolija močno povezana s številnimi klimatskimi (toplotni režim in kontinentalnost podnebja) in predvsem edafskimi ekološkimi dejavniki (vlažnost, kislost tal in vsebnost karbonata).

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Introduction

The territory of Ukraine is characterised by a considerable variety of natural and climatic zones, among which the Steppe zone occupies about 40% of the state area. Due to the unceasing intensification of the exploitation of natural resources, which has begun about a century ago, the steppe biome has undergone a major transformation in comparison with other natural ecosystems. This resulted in significant, sometimes critical changes of all components of the natural steppe ecosystems, from the pedosphere to the plant cover and the consumer (heterotroph) component. Nowadays most Ukrainian steppe habitats are located in numerous protected areas with different status and rank. But they are small in size and usually lacking some constituent components in both landscape and biotic aspect (Lavrenko 2000, Török et al. 2018).

This situation is very typical for the western regions of Ukraine, especially for the Podolia Upland, where steppe vegetation is extrazonal and belongs to extrazonal xeric grasslands (Melnik 1993, Kajtoch et al. 2016). Steppe vegetation here is represented mainly by small-sized species poor secondary communities formed on the slopes of the hills (Kukovytsia 1970, Sheliag-Sosonko et al. 1975, 1980a, b, Melnik 2001). At the same time, the climatic (highly oceanic) and edaphic (high soil carbonate content) conditions determine the formation of a specific type of meadow steppe plant communities here (Zaverukha 1985). According to Lavrenko (2000), they are characterised by the dominance of perennial, mainly polycarpic xerophilous plants with long vegetation period, in particular grasses of the genera *Stipa*, *Festuca*, *Agropyron*, *Koeleria*, *Cleistogenes*, *Helictotrichon* etc. The structure of the analysed vegetation also depends on the peculiarities of the study area and its location between Central European and Eastern European floristic provinces.

Earlier studies on flora and vegetation of Podolia were mostly conducted using the ecological-coenotic (dominant) approach based on species dominance (Mądalski 1936, Motyka & Kulczyński 1936, Boiko 1962, Kukovytsia 1970, 1984). According to their results, the most common communities of steppe vegetation in the Podolia region belong to the formations *Cariceta humilis*, *Koelerieta gracilis* and *Festucetea sulcatae*. It was concluded that these meadow steppe communities are similar in ecological and coenotical aspects to Central European meadow steppes of the neighboring Lublin Upland (northwest edge of Volyno-Podolia Upland (Poland)) since the distribution of both of them is mostly specified by edaphic, namely geological and geomorphological factors rather than climatic ones (Motyka & Kulczyński 1936, Fijałkowski 1991, Melnik 2001).

Recent publications (Didukh & Korotchenko 2003, Kuzemko et al. 2014, 2016) have described several features of syntaxonomy, ecology and biodiversity of the steppe areas of Central Podolia. Besides, Willner et al. (2017, 2019) have proposed a new adjusted classification scheme for plant communities of the class *Festuco-Brometea* for the westernmost part of the Eurasian steppe zone.

Besides the above-mentioned studies, there is still a lack of knowledge on the ecological and coenological characteristics of the meadow steppes in the Western Podolia region. In the previous works on the meadow steppes in Western Podolia, the synphytoindicative approach was not used to characterise these meadow steppes ecologically. Therefore, the aim of our study is to establish the determinant ecological factors that have the greatest differential impact on the distribution of meadow steppe plant communities of Western Podolia on the base of a synphytoindication analysis, which combines phytosociological and phytoindication methods.

Material and Methods

Study area

Quasi-steppe areas occurring in the territory of western Ukraine belong to an ecotone zone represented by mosaic inclusions of xero-mesophytic, sometimes quite xerophytic herbaceous ecosystems in conjuction with forest type vegetation, which is a typical feature of the forest-steppe climatic zone. According to the classification of Lavrenko (2000), the studied areas represent the meadow steppes located within the Western Podolia Upland (Figure 1) and belong to the Eastern-European block of the Eurasian steppe area.

In the past large areas in this region were occupied by oak-hornbeam and oak forests dominated by *Quercus robur*, which have remained only in small areas. Meadow steppe plant communities were formed in watersheds, especially on steep slopes of southern exposure, on thin turf-carbonate soils. Western Podolia meadow steppes are rather peculiar regarding species composition: Although they include species that are commonly found in the Eastern European forest-steppe, they are still closer to the Central European type (Lavrenko 2000). Thus, they are characterised by a group of European species such as *Achillea pannonica*, *Salvia pratensis*, *Inula ensifolia* and *Centaurea rhenana* (Zaverukha 1985).

The meadow steppe vegetation of Western Podolia within the L'viv and Ivano-Frankivsk regions of Ukraine

Figure 1: Distribution of the meadow steppe localities (marked with yellow triangles) in the Western Podolia Upland.
Slika 1: Razširjenost stepskih travišč (označenih z rumenimi trikotniki) na planoti Zahodna Podolija.

mainly occurs on quite steep slopes of southern, south-western or south-eastern exposure. The soil-forming rocks, which sometimes crop out to the surface, are limestone, marl and calcareous sandstones. According to many authors (Sheliag-Sosonko et al. 1975, 1980a, b, Melnik 1993, Kagalo et al. 2004), the above-mentioned geological and morphological features caused the extrazonal distribution of steppe vegetation in conditions of subcontinental climate.

Data collection

Eight meadow steppe areas were chosen for the analysis. Each of the sites had homogeneous species composition and environmental conditions. We selected sites with the lowest degree of anthropogenic disturbance and with the best preserved natural vegetation. Forty-eight phytosociological relevés were taken in the studied areas in June and July 2009 (Table 1).

Table 1: Geographical location of the studied sites.
Tabela 1: Geografske lokacije preučevanih območij.

Site	Latitude	Longitude	Elevation above sea level, m	Number of relevés	Notes
1. Homets Hill	N 49°50'55.4"	E 24°04'20.9"	267–302	7	Regional Landscape Park "Znesinnia"
2. Lysa Hill	N 49°48'10.4"	E 24°42'51.5"	281–372	11	National Nature Park "Pivnichne Podolia"
3. Bila Hill	N 49°55'46.5"	E 24°50'12.5"	308–369	6	National Nature Park "Pivnichne Podolia"
4. Sviata Hill	N 49°54'15.4"	E 24°51'35.0"	285–288	2	National Nature Park "Pivnichne Podolia"
5. Vysoka Hill	N 49°52'12.5"	E 24°53'00.3"	311–334	4	National Nature Park "Pivnichne Podolia"
6. Kasova Hill	N 49°13'22.6"	E 24°41'33.6"	271–322	10	Halytskyi National Nature Park
7. Chortova Hill	N 49°24'03.8"	E 24°39'54.5"	304–348	5	Botanical Nature Monument
8. Stradchanska Hill	N 49°53'54.8"	E 24°45'33.9"	320–325	3	Nature Reserve "Roztochchia"

At each site the relevés were selected with attention to the homogeneity of physiognomic features and vegetation structure. They were sampled in 100 m^2 (10 m × 10 m) plots at altitudes of 267–372 m a.s.l. according to the Braun-Blanquet approach (Braun-Blanquet 1964). Cover/abundance data for all vascular plants were recorded in the field using the original Braun-Blanquet scale. The dataset was stored in TURBOVEG 2.1 (Hennekens & Schaminée 2001).

The nomenclature of vascular plants follows Cherepanov (1995). Species names were used without combining into aggregates for the description and analyses of the considered syntaxa.

To analyse the ecological features of plant communities, we used a number of both climatic and edaphic factors (Didukh & Plyuta 1994, Didukh 2011). The climatic factors include generalised thermoregime (Tm), which means the radiation balance of the territory; ombroregime (Om), combining the amount of precipitation and thermal resources of the territory; continentality (Kn) and cryoregime (Cr). The latter factor, cryoregime, depends on the frostiness of the climate, in particular the average temperature in the coldest month of the year, in a certain area. The edaphic factors studied included: soil humidity (Hd) and variability of moisture ("damping" by Didukh 2011) (fH), nitrogen content of the soil (Nt), soil acidity (Rc) and total soil salt regime (Sl). The latter factor depends on soil structure and water supply as well as content of carbonates (Ca), which not only participate in soil-forming processes, but also act as a parent rock (Table 2).

The value of each factor was calculated using the synphytoindication method, i.e. on the basis of the average values of the tolerance amplitudes of species growing in the studied communities according to the given ecological factor (Didukh 2011).

Data analysis

The relevés were classified using the method of two-factor indicator species analysis (TWINSPAN), in particular its modified algorithm (Roleček et al. 2009) implemented in the JUICE 7.0 software (Tichý 2002). The "pseudospecies" cut level were set at 0, 5 and 15%. Diagnostic species were identified using the fidelity coefficient (phi) (Chytrý et al. 2002), whose significance was tested using Fisher's exact test at $p < 0.001$. To avoid dependence of the phi coefficient on the size of the target site group, group size was standardised to equal the average size of all groups present in the entire dataset. The species were accepted as diagnostic when phi > 0.25 and as highly diagnostic when phi > 0.5; species with frequencies > 25% were considered as constant, species with frequencies > 50% as highly constant and species with a mean cover > 25% and a 10% threshold of frequency as dominant.

To determine the ecological features of the analysed vegetation, we used the method of Detrended Correspondence Analysis (DCA) implemented in the JUICE programme. For the ecological evaluation of the syntaxa, the ecological scales of Didukh (2011) were applied. The plant community, which forms its microenvironment, is largely determined by a set of species that is sensitive to changes in environmental parameters and thus reflects the ecology of the ecotope. Therefore, the species composition of a coenoses is a fairly reliable indicator of changes in the ecological factors. The distinctive feature of synphytoindication consists in the use of plant communities rather than individual species, taking into account the projective cover of their constituent species.

Descriptive statistics were calculated using the Statistica 7.0 programme (StatSoft, Inc. (2005) STATISTICA for Windows, Version 7.0).

Table 2: Main statistical indices of the values of ecological factors (in points of phytoindication scale) assessed in the investigated region.
Tabela 2: Glavni statistični indeksi vrednosti ekoloških dejavnikov (po fitoindikacijski skali) v preučevanem območju.

