Cynosurus cristatus grasslands in West Bulgaria

Nikolay Velev[1], Iva Apostolova[1] & Zuzana Fajmonová[2,3]

[1] Department of Plant and Fungal Diversity and Resources, Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Acad. Georgi Bonchev St., bl. 23, 1113 Sofia, Bulgaria, e-mail: nvelev@bio.bas.bg (corresponding author); iva@bio.bas.bg

[2] Department of Vegetation Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Lidická 25/27, CZ-60200 Brno, Czech Republic

[3] Department of Botany and Zoology, Faculty of Science, Masaryk University, Kotlářská 2, CZ-61137 Brno, Czech Republic, e-mail: zuzkaroz@sci.muni.cz

Received: May 28, 2011 ▷ Accepted: July 28, 2011

Abstract. Vegetation traditionally related to the alliance *Cynosurion cristati* was studied in the central part of West Bulgaria. The analysis was based on 202 phytosociological relevés. Classification and ordination of the vegetation were made. As a result of the analyses, four associations were identified: *Anthoxantho odorati-Agrostietum tenuis, Festuco rubrae-Agrostetum capillaris, Bromo racemosi-Cynosuretum cristati,* and *Cirsio cani-Festucetum pratensis*. The ecological conditions of the habitats were assessed by means of Ellenberg Indicator Values. Management regimes of the vegetation within the framework of the four associations are commented on.

Key words: classification, mesic grasslands, ordination, syntaxonomy, vegetation.

Introduction

Cynosurion cristati vegetation includes semi-natural grasslands which are important elements of the landscape. They have developed on soils with a good water and nutrient supply and usually provide high primary production. Their rich biodiversity and economic value merit conservation and appropriate management. The alliance *Cynosurion cristati* was reported for the first time for Bulgaria by Dimitrov (2001) and further discussed by Meshinev & al. (2005) and Velev & al. (2010). According the overview on published syntaxa (Tzonev & al. 2009), two associations have been identified so far for the alliance *Cynosurion cristati* in Bulgaria. The association *Pastinaco hirsutae-Festucetum nigrescentis* Dimitrov 2001 was reported for the Rila and Rhodopi Mts (Dimitrov 2001, 2004, 2010; Roussakova & Dimitrov 2010). Within the framework of this association, two subassocitions were described: subass. *typicum* and subass. *verbascetosum longifolii* Dimitrov 2001, as well as two variants: var. *Galium verum* and var. *Dianthus armeria.* The association *Festuco-Agrostetum* Horvat 1951 was reported for Northwest Bulgaria (Apostolova & Meshinev 2006). Some plant communities dominated by *Lerchenfeldia flexuosa* may also be related to *Cynosurion* alliance (Pavlov & al. 2006).

Kojić & Stojanović (2008) have presented an overview on the meadow and pasture vegetation in the central part of the Balkan Peninsula. No data from Bulgaria were included in the overview. The authors included *Cynosurus cristatus* communities into the association *Cynosutetum cristati* Kojić & al. 2003 s.l., referring it to the alliance *Arrhenatherion elatioris*.

There is lack of knowledge about the diversity of *Cynosurion* alliance in Bulgaria. The aim of the present study is to establish the vegetational diversity of *Cynosurion* alliance in the central part of West Bulgaria.

Material and methods

The area of study lies in the central part of West Bulgaria, covering about 10 000 km^2, which account approximately for 1/10th of the territory of the country. The physical and geographical characteristic and the map of the studied area are given by Velev & al. (2010). During three vegetation seasons (2007–2009) a total of 539 relevés have been collected. The sampling plots were situated so as to cover uniformly the entire study area. A set of 205 relevés, preliminarily classified as alliance *Cynosurion cristati* (cf. Velev & al. 2010) was used for the current analysis. In the course of work three relevés were removed as outliers. The relevé sampling followed the Braun-Blanquet approach (Braun-Blanquet 1965; Westhoff & van der Maarel 1973). Soil samples were collected during the field work. The method was described in details by Velev & al. (2010).

All 539 relevés are stored in TURBOVEG database (Hennekens & Schaminèe 2001). The classification follows the Isopam method (Schmidtlein & al. 2010) using the JUICE 7.0 (Tichý 2002) software package. Indirect Gradient Analysis is applied by two approaches: Detrended Correspondence Analysis (DCA) using the R-project (Ihaka & Gentleman 1996) and JUICE 7.0 software package, and Principal Component Analysis (PCA) using the CANOCO software package (ter Braak & Šmilauer 2002).

Environmental conditions in the habitats were assessed by the unweighted means of Ellenberg Indicator Values (EIV) calculated for each relevé, according to Ellenberg & al. (1992). Only species present in Ellenberg & al. (1992) were used for this calculation. All variables (EIV, total cover, altitudes and species richness) were summarized and presented by eight box and whiskers plots, using Statistica 9.0 software (Statsoft Inc. www.statsoft.com). 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 was made, in order to show which of them manifested statistically significant difference among the studied vegetation units (Table 3).

Soil pH range for each association was based on original measurements.

The species in the synoptic table (Table 1) are represented by two indicators: Fidelity measure, expressed by the Phi-coefficient multiplied by 100 (Chytrý & al. 2002), and Constancy, expressed in percentage. For the fidelity calculation, all relevé groups were standardized to equal size according to the protocol of the JUICE 7.0 software package. The values of Phi-coefficient are corrected by Fisher`s exact test ($P<0.05$), in order to eliminate the statistically insignificant values of Phi-coefficients.

The quality of the classified syntaxa is expressed by the indexes of Sharpness and Uniqueness. Analyses of these indicators have expressed the well-defined and poorly defined vegetation units (Chytrý & Tichý 2003).

Diagnostic species were assessed on the basis of literature and fidelity measure. The threshold value for a

Table 3. Multiple comparison of environmental factors among the studied associations in one-way ANOVA with Bonferroni and Tamhane post-hoc tests

	Festuco-Agrostetum	*Bromo-Cynosuretum*	*Cirsio cani-Festucetum*
Anthoxantho-Agrostietum	M; R	Cov; T; M; R	Rich; M
Festuco-Agrostetum		T	Rich; R
Bromo-Cynosuretum			Rich; T; M; R
Cirsio cani-Festucetum			

Note: Only the variables different at significance level of $P<0.05$ are presented. Abbreviations: **A** = altitude, **Cov** = total cover, **L** = light, **M** = moisture, **N** = nutrients, **R** = soil reaction obtained using Ellenberg Indicator Values, **Rich** = species richness, **T** = temperature.

Table 1. Synoptic table of the studied vegetation units. The species are represented by two indicators: Fidelity measure, expressed by the Phi-coefficient multiplied by 100 (Chytrý & al. 2002) and Constancy, expressed in percentage. Only species with constancy > 5 % at least in one cluster, or > 2 % when cited in literature as characteristic, were included in the synoptic table.

