

THE ALLIANCES *ARRHENATHERION*, *CYNOSURION* AND *TRIFOLION MEDII* IN WESTERN BULGARIA – ENVIRONMENTAL GRADIENTS AND ECOLOGICAL LIMITATIONS

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Abstract

The vegetation of mesic grasslands distributed in the central part of Western Bulgaria is studied. A significant number of 533 relevés were made following the Braun-Blanquet approach. Classification and ordination of the vegetation was performed. The vegetation is classified up to alliance level. The result of the classification are four groups which correspond to the alliances *Arrhenatherion elatioris*, *Cynosurion cristati* and *Trifolion medii*. Within *Cynosurion* alliance two well distinct subgroups are observed, differing in moisture of the substrate – provisionally called “wet” and “dry” *Cynosurion*. Ellenberg Indicator Values are used for assessment of ecology of the habitats. The pasture/mowing management of the studied vegetation types is commented.

Key words: *Arrhenatherion*, Bulgaria, classification, *Cynosurion*, formal definitions, mesic grasslands, ordination, *Trifolion medii*.

Izveček

Proučevali smo vegetacijo mezofilnih travnikov razširjeno v srednjem delu zahodne Bolgarije. Naredili smo pomembno veliko število (553) popisov po Braun-Blanquetovem pristopu in jih analizirali s klasifikacijo in ordinacijo. Vegetacijo smo nato uvrstili do nivoja zveze. Rezultat klasifikacije so štiri skupine, ki odgovarjajo zvezam *Arrhenatherion elatioris*, *Cynosurion cristati* in *Trifolion medii*. Znotraj zveze *Cynosurion* smo izločili dve posebni skupini popisov, ki se ločita po vlažnosti tal in ju provizorno imenujemo “vlažni” in “suhi” *Cynosurion*. Za opis ekologije rastišč smo uporabili Ellenbergove Indikatorske Vrednosti. Komentirali smo tudi gospodarjenje obravnavanih vegetacijskih tipov s košnjo oziroma pašo.

Ključne besede: *Arrhenatherion*, Bolgarija, klasifikacija, *Cynosurion*, formalne definicije, mezofilni travniki, ordinacija, *Trifolion medii*.

1. INTRODUCTION

The mesic grasslands encompass mostly meadows of high productivity in the lowlands up to the sub-mountain level, that are of significant value for practical and nature conservation purposes. We considered as target vegetation during the field work the content of *Arrhenatheretalia elatioris* Tüxen 1931 order which according to Ellen-

berg (1988) has suboceanic submeridional distribution. In South-Eastern Europe this vegetation type is less frequent as compared to Western Europe due to limited moisture. Horvat et al. (1974) explain also this limitation with distribution boundaries for many diagnostic species in the region. The diversity of these community types in Central Europe has been well studied (Ellmauer & Mucina 1993, Dierschke 1995, 1997, Chytrý

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2007a, Janišová 2007). For the Balkan Peninsula, a significant amount of information about the vegetation concerned is provided by Horvat et al. (1974), Kojić et al. (1998) and Zelnik (2007). Development and implementation of the recent nature conservation initiatives, namely designation of High Nature Value grasslands (see Veen et al. 2009) requires better knowledge on the species composition, ecological conditions and syntaxonomical diversity of this vegetation.

For the territory of Bulgaria there was no comprehensive information about the diversity of mesic grasslands based on the floristic-ecological studies (see Apostolova & Slavova 1997). Tzonev et al. (2009) report three associations and one community, assigned to *Arrhenatheretalia* order, published in the last ten years for the country. The deficiency in the knowledge of Bulgarian meadows has started to be rectified by recent studies on *Cynosurion cristati* (Dimitrov 2001, 2004; Apostolova & Meshinev 2006; Pavlov et al. 2006), *Arrhenatherion elatioris* (Pavlov et al. 2006; Apostolova et al. 2007) and *Trifolion medii* (Meshinev et al. 2005).

Despite the remarkable progress in implementation of the Braun-Blanquet approach in Bulgaria in the past decade it could be argued that the classification of mesic grasslands is still at the beginning.

The aim of the current study is to establish the high rank syntaxa of the mesic meadows and pastures from the central part of Western Bulgaria, and to provide coherent environmental characteristics for their habitats.

2. MATERIAL AND METHODS

2.1 STUDY AREA

The studied area is situated in the central part of Western Bulgaria (Figure 1). The total observed area is 10 796 sq. km., which is approximately a 1/10 part of the territory of the country. According to the climatic division of Bulgaria (Velev 2002) the studied area falls into temperate-continental and transitional-continental regions. The climate in these regions is characterized by warm summers and cold winters and by a high annual amplitude of air temperature. An ombrothermic climatic diagram from Sofia observatory (situated at the centre of the investigated area) is given in Figure 2 according to Lieth et al. (1999). The base rock is mainly silicate.



Figure 1: Map of Bulgaria. The studied area is marked in dark gray.

Slika 1: Zemljevid Bolgarije. Obravnavano območje je sivo označeno.

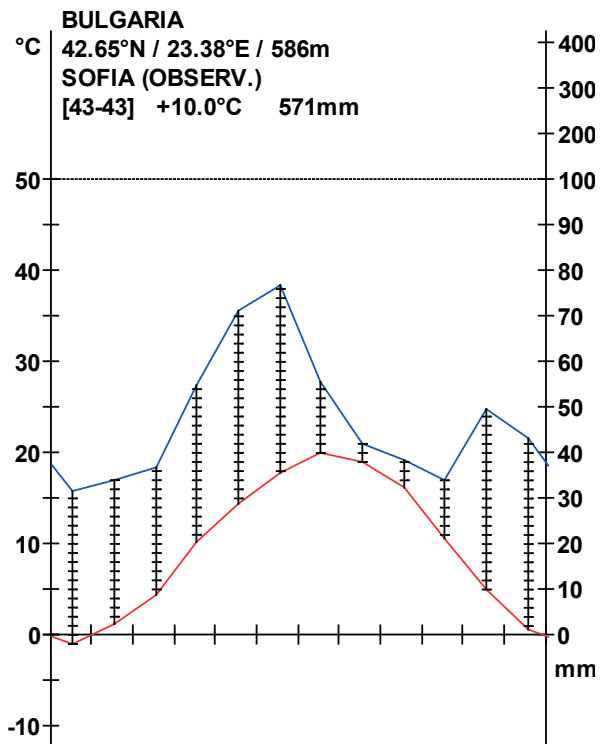


Figure 2: Ombrothermic climatic diagram from the studied area.