Statistical indices	Ecological factors									
	Tm	Kn	Om	Cr	Rc	Sl	Nt	Hd	fH	Ca
X	8.65	8.52	7.51	8.04	8.50	7.48	4.91	9.79	3.78	8.32
x	0.027	0.032	0.029	0.025	0.036	0.037	0.053	0.084	0.071	0.097
Me	8.65	8.52	7.50	8.07	8.54	7.47	4.79	9.72	3.69	8.47
Mo	8.29	8.46	7.65	8.03	8.52	7.32	4.78	9.69	3.77	8.78
t	0.19	0.22	0.20	0.17	0.25	0.26	0.37	0.56	0.47	0.67
σ^2	0.04	0.05	0.04	0.03	0.06	0.06	0.13	0.34	0.22	0.45
Min	8.29	7.88	7.07	7.75	7.60	6.58	4.41	8.52	2.53	6.62
Max	9.11	9.21	8.46	8.48	8.95	8.06	5.90	10.96	4.82	9.37

Legend:
Tm – thermoregime; Kn – continentality of climate; Om – ombroregime; Cr – cryoclimate; Rc – soil acidity; Sl – total soil salt regime; Nt – nitrogen content of the soil; Hd – soil water regime; fH – variability of damping; Ca – carbonate content of the soil.

Results

Syntaxonomy

Numerical classification divided the dataset into five clusters, which were identified by diagnostic and constant species as associations of three classes: *Molinio-Arrhenatheretea, Festuco-Brometea* and *Trifolio-Geranietea sanguinei* (Table 3).

The syntaxonomic affiliation of the clusters allocated by the numerical classification has the following format:

Molinio-Arrhenatheretea Tx. 1937
Arrhenatheretalia elatioris Tx. 1931
Arrhenatherion elatioris Luquet 1926
Pastinaco sativae-Arrhenatheretum elatioris Passarge 1964

Trifolio-Geranietea sanguinei T. Müller 1962
Antherico ramosi-Geranietalia sanguinei Julve ex Dengler in Dengler et al. 2003
Geranion sanguinei Tx. in T. Müller 1962
Geranio sanguinei-Trifolietum alpestris T. Müller 1962

Festuco-Brometea Br.-Bl. et Tx. ex Soó 1947
Brachypodietalia pinnati Korneck 1974
Cirsio-Brachypodion pinnati Hadač et Klika in Klika et Hadač 1944
Lembotropio nigricans-Potentilletum arenariae Kukovitsa et al. ex Kukovitsa in Solomakha 1995
Jurineo calcareae-Stipetum capillatae Kukovitsa et al. ex Kukovitsa in Solomakha 1995
Inuletum ensifoliae Kozłowska 1925

Table 3: Shortened synoptic table of studied plant communities. Species with frequencies < 30% and phi < 25 are not included in the table. Associations: 1 – *Pastinaco sativae-Arrhenatheretum elatioris*, 2 – *Geranio sanguinei-Trifolietum alpestris*, 3 – *Lembotropio nigricans-Potentilletum arenariae*, 4 – *Jurineo calcareae-Stipetum capillatae*, 5 – *Inuletum ensifoliae*. Figures represent the percentage frequency; the phi coefficient multiplied by 100 is indicated as superscript. Species are arranged according to phi values.

Tabela 3: Skrajšana sinoptična tabela preučevanih rastlinskih združb. Vrste s frekvenco < 30% in navezanostjo phi < 25 niso prikazane v tabeli. Asociacije: 1 – *Pastinaco sativae-Arrhenatheretum elatioris*, 2 – *Geranio sanguinei-Trifolietum alpestris*, 3 – *Lembotropio nigricans-Potentilletum arenariae*, 4 – *Jurineo calcareae-Stipetum capillatae*, 5 – *Inuletum ensifoliae*. Številke predstavljajo frekvenco v odstotkih, nadpisani phi koeficient je pomnožen s 100. Vrste so razvrščene v skaldu s phi vrednostmi.

Group №	1	2	3	4	5
№ of relevés	2	8	3	11	24
Association *Pastinaco sativae-Arrhenatheretum elatioris*					
Pastinaca sativa	100 ^{100}	---	---	---	---
Chrysaspis dubia	100 ^{100}	---	---	---	---
Association *Geranio sanguinei-Trifolietum alpestris*					
Calamagrostis arundinacea	---	78 ^{61}	---	---	---
Stachys officinalis	---	89 ^{60}	---	---	---
Association *Lembotropio nigricans-Potentilletum arenariae*					
Potentilla arenaria	---	---	100 ^{94}	9	---
Rubus caesius	---	11	100 ^{88}	9	---
Association *Jurineo calcareae-Stipetum capillatae*					
Stipa pennata	---	---	---	73 ^{79}	4
Vicia tenuifolia	---	11	---	73 ^{74}	---
Stipa capillata	---	---	---	55 ^{70}	---
Dianthus andrzejowskianus	---	44	---	91 ^{68}	9
Falcaria vulgaris	---	---	---	55 ^{66}	4
Campanula bononiensis	---	---	---	45 ^{63}	---
Elytrigia intermedia	---	22	67	100 ^{63}	4
Genista tinctoria	---	56	---	82 ^{56}	13
Association *Inuletum ensifoliae*					
Lembotropis nigricans	---	---	67	36	91 ^{75}
Carex flacca	---	22	---	---	74 ^{69}
Briza media	---	33	---	27	91 ^{66}
Inula ensifolia	---	---	---	9	57 ^{64}
Pulsatilla grandis	---	---	---	27	70 ^{63}
Pulsatilla patens	---	---	---	---	39 ^{58}
Stellaria graminea	---	---	---	9	48 ^{57}
Primula elatior	50	---	---	9	78 ^{56}
Salvia pratensis	---	33	---	73	96 ^{56}
Leucanthemum vulgare	100	11	---	18	78 ^{37}
Helictotrichon desertorum	---	---	---	---	52 ^{33}

Cluster 1 – association *Pastinaco sativae-Arrhenatheretum elatioris* (Table 4, rels. 1–2).

This association includes thermophilous meadow stands dominated by *Arrhenatherum elatius* and *Festuca pratensis*. This is an infrequent community in the study area, usually with three-layered stands. The mesophilous species of the alliance *Arrhenatherion elatioris* are constant. The herb layer cover ranged from 55% to 60%. An average of 45 species per relevé were recorded for this species-rich vegetation type. This community grows on slopes with southern exposure and average 7° inclination and prefers neutral or calcareous sandy soils. It represents natural grasslands that have been used as hay meadows before the national park was created.

Table 4: Floristic table of the associations *Pastinaco sativae-Arrhenatheretum elatioris* (*Molinio-Arrhenatheretea*) (rel. 1–2) and *Geranio sanguinei-Trifolietum alpestris* (*Trifolio-Geranietea*) (rel. 3–10).

Tabela 4: Floristična tabela asociacij *Pastinaco sativae-Arrhenatheretum elatioris* (*Molinio-Arrhenatheretea*) (rel. 1–2) in *Geranio sanguinei-Trifolietum alpestris* (*Trifolio-Geranietea*) (rel. 3–10).

Relevé №	1	2	3	4	5	6	7	8	9	10
Altitude (m a. s. l.)	285	288	292	333	267	323	299	302	286	304
Slope (°)	5	5	20	40	15	40	40	40	35	25
Aspect	S	S	N	N	NW	N	S	S	SE	N
Cover total (%)	60	55	95	100	100	100	90	90	100	100
Diagnostic species for the association *Pastinaco sativae-Arrhenatheretum elatioris*										
Pastinaca sativa	+	+	.	.	.	.	.	.	.	.
Chrysaspis dubia	+	+	.	.	.	.	.	.	.	.
Diagnostic species for the association *Geranio sanguinei-Trifolietum alpestris*										
Calamagrostis arundinacea	.	.	.	.	1	1	1	1	1	1
Stachys officinalis	.	.	.	1	+	+	1	1	+	1
Other species										
Achillea millefolium	+	.	1	.	+	.	.	+	.	.
Arrhenatherum elatius	+	4	2	.	2	.	.	.	.	.
Dactylis glomerata	+	1	1	2	1	1	.	.	1	1
Daucus carota	+	1	.	.	.	.	.	.	.	.
Geranium sanguineum	.	.	1	1	+	1	1	1	.	3
Trifolium alpestre	.	.	.	+	+	.	.	1	.	.
Brachypodium pinnatum	.	.	5	4	5	5	2	4	5	5
Euphorbia cyparissias	.	.	.	.	.	.	1	+	+	.
Festuca pratensis	5	3	1	.	.	.	.	+	1	.
Hypericum perforatum	+	.	.	.	.	+	1	+	.	.
Leucanthemum vulgare	+	1	+	.	.	.	.	.	.	.
Plantago lanceolata	1	+	.	.	.	.	.	.	.	.
Rumex confertus	+	+	.	.	.	+	.	.	.	.
Peucedanum oreoselinum	.	.	.	.	1	.	1	1	.	.
Anthericum ramosum	.	.	.	.	.	+	.	.	1	+
Laserpitium latifolium	.	.	.	4	.	3	.	.	.	1
Salvia pratensis	.	.	.	+	.	+	.	.	.	+
Polygonatum odoratum	.	.	.	.	.	1	+	.	.	1
Medicago romanica	+	+	2	1	1	2	.	1	+	+
Galium mollugo	+	.	1	+	+	+	.	.	.	1
Leontodon autumnalis	+	.	1	.	+	.	.	.	.	+
Briza media	.	.	1	.	.	.	1	.	.	.
Cichorium intybus	+	.	1	.	+	.	.	.	.	.
Pimpinella saxifraga	+	.	1	.	+	.	.	.	.	.
Trifolium pratense	.	.	1	.	+	.	.	.	+	.