Syntaxa	Anthoxantho-Agrostietum		Festuco-Agrostetum		Bromo-Cynosuretum		Cirsio-Festucetum	
Number of relevés	71		67		17		47	
Fidelity / Constnacy	Phi	%	Phi	%	Phi	%	Phi	%
Anthoxantho-Agrostietum								
Euphorbia cyparissias	**46.8**	38	---	5	---	.	---	4
Briza media	**40.3**	68	---	12	---	6	**22.3**	53
Leontodon hispidus	**40.1**	81	---	38	---	6	---	60
Carlina vulgaris	**36.1**	17	---	.	---	.	---	.
Dactylis glomerata	**35.1**	83	---	42	---	12	**24.8**	74
Hypericum perforatum	**34.4**	53	---	42	---	.	---	11
Trifolium montanum	**33.8**	25	---	3	---	.	---	6
Galium verum	**33.8**	96	---	68	---	24	---	87
Thymus pulegioides	**29.5**	19	---	3	---	.	---	4
Bellis perennis	**23.7**	24	---	9	---	.	---	11
Polygala vulgaris	**19.6**	19	---	2	---	.	---	17
Avenula pubescens	**18.1**	7	---	.	---	.	---	2
Anthoxanthum odoratum	---	69	---	73	---	71	**14.1**	85
Centaurea jacea	**13.8**	21	---	8	---	6	---	17
Ononis spinosa	---	4	---	9	---	.	---	2
Festuco-Agrostetum								
Agrostis capillaris	**23.2**	94	**30.9**	100	---	59	---	57
Festuca rubra agg.	---	62	**27.5**	70	---	18	---	34
Lotus corniculatus	---	69	**26.5**	89	---	47	---	66
Hypochaeris radicata	---	4	**19**	15	---	6	---	2
Ranunculus polyanthemos	---	7	**12.9**	32	---	24	---	28
Trifolium campestre	---	22	---	26	---	24	---	30
Moenchia mantica	---	.	---	5	---	12	---	4
Veronica officinalis	---	1	---	5	---	6	---	2
Nardus stricta	---	1	---	5	---	.	---	2
Alchemilla vulgaris s.l.	---	.	---	3	---	.	---	.
Dianthus deltoides	---	.	---	2	---	.	---	.
Omalotheca sylvatica	---	.	---	2	---	.	---	.
Bromo-Cynosuretum								
Trifolium patens	---	1	---	12	**54.9**	76	**7.7**	38
Rhinanthus minor	---	15	---	21	**28.3**	47	---	19
Alopecurus rendlei	---	.	---	.	**26.1**	12	---	2
Festuca pratensis	---	56	---	62	**24.7**	94	**21.1**	91
Hordeum secalinum	---	.	---	.	**22.8**	12	---	4
Bromus racemosus agg.	---	.	---	2	---	6	---	.
Cirsio cani-Festucetum								
Cirsium canum	---	7	---	11	**35.3**	65	**29.1**	60
Potentilla reptans	---	10	---	30	---	35	**20.4**	47
Poa trivialis	---	1	---	2	---	.	**19.6**	9
Alopecurus pratensis	---	22	---	64	**36.1**	94	**15**	77
Carex muricata	---	1	---	6	---	12	**13.2**	15
Lysimachia nummularia	---	.	---	6	**26.5**	29	**9.2**	19
Carex hirta	---	6	---	18	**37.7**	59	**6.2**	34
Cynosurion								
Plantago major	---	3	**1.1**	21	**38.1**	47	---	11
Linum catharticum	---	.	---	.	---	.	**38.8**	19
Cichorium intybus	**19.8**	50	**32.7**	61	---	12	---	13

Table 1. Continuation.

Syntaxa	Anthoxantho-Agrostietum		Festuco-Agrostetum		Bromo-Cynosuretum		Cirsio-Festucetum	
Number of relevés	71		67		17		47	
Fidelity / Constnacy	Phi	%	Phi	%	Phi	%	Phi	%
Leontodon autumnalis	---	35	**31.5**	71	---	47	---	23
Odontites verna	**25.9**	18	---	9	---	.	---	.
Plantago media	---	24	---	12	---	.	**25.3**	34
Prunella vulgaris	---	28	---	42	---	47	**21.5**	64
Lolium perenne	---	11	**18.7**	50	---	41	---	36
Poa annua	---	1	**14.8**	11	---	6	---	2
Trifolium repens	---	56	---	73	---	71	**13.7**	81
Veronica serpyllifolia	---	.	**11.6**	9	---	6	---	4
Cynosurus cristatus	---	65	**9.7**	91	---	94	---	89
Rhinanthus rumelicus	---	57	---	52	---	76	---	70
Phleum pratense	---	42	---	38	---	12	---	26
Cirsium arvense	---	14	---	12	---	18	---	9
Ranunculus repens	---	3	---	8	---	6	---	4
Luzula campestris	---	8	---	5	---	.	---	13
Arrhenatheretalia* and *Arrhenatherion								
Arrhenatherum elatius	**41.3**	69	---	23	---	.	---	49
Carum carvi	---	11	---	17	**39.4**	65	**6.9**	38
Rumex acetosa	---	46	---	39	---	59	**32.5**	85
Tragopogon pratensis	---	10	---	2	---	.	**30.3**	23
Crepis biennis	---	39	---	27	---	12	**28.8**	57
Trifolium dubium	---	3	**9.5**	33	**27.5**	47	---	21
Leucanthemum vulgare	---	44	---	26	---	47	**27**	70
Medicago lupulina	---	6	---	14	---	.	**26.3**	26
Ranunculus acris	---	60	---	61	**24.4**	88	---	66
Galium album	**23.7**	17	---	3	---	.	---	6
Equisetum arvense	---	3	---	5	---	12	**21.4**	21
Daucus carota	**21.3**	51	---	35	---	18	---	32
Cerastium holosteoides	---	32	---	56	---	53	**20.1**	70
Knautia arvensis	**12.2**	46	---	17	---	29	**18.5**	51
Ranunculus bulbosus	---	1	**17.9**	6	---	.	---	.
Holcus lanatus	---	39	**17.5**	68	---	41	---	64
Tragopogon orientalis	---	6	---	.	---	6	**16.3**	13
Vicia cracca	**15.3**	29	---	15	---	12	---	19
Taraxacum officinale	---	44	**10.8**	70	---	71	---	57
Plantago lanceolata	---	81	**13.1**	92	---	76	---	87
Trifolium pratense	---	68	---	76	---	76	---	72
Poa pratensis	---	50	---	68	---	65	---	70
Veronica chamaedrys	---	15	---	8	---	12	---	19
Trisetum flavescens	---	21	---	12	---	.	---	17
Veronica arvensis	---	1	---	6	---	.	---	11
Campanula patula	---	11	---	6	---	.	---	9
Geranium pratense	---	6	---	.	---	.	---	2
Molinietalia								
Lychnis flos-cuculi	---	4	---	11	**40.7**	41	---	6
Stachys officinalis	---	19	---	8	---	6	**36.9**	45
Juncus effusus	---	.	---	11	**35.5**	29	---	2
Sanguisorba officinalis	---	11	---	2	---	18	**28.2**	34
Carex panicea	---	.	---	.	**25.9**	18	---	9
Colchicum autumnale	---	7	---	.	---	12	**24.2**	23

Table 1. Continuation.

Syntaxa	Anthoxantho-Agrostietum		Festuco-Agrostetum		Bromo-Cynosuretum		Cirsio-Festucetum	
Number of relevés	71		67		17		47	
Fidelity / Constnacy	Phi	%	Phi	%	Phi	%	Phi	%
Rhinanthus angustifolius	---	.	---	.	---	6	**18.9**	11
Poa sylvicola	---	.	---	.	---	12	**16**	13
Juncus articulatus	---	.	**9.1**	11	---	12	---	4
Deschampsia caespitosa	---	36	---	42	---	29	---	23
Trifolium hybridum	---	31	---	32	---	6	---	32
Mentha arvensis	---	.	---	5	---	6	---	2
Equisetum palustre	---	.	---	.	---	6	---	2
Galium palustre	---	.	---	.	---	6	---	2
Bistorta major	---	.	---	.	---	6	---	2
Molinio-Arrhenatheretea								
Lathyrus pratensis	---	44	---	17	---	41	**31.6**	70
Gratiola officinalis	---	.	---	.	**30.2**	12	---	.
Carex vulpina	---	.	---	3	**25**	18	---	6
Juncus tenuis	---	.	**24.1**	8	---	.	---	.
Stellaria graminea	---	50	---	64	---	76	**18.2**	83
Rumex crispus	---	1	---	12	---	6	**15.9**	17
Vicia tetrasperma	---	21	**13.3**	32	---	24	---	13
Achillea millefolium	---	85	---	86	---	71	---	87
Mentha longifolia	---	3	---	5	---	.	---	6
Verbena officinalis	---	3	---	8	---	.	---	2
Trifolium resupinatum	---	.	---	.	---	6	---	2
Poa palustris	---	.	---	.	---	6	---	.
Festuco-Brometea								
Poa bulbosa	---	4	**40.1**	26	---	.	---	.
Poa compressa	---	17	**39.2**	39	---	.	---	4
Festuca valesiaca	**37.1**	69	---	41	---	.	---	43
Festuca rupicola	---	.	---	.	---	.	**34.1**	15
Eryngium campestre	**31.2**	29	---	14	---	.	---	4
Filipendula vulgaris	---	39	---	9	---	35	**30.6**	62
Potentilla neglecta	**25.1**	25	---	14	---	.	---	6
Danthonia alpina	**13.8**	29	---	2	---	12	**24**	36
Potentilla argentea	---	39	**23.8**	44	---	6	---	15
Centaurea rhenana	---	6	**21.6**	12	---	.	---	.
Orchis morio	---	.	---	.	---	.	**22.1**	6
Brachypodium pinnatum	**20.7**	8	---	.	---	.	---	2
Onobrychis arenaria	---	3	---	.	---	.	**19.8**	9
Hieracium bauchinii agg.	---	24	**19.2**	30	---	6	---	11
Inula salicina	**19.1**	8	---	3	---	.	---	.
Medicago falcata	---	1	---	.	---	.	**18.6**	6
Linum austriacum	---	.	**18.6**	5	---	.	---	.
Thymus glabrescens	**18.1**	14	---	9	---	.	---	2
Scabiosa ochroleuca	**17.8**	4	---	.	---	.	---	.
Prunella laciniata	---	6	**16.8**	12	---	.	---	4
Festuca dalmatica	---	1	---	2	---	12	**13.5**	13
Allium flavum	---	.	---	3	---	6	---	9
Allium carinatum	---	12	---	3	---	.	---	13
Teucrium chamaedrys	---	7	---	3	---	.	---	2
Coronilla varia	---	7	---	2	---	.	---	6
Centaurea scabiosa	---	3	---	2	---	.	---	4
Helianthemum nummularium	---	4	---	2	---	6	---	.