Slika 2: Ombrotermični klimatski diagram obravnavanega območja.

2.2 FIELD SAMPLING

The sample plots were set in a manner to cover uniformly the whole area. Altogether 533 relevés within the period 2007–2009 were obtained. During the field sampling we focused on the vegeta-

tion that ecologically and floristically seemed to belong to *Arrhenatheretalia* order. The relevés are sampled following the classical approach (Braun-Blanquet 1965, Westhoff & van der Maarel 1973). This relevé type is suitable both for classification and ordination (Whittaker 1973). The form of the sample plots is square with an area of 16 sq. metres which is recommended for mesic meadows (Mueller-Dombois & Ellenberg 1974, Knapp 1984, Kent & Coker 1992, Chytrý & Otýpková 2003, van der Maarel 2005, Otýpková & Chytrý 2006). The sample plots are chosen in the most homogeneous part of the community. Species are estimated by the expanded combined scale for cover/abundance of Braun-Blanquet (Barkman et al. 1964, van der Maarel 1979, Parolly 2003). This scale is a good alternative to the classical (7-point) scale of Braun-Blanquet, which is relatively insensitive in the range covered by category "2". The expanded 9-point scale gives greater importance to the abundance (van der Maarel 1979, Parolly 2003).

Soil samples were taken from the depth range of 0–10 cm. Determination of pH was provided by pH-meter "Jenway 3310" in H₂O solution with a soil:water ratio of 1:5, which macerates for at least 18 hours (ISO 10390: Soil quality – Determination of pH). After every 10 soil samples the pH-meter was calibrated by HANNA Instruments buffer solutions (pH 4.01; pH 7.01; pH 10.01).

Pasture management is estimated categorically: 0 – not grazed, 1 – low intensity of grazing, 2 – moderate intensity of grazing, 3 – high intensity of grazing. Mowing management is estimated by two categories: 0 – not mown, 1 – mown.

2.3 DATA PROCESSING

All the relevés are stored in TURBOVEG database (Hennekens & Schaminée 2001). Before conducting any analysis the data were normalized by "square root transformation" (McDonald 2008). The classification was made using the program TWINSPAN (Hill 1979) and is performed within the software package JUICE 7.0 (Tichý 2002, Tichý & Holt 2006).

Formal definitions were assessed for all alliances using combinations of sociological species groups and species dominance. The sociological groups were generated by the Cocktail method (Bruehlheide 1995, 2000) within all relevés and contain species with the highest positive fidelity:

Sociological group *Trifolium montanum*: *Briza media*, *Chamaespartium sagittale*, *Danthonia alpina*, *Helianthemum nummularium*, *Trifolium montanum*;

Sociological group *Leontodon autumnalis*: *Agrostis capillaris*, *Anthoxanthum odoratum*, *Cynosurus cristatus*, *Holcus lanatus*, *Leontodon autumnalis*;

Sociological group *Trisetum flavescens*: *Medicago lupulina*, *Trifolium campestre*, *Trisetum flavescens*, *Vicia cracca*, *V. grandiflora*.

Delimitation of syntaxa is obtained using the logical operators: AND, OR and NOT. These operators determine which sociological group is to be presented or absent in a relevé, so that the relevé can be referred to the relevant syntaxon (Bruehlheide 1997, Chytrý 2007b).

Indirect Gradient Analysis (by Detrended Correspondence Analysis – DCA) using the software product CANOCO 4.5 (ter Braak & Šmilauer 2002, Lepš & Šmilauer 2003) is applied.

Environmental conditions in the habitats were assessed using the Ellenberg Indicator Values (EIV) according to Ellenberg et al. (1992). All variables (EIV, total cover, altitude, soil pH) are summarized and presented by seven box and whisker plots. The observed differences in variables among the studied vegetation units were tested by one-way ANOVA with Bonferroni (in case of equal variances) and Tamhane (in case of unequal variances) post-hoc tests. The homogeneity (equality) of variance assumption was tested by Levene's test (Levene 1960). A multiple comparison of the summarized variables is revealed in order to show which of them differ statistically significantly among the studied vegetation units. The univariate statistic analyses were performed by SPSS 16.0 software.

The species in the synoptic table (Table 1) are represented by two indicators: Fidelity measure, expressed by the Phi-coefficient (Chytrý et al. 2002) and Constancy, expressed in percentages. The Phi-coefficient values depend on the size of the syntaxa. This problem is avoided by virtual standardizing of the volume of the obtained clusters using the software package JUICE. Phi-coefficient calculated under the standardized database is independent of the actual differences in the volume of any group (Tichý & Holt 2006). The values of Phi-coefficient are corrected using Fisher's exact test. This is done in order to eliminate the values of Phi-coefficients which are statistically insignificant.

The quality of the classified syntaxa is ex-

pressed by Sharpness and Uniqueness indexes. A vegetation unit has a high Sharpness index if most of its species are frequent in it, while they are rare or absent in the other clusters in the database. The Uniqueness index searches syntaxa which are unique in a database. It shows whether there are similar vegetation units of the same rank in the dataset. These two indices consider the diagnostic species. The analyses of these indicators express well-defined and poorly defined vegetation units (Chytrý & Tichý 2003).

Dominant and constant species are listed for every alliance. Species with coverage above 25 % in 5 % of the relevés in any cluster are considered as dominant. Constant species are those having at least 50 % presence in a cluster.

Before determination of formal definitions, dominant and constant species of the two subgroups of *Cynosurion* alliance were merged into one cluster.