Relevé №	1	2	3	4	5	6	7	8	9	10
Vicia cracca	+	.	1	1	1	1	.	.	.	.
Galium verum	.	.	1	+	1	1	.	1	.	1
Agrimonia eupatoria	+	.	1	.	.	.	.	+	1	.
Pyrethrum corymbosum	.	.	.	1	.	+	.	.	.	+
Poa angustifolia	1	1	1	.	.	.	1	1	.	.
Knautia arvensis	.	1	+	.	+	.	.	.	.	.
Campanula persicifolia	.	.	1	.	.	+	.	.	.	.
Fragaria vesca	.	+	.	.	.	.	.	.	+	.
Origanum vulgare	+	.	.	.	1	.	1	1	.	.
Amoria montana	.	.	1	+	1	+	3	1	.	.
Sanguisorba officinalis	.	.	.	+	.	1	.	.	.	1
Inula ensifolia	.	.	.	.	.	+	1	.	.	+
Dianthus andrzejowskianus	.	.	.	1	.	.	+	+	.	.
Helianthemum ovatum	.	.	.	.	+	.	+	+	.	.
Serratula radiata	.	.	.	+	.	.	.	+	.	+
Clematis recta	.	.	.	1	.	1	+	1	2	+
Sonchus arvensis	+	+	.	.	+	.	.	.	.	.
Elytrigia intermedia	.	.	.	1	.	1	.	.	.	.
Genista tinctoria	.	.	.	.	+	.	1	1	.	+
Rosa canina	.	+	+	.	.	.	.	1	.	.
Campanula trachelium	+	.	+	.	.	.	.	.	.	.
Taraxacum officinale	+	+	+	.	.	.	.	.	1	.
Salvia glutinosa	.	.	.	.	1	.	.	.	1	.
Hieracium villosum	.	.	.	.	.	.	+	+	.	.
Veronica chamaedrys	.	+	+	.	.	.	.	.	.	+
Galium boreale	.	.	.	.	1	.	1	1	.	1
Salvia verticillata	+	.	+	+	.	+	.	.	.	.
Thymus serpyllum	.	.	+	.	.	.	.	+	.	.
Plantago media	+	.	1	.	+	.	.	+	.	.
Primula veris	.	1	+	.	+	.	.	.	.	.
Securigera varia	+	.	+	1	.	1	+	1	.	.
Festuca ovina	1	1	.	.	.	.	.	.	.	.
Medicago lupulina	+	+	.	.	.	.	.	.	1	.
Pimpinella major	.	.	.	.	+	.	1	1	+	.
Agrostis tenuis	.	.	.	.	.	.	1	1	.	.
Anthyllis macrocephala	+	+	.	.	.	.	.	.	.	.
Prunus spinosa	+	+	.	.	.	.	.	.	.	.
Phleum phleoides	.	.	.	.	.	.	1	2	.	.
Phalacroloma annuum	1	+	.	.	.	.	.	.	.	.
Oberna behen	+	1	.	+	.	.	.	.	.	.
Melilotus officinalis	+	+	.	.	.	.	.	.	.	.
Campanula rapunculoides	+	+	.	.	.	.	.	.	.	.
Trollius europaeus	.	.	.	.	.	+	.	.	.	+
Pulmonaria mollis	.	.	.	+	.	+	.	.	.	+
Mercurialis perennis	.	.	.	.	.	+	.	.	.	+
Veratrum nigrum	.	.	.	+	.	1	.	.	.	1
Gladiolus imbricatus	.	.	.	+	.	1	.	.	.	.
Euphorbia leptocaula	.	.	.	+	.	.	.	.	.	+
Geranium pratense	.	.	.	+	.	.	.	.	+	.

Relevé №	1	2	3	4	5	6	7	8	9	10
Scabiosa ochroleuca	.	.	.	.	.	.	+	+	.	.
Centaurea scabiosa	.	.	1	.	+	.	1	.	.	+
Carex montana	.	.	.	.	1	.	4	3	.	.
Cirsium vulgare	1	+	.	.	.	.	.	.	.	.
Onobrychis arenaria	.	.	.	+	.	+	.	.	.	+
Prunella grandiflora	.	.	.	1	.	1	.	.	.	1
Linaria vulgaris	.	.	+	.	.	.	.	1	.	.
Anthemis subtinctoria	+	1	.	.	.	.	.	.	.	.
Echium vulgare	+	+	.	.	.	.	.	.	.	.
Trommsdorfia maculata	.	.	.	+	.	.	.	.	.	+

Low frequency species: *Acer campestre* (1: +); *Aconitum moldavicum* (6: 1); *Aegopodium podagraria* (6: 1); *Anemonastrum narcissiflorum* (6: 1); *Arctium tomentosum* (1: +); *Asperula cynanchica* (10: +); *Astragalus glycyphyllos* (1: +); *Bellis perennis* (9: +); *Calamagrostis epigeios* (4: 1); *Carduus crispus* (1: +); *Carex humilis* (10: 1); *C. flacca* (3: 1); *C. pilulifera* (9: 1); *C. sylvatica* (9: 1); *Carlina cirsioides* (10: +); *C. vulgaris* (2: +); *Centaurea rhenana* (2: +); *C. stricta* (4: 1); *Cerastium holosteoides* (1: +); *Chamaecytisus ruthenicus* (6: +); *Cirsium arvense* (2: +); *Consolida paniculata* (2: +); *Corylus avellana* (10: +); *Crataegus monogyna* (8: +); *Crepis tectorum* (1: +); *Cruciata glabra* (10: +); *Dactylis polygama* (9: 1); *Elytrigia repens* (5: 1); *Equisetum arvense* (5: +); *Erigeron acris* (1: +); *Filipendula vulgaris* (4: 1); *Fraxinus excelsior* (2: +); *Galium ruthenicum* (10: +); *Geum urbanum* (9: +); *Jurinea calcarea* (6: +); *Lactuca serriola* (2: +); *Leontodon danubialis* (3: +); *L. hispidus* (1: +); *Lilium martagon* (10: +); *Lithospermum officinale* (2: +); *Melampyrum arvense* (10: +); *Ononis arvensis* (3: 1); *Phleum pratense* (2: +); *Polygala comosa* (2: +); *P. vulgaris* (3: +); *Primula elatior* (2: +); *Prunella vulgaris* (3: +); *Pyrus communis* (2: +); *Ranunculus acris* (1: +); *R. repens* (2: +); *Rubus caesius* (9: 2); *Rumex acetosa* (1: +); *Scorzonera purpurea* (6: +); *Serratula tinctoria* (3: +); *Stachys recta* (10: 1); *Swida sanguinea* (9: +); *Thesium arvense* (10: +); *Tragopogon orientalis* (1: +); *Verbascum laxum* (8: +); *Veronica teucrium* (3: +); *Vicia tenuifolia* (10: +); *V. tetrasperma* (1: +); *Vinca minor* (9: 1); *Viola odorata* (3: +).

Localities:

1 – Sviata, L'viv region; N 49°54'15.4", E 24°51'35.0"; 29.06.2009
2 – Sviata, L'viv region; N 49°54'14.5", E 24°51'34.9"; 29.06.2009
3 – Homets, L'viv region; N 49°50'55.4", E 24°04'20.9"; 26.06.2009
4 – Chortova, Ivano-Frankivsk region; N 49°24'09.3", E 24°39'48.7"; 30.06.2009
5 – Homets, L'viv region; N 49°50'53.5", E 24°04'30.3"; 26.06.2009
6 – Chortova, Ivano-Frankivsk region; N 49°24'10.7", E 24°39'49.8"; 30.06.2009
7 – Homets, L'viv region; N 49°50'52.8", E 24°04'33.0"; 26.06.2009
8 – Homets, L'viv region; N 49°50'53.6", E 24°04'33.2"; 26.06.2009
9 – Homets, L'viv region; N 49°50'53.6", E 24°04'33.5"; 100; 26.06.2009
10 – Chortova, Ivano-Frankivsk region; N 49°24'11.5", E 24°39'52.3"; 30.06.2009

Cluster 2 – association *Geranio sanguinei-Trifolietum alpestris* (Table 4, rels. 3–10).

This type of communities forms a transition between meadow steppes of the class *Festuco-Brometea* and forest or shrub vegetation of the order *Quercetalia pubescenti-petraeae*. These are polydominant stands with a prevalence of mesoxerophytic species. The communities are physiognomically rather heterogeneous. *Brachypodium pinnatum, Dactylis glomerata, Geranium sanguineum, Clematis recta* and *Carex montana* are dominants of the herb layer. In the plant communities of this association, single shrubs (*Crataegus monogyna, Rubus caesius, Swida sanguinea*) and trees (*Quercus robur, Sorbus aucuparia*) are common. An average of 38 species per relevé were recorded. The herb layer cover ranged from 90% to 100%. Communities are situated on slopes with different exposure on light sandy or loamy soils on carbonate rocks (Table 4).

Cluster 3 – association *Lembotropio nigricans-Potentilletum arenariae* (Table 5, rels. 12–14).

These communities cover only small areas. In contrast to other communities of meadow steppes in the studied area, these ones are characterised by ruderal species (*Plantago lanceolata*, *Geum urbanum*, *Phalacroloma annuum*, *Verbascum thapsus*, *Urtica dioica*) and numerous shrubs (*Rhamnus cathartica*, *Pyrus communis*, *Rosa andrzejowskii*, *Swida sanguinea*). In general, the basis of their floristic composition is represented by species of the classes *Molinio-Arrhenatheretea* and *Festuco-Brometea*. It is a species-rich vegetation with an average of 48 species per relevé and 80% herb layer cover. Communities prefer black soils on upper parts of southern slopes with inclinations up to 30°.

Table 5: Floristic table of the associations *Jurineo calcareae-Stipetum capillatae* (rel. 1–11) and *Lembotropio nigricans-Potentilletum arenariae* (*Festuco-Brometea*) (rel. 12–14).

Tabela 5: Floristična tabela asociacij *Jurineo calcareae-Stipetum capillatae* (rel. 1–11) in *Lembotropio nigricans-Potentilletum arenariae* (*Festuco-Brometea*) (rel. 12–14).