Table 1. Continuation.

Syntaxa	Anthoxantho-Agrostietum		Festuco-Agrostetum		Bromo-Cynosuretum		Cirsio-Festucetum	
Number of relevés	71		67		17		47	
Fidelity / Constnacy	Phi	%	Phi	%	Phi	%	Phi	%
Asperula cynanchica	---	6	---	.	---	6	---	.
Chondrilla juncea	---	3	---	5	---	.	---	.
Salvia nemorosa	---	1	---	2	---	.	---	6
Nardo-Callunetea								
Carex ovalis	---	1	**2.8**	17	**33**	35	---	6
Rumex acetosella	---	8	**26.9**	23	---	6	---	.
Sieglingia decumbens	---	6	---	2	---	.	**20.8**	13
Dianthus armeria	---	4	**18.6**	9	---	.	---	.
Carex pallescens	---	.	---	2	---	6	---	6
Potentilla erecta	---	1	---	2	---	6	---	.
Hypericum maculatum	---	.	---	2	---	6	---	.
Trifolio-Geranietea								
Vicia angustifolia	---	12	---	5	---	6	**40.9**	43
Dorycnium herbaceum	**37.5**	21	---	.	---	.	---	2
Agrimonia eupatoria	**34**	65	---	38	---	6	---	38
Clinopodium vulgare	**32.8**	26	---	2	---	.	---	11
Thesium bavarum	**25.2**	11	---	.	---	.	---	2
Astragalus glycyphyllos	**20.6**	6	---	.	---	.	---	.
Lathyrus niger	**20.6**	6	---	.	---	.	---	.
Fragaria vesca	---	15	---	2	---	.	**20.5**	19
Viola hirta	**18.7**	11	---	5	---	.	---	2
Trifolium medium	**18.1**	7	---	.	---	.	---	2
Clematis recta	**17.8**	4	---	.	---	.	---	.
Anthericum liliago	---	1	---	.	---	6	**13.5**	9
Trifolium alpestre	---	4	---	5	---	.	---	.
Thalictrum minus	---	6	---	.	---	.	---	2
Other species								
Trifolium michelianum	---	.	---	6	**47.3**	35	---	.
Trifolium striatum	---	3	---	8	---	.	**46.2**	38
Vulpia myurus	---	3	**43.8**	30	---	.	---	2
Trifolium incarnatum	---	12	---	17	---	.	**39**	45
Ornithogalum umbellatum	---	1	---	2	**38.5**	29	---	6
Rosa sp. juv.	**35.5**	57	---	30	---	12	---	17
Oenanthe silaifolia	---	.	---	2	**38.4**	24	---	2
Crataegus sp. juv.	**33.9**	43	---	17	---	.	---	19
Bromus arvensis	---	1	---	26	**32.7**	65	**24**	57
Mentha spicata	**32.9**	14	---	.	---	.	---	.
Allium scorodoprasum	---	4	---	3	---	.	**31.8**	21
Sanguisorba minor	**26.6**	32	---	6	---	.	---	23
Centaurea phrygia	---	8	---	15	**20.9**	47	**25.9**	51
Ornithogalum nutans	---	.	---	.	---	.	**25.5**	9
Pastinaca hirsuta	---	1	---	6	---	6	**23.3**	19
Hieracium caespitosum	---	.	---	.	---	.	**22.1**	6
Cirsium ligulare	**21.9**	54	---	36	---	24	---	30
Cynodon dactylon	---	.	**21.5**	6	---	.	---	.
Brachypodium sylvaticum	**20.6**	6	---	.	---	.	---	.
Lathyrus nissolia	**20.1**	12	---	3	---	.	---	4
Pyrus pyraster juv.	**19.6**	19	---	12	---	.	---	6
Bromus mollis	---	3	**18.7**	17	---	6	---	6
Avenula compressa	---	1	---	.	---	.	**18.6**	6

Table 1. Continuation.

Syntaxa	Anthoxantho-Agrostietum		Festuco-Agrostetum		Bromo-Cynosuretum		Cirsio-Festucetum	
Number of relevés	71		67		17		47	
Fidelity / Constnacy	Phi	%	Phi	%	Phi	%	Phi	%
Cerastium arvense	---	.	---	2	---	.	**18.3**	6
Chamomilla recutita	---	.	**18.6**	5	---	.	---	.
Rumex pulcher	---	.	**18.6**	5	---	.	---	.
Bromus sterilis	---	.	**18.5**	9	---	.	---	4
Ajuga genevensis	---	.	---	2	---	.	**18.3**	6
Geranium pusillum	---	.	---	2	---	.	**18.3**	6
Rubus caesius juv.	**18.3**	10	---	3	---	.	---	2
Cirsium vulgare	**18.1**	7	---	.	---	.	---	2
Ononis arvensis	---	8	---	6	---	6	**18**	19
Geum urbanum	---	1	---	6	---	6	**17.7**	15
Euphorbia esula	**17.8**	4	---	.	---	.	---	.
Salvia pratensis	**17.8**	4	---	.	---	.	---	.
Taeniatherum caput-medus	**17.8**	4	---	.	---	.	---	.
Trifolium arvense	**17.8**	4	---	.	---	.	---	.
Viola riviniana	**17.8**	4	---	.	---	.	---	.
Cynosurus echinatus	---	10	---	5	---	.	---	2
Vicia grandiflora	---	17	**17.7**	33	---	6	---	28
Gagea pratensis	---	.	---	.	---	6	**15.2**	9
Vicia hirsuta	---	10	**14.3**	18	---	6	---	9
Carex echinata	---	6	**12.7**	26	---	24	---	15
Knautia drymeja	**12.8**	24	---	6	---	18	---	15
Silene italica	---	.	---	.	---	6	**11.1**	6
Alchemilla viridiflora	---	.	**7.4**	8	---	12	---	.
Convolvulus arvensis	---	60	---	55	---	35	---	62
Elymus repens	---	24	---	33	---	47	---	34
Cruciata laevipes	---	31	---	11	---	18	---	32
Centaurium erythraea	---	11	---	15	---	.	---	4
Euphrasia stricta	---	12	---	12	---	6	---	6
Agrostis canina	---	11	---	5	---	6	---	9
Myosotis arvensis	---	4	---	6	---	6	---	13
Prunus sp. juv.	---	1	---	12	---	6	---	11
Dipsacus laciniatus	---	7	---	9	---	6	---	2
Hieracium hoppeanum	---	10	---	8	---	.	---	.
Tragopogon dubius	---	6	---	5	---	6	---	.
Rorippa thracica	---	3	---	6	---	6	---	13
Calamagrostis epigeios	---	3	---	3	---	.	---	2
Crepis setosa	---	6	---	5	---	.	---	.
Trifolium aureum	---	4	---	5	---	.	---	4
Lathyrus tuberosus	---	7	---	.	---	.	---	4
Potentilla inclinata	---	6	---	.	---	.	---	4
Viola tricolor	---	1	---	5	---	.	---	2
Salvia verticillata	---	7	---	2	---	.	---	2
Vicia villosa	---	3	---	2	---	.	---	6
Apera spica-venti	---	1	---	5	---	6	---	.
Bromus inermis	---	4	---	.	---	6	---	.
Carex otrubae	---	.	---	2	---	6	---	4
Luzula luzuloides	---	.	---	3	---	.	---	6
Ornithogalum narbonense	---	.	---	2	---	6	---	4
Rorippa pyrenaica	---	1	---	3	---	6	---	2
Asyneuma canescens	---	.	---	2	---	6	---	.

Table 1. Continuation.