2.4 NOMENCLATURE

Taxonomy of the species follows Kozhuharov (1992) and Delipavlov & Cheshmedjiev (2003). Diagnostic species are selected according to Resmeriță (1970), Boșcaiu (1971), Dihoru (1975), Lopez (1978), Zuidhoff et al. (1995), Dierschke (1997), Micina (1997), Sanda et al. (1997), Čarni (1997, 2005), Pop et al. (2002), Šeffler et al. (2002), Chytrý & Tichý (2003), Dutoit (2003), Valachovič (2004), Čarni et al. (2000, 2005), Gandullo & Faggi (2005), Meshinev et al. (2005), Snowarski (2005), Bărbos (2006), Hájková et al. (2007) and Stančić (2008). Biogeographical affiliation of the species follow Oberdorfer (1994) and for the Balkan endemics Assyo & Petrova (2006).

3. RESULTS

3.1 CLASSIFICATION AND ORDINATION

The TWINSPLAN classification and the DCA-ordination analysis of the relevés distinguished four groups (Table 1, Figure 3) which correspond to the alliances *Trifolium medii*, *Cynosurion cristati* with two well delimited subgroups with respect to the soil moisture provisionally called “dry” and “wet” type and *Arrhenatherion elatioris*.

The largest number of relevés is confined to the *Arrhenatherion elatioris*. Although species di-

versity per sample plot is lowest (36) as compared to the other studied groups, the total species sampled within this alliance numbers 411. *Arrhenatherion* alliance is defined by a very low Sharpness index (9.14), which is a result of many generalist species presented. Similar could be stated for the “dry” *Cynosurion* which has a Sharpness index of 3.78. On the other hand the “wet” *Cynosurion* includes species which are not presented in the rest of the data, and the Uniqueness index has the highest value of 42 within the studied samples.

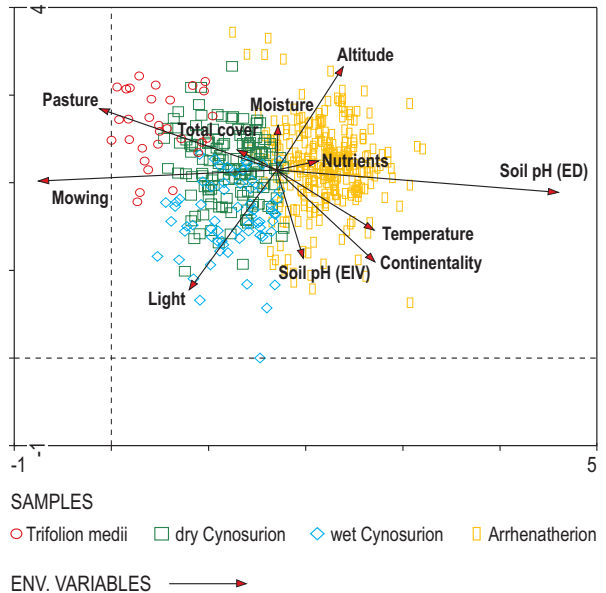


Figure 3: Indirect gradient analysis. Biplot diagram of DCA. The main axes correlate with the gradients of moisture and soil reaction. ED – Empirical Data, EIV – Ellenberg Indicator Values.

Slika 3: Indirektna gradientna analiza. DCA dvorazsežnostni diagram. Glavni osi z gradientoma vlažnosti in reakcije tal. ED – empirični podatki, EIV – Ellenbergove Indikatorske Vrednosti.

3.2 ECOLOGICAL DIFFERENCES AMONG ALLIANCES

Trifolium medii occupies habitats with most dry soils, the lowest values of pH and with a minimum of nutrients (Figure 5). This alliance shows a resemblance to “dry” *Cynosurion*. The latter, in turn, shows the least expressed specifics for environmental factors in comparison with the other three vegetation units. The wettest sites are occupied by the “wet” *Cynosurion*. *Arrhenatherion* alliance is well distinguished by many variables compared to the other vegetation units (Table 3).

Its habitats are located at lowest altitudes and are characterized by their highest values of temperature and soil pH (Figure 5).

3.3 DESCRIPTION OF PARTICULAR ALLIANCES

In order to present the characteristics of the obtained alliances in the studied area a short description is provided for each of them:

Trifolio-Geranieta Müller 1962

Origanetalia vulgaris Müller 1962

Trifolium medii Müller 1962

Diagnostic species: *Centaurea jacea*, *Trifolium medium*, *T. montanum*.

Constant species: *Achillea millefolium*, *Agrostis capillaris*, *Anthoxanthum odoratum*, *Briza media*, *Chamaespartium sagittale*, *Danthonia alpina*, *Festuca nigrescens*, *F. valesiaca*, *Filipendula vulgaris*, *Galium verum*, *Leontodon hispidus*, *Lotus corniculatus*, *Plantago lanceolata*, *Rumex acetosa*, *Stellaria graminea*.

Dominant species: *Danthonia alpina*.

Formal definition: Group *Trifolium montanum* NOT Group *Leontodon autumnalis*.

Soil pH optimum: medium acidic (5.4–6.0).

Altitude range: 798–1242 m.

Base rock: silicate.

This is the best separated alliance in our database. The Sharpness index (24.08) and the

Uniqueness index (38.80) values prove its distinctness within the data set. It contains a relatively small number of relevés but the species diversity is high – total species number is 220 and average species per relevé is 39 (Table 2). The vegetation is used for hay-making and pasturing (Figure 4).

Molinio-Arrhenatheretea Tüxen 1937

Arrhenatheretalia elatioris Tüxen 1931

Cynosurion cristati Tüxen 1947

Diagnostic species: *Agrostis capillaris*, *Anthoxanthum odoratum*, *Cichorium intybus*, *Cynosurus cristatus*, *Leontodon autumnalis*.

Constant species: *Achillea millefolium*, *Agrostis capillaris*, *Anthoxanthum odoratum*, *Alopecurus pratensis*, *Convolvulus arvensis*, *Cynosurus cristatus*, *Dactylis glomerata*, *Festuca pratensis*, *Galium verum*, *Holcus lanatus*, *Leontodon hispidus*, *Lotus corniculatus*, *Poa pratensis*, *Plantago lanceolata*, *Ranunculus acris*, *Rhinanthus rumelicus*, *Rumex acetosa*, *Stellaria graminea*, *Taraxacum officinale*, *Trifolium pratense*, *T. repens*.