Relevé №	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Altitude (m a. s. l.)	271	302	322	297	321	317	321	348	319	312	310	324	325	324
Slope (°)	40	5	15	30	-	-	15	-	-	5	15	30	5	5
Aspect	SW	SW	S	SE	-	-	S	-	-	S	SE	S	S	S
Cover total (%)	90	90	80	70	95	75	60	95	90	100	100	70	80	90
Diagnostic species for the association *Jurineo calcareae-Stipetum capillatae*														
Stipa pennata	+	3	4	1	4	1	1	.	1	.	.	.	.	.
Vicia tenuifolia	.	.	+	1	.	+	1	1	1	+	1	.	.	.
Stipa capillata	.	.	+	4	3	1	3	2	.	.	.	.	.	.
Dianthus andrzejowskianus	.	1	+	1	1	+	1	1	1	+	+	.	.	.
Falcaria vulgaris	+	.	.	+	+	+	+	.	+	.	.	.	.	.
Campanula bononiensis	.	.	.	.	+	+	.	.	+	+	+	.	.	.
Elytrigia intermedia	1	1	1	2	1	1	1	2	4	1	4	2	.	4
Genista tinctoria	2	2	+	.	1	+	1	.	2	+	1	.	.	.
Diagnostic species for the association *Lembotropio nigricans-Potentilletum arenariae*														
Potentilla arenaria	.	.	.	.	+	.	.	.	.	.	.	1	+	+
Rubus caesius	.	.	.	.	.	.	.	.	.	.	.	+	1	+
Other species														
Anthericum ramosum	1	+	1	.	1	+	+	.	+	.	.	+	+	.
Brachypodium pinnatum	2	2	2	1	1	1	1	1	2	3	3	.	1	+
Bupleurum falcatum	+	1	+	+	+	.	.	+	+	+	.	.	.	.
Carex humilis	2	2	3	2	1	2	2	+	.	.	.	.	.	.
Campanula sibirica	+	+	+	+	+	+	+	.	.	.	.	+	+	+
Euphorbia cyparissias	.	+	.	+	1	1	1	1	.	.	.	1	+	1
Inula ensifolia	+	1	1	1	+	+	.	2	.	+	.	.	.	.
Briza media	.	.	1	.	.	+	.	.	.	1	.	.	.	.
Centaurea scabiosa	1	1	+	.	1	.	.	+	.	+	+	.	.	.
Prunella grandiflora	5	2	+	+	+	.	.	1	+	.	.	.	.	.
Poa angustifolia	.	.	.	.	.	.	.	.	.	.	.	+	1	+
Clinopodium vulgare	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Euonymus europaea	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Acinos arvensis	.	.	.	.	.	+	.	.	.	.	.	+	.	.
Onobrychis arenaria	1	.	+	1	+	+	+	1	.	.	+	.	.	.
Medicago romanica	1	+	+	1	+	+	1	1	+	+	3	.	.	1
Asperula cynanchica	+	+	+	+	.	+	+	+	.	.	.	.	.	.
Salvia pratensis	1	1	1	.	+	+	+	.	1	.	+	.	.	.
Veronica spicata	.	+	.	.	+	+	1	1	.	.	.	+	+	+
Salvia verticillata	1	1	1	1	+	.	+	+	+	1	1	.	.	.
Teucrium chamaedrys	1	1	1	1	1	+	+	.	+	.	.	1	+	.
Plantago media	1	1	1	+	+	+	1	+	+	.	.	.	.	.
Stachys recta	+	1	+	1	+	+	1	+	+	.	1	.	.	.
Thalictrum minus	+	.	+	.	1	+	+	1	1	.	1	.	.	1
Astragalus onobrychis	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Achillea setacea	.	.	.	.	.	+	.	+	+	+	.	1	+	+
Origanum vulgare	.	+	+	+	.	.	.	.	1	1	1	+	.	.

Relevé №	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Silene densiflora	.	.	.	+	.	+	+	.	.	.	.	.	.	.
Agrostis tenuis	.	.	.	.	.	1	.	.	1	.	.	.	+	.
Helianthemum ovatum	.	.	1	.	.	.	.	.	.	.	.	1	+	.
Hypericum perforatum	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Fragaria viridis	.	+	.	.	.	.	1	.	+	+	.	1	.	.
Linum flavum	+	1	+	.	.	+	.	+	.	.	.	.	.	.
Galium mollugo	.	+	.	.	.	.	.	.	+	1	1	1	+	1
Phleum phleoides	.	1	.	.	1	.	.	.	1	.	1	.	.	.
Lembotropis nigricans	1	.	.	+	1	1	.	.	.	.	.	.	.	.
Pulsatilla grandis	+	.	.	.	.	+	.	+	.	.	.	.	.	.
Gypsophila paniculata	.	.	.	+	1	+	+	.	.	.	.	.	.	.
Securigera varia	1	+	+	+	+	+	+	1	1	+	1	+	+	1
Echium russicum	+	.	+	.	+	.	.	+	.	.	.	.	.	.
Adonis vernalis	+	.	1	.	1	+	+	+	+	.	.	.	.	.
Chamaecytisus ratisbonensis	1	+	.	+	.	1	1	+	1	.	.	.	.	.
Viola collina	.	.	+	+	.	.	.	.	+	.	.	.	.	.
Plantago lanceolata	+	+	+	.	+	.	.	.	.	.	.	.	+	+
Filipendula vulgaris	1	+	.	+	1	.	+	+	1	1	.	.	.	.
Pyrus communis	.	.	.	.	.	.	.	.	.	+	.	+	.	+
Vincetoxicum hirundinaria	+	.	.	.	+	+	+	.	.	.	.	.	.	.
Nepeta pannonica	.	+	.	1	.	.	.	.	.	+	2	.	.	.
Iris hungarica	+	+	.	.	1	+	1	+	.	.	.	.	.	.
Thesium arvense	+	+	.	1	.	.	.	1	.	.	.	.	.	.
Festuca rupicola	2	1	.	1	2	3	2	4	1	.	.	.	.	+
Cruciata glabra	.	+	.	.	.	.	.	.	.	.	.	1	+	.
Pyrethrum corymbosum	+	.	.	.	.	.	.	+	.	+	+	.	.	.
Polygala vulgaris	.	.	.	.	.	+	.	+	.	.	.	+	.	.
Fragaria vesca	.	.	.	.	.	.	.	.	.	.	.	2	2	2
Peucedanum oreoselinum	+	1	.	.	+	+	.	.	.	.	.	.	.	.
Amoria montana	.	.	.	.	.	1	.	1	+	+	1	.	.	.
Dactylis glomerata	.	+	1	.	.	.	.	1	1	1	1	.	1	+
Leontodon autumnalis	+	.	+	+	.	+	.	+	.	.	.	+	.	.
Knautia arvensis	1	1	+	+	+	.	.	.	1	1	1	1	.	+
Achillea millefolium	+	+	.	.	+	.	.	.	+	+	.	.	+	+
Cichorium intybus	.	.	.	.	.	.	.	.	+	+	+	.	.	.
Galium verum	+	1	+	.	1	.	1	.	1	1	1	+	+	1
Agrimonia eupatoria	1	1	+	+	.	.	.	.	.	1	1	.	.	.
Arrhenatherum elatius	.	.	.	.	.	.	.	.	1	5	1	.	.	+
Trifolium pratense	.	.	.	.	.	.	.	+	+	.	.	+	.	.
Allium montanum	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Calamagrostis arundinacea	.	+	.	.	1	.	.	.	1	1	.	.	.	.
Stachys officinalis	+	+	+	.	.	.	.	1	1	1	1	.	.	.
Thymus marschallianus	.	+	+	+	.	.	2	+	1	.	.	+	.	.
Verbascum lychnitis	.	+	.	.	+	+	1	+	.	.	+	+	.	+
Potentilla argentea	+	.	.	+	.	+	.	.	.	.	.	.	.	+
Artemisia vulgaris	.	.	.	.	.	.	.	.	+	+	1	.	.	.
Veronica chamaedrys	.	.	+	.	.	.	.	.	.	+	+	+	+	1
Oberna behen	.	+	.	.	.	.	.	.	.	.	+	.	+	.

Relevé №	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rhinanthus vernalis	.	+	.	.	.	+	.	.	+	+	1	.	.	.
Campanula glomerata	.	+	+	.	.	.	.	+	+	+	.	.	.	.
Melilotus officinalis	.	.	+	.	.	.	+	.	.	+	.	.	.	.
Quercus robur	.	.	.	.	.	.	.	.	.	.	.	+	+	+
Valeriana collina	.	+	.	.	.	.	.	.	1	+	1	.	.	.
Galium ruthenicum	.	.	.	1	.	1	.	1	.	.	.	.	.	.
Pinus sylvestris	.	.	.	.	.	.	.	.	.	.	.	+	2	+
Pteridium aquilinum	.	.	.	.	.	.	.	.	.	+	+	+	.	.
Convolvulus arvensis	.	.	.	+	.	.	.	.	+	1	1	.	.	.
Hylotelephium ruprechtii	.	.	.	.	1	+	.	.	.	.	.	+	.	.

Low frequency species: *Acer pseudoplatanus* (12: +); *Agrostis canina* (2: +); *A. stolonifera* (14: +); *Ajuga genevensis* (8: +; 13: +); *Allium oleraceum* (8: +); *A. waldsteinii* (11: +); *Amoria repens* (8: +; 13: +); *Anemone sylvestris* (8: +); *Anemonoides nemorosa* (13: +); *Anthoxanthum odoratum* (13: 1); *Arabidopsis thaliana* (13: +); *Asparagus officinalis* (6: +); *Asplenium ruta-muraria* (12: 1; 13: +); *A. trichomanes* (12: 1); *Aster amellus* (1: +); *Bromopsis inermis* (8: +); *Calamagrostis epigeios* (12: 2; 13: 1); *Campanula cervicaria* (9: +); *C. rapunculoides* (10: +); *Carduus acanthoides* (10: +); *Carex caryophyllea* (12: +); *C. contigua* (12: +); *C. digitata* (12: +; 13: 1); *C. hirta* (14: 3); *Carlina cirsioides* (9: +); *Carpinus betulus* (12: +; 13: +); *Centaurea rhenana* (8: +; 10: +); *C. stricta* (2: +; 8: +); *Cerastium holosteoides* (13: +); *Cerinthe minor* (6: +); *Chamaecytisus albus* (1: +; 6: +); *Ch. ruthenicus* (5: +); *Cirsium ucranicum* (9: +); *Crambe tataria* (1: +); *Crataegus monogyna* (12: +); *Digitalis grandiflora* (9: 1); *Equisetum arvense* (11: +); *Euphorbia seguierana* (8: +); *Festuca ovina* (12: +; 13: 1); *F. pratensis* (12: +; 14: +); *Galium boreale* (8: +; 12: +); *Geranium pratense* (10: +; 11: +); *G. robertianum* (12: 1); *G. sanguineum* (2: +; 5: +); *Geum urbanum* (12: +); *Glechoma hederacea* (12: +); *Helictotrichon desertorum* (12: +; 14: +); *Hepatica nobilis* (12: 1; 13: +); *Hieracium pilosella* (12: +; 13: +); *H. virosum* (9: +); *Humulus lupulus* (14: +); *Hypericum elegans* (6: +; 7: +); *Inula hirta* (1: +); *Leucanthemum vulgare* (9: +; 10: +); *Lithospermum officinale* (1: +); *Luzula pilosa* (13: 1); *Lysimachia nummularia* (13: +); *Medicago lupulina* (2: +; 12: +); *Melampyrum sylvaticum* (13: +); *Melica nutans* (12: 1; 13: 1); *Melilotus albus* (10: +); *Ononis arvensis* (11: +); *Orchis ustulata* (3: +); *Peucedanum carvifolia* (1: +; 8: +); *P. ruthenicum* (4: +); *Phalacroloma annuum* (10: +; 14: +); *Phleum pretense* (2: +; 10: 1); *Phlomoides tuberosa* (5: +); *Pimpinella major* (1: +); *P. saxifrage* (1: +; 13: +); *Poa compressa* (12: 1); *Polygonatum odoratum* (3: 1; 5: +); *Populus tremula* (14: +); *Potentilla alba* (2: 1; 9: +); *P. patula* (7: 1); *Primula elatior* (9: +); *P. veris* (8: +); *Prunella vulgaris* (12: 1); *Pulmonaria mollis* (8: +); *Ranunculus polyanthemos* (10: +; 12: +); *Rhamnus cathartica* (12: +); *Rosa andrzejowskii* (14: +); *R. canina* (11: +); *R. rubiginosa* (1: +); *Rumex acetosa* (13: +; 14: +); *R. confertus* (10: +); *Scabiosa ochroleuca* (12: +); *Scorzonera purpurea* (5: +; 6: +); *Senecio jacobaea* (1: +; 4: +); *Serratula lycopifolia* (8: +); *Solidago virgaurea* (9: +); *Sorbus aucuparia* (12: +; 13: +); *Stellaria graminea* (10: +); *Stipa tirsa* (4: 1); *Swida sanguinea* (12: +); *Taraxacum officinale* (12: +); *Thalictrum simplex* (10: +); *Thymus pulegioides* (6: 2); *Th. serpyllum* (13: +); *Tragopogon orientalis* (8: +); *Trifolium medium* (8: 1); *Trifolium rubens* (5: +; 9: 2); *Turritis glabra* (5: +); *Urtica dioica* (13: +); *Vaccinium myrtillus* (13: 1); *Verbascum thapsus* (5: +; 12: +); *Vicia cracca* (5: +); *Viola hirta* (10: +).