Syntaxa	Anthoxantho-Agrostietum		Festuco-Agrostetum		Bromo-Cynosuretum		Cirsio-Festucetum	
Number of relevés	71		67		17		47	
Fidelity / Constnacy	Phi	%	Phi	%	Phi	%	Phi	%
Carex distans	---	.	---	.	---	6	---	2
Geranium dissectum	---	.	---	2	---	6	---	2
Geranium macrorrhizum	---	.	---	.	---	6	---	.
Hieracium pilosella	---	.	---	.	---	6	---	2
Hordeum bulbosum	---	.	---	.	---	6	---	.
Juncus compressus	---	.	---	.	---	6	---	2
Lactuca serriola	---	.	---	2	---	6	---	.
Lathyrus aphaca	---	.	---	.	---	6	---	.

species to be considered as diagnostic was set at a Phi-coefficient ≥ 20 (multiplied by 100). Species whose cover is ≥ 25 % in minimum 5 % of the relevés of any association have been considered as dominant. Species that have been recorded in minimum 50 % of the relevés of any association were considered constant. The diagnostic, constant and dominant species were alphabetically arranged. Only species with constancy > 5 % at least in one cluster, or > 2 % when cited in literature as characteristic, were included in the synoptic table.

The taxonomy of species follows Kozhuharov (1992) and Delipavlov & Cheshmedjiev (2003). The diagnostic species and the established syntaxa are in compliance with Horvatić & Tomažič (1941), Horvat (1962), Danon & Radmić (1962), Horvatić (1963), Jurko (1969a, b, 1974), Zuidhoff & al. (1995), Dierschke (1997, 2004), Mucina (1997), Kaligaric & al. (2003), Hájková & al. (2007), Uhliarová & al. (2007), Ferrez (2007), Sanda & al. (2008), Stančić (2008) and Janišová & al. (2010).

Results and discussion

As a result from the analyses, four distinct clusters were obtained: *Anthoxantho odorati-Agrostietum tenuis* (represented by 71 relevés), *Festuco rubrae-Agrostetum capillaris* (67 relevés), *Bromo racemosi-Cynosuretum cristati* (17 relevés), and *Cirsio cani-Festucetum pratensis* (47 relevés). The first two associations could be referred to the "dry type" of *Cynosurion*, and the latter two to the "wet type" of *Cynosurion* (cf. Velev & al. 2010). This is well illustrated on Fig. 1, as well as by the presence of a number of diagnostic species for *Festuco-Brometea* in the "dry type" and for *Molinietalia*, respectively, in the "wet type" (Fig. 2, Table 1).

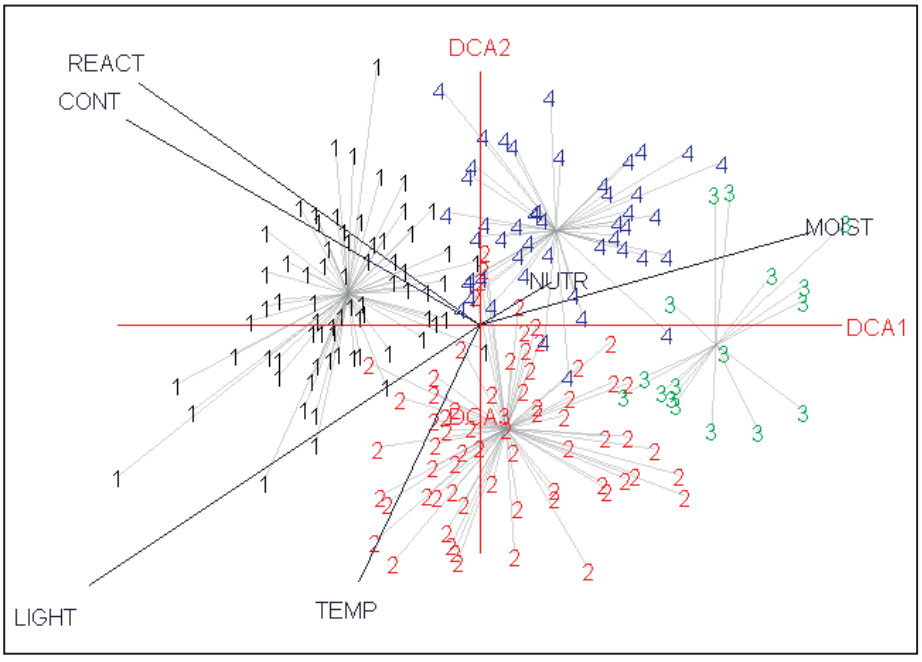

Fig. 1. Indirect gradient analysis. Biplot diagram of DCA. The vectors represent the Ellenberg Indicator Values.
Abbreviations: REACT = reaction, **CONT** = continentality, **TEMP** = temperature, **MOIST**=moisture, NUTR=nutrients; **1** = *Anthoxantho-Agrostietum*, **2** = *Festuco-Agrostetum*, **3** = *Bromo-Cynosuretum*, **4** = *Cirsio cani-Festucetum*

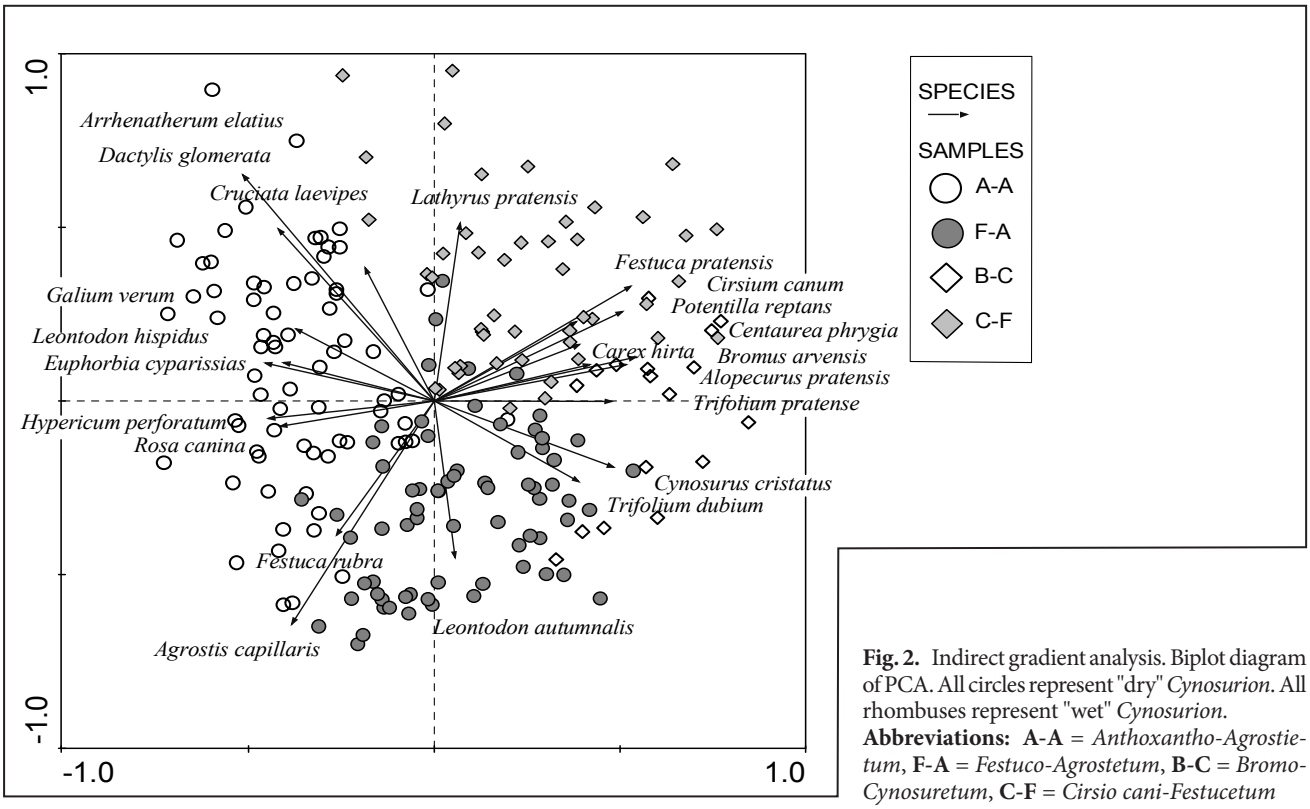

Fig. 2. Indirect gradient analysis. Biplot diagram of PCA. All circles represent "dry" *Cynosurion*. All rhombuses represent "wet" *Cynosurion*.
Abbreviations: **A-A** = *Anthoxantho-Agrostietum*, **F-A** = *Festuco-Agrostetum*, **B-C** = *Bromo-Cynosuretum*, **C-F** = *Cirsio cani-Festucetum*

Molinio-Arrhenatheretea Tüxen 1937
Arrhenatheretalia elatioris Tüxen 1931
Cynosurion cristati Tüxen 1947

Ass. *Anthoxantho odorati-Agrostietum tenuis* Sillinger 1933

Diagnostic species: *Agrostis capillaris, Bellis perennis, Briza media, Carlina vulgaris, Dactylis glomerata, Euphorbia cyparissias, Galium verum, Hypericum perforatum, Leontodon hispidus, Thymus pulegioides, Trifolum montanum*.
Constant species: *Achillea millefolium, Agrimonia eupatoria, Agrostis capillaris, Anthoxanthum odoratum, Arrhenatherum elatius, Briza media, Cirsium ligulare, Convolvulus arvensis, Cynosurus cristatus, Dactylis glomerata, Daucus carota, Festuca pratensis, F. rubra* agg., *F. valesiaca, Galium verum, Hypericum perforatum, Leontodon hispidus, Lotus corniculatus, Plantago lanceolata, Ranunculus acris, Rhinanthus rumelicus, Rosa sp.* juv., *Trifolium pratense, T. repens.*
Dominant species: *Agrostis capillaris, Arrhenatherum elatius.*
Total cover: 60–95 %.
Soil pH range: from medium acidic to slightly acidic (5.07–6.45).
Altitude range: 359–1173 m a.s.l.
Base rock: silicate.