Dominant species: *Agrostis capillaris*.

Formal definition: Group *Leontodon autumnalis* NOT Group *Trisetum flavescens* NOT *Chamaespartium sagittale* cover > 5 % NOT *Trifolium medium* cover > 5 %.

Soil pH optimum: from medium acidic to slightly acidic (5.5–6.3).

Altitude range: 359–1629 m.

Base rock: silicate.

The TWINSpan divides these relevés into two groups which share the diagnostic species of the alliance. Irrespective of this division, the two groups relate to *Cynosurion*. The floristic similarity can be seen in Figure 3 where the two groups are not clearly separated but overlap to a large extent, unlike the other two alliances. The vegetation of alliance *Cynosurion* is used as pastures and hay-making meadows. In the dry subgroup grazing and mowing are dealt evenly, but in the wet subgroup there is observed a significant prevalence of mowing. This vegetation has the highest total cover (Figure 5), which emphasizes its high agricultural value. The “dry” *Cynosurion* is the only vegetation type managed at some places by an intensive grazing regime (Figure 4).

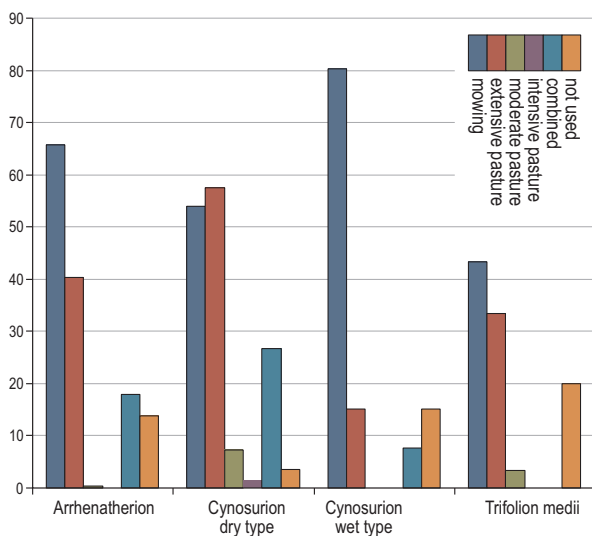
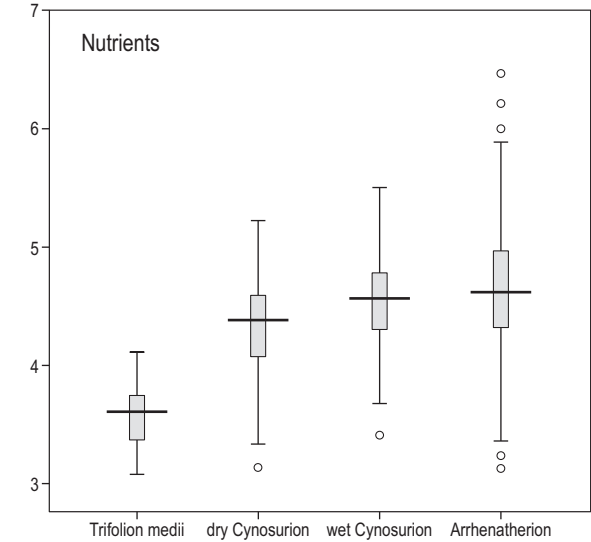
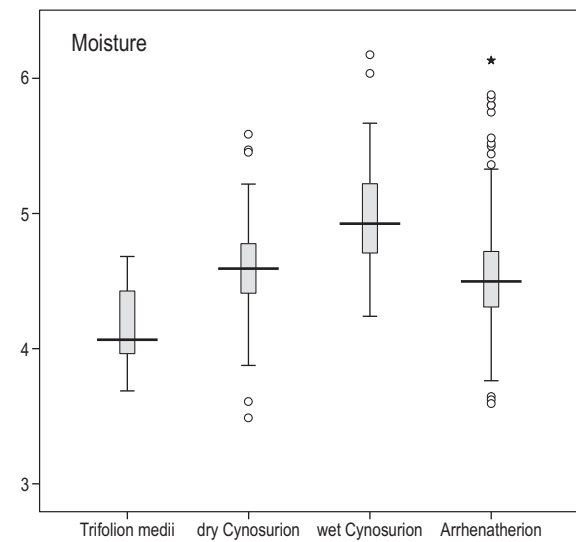
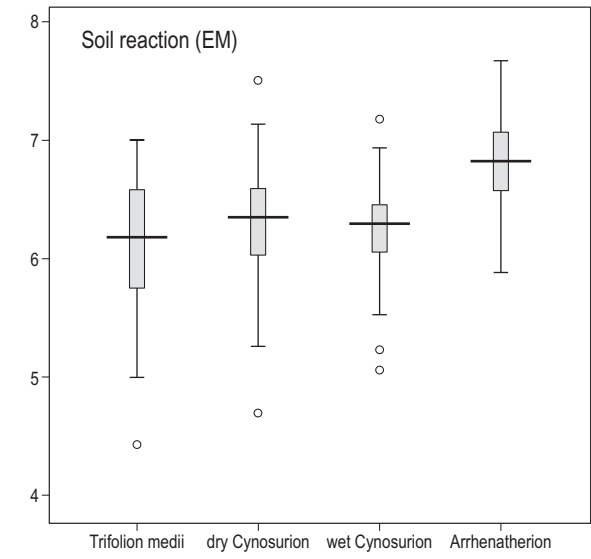
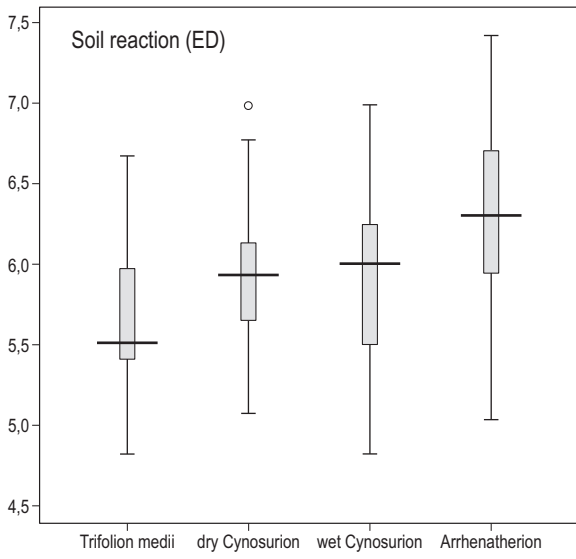
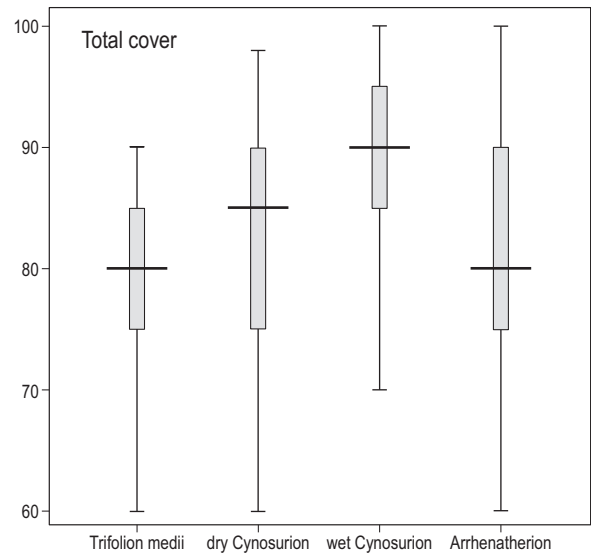
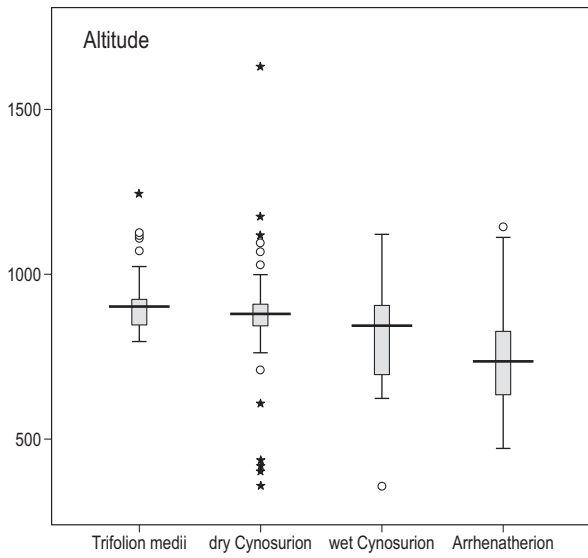