Localities:

1 – Kasova, Ivano-Frankivsk region; N 49°13'22.6", E 24°41'33.6"; 30.06.2009
2 – Kasova, Ivano-Frankivsk region; N 49°13'34.4", E 24°41'37.0"; 30.06.2009
3 – Kasova, Ivano-Frankivsk region; N 49°13'27.9", E 24°42'10.2"; 30.06.2009
4 – Kasova, Ivano-Frankivsk region; N 49°13'22.7", E 24°42'07.4"; 30.06.2009
5 – Kasova, Ivano-Frankivsk region; N 49°13'36.1", E 24°41'39.8"; 30.06.2009
6 – Kasova, Ivano-Frankivsk region; N 49°13'36.4", E 24°41'41.3"; 30.06.2009
7 – Kasova, Ivano-Frankivsk region; N 49°13'35.4", E 24°41'47.8"; 30.06.2009
8 – Chortova, Ivano-Frankivsk region; N 49°24'03.8", E 24°39'54.5"; 30.06.2009
9 – Kasova, Ivano-Frankivsk region; N 49°13'36.4", E 24°41'43.3"; 30.06.2009
10 – Kasova, Ivano-Frankivsk region; N 49°13'34.4", E 24°41'52.1"; 30.06.2009
11 – Kasova, Ivano-Frankivsk region; N 49°13'31.0", E 24°42'05.7"; 30.06.2009
12 – Stradchanska, Lviv region; N 49°53'54.8", E 24°45'33.9"; 01.07.2009
13 – Stradchanska, Lviv region; N 49°53'54.9", E 24°45'35.1"; 01.07.2009
14 – Stradchanska, Lviv region; N 49°53'54.8", E 24°45'33.7"; 01.07.2009

Cluster 4 – association *Inuletum ensifoliae* (Table 6). The data were collected mainly in the L'viv region on Homets', Lysa (Figure, 2), Bila (Figure, 3) and Vysoka Hills and in the Ivano-Frankivsk region on Chortova Hill.

Figure 2: *Inuletum ensifoliae* on the slope of Lysa Hill, Chervone village, Zolochiv district, L'viv region. *Gymnadenia conopsea* in the foreground. Photo: I. M. Danylyk.
Slika 2: *Inuletum ensifoliae* na pobočjih hriba Lysa pri vasi Chervone, distrikt Zolochiv, regija L'viv. V ospredju *Gymnadenia conopsea*. Foto: I. M. Danylyk.

Figure 3: *Inuletum ensifoliae* on the upper part of Bila Hill, Pidlyssia village, Zolochiv district, L'viv region. *Chamaecytisus albus* in the foreground. Photo: I. M. Danylyk.
Slika 3: *Inuletum ensifoliae* na zgornjem delu hriba Bila pri vasi Pidlyssia, distrikt Zolochiv, regija L'viv. V ospredju *Chamaecytisus albus*. Foto: I. M. Danylyk.

Communities of this association have been found on the upper and middle parts of slopes with different exposures (mostly southern and southwest) and average inclinations from 10° to 40°. These are the most widespread communities in the study area. Dominant species (recorded in at least one relevé) were *Brachypodium pinnatum*, *Briza media*, *Bromopsis erecta*, *Carex flacca* and *Festuca rupicola*. When the communities are formed on eroded slopes, the proportion of species of the class *Artemisietea vulgaris* (*Elytrigia repens*, *Hieracium pilosella*, *Falcaria vulgaris*, *Poa angustifolia*) increases in the floristic composition. At the same time, the number of meadow species of the class *Molinio-Arrhenatheretea* (in particular alliance *Arrhenatherion elatioris*) is reduced. There is a 65–100% herb layer cover here and a mean number of 49 species per relevé (Table 6).

Cluster 5 – association *Jurineo calcareae-Stipetum capillatae* (Table 5, rels. 1–11). This cluster includes 11 relevés recorded in the Ivano-Frankivsk region on Kasova Hill (Figure 4) and Chortova Hill.

These communities include thermophilous stands of grasses dominated by *Elytrigia intermedia, Festuca rupicola, Carex humilis, Stipa capillata* and *S. pennata* and occupy large areas. In addition to the constant presence of species of the alliance *Cirsio-Brachypodion pinnati*, this association includes species affined to the class *Molinio-Arrhenatheretea*. The communities grow mainly on upper and middle parts of southern, southwestern or southeastern slopes with average inclinations from 5° to 40° and turf carbonate soils. These are the most species-rich meadow steppes in the study area, with an average of 51 species per relevé and 85% herb layer cover (Table 5).

Figure 4: *Jurineo calcareae-Stipetum capillatae* on Kasova Hill, Bovshiv village, Halych district, Ivano-Frankivsk region. Photo: I. M. Danylyk.
Slika 4: *Jurineo calcareae-Stipetum capillatae* na hribu Kasova pri vasi Bovshiv, distrikt Halych, regija Ivano-Frankivsk. Foto: I. M. Danylyk.

3.2. Gradient analyses

The result of the ordination analysis (Figure 5) shows that the most important factors of ecological differentiation of Western Podolia meadow steppes are the thermoregime of climate, the variability of moisture, soil acidity and the carbonate content of the soil. The vectors belonging to these factors are closest to the ordination axes, along which syntaxa are distributed.

Clusters 3, 4 and 5 are projected in the central part of the ordination diagram. These clusters are assigned to the

Figure 5: DCA ordination results of the plant communities of Western Podolia meadow steppes. Axis 1 explains 33.4% of the variation, Axis 2 explains 25.3%.

Legend: *Hd* – soil water regime; *fH* – variability of moisture; *Rc* – soil acidity; *Sl* – total soil salt regime; *Ca* – carbonate content of the soil; *Nt* – nitrogen content of the soil; *Ae* – soil aeration; *Tm* – thermoregime; *Om* – ombroregime; *Kn* – continentality of climate; *Cr* – cryoclimate; *Lc* – light; DCA1, DCA2 – ordination axes.

Slika 5: DCA ordinacija rastlinskih stepskih travniških združb Zahodne Podolije. Os 1 pojasnjuje 33,4% variabilnosti, os 2 pa 25,3%.

Legenda: *Hd* – talni vodni režim; *fH* – spremenljivost vlažnosti; *Rc* – kislost tal; *Sl* – skupni režim slanosti tal; *Ca* – vsebnost karbonata v tleh; *Nt* – vsebnost dušika v tleh; *Ae* – zračnost tal; *Tm* – toplotni režim; *Om* – režim padavin; *Kn* – kontinentalnost podnebja; *Cr* – krioklima; *Lc* – svetloba; DCA1, DCA2 – ordinacijski osi.

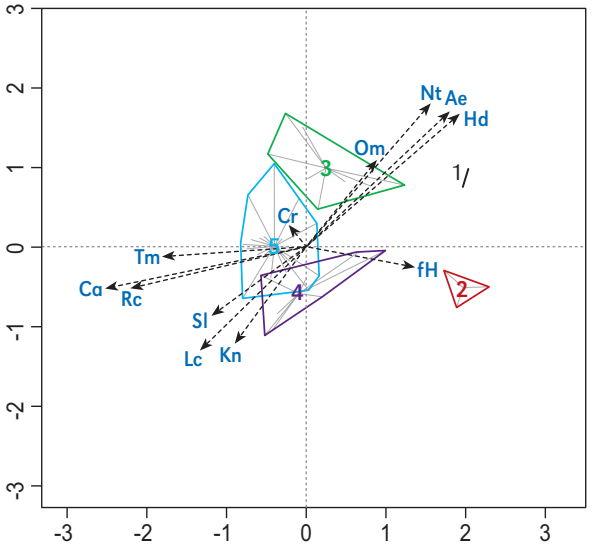

Table 6: Floristic table of the association *Inuletum ensifoliae* (*Festuco-Brometea*).
Tabela 6: Floristična tabela asociacije *Inuletum ensifoliae* (*Festuco-Brometea*).