The substrates on which this association develops have shown the highest values of soil reaction and are poor in nutrients. Its habitats are among the least water-supplied, as compared to the other three associations (Fig. 3). Sanda & al. (2008) have determined this association as xeromesophilous. The species forming this association are mesophilous to xerophilous. Many diagnostic species of the class *Festuco-Brometea* are present in its composition. Some of them are simultaneously diagnostic species for the association. Their concentration in the association *Anthoxantho-Agrostietum* and their absence in the other three associations are explained by the high Sharpness Index (Table 2) of that cluster.

In terms of classification, this association is traditionally placed into the alliance *Cynosurion*. There are, however, other syntaxonomic decisions. Uhliarová & al. (2007), Janišová & al. (2010) and Rozbrojová & al. (2010) refer the association to the alliance *Arrhenatherion elatioris* Luquet 1926. According to Kovács (1995), this association should be referred to the alliance *Nardo-Agrostion* Sillinger 1933. Further study is needed to clarify the syntaxonomical position of the association, as well as the correspondence with

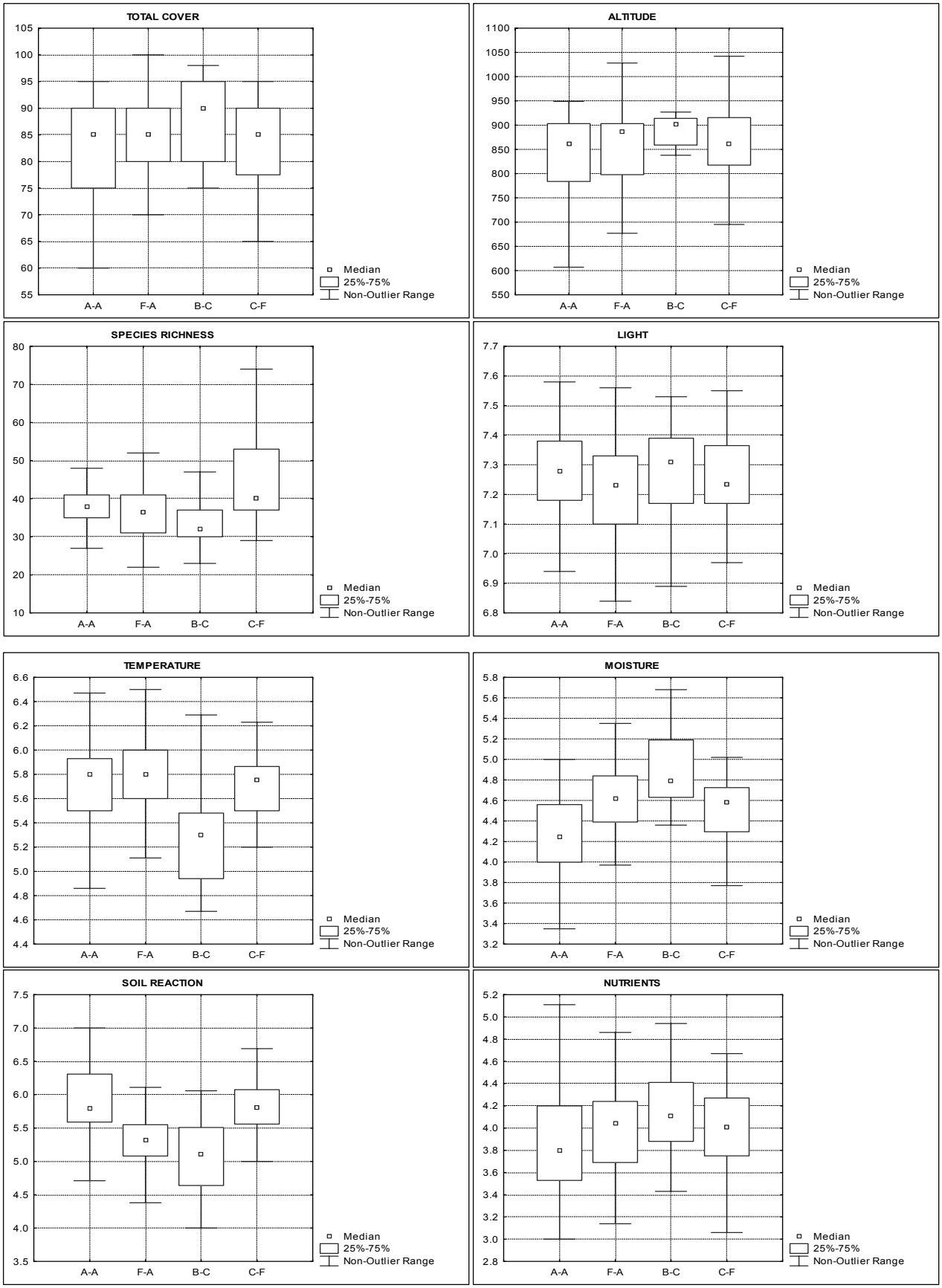

Fig. 3. Box and whiskers plots of the most important variables.

Table 2. Summarized statistical components of the obtained vegetation units

Vegetation unit	Statistical components						
	Number of releves	Total species number	Average species number	Average relative frequency	Average positive fidelity	Sharpness index	Uniqueness index
Anthoxantho-Agrostietum	72	141	38.4	16.41	9.54	19.53	1
Festuco-Agrostetum	66	146	36.8	14.97	5.32	8.16	1
Bromo-Cynosuretum	17	98	33.6	23.16	8.06	20.79	0.961
Cirsio cani-Festucetum	47	186	44.8	17.23	7.27	13.61	0.951

the Sillinger´s type material which does not contain warm-demanding species which are quite common in Bulgarian stands. The current conception of the association is probably too wide even in Central Europe (Rozbrojová & al. 2010)

The vegetation is used for grazing and hay (Fig. 4). A mixed type of utilization of this association is reported from Romania, too (Chifu & al. 2008).

Ass. *Festuco rubrae-Agrostetum capillaris* Horvat 1951

Diagnostic species: *Agrosris capillaris, Festuca rubra* agg., *Lotus corniculatus*.
Constant species: *Achillea millefolium, Alopecurus pratensis, Anthoxanthum odoratum, Cerastium holosteoides, Cichorium intybus, Convolvulus arvensis, Cynosurus cristatus, Festuca pratensis, F. rubra* agg., *Galium verum, Holcus lanatus, Leontodon autumnalis, Lolium perenne, Lotus corniculatus, Poa pratensis, Ranunculus acris, Stellaria graminea, Taraxacum officinale, Trifolium pratense, T. repens.*
Dominant species: *Agrostis capillaris.*
Total cover: 70–100 %.
Soil pH range: from highly acidic to neutral (4.82–6.99).
Altitude range: 677–1629 m a.s.l.
Base rock: silicate.

According to the current knowledge about alliance *Cynosurion*, this association has the largest distribution in the country – from Northeast Bulgaria (Apostolova & Meshinev 2006) to the western boundary. Ecologically, it is closest to the association *Anthoxantho odorati-Agrostietum tenuis.* It differs from the latter by the lower optimum values of soil reaction (Fig. 2, 3). According to some authors (Jovanović-Dunjć & Jovanović 1989), this association is of the mesophilous and even hygromesophilous type, which by our opinion is a very particular case, because in the study area the association is represented by typical mesophilous herbaceous vegetation.