Figure 4. The mowing/grazing management of the studied vegetation types.

Slika 4: Gospodarjenje (paša/košnja) s proučevanimi vegetacijskimi tipovi.

Arrhenatherion elatioris Luquet 1926

Diagnostic species: *Cirsium arvense*, *Medicago lupulina*, *Poa pratensis*, *Silene vulgaris*, *Trifolium campestre*, *Trisetum flavescens*, *Vicia cracca*.



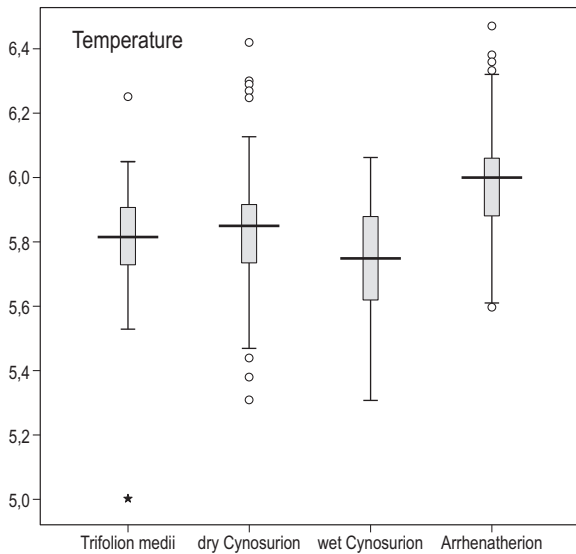


Figure 5: Box and whiskers plots of the most important variables.

Slika 5: Graf (šklatla in brki) najpomembnejših spremenljivk.

Constant species: *Achillea millefolium*, *Agrimonia eupatoria*, *Arrhenatherum elatius*, *Cirsium ligulare*, *Convolvulus arvensis*, *Dactylis glomerata*, *Elymus repens*, *Festuca pratensis*, *F. valesiaca*, *Galium verum*, *Lotus corniculatus*, *Plantago lanceolata*, *Poa pratensis*, *Taraxacum officinale*, *Trifolium campestre*, *T. pratense*, *T. repens*, *V. grandiflora*.

Dominant species: *Arrhenatherum elatius*.

Formal definition: Group *Trisetum flavescens* NOT Group *Leontodon autumnalis* NOT Group *Trifolium montanum*.

Soil pH optimum: from medium acidic to slightly acidic (5.9–6.7).

Altitude range: 472–1143 m.

Base rock: in 90 % of the localities is silicate and in 10 % is limestone.

Communities confined to *Arrhenatherion* alliance are widespread in the studied area. They occupy mainly the lowest altitudes, close to settlements and agricultural fields. Some sample plots are arable lands, abandoned since 1990s, which have been recovered by the species pool of the adjacent not utilized areas. This is a reason for high fidelity coefficients for *Lathyrus aphaca*, *Dipsacus laciniatus*, *Vicia pannonica*, *V. grandiflora*, *Convolvulus arvensis* (Table 1). Currently these grasslands are utilized as pastures and hay-making meadows with a noticeable prevalence of mowing (Figure 4).