Relevé №	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Altitude (m a. s. l.)	279	372	349	311	281	287	308	316	337	344	330	335	329	327	334	329	341	316	349	328	308	332	369	314
Slope (°)	30	20	15	15	15	40	30	10	10	20	25	15	10	20	15	30	20	15	5	20	15	7	5	10
Aspect	SE	S	E	S	NE	S	NE	NE	SW	SW	SW	NE	S	S	SE	S	S	SW	SW	E	SE	S	S	SE
Cover total (%)	90	85	100	80	70	95	100	80	90	90	65	90	80	95	90	100	95	85	95	80	80	90	95	70
Diagnostic species for the association *Inuletum ensifoliae*																								
Lembotropis nigricans	1	+	+	2	1	.	.	1	1	+	1	+	+	+	.	+	1	+	+	+	+	+	+	+
Carex flacca	3	+	1	2	3	1	2	2	1	.	.	.	1	1	1	+	.	4	1	3	+	.	.	3
Briza media	.	+	1	1	1	1	.	1	1	1	1	1	2	1	1	2	1	+	2	1	1	1	4	1
Inula ensifolia	+	+	.	1	1	5	+	1	+	+	.	1	+	1	1	+	1	2	.	+	2	1	.	
Pulsatilla grandis	.	+	+	.	.	.	.	+	1	+	.	+	1	+	+	+	1	+	+	+	1	+	.	.
Pulsatilla patens	.	.	.	.	.	.	1	2	1	+	+	1	+	.	1	.	+	.	.	.	.	.	.	.
Stellaria graminea	.	+	.	.	+	.	.	.	.	+	+	+	+	.	.	.	.	.	+	.	+	+	+	+
Primula elatior	+	+	+	+	+	.	.	+	+	.	+	+	.	.	+	+	.	+	+	1	+	1	1	+
Salvia pratensis	+	+	1	.	+	.	1	1	1	+	1	1	1	1	1	1	+	1	1	+	+	1	1	+
Leucanthemum vulgare	.	+	+	1	.	.	.	+	+	+	+	1	+	+	1	.	.	+	1	+	+	+	1	+
Helictotrichon desertorum	.	+	.	1	.	.	.	.	.	.	.	1	+	1	1	.	1	+	1	1	+	1	.	.
Other species																								
Aster amellus	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	+	+	.	.
Linum flavum	.	.	.	1	.	+	.	+	+	.	1	+	1	1	1	1	+	.	.	1	+	+	1	+
Carlina onopordifolia	.	.	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.	+	+	1	1	.	.	1
Carlina vulgaris	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	+	+	+	+
Centaurea scabiosa	.	.	.	1	.	1	+	+	1	.	1	1	1	1	.	+	1	+	+	+	1	+	.	.
Prunella grandiflora	+	.	+	1	+	.	+	1	1	+	1	1	1	1	1	1	1	.	.	1	.	1	1	1
Viola hirta	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.
Brachypodium pinnatum	5	5	5	4	4	4	3	4	4	5	4	4	5	4	4	4	3	.	1	2	2	4	1	.
Asperula cynanchica	.	.	+	+	+	+	.	+	+	+	.	.	.	+	+	+	+	+	+	+	.	.	.	.
Inula hirta	.	+	.	.	.	.	1	+	1	+	1	1	1	.	.	1	+	1	+	+	.	.	.	.
Euphorbia cyparissias	+	+	+	+	1	+	.	.	.	+	+	1	+	.	+	1	+	+	1	+	1	1	1	1
Carex humilis	.	2	.	3	.	.	.	.	2	3	2	2	1	2	1	2	2	1	1	1	1	2	1	1
Koeleria cristata	.	.	.	.	.	.	.	.	.	+	.	1	.	1	.	.	.	.	.	.	1	.	.	.
Medicago romanica	+	.	+	.	+	1	1	1	.	+	.	.	.	.	+	.	.	.	+	.	.	.	.	+
Teucrium chamaedrys	+	.	1	1	+	.	.	.	+	+	1	+	+	+	+	1	.	1	.	.	1	+	+	+
Stachys recta	+	+	.	.	.	.	+	+	+	+	+	+	+	+	+	1	+	.	+	+	.	.	.	.

Relevé №	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Onobrychis arenaria	+	+	.	.	+	.	.	+	+	+	+	1	.	.	+	.	1	.	.	+	+	.	+	+
Thalictrum minus	.	.	.	.	.	.	.	.	.	+	+	+	1	+	+	+	1	1	.	.	1	1	1	.
Pimpinella saxifraga	.	.	1	+	+	.	.	.	.	.	+	.	.	+	+	.	+	+	+	+	+	+	+	+
Plantago media	+	+	+	.	+	1	+	+	+	+	+	+	1	+	1	+	+	.	1	+	+	+	1	+
Poterium sanguisorba	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+	+
Salvia verticillata	.	.	+	+	.	1	.	.	.	.	.	.	.	1	+	+	.	.	.	1	+	+	1	.
Pinus sylvestris	+	+	+	2	.	.	.	.	+	+	+	.	+	+	+	+	.	.	.	+	+	+	+	+
Calamagrostis arundinacea	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Genista tinctoria	.	.	.	.	.	1	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.
Stachys officinalis	.	.	.	.	.	1	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dianthus andrzejowskianus	.	.	.	.	.	1	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Malus sylvestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	.	.
Gypsophila paniculata	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
Thymus marschallianus	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	1	+	+	+
Chamaecytisus albus	.	.	+	.	.	.	.	.	.	.	.	.	.	+	1	1	.	.	.	.	.	1	+	+
Medicago lupulina	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Pimpinella major	+	.	.	.	+	1	.	.	1	+	+	+	.	1	.	.	.	.	.	.	.	.	.	.
Rosa rubiginosa	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	+	.	.
Elytrigia repens	.	.	.	.	.	.	.	.	.	+	.	1	2	.	.	.	.	+	1	.	.	.	.	.
Origanum vulgare	.	+	+	.	+	.	1	.	.	.	.	.	1	+	.	.	.	1	1	.	.	+	.	.
Anthyllis macrocephala	.	+	.	.	+	+	.	.	.	.	.	.	.	.	+	.	+	+	+	.	+	1	.	+
Helianthemum ovatum	.	+	+	.	.	+	.	.	+	+	+	+	.	+	+	+	.	+	.	+	+	+	.	.
Polygonatum odoratum	.	.	.	.	.	.	.	+	.	+	+	.	+	.	+	.	+	.	.	.	.	.	.	.
Hypericum perforatum	+	.	.	.	.	.	+	+	.	+	.	.	.	.	+	.	.	+	+	.	.	+	+	.
Fragaria viridis	.	+	.	.	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Clematis recta	.	+	1	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Geranium sanguineum	+	.	.	.	1	.	4	1	.	.	.	.	.	1	+	+	.	.	.	.	.	.	.	.
Anthericum ramosum	+	.	1	1	.	.	1	+	1	+	+	1	1	2	1	+	2	.	.	1	1	1	1	1
Festuca pratensis	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	1	.
Peucedanum oreoselinum	.	.	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Prunella vulgaris	+	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Carex montana	.	.	.	.	1	1	.	1	1	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.
Amoria montana	.	.	.	.	+	2	+	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Dactylis glomerata	.	.	.	.	1	.	1	.	.	1	.	1	1	.	.	.	.	.	1	.	1	1	.	.
Rosa canina	+	.	+	.	+	+	.	.	+	+	+	.	+	.	.	+	.	.	+	+	.	.	.	.
Leontodon autumnalis	.	.	.	+	+	1	.	.	+	.	+	.	.	+	.	.	+	.	.	.	.	+	+	.
Knautia arvensis	.	+	+	1	+	+	.	+	+	+	+	+	+	+	+	+	.	+	1	1	1	1	+	+
Achillea millefolium	.	.	.	+	.	+	.	.	.	.	.	.	+	.	.	.	.	+	+	+	.	+	.	.
Cichorium intybus	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium verum	.	.	1	1	1	+	1	+	1	+	+	1	1	1	1	1	.	1	+	1	+	+	1	1
Agrimonia eupatoria	.	.	.	.	+	+	.	.	.	+	.	.	+	.	.	.	.	1	+	.	.	1	+	.
Arrhenatherum elatius	1	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Poa angustifolia	.	.	.	.	1	.	.	1	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Trifolium pratense	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.
Serratula tinctoria	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Galium boreale	+	.	1	.	+	+	1	+	1	.	.	.	+	1	1	+	+	.	.	1	1	+	+	1
Primula veris	+	+	.	+	+	.	.	1	1	.	1	+	1	.	.	+	.	1	1	.	.	.	.	.
Securigera varia	+	.	.	.	+	1	.	.	.	.	.	.	+	+	.	+	.	+	+	+	+	1	.	.
Vicia cracca	.	.	.	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Hypericum elegans	.	.	.	.	.	.	.	.	+	1	.	.	.	+	+	.	.	.	.	.	.	.	+	.
Echium russicum	.	.	.	.	.	.	.	.	+	1	+	.	+	.	.	.	+	.	.	.	.	.	.	.
Adonis vernalis	.	.	+	.	.	.	.	+	+	+	+	1	+	.	.	+	1	.	1	+	+	+	+	.
Corylus avellana	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Viola collina	.	.	.	.	.	.	.	.	+	+	+	+	+	+	1	+	.	.	.	.	.	+	.	+
Prunus spinosa	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	+	.	.	.	.
Chamaecytisus ratisbonensis	.	.	+	.	.	.	.	.	1	.	1	+	+	+	.	1	1	.	.	+	.	1	.	.
Rhamnus cathartica	.	.	+	.	.	.	+	.	.	.	.	.	+	.	+	+	.	.	+	.	.	.	.	.
Scorzonera purpurea	.	.	.	.	.	.	.	.	+	.	.	+	.	+	+	+	+	.	.	.	.	.	.	.
Centaurea rhenana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.
Daphne cneorum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.	1	.	.

Relevé №	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Iris pumila	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Anemone sylvestris	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	+	+	.	.	.	.	.	+	.
Plantago lanceolata	.	.	.	+	.	.	.	.	.	.	.	.	+	+	.	+	.	+	+	.	.	.	.	.
Pyrus communis	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	.
Melampyrum arvense	.	.	.	2	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	+	1	1	+
Solidago virgaurea	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	+	.	.	.	.	+
Coronilla coronata	.	+	.	.	.	.	.	1	1	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.
Vincetoxicum hirundinaria	+	+	.	.	.	.	.	.	.	+	+	1	.	.	+	2	+	+	1	.	+	2	.	+
Orchis militaris	.	.	.	+	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.
Carduus glaucinus	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carlina cirsioides	.	.	.	.	+	.	+	+	+	+	.	+	1	.	.	.	+	.	.	.	.	.	.	.
Bupleurum falcatum	.	.	+	+	+	.	.	.	.	.	+	.	.	1	.	.	+	+	.	.	+	+	+	+
Swida sanguinea	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.
Campanula sibirica	+	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	+	.	.	.
Carex michelii	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	2	.	.	.	.	.	.
Filipendula vulgaris	+	+	1	1	.	.	1	1	+	+	+	1	1	1	1	1	+	.	+	+	1	.	.	+
Chamaecytisus blockianus	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Centaurea stricta	.	.	.	+	.	.	+	+	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.
Crataegus monogyna	.	+	.	.	.	.	+	.	.	.	.	.	+	+	+	+	.	.	+	.	.	.	.	.
Laserpitium latifolium	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Iris hungarica	.	+	.	.	.	.	.	.	+	1	+	.	.	.	.	+	1	.	.	.	.	.	.	.
Thesium arvense	.	+	.	+	+	.	.	1	1	.	+	.	.	+	+	+	.	.	.	+	+	.	1	.
Gymnadenia conopsea	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciata glabra	.	.	+	.	+	.	+	.	.	+	+	+	.	.	+	.	.	.	.	+	.	.	.	.
Festuca rupicola	.	+	.	.	1	.	1	2	3	2	1	2	1	3	2	1	.	.	3	4	2	.	.	.
Sanguisorba officinalis	.	.	+	.	+	.	1	1	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Pyrethrum corymbosum	.	.	1	.	+	.	+	1	.	.	.	.	.	+	+	+	+	.	.	+	.	.	.	.
Allium montanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.+	.