Festuco rubrae-Agrostetum capillaris has few own diagnostic species with Phi-coefficient ≥ 20 (multiplied by 100) and, along with this, contains the species diagnostic for the alliance *Cynosurion* (Table 1). Its floristic composition comprises mainly generalist species, owing to which it has a low Sharpness Index (Table 2). Although positively defined, this association is less differentiated from the other three associations and is close to the central syntaxon concept (Dengler & al. 2005). Apparently, the low number of distinctively diagnostic species explains why the association has been referred to diverse syntaxonomic schemes. Our results (see also Velev & al. 2010) have shown that the place of this association is within the *Cynosurion cristati* alliance. This view is also sup-

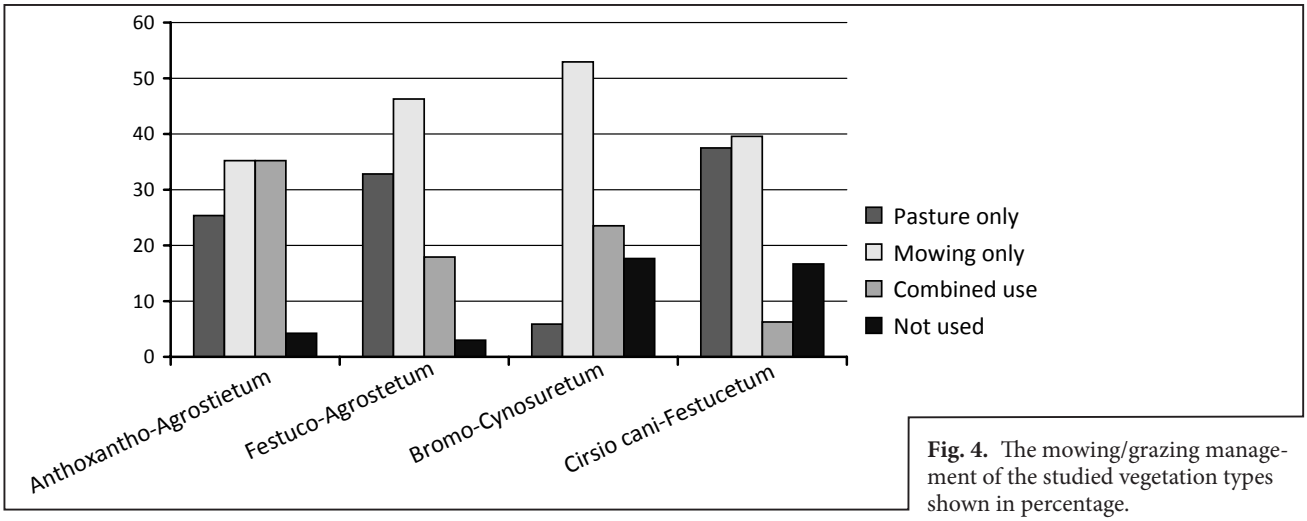

Fig. 4. The mowing/grazing management of the studied vegetation types shown in percentage.

ported by Jurko (1969a, 1974), Pop & al. (1988), Coldea (1990), Zuidhoff & al. (1995), Sanda & al. (1998, 2008), Mihăilescu (2001), Apostolova & Meshinev (2006), and Bărbos (2006). Along with this, a considerable number of authors from former Yugoslavia refer this association to *Arrhenatherion* alliance: Horvat (1962), Horvat & al. (1974), Blečić & Lakušić (1976), Petković (1985), Jovanović-Dunjć & Jovanović (1989), Kojić & al. (1998), Stančić (2000), Šegulja (2005), and Trinajstić (2008). Other syntaxonomic decisions also exist. According to Wendelberger (1965), the association should be referred to alliance *Polygono-Trisetion,* and according to Redžić (2007), to alliance *Festuco-Agrostion capillaris* Redžić 1990.

Within the framework of the study this association occurs at the highest altitudes and could be encountered even above 1600 m a.s.l. Kojić & al. (1998) reported that in Serbia this association occurs above 1000 m a.s.l., most frequently in the altitude range of 1400–1600 m. In Romania, however, it was reported from much lower altitudes, between 350–700 m a.s.l. (Sarbu & al. 2004; Doniță & al. 2005).

Mowing is the prevailing type of its management as for the study region (Fig. 4), as well as for other parts of the country (Apostolova & Meshinev 2006). A prevalent mowing regime was mentioned for Romania too (Frink 2009). Coldea & al. (2008) have reported the succession changes in this association in the region of the Vlădeasa Massif (Romania), depending on the utilization mode of vegetation: Grazing impact and absence of fertilization result in the associations *Violo declinatae-Nardetum* and *Gentiano lutescentis-Nardetum*. Mowing and fertilization result in the association *Poo-Trisetetum flavescentis.*

Ass. *Bromo racemosi-Cynosuretum cristati*
Horvatić (1930) 1958

Diagnostic species: *Alopecurus rendlei, Festuca pratensis, Hordeum secalinum, Rhinanthus minor, Trifolium patens.*

Constant species: *Achillea millefolium, Agrostis capillaris, Alopecurus pratensis, Anthoxanthum odoratum, Bromus arvensis, Carex hirta, Carum carvi, Cerastium holosteoides, Cirsium canum, Cynosurus cristatus, Festuca pratensis, Plantago lanceolata, Poa pratensis, Ranunculus acris, Rhinanthus rumelicus, Rumex acetosa, Stellaria graminea, Taraxacum officinale, Trifolium patens, T. pratense, T. repens.*

Dominant species: *Alopecurus pratensis, Festuca pratensis, Hordeum secalinum, Trifolium dubium, T. michelianum, T. patens.*

Total cover: 75–98 %.

Soil pH range: from medium acidic to slightly acidic (5.28–6.30).

Altitude range: 690–1119 m a.s.l.

Base rock: silicate.

The vegetation is mesophilous to hygrophilous. Its floristic composition comprises a considerable number of diagnostic species for the *Molinietalia* order (Table 1). This distinguishes it from the other three associations and determines its high Sharpness Index (Table 2). Its habitats are characterised by low temperature and soil reaction values and by high moisture and nutrients values. The total cover of vegetation in this association is higher than in the other three associations (Fig. 3). The association develops on temporarily inundated substrates and often borders hygrophilous grassy communities dominated by *Deschampsia caespitosa* (Gaži-Baskova 1964). Considering the ecological peculiarity of the association, Horvatić (1958) placed it in the following succession series related to the soil water supply: *Deschampsietum caespitosae* H-ić 1930 → *Bromo-Cynosuretum cristati* H-ić 1930 → *Arrhenatheretum hircinietosum* H-ić 1956 (=*Arrhenatheretum elatioris* var. *orientalis* H-ić 1941). This manifests the transitional character of the association and explains why it comprises simultaneously diagnostic species for the orders *Molinietalia caeruleae* W. Koch 1926 and *Arrhenatheretalia elatioris* Tüxen 1931 (Table 1). In terms of substrate moisture, Cincović & Kojić (1955) have placed this vegetation between the communities of *Nardus stricta* (moister type) and *Danthonia alpina* (dryer type). The following facies are known within the framework of the association: fac. *Festuca pratensis*, fac. *Trifolium patens* (on moister substrates), fac. *T. incarnatum* (on dryer substrates) and fac. *Carex distans* (Cincović 1956, 1957; Blečic & al. 1973). Horvatić (1963) also reported that *Trifolium patens* often dominated the communities of this association.

This association was described for the first time for Croatia and Slovenia under the name *Cynosutetum cristati* (Horvatić 1930). Floristically and ecologically, this association is very close to ass. *Trifolio-Cynosuretum cristati* Veljović 1967 (cf. Jovanović-Dunjć & al. 1986). In terms of classification, various syntax-

onomic conclusions exist about the affiliation of the association *Bromo-Cynosuretum* to higher-rank syntaxa. Kojić & al. (2004) have classified this type of vegetation as *Cynosutetum cristati* Kojić & al. 2003 s.l. subass. *trifolietosum patensi* Kojić & al. 2003, within the alliance *Arrhenatherion*. Horvatić (1958), Blečic & al. (1973), Blečić & Lakušić (1976), Stančić (2000), and Šegulja (2005) have also referred this association to *Arrhenatherion* alliance. Jovanović (1966) referred some mesophilous grassy communities in Serbia (including the ass. *Bromo-Cynosuretum cristati*) to the alliances *Arrhenatherion elatioris* and *Trifolion resupinati* Micevski 1957. Wendelberger (1965) and Trinajstić (2008) have referred it to the alliance *Cynosurion*. Our analyses have also confirmed the affiliation of this association to the *Cynosurion* alliance.