4. DISCUSSION

The mesic grasslands in the lowlands and hilly regions of western Bulgaria are classified into two distinct classes (*Trifolio-Geranietea* Müller 1962 and *Molinio-Arrhenatheretea* Tüxen 1937). It was not surprising that within the mesic grasslands the *Trifolium medii* alliance was also recognized, because it is pointed out by Čarni (2005) as “the most humid and rich in nutrients” representative of the class *Trifolio-Geranietea*. The presence of *Trifolium medii* within the vegetation targeted in this study reveals its ecological similarity with *Arrhenatherion* and *Cynosurion*. The fringe vegetation (like *Trifolium medii*) is a good example of ecotone habitats that contain a significant number of species, coming from surrounding areas (Valachovič 2004). The floristic composition of fringe communities as semi-natural grasslands largely depends on human activity, and despite the very low intensity of mowing and grazing, the management preserves the grasslands from further development into shrublands. In Bulgaria, similarly to other parts of Europe, *Trifolium medii* communities contain species diagnostic for other syntaxa (see Table 1). This is a reason why its position into the higher syntaxa varies significantly among different authors. Čarni (1997, 2005), Rodwell et al. (2002), Dengler (2004), Valachovič (2004) and Čarni et al. (2005) refer this alliance to *Trifolio-Geranietea*. According to Chytrý et al. (2007) the alliance belongs to *Festuco-Brometea* Br.-Bl. & Tüxen ex Soó 1947. Some other authors classify *Trifolium medii* communities into *Carpinion betuli* Issler 1931 or *Fagion* Luquet 1926 and also into class *Molinio-Arrhenatheretea* (see Čarni et al. 2000, Valachovič 2004). The close vicinity of other semi-natural vegetation types managed as pastures or meadows for a long time supports transference of many species diagnostic for *Festuco-Brometea* and *Molinio-Arrhenatheretea* into the fringe communities where these species fall into similar ecological conditions. In the present study we obtained data showing that, floristically and ecologically, *Trifolium medii* is close to *Cynosurion* and especially to its “dry type” (Figure 3, Table 3).

According to Dierschke (1999) *Cynosurion cristati* is characterized by a pronounced absence of good diagnostic species. This alliance has been defined negatively in comparison with the hay-making meadows of the alliances *Arrhenatherion* and *Polygono-Trisetion* and with the pastures of the

alliance *Mesobromion* (Zuidhoff et al. 1995). Horvat et al. (1974) mention that in the Balkans the *Cynosurion* vegetation is managed in a different way as compared to Central Europe, where it is managed as pastures and in many cases is maintained by manuring. In Bulgaria neither of the *Cynosurion* types is enhanced by man. Nevertheless the vegetation is composed of the same species which have emphasized European or Euro-Asiatic distribution (see table 1). Only a few specific Balkan plants are included in the floral diversity. The same is obvious also for *Arrhenatherion*. This brings us to the conclusion that lowland mesic grasslands in the studied area do not exhibit a particular South-East European specificity. Further, this fact also allows us to use Ellenberg Indicator Values for Bulgarian mesic meadows, in spite of their origin in the Central Europe.

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Table 1: Synoptic table of the studied vegetation units.

The species are represented by two indicators: Fidelity measure, expressed by the Phi-coefficient (Chytrý & al. 2002) and Constancy, expressed in percentages.

Tabela 1: Sinoptična tabela proučevanih vegetacijskih tipov.

Vrste so predstavljene z dvema indikatorjema: mero naveznosti, kot Fi koeficient (Chytrý & al. 2002) in prisotnostjo v odstotkih.

Biogeographical affiliation of the species	Syntaxa	<i>Trifolion medii</i>		<i>Cynosurion cristati</i>				<i>Arrhenatherion elatioris</i>	
				dry type		wet type			
		Number of relevés	30	139	66	298			
	Fidelity / Constnacy	Phi	%	Phi	%	Phi	%	Phi	%
<i>Trifolion medii</i>									
Eur-subMed	<i>Trifolium montanum</i>	47,5	50	–	14	–	5	–	4
Euras	<i>Trifolium medium</i>	39,6	27	–	4	–	2	–	1
Euras	<i>Centaurea jacea</i>	36,8	47	–	12	–	18	–	6
<i>Trifolio-Geranietea</i>									
Epralp	<i>Thesium bavarum</i>	43,9	37	–	6	–	2	–	4
Eur-subMed	<i>Geranium sanguineum</i>	29,4	13	–	.	–	2	–	.
Med-subMed	<i>Dorycnium herbaceum</i>	27,8	23	–	11	–	2	–	2
EEur	<i>Ferulago sylvatica</i>	27,7	10	–	.	–	.	–	.
subMed-Eur	<i>Lathyrus niger</i>	27,2	13	–	3	–	.	–	.
<i>Festuco-Brometea</i>									
subMed	<i>Helianthemum nummularium</i>	54,6	43	–	2	–	3	–	1
Ealp	<i>Hieracium hoppeanum</i>	50,1	43	–	9	–	.	–	2
Med-Eur	<i>Danthonia alpina</i>	46,1	63	–	15	3,5	30	–	2
Euras	<i>Hypochaeris maculata</i>	41	23	–	.	–	2	–	.
Euras	<i>Inula salicina</i>	38,5	27	–	6	–	.	–	1
Euras	<i>Briza media</i>	37,6	73	–	39	3,1	44	–	9
subMed	<i>Asperula cynanchica</i>	35,7	23	–	3	–	2	–	1
Balc	<i>Dianthus cruentus</i>	35,5	20	–	3	–	.	–	.
Eur	<i>Veronica austriaca</i>	35,5	17	–	.	–	.	–	1
Euras	<i>Thymus pulegioides</i>	33,3	30	–	12	–	3	–	2
Eur	<i>Thymus glabrescens</i>	32,6	33	–	12	–	2	–	9
subMed	<i>Euphorbia cyparissias</i>	32,5	40	5	22	–	3	–	8
Euras	<i>Koeleria macrantha</i>	28,2	20	–	2	–	3	–	4
Pont-Med	<i>Chrysopogon gryllus</i>	27,1	13	–	1	–	2	–	1