Low frequency species: *Acer tataricum* (19: +); *Allium podolicum* (2: +; 19: +); *Anemonastrum narcissiflorum* (11: 1; 18: +); *Anthemis subtinctoria* (18: +); *Anthyllis schiwereckii* (23: +); *Artemisia vulgaris* (18: +); *Astragalus glycyphyllos* (1: +); *A. onobrychis* (24: +); *Bromopsis erecta* (24: 5); *Calamagrostis epigeios* (5: +; 9: +); *Campanula glomerata* (23: +); *C. persicifolia* (7: +); *C. rapunculoides* (15: +; 20: +); *Carlina biebersteinii* (11: +); *Carpinus betulus* (1: +); *Centaurea jacea* (3: +); *Centaurium pulchellum* (24: +); *Cerinthe minor* (18: +; 19: +); *Chamaecytisus ruthenicus* (2: +); *Cirsium pannonicum* (17: +; 20: +); *Cornus mas* (3: +); *Crataegus ceratocarpa* (3: +; 22: +); *Cuscuta monogyna* (6: +); *Daucus carota* (6: +; 11: +); *Echium vulgare* (4: 1; 18: +); *Elytrigia intermedia* (15: 1); *Eryngium planum* (18: +); *Falcaria vulgaris* (17: +); *Festuca ovina* (21: +; 23: 3); *Filaginella uliginosa* (3: +; 23: +); *Fragaria vesca* (1: +); *Fraxinus excelsior* (7: +; 11: +); *Helictotrichon schellianum* (10: +; 11: 2); *Hieracium pilosella* (18: +); *Hieracium virosum* (10: +); *Jurinea calcarea* (16: +; 17: +); *Leontodon hispidus* (20: +); *Lilium martagon* (8: +); *Linaria vulgaris* (17: +); *Melampyrum cristatum* (5: 1); *Nepeta pannonica* (7: +); *Oberna behen* (18: +); *Omalotheca sylvatica* (22: +); *Ononis arvensis* (13: 1; 19: +); *Peucedanum cervaria* (1: +; 17: 1); *Phleum phleoides* (15: +); *Poa compressa* (18: 1; 23: 1); *Polygala comosa* (4: +); *Polygala vulgaris* (19: +; 21: +); *Potentilla argentea* (24: +); *P. obscura* (5: +); *P. reptans* (18: +); *Quercus petraea* (3: +); *Ranunculus bulbosus* (23: +); *R. polyanthemos* (18: +; 19: +); *Reseda lutea* (16: +); *Rhinanthus vernalis* (3: 1; 23: +); *Rosa caryophyllacea* (12: 2); *Senecio jacobaea* (17: +); *Senecio umbrosus* (7: 1); *Stipa pennata* (15: +); *Taraxacum officinale* (1: +; 23: +); *Thalictrum minus* (23: +); *Th. simplex* (16: +); *Tragopogon major* (16: +; 17: +); *T. orientalis* (4: +; 17: +); *Trinia multicaulis* (16: +; 19: +); *Trommsdorfia maculata*(12: +; 17: +); *Turritis glabra* (18: +); *Verbascum lychnitis* (2: +; 18: +); *Veronica dentata* (6: +); *V. prostrata* (8: +); *Veronica spicata* (9: +; 17: +).

Localities:

1 – Homets, Lviv region; N 49° 50'53.33", E 24° 04'33.2"; 26.06.2009
2 – Lysa, Lviv region; N 49° 47'21.6", E 24° 43'20.1"; 27.06.2009
3 – Bila, Lviv region; N 49° 56'08.9", E 24° 50'41.1"; 28.06.2009
4 – Vysoka, Lviv region; N 49° 52'12.5", E 24° 53'00.3"; 29.06.2009
5 – Lysa, Lviv region; N 49° 48'10.4", E 24° 42'51.5"; 27.06.2009
6 – Homets, Lviv region; N 49° 50'52.0", E 24° 04'31.0"; 26.06.2009
7 – Lysa, Lviv region; N 49° 48'08.6", E 24° 42'52.8"; 27.06.2009
8 – Lysa, Lviv region; N 49° 48'07.6", E 24° 42'52.8"; 27.06.2009
9 – Lysa, Lviv region; N 49° 48'04.8", E 24° 42'53.8"; 27.06.2009
10 – Lysa, Lviv region; N 49° 48'03.2", E 24° 42'54.2"; 27.06.2009
11 – Lysa, Lviv region; N 49° 47'54.4", E 24° 42'49.6"; 27.06.2009
12 – Lysa, Lviv region; N 49° 47'58.0", E 24° 42'48.1"; 27.06.2009
13 – Lysa, Lviv region; N 49° 47'49.7", E 24° 42'53.3"; 27.06.2009
14 – Vysoka, Lviv region; N 49° 52'18.2", E 24° 53'00.8"; 29.06.2009
15 – Vysoka, Lviv region; N 49° 52'16.6", E 24° 53'07.1"; 29.06.2009
16 – Vysoka, Lviv region; N 49° 52'17.7", E 24° 53'03.2"; 29.06.2009
17 – Chortova, Ivano-Frankivsk region; N 49° 24'03.8", E 24° 39'54.3"; 30.06.2009
18 – Lysa, Lviv region; N 49° 47'15.3", E 24° 43'29.4"; 27.06.2009
19 – Lysa, Lviv region; N 49° 47'19.4", E 24° 43'24.5"; 27.06.2009
20 – Bila, Lviv region; N 49° 56'10.0", E 24° 50'38.7"; 28.06.2009
21 – Bila, Lviv region; N 49° 55'46.5", E 24° 50'12.5"; 28.06.2009
22 – Bila, Lviv region; N 49° 55'42.6", E 24° 50'23.1"; 28.06.2009
23 – Bila, Lviv region; N 49° 56'05.0", E 24° 50'43.3"; 28.06.2009
24 – Bila, Lviv region; N 49° 55'48.0", E 24° 50'45.5"; 28.06.2009

class *Festuco-Brometea* and characterised by high values of radiation balance (thermoregime) and continentality of climate. These communities are also associated with alkaline soil condition, high carbonate content and high total salt regime. Clusters 1 and 2, which belong to the classes *Molinio-Arrhenatheretea* and *Trifolio-Geranietea sanguinei*, respectively, are considerably distant from each other and from other class. They are characterised by irregular precipitation and high values of climate humidity (ombroregime). In general, the ecological amplitudes of the determined syntaxa do not overlap, except for the associations *Inuletum ensifoliae* and *Jurineo calcareae-Stipetum capillatae*, which have a slight overlap considering their floristic and ecological similarity.

The average values of the thermoregime factor (Tm) calculated for the studied communities of the Western Podolia meadow steppes are quite close and increase in the following order: *Lembotropio nigricans-Potentilletum arenariae* (8.64 points) → *Pastinaco sativae-Arrhenatheretum elatioris* (8.74) → *Geranio sanguinei-Trifolietum alpestris* (8.77) → *Inuletum ensifoliae* (8.93) → *Jurineo calcareae-Stipetum capillatae* (8.96) (Figure 6).

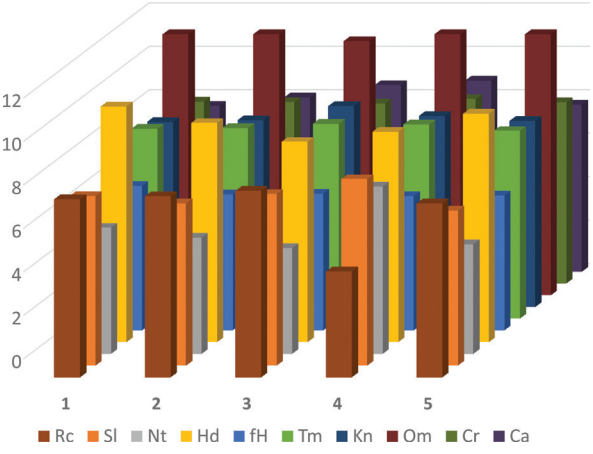

Figure 6: Mean values of ecological factors (in points of phytoindication scale) for each association: 1 – *Pastinaco sativae-Arrhenatheretum elatioris*; 2 – *Geranio sanguinei-Trifolietum alpestris;* 3 – *Jurineo calcareae-Stipetum capillatae*; 4 – *Inuletum ensifoliae*; 5 – *Lembotropio nigricans-Potentilletum arenariae*.

Legend: *Rc* – soil acidity; *Sl* – total soil salt regime; *Nt* – nitrogen content of the soil; *Hd* – soil water regime; *fH* – variability of moisture; *Tm* – thermoregime; *Kn* – continentality of climate; *Om* – ombroregime; *Cr* – cryoclimate; *Ca* – carbonate content of the soil.

Slika 6: Povprečne vrednosti ekoloških dejavnikov (na fitoindikacijski skali) za posamezno asociacijo: 1 – *Pastinaco sativae-Arrhenatheretum elatioris*; 2 – *Geranio sanguinei-Trifolietum alpestris;* 3 – *Jurineo calcareae-Stipetum capillatae*; 4 – *Inuletum ensifoliae*; 5 – *Lembotropio nigricans-Potentilletum arenariae*.

Legenda: *Rc* – kislost tal; *Sl* – skupni režim slanosti tal; *Nt* – vsebnost dušika v tleh; *Hd* – talni vodni režim; *fH* – spremenljivost vlažnosti; *Tm* – toplotni režim; *Ae* – zračnost tal; *Kn* – kontinentalnost podnebja; *Om* – režim padavin; *Cr* – krioklima; *Ca* – vsebnost karbonata v tleh.

The values calculated for the Kn factor show a rather specific distribution of meadow steppe plant communities along a continentality gradient. The highest average Kn value, which indicates a harsh continental climate, belongs to the *Jurineo calcareae-Stipetum capillatae* (9.24 points), while the *Pastinaco sativae-Arrhenatheretum elatioris* are characterised by the lowest value (8.51 points) (Figure 6). For the other syntaxa, the Kn values increase in the order *Lembotropio nigricans-Potentilletum arenariae* (8.55 points) → *Geranio sanguinei-Trifolietum alpestris* (8.59) → *Inuletum ensifoliae* (8.78). The results of the synphytoindication show that Western Podolia meadow steppes are characterised by a relatively narrow range of climate humidity values (Table 2).