Kojić & Ivanović (1954) mentioned the communities of *Cynosurus cristatus* as an indistinct association *Cynosutetum cristati* (=*Bromo-Cynosuretum cristati*) – with some diagnostic species missing, e.g., *Rhinanthus minor, Alopecurus rendlei, Hordeum secalinum, Bromus racemosus*.

The vegetation is mainly used for mowing (Fig. 4).

Ass. *Cirsio cani-Festucetum pratensis* Májovski & Růžičková 1971

Diagnostic species: *Cirsium canum, Festuca pratensis, Potentilla reptans.*
Constant species: *Achillea millefolium, Agrostis capillaris, Alopecurus pratensis, Anthoxanthum odoratum, Bromus arvensis, Centaurea phrygia, Briza media, Cerastium holosteoides, Cirsium canum, Convolvulus arvensis, Crepis biennis, Cynosurus cristatus, Dactylis glomerata, Festuca pratensis, Filipendula vulgaris, Galium verum, Holcus lanatus, Lathyrus pratensis, Leontodon hispidus, Leucanthemum vulgare, Lotus corniculatus, Plantago lanceolata, Poa pratensis, Prunella vulgaris, Ranunculus acris, Rhinanthus rumelicus, Rumex acetosa, Stellaria graminea, Taraxacum officinale, Trifolium pratense, T. repens.*
Dominant species: *Festuca pratensis.*
Total cover: 65–95 %.
Soil pH range: from medium acidic to neutral (5.28–6.99).
Altitude range: 358–1117 m a.s.l.
Base rock: silicate – 96 %, limestone – 4 %.

Within the study area, this association has the highest species diversity of *Cynosurion* alliance (Table 2). The vegetation is mesophilous, but at the same time with a number of diagnostic species for the *Molinietalia* order (Table 1). These grasslands show similarity also with association *Lolio perennis-Cynosuretum cristati* Tüxen 1937, which is referred by Zuidhoff & al. (1995) to the moist *Cynosurion* pastures. Considering Table 1, some of the diagnostic species for *Lolio-Cynosuretum* are to be found, presented with high Phi-coefficients: *Cerastium holosteoides, Dactylis glomerata, Festuca pratensis, F. rupicola, Linum catharticum, Medicago lupulina, Plantago media,* and *Potentilla reptans*.

The vegetation of association *Cirsio cani-Festucetum* (=*Agrostio stoloniferae-Deschampsietum caespitosae* Ujvárosi 1947) is reported to have a pontic-pannonian distribution with distribution centre in South-Eastern Europe (Hájková 2007). Traditionally this type of vegetation is classified within the alliances *Arrhenatherion elatioris* and *Deschampsion caespitosae*. Velev & al. (2010) referred these grasslands to a "wet type" of *Cynosurion.* According to Zuidhoff & al. (1995), some *Cynosurion* pastures may develop from *Calthion* hay meadows under the impact of grazing. Nevertheless, the classification of *Cynosurus cristatus* grasslands in Bulgaria to the higher ranks is still open, until a complete vegetation survey of the country will be fulfilled.

In the studied region this vegetation is subject to combined utilization, with equally for grazing and mowing (Fig. 4).

Conclusions

A study of a large area in Bulgaria has shown that vegetation diversity within *Cynosurion* alliance is presented by four distinct vegetation types which can be treated as associations which have been long known in Central Europe. Three of them are reported for the first time for Bulgaria.

It is generally known that the vegetation forming *Cynosurion* alliance is traditionally used as pastures. In the last 20 years, however, in Bulgaria the management has changed. Farm animals have considerably decreased in number and the use of grazing was strongly down. Figure 4 shows that the vegetation of *Cynosurion* alliance is presently used mainly for mowing. Current changes in management regime might result in succession as it was mentioned before. Unlike Central Europe *Cynosurion* vegetation has not been

fertilized or improved in Bulgaria. The lack of grazing animals results in shrub encroachment; we indeed detected *Rosa* sp. juv. and *Crataegus* sp. juv. in some relevés.

Acknowledgements. Part of this investigation was implemented within an exchange project between the Bulgarian and the Czech Academies of Sciences (2008–2010) and the long-term research plan of Masaryk University no.MSM0021622416 and the research projects AVZ0Z6005908 and GD526/09/H025. The authors express sincere thanks to the reviewer.

References

Apostolova, I. & Meshinev, T. 2006. Classification of seminatural grasslands in Northeastern Bulgaria. – Ann. Bot., **6:** 29-52.

Bărbos, M.I. 2006. Montaine grasslands dominated by *Agrostis capillaris* and *Festuca rubra* in Maramureş County. I. Phytosociological analysis. – Contr. Bot. Univ. "Babeş-Bolyai" Cluj-Napoca, **41**(2): 41-52.

Blečić, V. & Lakušić, R. 1976. Prodromus der pflanzengeselschaften von Montenegro. – Glasn. Republ. zavoda zašt. prirode – Prirodnjačkog muz., **9**: 57-98.

Blečic, V., Tatić, B. & Atanacković, B. 1973. Meadow communities of ass. *Bromo-Cynosuretum* in the valley of river Vape. – Journal Geographical Institute "Jovan Cvijić" SASA: 83-87 (in Serbian).

Braun-Blanquet, J. 1965. Plant Sociology: The Study of Plant Communities. (Transl. rev. and ed. by C.D. Fuller and H.S. Conard.) Hafner, London.

Chifu, T., Mânzu, C. & Zamfirescu, O. 2008. Contribution to the study of grassy vegetation in the Ceahlău Mountain. – Analele Şti. Univ. "Al. I. Cuza" Iaşi, s. II a. Biol. veg., **54**(1): 94-102.

Chytrý, M. & Tichý, L. 2003. Diagnostic, constant and dominant species of vegetation classes and alliances of the Czech Republic: a statistical revision. – Folia Fac. Sci. Nat. Univ. Masaryk. Brun., Biol., **108**: 1-231.

Chytrý, M., Tichý, L., Holt, J. & Botta-Dukát, Z. 2002. Determination of diagnostic species with statistical fidelity measures. – J. Veg. Sci., **13**: 79-90.

Cincović, T. 1956. Wiesentypen in Posavina (Serbien). – Der Sammlung Wissenschaftlicher Arbeiten der Landwirtschaftlichen Fakultät, **1**: 1-26.

Cincović, T. 1957. Wiesenphytocenosen im tale der Westlichen Morava (Zapadna Morava). – Der Sammlung Wissenschaftlicher Arbeiten der Landwirtschaftlichen Fakultät, **2**: 1-9.

Cincović, T. & Kojić, M. 1955. Die pflanzengesellschaften der wiesen auf dem Maljengebirge. – Der Sammlung Wissenschaftlicher Arbeiten der Landwirtschaftlichen Fakultät, **1**: 1-6.

Coldea, G. 1990. The Rodna Mountains. A Geobotanical Study. Edit. Acad. Press, Bucharest.

Coldea, G., Filipaş, L., Fărcaş, S., Stoica, A., Ursu, T. & Pop, A.-M. 2008. The relationship between the structure of grasslands from the northeastern slope of the Vlădeasa Massif and socio-economic activities. – Contr. Bot. Univ. "Babeş-Bolyai" Cluj-Napoca, **43**: 53-65.

Danon, J. & Radmić, S. 1962. Ökologische der krautartigen vegetation des Südlichen Kučaj. – Arh. Biol. Nauka, **14**(3-4): 197-213.

Delipavlov, D. & Cheshmedzhiev, I. (eds). 2003. Key to the Plants of Bulgaria. Pp. 65-88. Acad. Press Agrarian Univ., Plovdiv, (in Bulgarian).

Dengler, J., Berg, C. & Jansen, F. 2005. New ideas for modern phytosociological monographs. – Ann. Bot., **5**: 193-210.

Dierschke, H. 1997. *Molinio-Arrhenatheretea* (E 1). Kulturgrasland und verwandte Vegetationstypen. Teil 1: *Arrhenatheretalia*. Wiesen und Weiden frischer Standorte. Göttingen.

Dierschke, H. 2004. *Molinio-Arrhenatheretea* (E 1). Kulturgrasland und verwandte Vegetationstypen. Teil 2: *Molinietalia*. Göttingen.

Dimitrov, M. 2001. Syntaxonomic analysis of herbaceous vegetation in the Yundola Forestry Experimental Station. – In: **Temniskova, D.** (ed.), Proc. Sixth Nat. Conf. Botany, Sofia. Pp. 263-276. Sofia Univ. Press, Sofia (in Bulgarian).