Biogeogr. affiliation	Number of relevés	30	139	66	298				
Eur	<i>Prunella grandiflora</i>	24,6	10	–	2	–	.		
	Cynosurion dry type								
Euras	<i>Agrostis capillaris</i>	26,5	83	42,8	97	–	59	–	4
Euras	<i>Cichorium intybus</i>	–	13	32,8	57	–	12	–	40
Eur-subatl	<i>Leontodon autumnalis</i>	–	10	32,7	50	–	33	–	9
Euras	<i>Phleum pratense</i>	–	13	23,5	38	–	26	–	8
	Cynosurion wet type								
satl-subMed	<i>Cynosurus cristatus</i>	–	47	18,6	75	41	94	–	20
Euras	<i>Anthoxanthum odoratum</i>	–	60	14,2	68	31,7	83	–	13
Euras	<i>Trifolium repens</i>	–	33	–	64	24,2	79	–	56
satl-subMed	<i>Holcus lanatus</i>	–	37	16,7	53	23,7	59	–	7
	Arrhenatherion								
Euras	<i>Medicago lupulina</i>	–	.	–	10	–	17	43,4	48
Euras	<i>Vicia cracca</i>	–	17	–	22	–	17	38,2	58
Euras	<i>Silene vulgaris</i>	–	.	–	1	–	2	32	17
Euras	<i>Poa pratensis</i>	–	40	–	59	–	68	29,6	89
preAlp-subMed	<i>Trisetum flavescens</i>	–	17	–	16	–	14	27,8	42
subMed-satl	<i>Trifolium campestre</i>	–	30	–	23	–	29	25	55
Euras	<i>Cirsium arvense</i>	–	3	–	14	–	9	25	29
Euras	<i>Galium album</i>	–	3	–	11	–	5	24,3	23
satl-subMed	<i>Arrhenatherum elatius</i>	–	20	–	47	–	38	23,9	62
Euras	<i>Dactylis glomerata</i>	–	23	–	65	–	58	21,7	73
	Molinio-Arrhenatheretea								
Euras	<i>Rumex acetosella</i>	38,9	37	2,6	15	–	2	–	1
Eur	<i>Potentilla alba</i>	35,5	23	–	1	–	5	–	.
Euras	<i>Avenula pubescens</i>	33,4	23	–	3	–	3	–	2
Euras	<i>Festuca rubra</i>	31	43	0,4	22	–	17	–	4
Euras	<i>Luzula campestris</i>	29,7	27	–	6	–	9	–	1
Euras	<i>Deschampsia caespitosa</i>	–	3	29,4	39	–	29	–	5
Euras	<i>Lotus corniculatus</i>	–	53	20,7	80	–	61	–	56
Eur	<i>Festuca nigrescens</i>	–	57	10,2	45	–	20	–	23
Eur	<i>Cirsium canum</i>	–	.	–	9	56,5	59	–	12
subMed-Med	<i>Trifolium patens</i>	–	3	–	6	51,3	47	–	4
Eur	<i>Centaurea phrygia</i>	–	10	–	11	48,2	50	–	1
Euras	<i>Alopecurus pratensis</i>	–	7	–	42	45,3	80	–	38
Euras	<i>Carex hirta</i>	–	7	–	10	39,8	42	–	8
Euras	<i>Prunella vulgaris</i>	–	13	6,9	34	39,3	59	–	7
Euras	<i>Lathyrus pratensis</i>	–	3	–	30	38,9	62	–	28
Euras	<i>Lysimachia nummularia</i>	–	.	–	3	34,7	21	–	2
Euras	<i>Rumex acetosa</i>	24,7	73	–	40	32,8	80	–	14
Euras	<i>Festuca pratensis</i>	–	37	–	58	32,1	91	–	72
preAlp	<i>Carum carvi</i>	–	20	–	14	29,6	44	–	12
Euras	<i>Ranunculus acris</i>	–	33	–	58	28,7	76	–	36
EsubMed	<i>Leucanthemum vulgare</i>	–	47	–	34	25,8	65	–	27
Euras	<i>Cerastium holosteoides</i>	–	43	–	42	24,7	67	–	30
Euras	<i>Stellaria graminea</i>	–	70	–	55	23,5	82	–	41
subMed-satl	<i>Colchicum autumnale</i>	–	7	–	4	23,2	20	–	4
EsubMed	<i>Rhinanthus rumelicus</i>	–	50	–	53	23,1	74	–	41
Euras	<i>Carex pallescens</i>	–	.	–	1	19,5	6	–	.
Euras	<i>Mentha longifolia</i>	–	.	–	4	–	5	23,4	15
Euras	<i>Vicia tetrasperma</i>	–	10	–	26	–	15	21,8	38
Euras	<i>Poa trivialis</i>	–	.	–	1	–	6	19,7	12
	Other species								