The maximum average value of ombroregime (12.31 points) belongs to the *Pastinaco sativae-Arrhenatheretum elatioris*, while the *Jurineo calcareae-Stipetum capillatae* are characterised by the lowest average of this factor (11.69 points). In general, this ecological index is increasing in the order *Jurineo calcareae-Stipetum capillatae* (11.69 points) → *Inuletum ensifoliae* (12.11) → *Geranio sanguinei-Trifolietum alpestris* (12.14) → *Lembotropio nigricans-Potentilletum arenariae* (12.21) → *Pastinaco sativae-Arrhenatheretum elatioris* (12.31). The average values of the Om factor are very similar across the studied communities, implying that climate humidity is not a differential factor for Western Podolia meadow steppes (Figure 6).

The climate cryoregime directly affects the distribution of species and plant communities in the area because in many cases only the wintering conditions determine the possibility of plant life in a certain ecotope. Synphytoindication results show that the Cr factor amplitude is only 0.73 points (from 7.75 to 8.48) (Table 2) for all studied plant communities, corresponding to 2.92 ° C, and determines winters with temperatures from –10° to – 6° C. It should be noted that higher climate cryoregime values correspond to milder winters and, in contrast, lower values characterise fairly severe winters. However, the *Lembotropio nigricans-Potentilletum arenariae*, which are the most western communities in the study area, are characterised by the lowest average value of climate cryoregime (8.29 points), while all other associations have average values in the range from 8.33 to 8.49 points (Figure 6).

For arid ecosystems in general and for the steppe ecosystems in particular, the soil water regime directly affects the distribution of zonal phytocoenotic structures. Thus the average value of the Hd factor of the meadow steppe communities of Western Podolia increases in the order *Jurineo calcareae-Stipetum capillatae* (9.22 points) → *Inuletum ensifoliae* (9.67) → *Lembotropio nigricans-Potentilletum arenariae* (10.05) → *Geranio sanguinei-Trifolietum alpestris* (10.08) → *Pastinaco sativae-Arrhenatheretum elatioris*

(10.83), which is completely consistent with the features of the natural and zonal variability of the factor.

The variability of moisture (damping) (fH) is a gradient which corresponds to soils with relatively constant or weakly variable water supply. The distribution of the average values of this factor is rather narrow (from 6.17 to 6.25 points) across all studied syntaxa except the *Pastinaco sativae-Arrhenatheretum elatioris* communities (6.64 points) (Figure 6).

The average value of the Rc factor for Western Podolia meadow steppes is 8.50 points, corresponding to soils with neutral reaction of soil solution (Table 2). For the studied plant communities, the average values of this factor cover the range from 7.60 to 8.95 points, corresponding to soils from slightly acidic (pH 5.5-6.5) to more or less neutral (pH 6.5-7.2). Within this narrow range, the average value of the Rc factor increases in the order *Lembotropio nigricans-Potentilletum arenariae* (7.99 points) → *Pastinaco sativae-Arrhenatheretum elatioris* (8.19) → *Geranio sanguinei-Trifolietum alpestris* (8.32) → *Jurineo calcareae-Stipetum capillatae* (8.57) → *Inuletum ensifoliae* (8.58) (Figure 6). In general, the soil acidity is characterised by nonspecific features because of the peculiarities of soil formation processes under the grass vegetation.

Compared with the previous factor, plant communities are very sensitive to the mineral nitrogen content in the soil; hence the nitrogen regime is one of the leading differential ecological factors. Since the soils in the study area are fertile substrates, the formation of which is closely linked to domination of herbaceous ecological biomorphs, they are characterised by relatively high levels of mineral nitrogen content. The investigated meadow steppe communities have a quite considerable range of Nt values from 4.41 to 5.90 points (Δ = 1.49 points), which in absolute terms corresponds to 14.0–21.0 mg mineral nitrogen / 100 g of soil, from poor soils to soils that are well supplied with nitrogen. However, the distribution of the average Nt values of the studied communities is characterised by a relatively narrow amplitude and increases in the order *Jurineo calcareae-Stipetum capillatae* & *Inuletum ensifoliae* (4.86 points) → *Lembotropio nigricans-Potentilletum arenariae* (5.04) → *Geranio sanguinei-Trifolietum alpestris* (5.34) → *Pastinaco sativae-Arrhenatheretum elatioris* (5.8) (Figure 6).

The carbonate content of the soil is one of the leading ecological factors, which specifies both the distribution and the formation of steppe vegetation (Sakalo 1955). For the studied vegetation, the total range of calcium content of the soil (Ca) is very wide – 2.75 points, varying from 6.62 to 9.37 points (Table 2). The highest average values of calcium content belong to the habitats of the *Jurineo calcareae-Stipetum capillatae* and the *Inuletum ensifoliae* (8.8 and 8.59 points, respectively), closely followed by *Lembotropio nigricans-Potentilletum arenariae* (8.02) habitats, due to peculiarities of the underlying rocks with a high content of carbonates (limestone, marl and calcareous sandstone). As expected, the soils of the *Pastinaco sativae-Arrhenatheretum elatioris* (7.63 points) and the *Geranio sanguinei-Trifolietum alpestris* (7.68 points) have the lowest Ca factor values (Figure 6).

Synphytoindication results of the total salt regime indicate that the lowest average Sl value belongs to the *Lembotropio nigricans-Potentilletum arenariae* habitats (7.13 points) and the highest to the *Jurineo calcareae-Stipetum capillatae* (7.89). For the other studied plant communities, the average Sl value increases in the order *Geranio sanguinei-Trifolietum alpestris* (7.46 points) → *Inuletum ensifoliae* (7.7) → *Pastinaco sativae-Arrhenatheretum elatioris* (7.8) (Figure 6).

Discussion

Within the sites studied in the Western Podolia territory, a significant differentiation of meadow steppe vegetation, which is represented by associations of three classes of vegetation, was revealed. Among the most common communities of the investigated region are the associations *Jurineo calcareae-Stipetum capillatae* and *Inuletum ensifoliae*, while at the other grassland stands (in the central and southern parts of the Steppe zone), these communities were either lacking or extremely rare. This is a confirmation of the assertion that the class *Festuco-Brometea* includes extraordinary communities of meadow steppes, which are climatically and edaphically predetermined and represented in the territory of Ukraine by steppe communities close to the Central European type (Didukh & Korotchenko 2003).

The results of our research show that most plant communities of the studied region are dominated by *Brachypodium pinnatum*, *Carex humilis*, *C. flacca*, *Briza media*, *Dactilys glomerata* and *Elytrigia intermedia*. Constant species of meadow steppe communities are also *Antheric um ramosum*, *Centaurea scabiosa*, *Euphorbia cyparissias*, *Galium verum*, *Knautia arvensis*, *Leucanthemum vulgare*, *Medicago romanica*, *Onobrychis arenaria*, *Plantago media*, *Prunella grandiflora*, *Salvia pratensis*, *Stachys recta*, *Teucrium chamaedrys* and *Thalictrum minus*. It should be noted that in the studied meadow steppe communities we have found a number of rare species included in the Red Data Book of Ukraine (Didukh 2009): *Anemone narcissiflora*, *Cypripedium calceolus*, *Orchis militaris*, *Pulsatilla grandis*, *Daphne cneorum*, *Chamaecytisus albus*, *Carlina cirsioides*, *C. onopordifolia*, *Stipa pennata* and the rare relict species *Coronilla coronata*.

The presence of typical steppe species in the studied communities indicates on the existence of certain genetic relations between the meadow steppes of Western Podolia and fairly remote steppes of Left-bank Ukraine and steppes of the Central Russian Upland (Lysenko 1992a, b, 1998, 2004a, b, 2005, 2007a, b, Didukh et al. 2018). This fact suggests a similarity in the evolutionary processes of biocoenoses dominated by herbaceous life forms.

The values of the ecological factors allow to assert that the *Jurineo calcareae-Stipetum capillatae* habitats are closest to natural northern meadow steppes common in Left-bank Ukraine, while habitats of the *Geranio sanguinei-Trifolietum alpestris* are more similar to forest steppes. Ecological characteristics of the *Lembotropio nigricans-Potentilletum arenariae,* the *Inuletum ensifoliae* and the *Pastinaco sativae-Arrhenatheretum elatioris* have an intermediate position. The results indicate that the distribution of meadow steppe vegetation in Podolia Upland closely correlates with a number of climatic (thermoregime and continentality of climate) and especially edaphic (soil humidity, soil acidity and carbonate content of the soil) ecological factors, which are determinant for the study area.

The geographical differentiation of plant communities is primarily determined by the variation of climatic factors. The minimum and maximum thermoregime values of meadow steppes in the studied region are quite close to those of the habitats of fescue-feather grass steppes (Tkachenko 2006). This is due to orographic features of the Podolia meadow steppes, which occur on slopes with southern and southwestern exposures and accordingly higher rates of radiation balance.

The meadow steppe communities of the association *Inuletum ensifoliae* distributed on Billa Hill form a complex mosaic with zonal forest communities, which are able to form their own coenotic environment and directly influence the continentality indices (Lavrenko 2000). The vegetation of the associations *Pastinaco sativae-Arrhenatheretum elatioris, Geranio sanguinei-Trifolietum alpestris* and *Lembotropio nigricans-Potentilletum arenariae* is characterised by an ecotone effect because the top and the foot of the slopes are occupied by forest vegetation, whereas the prevailing coenotic structures of the *Inuletum ensifoliae* and the *Jurineo calcareae-Stipetum capillatae* are herbaceous communities with significant participation of xerothermophile species.

The additive influence of the investigated environmental factors and their variations explain the extraordinary mosaic of the vegetation cover of the studied area, which appears in the interchanges of forest and meadow-steppe phytocoenotic structures. This circumstance determines the presence of fast dynamic changes in phytocoenoses, which must be taken into account when developing strategies for the conservation of species and coenotic diversity.

Conclusions

The obtained results indicate a certain ecological specificity of the main phytocoenotic structures representing Western Podolia meadow steppes, whose distribution and genesis are closely correlated with microclimatic and orographic features of the habitats. The synphytoindication analysis shows that among climatic factors the generalised thermoregime and continentality have the greatest differential impact on the distribution of meadow-steppe plant communities. Another important factor affecting the mosaic of vegetation is the soil specificity of the studied region. Among the edaphic factors that contribute to the distribution of meadow steppes are soil humidity, its acidity and its carbonate content.

Given that the vast majority of the studied meadow-steppes are located on the territory of the Nature Reserve Fund of Ukraine and that they contain rare plant communities and a number of plant species listed in the Red Data Book of Ukraine, it is necessary to conduct a comprehensive study of these meadow-steppe "benchmarks" of our nature to ensure their protection. In this aspect the obtained results of the synphytoindication assessment of the ecological factors are very important since they not only allow to determine the distribution of plant communities in space, but can also be used in the development of management plans and the selection of optimal regulatory measures in the nature protected areas.

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