Biogeogr. affiliation	Number of relevés	30	139	66	298				
subatl-subMed	<i>Chamaespartium sagittale</i>	79,5	73	–	1	–	2	–	1
	<i>Orobanche sp.</i>	42,1	23	–	1	–	.	–	.
Alp	<i>Plantago subulata</i>	32,2	13	–	.	–	.	–	.
subatl-subMed	<i>Hypochaeris radicata</i>	28,6	23	–	9	–	3	–	1
Balc	<i>Armeria rumelica</i>	27,7	10	–	.	–	.	–	.
Eur	<i>Silene otites</i>	27,7	10	–	.	–	.	–	.
Euras	<i>Cuscuta europaea</i>	26,2	10	–	1	–	.	–	.
Euras	<i>Poa compressa</i>	–	7	31,4	29	–	3	–	8
Euras	<i>Rosa canina</i>	–	30	25	46	–	14	–	18
subMed-subatl	<i>Centaurium erythraea</i>	–	3	21,9	13	–	3	–	.
subatl-subMed	<i>Dianthus armeria</i>	–	.	21,3	6	–	.	–	1
Euras	<i>Hypericum perforatum</i>	–	47	21	47	–	8	–	21
EsubMed	<i>Hieracium praealtum</i>	–	13	19,1	27	–	9	–	12
Euras	<i>Bromus arvensis</i>	–	.	–	13	43,1	58	–	30
Euras	<i>Vicia angustifolia</i>	–	3	–	9	27,3	30	–	13
Euras	<i>Poa sylvicola</i>	–	.	–	.	26,9	12	–	2
Euras	<i>Filipendula vulgaris</i>	25,7	57	–	22	26,8	58	–	5
Euras	<i>Festuca rupicola</i>	–	.	–	.	23,5	11	–	3
Eur-Med	<i>Silene italica</i>	–	.	–	.	21,5	6	–	.
subatl-subMed	<i>Ornithogalum umbellatum</i>	–	7	–	1	21,3	14	–	1
Euras	<i>Linum catharticum</i>	–	7	–	.	20,6	14	–	2
subMed-pralp	<i>Allium carinatum</i>	–	.	–	6	20,1	12	–	1
Eur	<i>Gagea pratensis</i>	–	.	–	1	19,5	6	–	.
EsubMed	<i>Allium flavum</i>	–	3	–	1	18,8	9	–	.
subMed-subatl	<i>Geranium dissectum</i>	–	3	–	1	–	3	42,5	31
Eur	<i>Salvia nemorosa</i>	–	3	–	1	–	5	40,3	31
EsubMed	<i>Vicia grandiflora</i>	–	20	–	25	–	20	35,6	60
subMed	<i>Tragopogon dubius</i>	–	.	–	5	–	2	31,9	21
Med-subMed	<i>Lathyrus aphaca</i>	–	.	–	.	–	2	30,8	14
EsubMed-Med	<i>Vicia pannonica</i>	–	.	–	.	–	2	30,4	14
Euras	<i>Convolvulus arvensis</i>	–	10	–	58	–	52	29,9	74
EMed	<i>Dipsacus laciniatus</i>	–	.	–	8	–	3	29,5	22
Eur	<i>Onobrychis arenaria</i>	–	.	–	1	–	6	28,9	19
Med-subMed	<i>Xeranthemum annuum</i>	–	.	–	.	–	2	28,1	12
Euras	<i>Elymus repens</i>	–	10	–	31	–	33	27,4	54
Euras	<i>Myosotis arvensis</i>	–	3	–	5	–	11	26,8	26
Euras	<i>Cirsium vulgare</i>	–	.	–	4	–	2	26,5	15
Euras	<i>Echium vulgare</i>	–	.	–	1	–	.	26,4	11
subMed-Med	<i>Lathyrus nissolia</i>	–	.	–	7	–	5	25,5	20
EsubMed	<i>Vicia villosa</i>	–	3	–	2	–	5	23,7	17
subMed	<i>Dasypyrum villosum</i>	–	.	–	.	–	.	23,2	7
subMed	<i>Bromus sterilis</i>	–	.	–	4	–	3	22,9	14
Eur	<i>Coronilla varia</i>	–	7	–	4	–	5	22,7	20
Euras	<i>Astragalus glycyphyllos</i>	–	3	–	3	–	.	21,3	12
Euras	<i>Chamomilla recutita</i>	–	.	–	2	–	.	21,3	9
Eur	<i>Cirsium ligulare</i>	–	13	–	45	–	29	21,1	52
Euras	<i>Chondrilla juncea</i>	–	.	–	4	–	.	20	9
subMed-Med	<i>Galium aparine</i>	–	.	–	.	–	3	19,8	9
Euras	<i>Alopecurus myosuroides</i>	–	.	–	.	–	.	19,6	5
Euras	<i>Arctium lappa</i>	–	.	–	.	–	.	19,6	5
Euras	<i>Medicago falcata</i>	–	.	–	1	–	5	19,3	10
Euras	<i>Artemisia vulgaris</i>	–	3	–	.	–	2	19,3	10
Eur	<i>Cardaria draba</i>	–	.	–	.	–	.	18,9	5

Biogeogr. affiliation	Number of relevés	30	139	66	298	
subMed-subatl	<i>Clematis vitalba</i>	–	–	–	18,9	5
EsubMed	<i>Melissa officinalis</i>	–	–	–	18,9	5
Euras	<i>Taeniatherum caput-medusae</i>	–	2	–	18,9	7
Euras	<i>Euphorbia esula</i>	–	2	–	18,3	7
Euras	<i>Erodium cicutarium</i>	–	–	–	18,2	4
Med-subMed	<i>Medicago minima</i>	–	–	–	18,2	4
Euras	<i>Tanacetum vulgare</i>	–	1	–	18,1	5
subatl-subMed	<i>Trifolium striatum</i>	–	5	–	13,3	24

Table 2: Summarized statistical components of the obtained vegetation units.

Tabela 2: Statističen povzetek lastnosti vegetacijskih enot.

Vegetation unit	Statistical components						
	Number of relevés	Total species number	Average species number	Average relative frequency	Average positive fidelity	Sharpness index	Uniqueness index
<i>Trifolium medii</i>	30	220	39	17,64	34,43	24,08	38,8
<i>Cynosurion</i> wet type	66	286	42	14,67	27,44	12,77	42
<i>Arrhenatherion</i>	298	411	36	8,68	24,4	9,14	35,7
<i>Cynosurion</i> dry type	139	316	37	11,79	18,6	3,78	37,3

Table 3: Multiple comparison of environmental factors among studied alliances in one-way ANOVA with Bonferroni and Tamhane post-hoc tests. Only variables different at significance level $P < 0.05$ are presented. Abbreviations: A = altitude, Cov = total cover, Cont = continentality, L = light, M = moisture, N = nutrients, pH-ED = empirical obtained soil reaction, pH-Ell = soil reaction obtained using EIV, rich = species richness, T = temperature.

Tabela 3: Primerjava rastiščnih faktorjev med obravnavanimi zvezami z enosmerno analizo variance (ANOVA) z post-hoc testi (Bonferroni in Tamhane). Prikazane so samo spremenljivke, ki so statistično signifikantne ($P < 0.05$). Okrajšave: A = višina, Cov = skupna pokrovnost, Cont = kontinentalnost, L = svetloba, M = vlažnost, N = hranila, pH-ED = izmerjena reakcija tal, pH-Ell = reakcij tal z EIV, rich = število vrst, T = temperatura.

	Dry Cynosurion	Wet Cynosurion	Arrhenatherion
<i>Trifolion medii</i>	Cont; M; N; pH-ED	A; Cov; L; Cont; M; N; pH-Ell; pH-ED	A; Cov; L; T; M; N; pH-Ell; pH-ED
Dry Cynosurion		Cov; L; T; M; rich	A; L; T; Cont; N; pH-Ell; pH-ED
		Wet Cynosurion	A; Cov; L; T; Cont; M; pH-Ell; pH-ED; rich