Dimitrov, M. 2004. Floristic classification of the vegetation in the Yundola Forestry Experimental Station. PhD Thesis, Univ. Forestry, Sofia (in Bulgarian, unpubl.).

Dimitrov, M. 2010. Mountain pastures. – In: **Biserkov, V.** (ed.), Red Data Book. Republic of Bulgaria. Vol. 3. Habitats., Sofia, BAS & MOEW, Electronic edition (in Bulgarian).

Doniţă, N., Popescu, A., Paucă-Comănescu, M., Mihăilescu, S. & Biriş, I. A. 2005. Habitats of Romania. Tehnică Silvică Press, Bucharest (in Romanian).

Ellenberg, H., Weber, H., Düll, R., Wirth, W., Werner, W. & Paulissen, D. 1992. Zeigerwerte von Pflanzen in Mitteleuropa. Ed. 2. – Scripta Geobot., **18**: 1-258.

Ferrez, Y. 2007. Contribution à l'étude phytosociologique des prairies mésophiles de Franche-Comté. – Les Nouvelles Archives de la Flore jurassienne, **5**: 67-159.

Frink, J.P. 2009. Overview of the seminatural grassland communities from the middle and lower Arieş river valley (Transylvania, Romania): syntaxonomical checklist. – Transylv. Rev. Syst. Ecol. Res., **7**: 29-40.

Gaži-Baskova, V. 1964. A contribution to the knowledge of the valley meadows of Croatia. – Biol. Glasn., **17**: 33-40 (in Croatian).

Hájková, P. 2007. *Deschampsion cespitosae* Horvatić 1930. – In: **Janišová, M.** (ed.), Grassland vegetation of Slovak Republic – electronic expert system for identification of syntaxa. Pp. 166-180. SAV, Bratislava.

Hájková, P., Hájek, M., Blažková, D., Kučera, T., Chytrý, M., Řezníčková, M., Šumberová, K., Černý, T., Novák, J. & Simonová, D. 2007. Meadows and mesic pastures (*Molinio-Arrhenatheretea*). – In: **Chytrý, M.** (ed.), Vegetation of the Czech Republic. Grassland and heathland vegetation. Vol. **1**, pp. 165-280. Academia, Prague.

Hennekens, S. & Schaminée, J.H.J. 2001. TURBOVEG, a comprehensive data base management system for vegetation data. – J. Veg. Sci., **12**: 589-591.

Horvat, I. 1962. The vegetation of the mountains of Western Croatia. – Prirodoslovna istraživanja JAZU, Acta Biol., **2**(30): 5-179 (in Croatian).

Horvat, I., Glavač, V. & Ellenberg, H. 1974. Vegetation Südosteuropas. G. Fisher Verl. Stuttgart.

Horvatić, S. 1930. Soziologische Einheiten der Niederungswiesen in Kroatien und Slavonien. – Acta Bot. Inst. Bot. Univ. Zagreb, **5**: 57-118.

Horvatić, S. 1958. Geographisch-typologische Gliederung der Niederung-Wiesen und Weiden Kroatiens. – Angewandte pflanzensociologie, **15**: 63–73.

Horvatić, S. 1963. Map of the plant communities of the North Adriatic island of Pag, with a general overview of the vegetation units of the Croatian coastline. – Prirodoslovna istraživanja JAZU, Acta Biol., **4** (33): 5-181 (in Croatian).

Horvatić, S. & Tomažič, G. 1941. Grassland vegetation of the order *Arrhenatheretalia* in the lowlands of Slovenia. – Zborn. Prir. Društva, **2**: 68-75 (in Slovenian).

Ihaka, R. & Gentleman, R. 1996. R: A language for data analysis and graphics. – J. Comput. Graph. Stat., **5**(3): 299–314.

Janišová, M., Uhliarová, E. & Ružičková, H. 2010. Expert system-based classification of seminatural grasslands in submontane and montane regions of central Slovakia. – Tuexenia, **30**: 375-422.

Jovanović, R. 1966. Übersicht der gesellschaften der talwiesen und der sumpfvegetation in Serbien. – In: **Tüxen, R.** (ed.), Antropogene Vegetation. Symposium 1961: XIII-XV, pp. 194-199. Verl. Dr. W. Junk, Den Haag.

Jovanović-Dunjć, R., Stefanović, K., Popović, R. & Dimitrijević, J. 1986. A contribution to the study of meadow ecosystems in the region of the Veliki Jastrebac Mountain. – Glasn. Inst. Bot. Bašte Univ. Beograd, **20**: 7-31.

Jovanović-Dunjć, R. & Jovanović, S. 1989. Review of plant communities of meadows, pastures and mountain peat bogs in the National Park of Tara (Serbia). – Glasn. Inst. Bot. Bašte Univ. Beograd, **23**: 69-75 (in Serbian).

Jurko, A. 1969a. Syntaxonomische revision der gesellschaften des *Cynosurion* – verbandes in den Rumanischen karpaten. – Acta Bot. Croat., **28**: 207-219.

Jurko, A. 1969b. Die weidegesellschaften des Strážover Berglandes in der Nordwestslowakei und die syntaxonomischen probleme des *Cynosurion* – Verbandes in den Westkarpaten. – Folia Geobot. Phytotax., **4**: 101-132.

Jurko, A. 1974. Prodromus der *Cynosurion* – Gesellschaften in den Westkarpaten. – Folia Geobot. Phytotax., **9**: 1-44.

Kaligaric, M., Seliskar, A. & Veen, P. 2003. Grasslands of Slovenia. Status and conservation of seminatural grasslands. – Society for Natural History in Slovenia and Royal Dutch Society for Nature Conservation.

Kojić, M. & Ivanović, M. 1954. Phytocoenologic investigations of meadows on the southern slopes of the Maljen Mountain – Zborn. Rad. Poljopr. Fak. Univ. Beogradu, **2**: 59-75 (in Serbian).

Kojić, M. & Stojanović, S. 2008. Meadow and pasture vegetation cover in the central part of the Balkan Peninsula – general characteristics and syntaxonomic status. – I Symposium of Serbian Biologists. Banja Luka 10-12.11.2005. Univ. Banja Luka, Fac. Sci., Series Skup., **2**: 23-40 (in Serbian).

Kojić, M., Popović, R. & Karadžić, B. 1998. A syntaxonomic review of vegetation in Serbia. Inst. Biol. Istraž. "S. Stanković" Press., Belgrade (in Serbian).

Kojić, M., Mrfat-Vukelić, S., Dajić, Z. & Djordjević-Milosević, S. 2004. Meadows and Pastures of Serbia. Agricultural Research Institute Serbia, Belgrade: 1-89 (in Serbian).

Kovács, A. 1995. Syntaxonomical overview of the grasslands. – Tilia, **1**: 86-144 (in Hungarian).

Kozhuharov, S., (ed.). 1992. Field Guide to the Vascular Plants in Bulgaria. Nauka & Izkustvo, Sofia (in Bulgarian).

Levene, H. 1960. Robust tests for equality of variances. – In: **Olkin, I. & al.** (eds), Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling. Pp. 278-292. Stanford Univ. Press, Stanford.

Meshinev, T., Apostolova, I., Georgiev, V., Dimitrov, V., Petrova, A. & Veen, P. 2005. Grasslands of Bulgaria. Final Report on the National Grasslands Inventory Project – Bulgaria, 2001–2004. Dragon 2003 Ltd. Publishers, Sofia.

Mihăilescu, S. 2001. The flora and vegetation of Piatra Craiuliu Massif. Vergiliu, Bucharest.

Mucina, L. 1997. Conspectus of classes of European vegetation. – Folia Geobot. Phytotax., **32**: 117–172.

Pavlov, D., Dimitrov, M. & Malinova, D. 2006. Syntaxonomic analysis of the vegetation in landscape types in Bulgarka Nature Park. – Nauka Gorata, **1**: 3-29 (in Bulgarian).

Petković, B. 1985. Die Bergwiesen und Weiden in Tutin`s Gebiet. – Glasn. Inst. Bot. Bašte Univ. Beograd, **19**: 175-189.

Pop, I., Cristea, V., Hodişan, I. & Gergely, I. 1988. Le Conspectus des associations végétales sur l`étendue du department de Cluj. – Contr. Bot. Univ. "Babeş-Bolyai" Cluj-Napoca, **28**: 10-23.

Redžić, S. 2007. Syntaxonomic diversity as an indicator of ecological diversity – case study Vranica Mts in the Central Bosnia. – Biologia, **62**(2): 173-184.

Roussakova, V. & Dimitrov, M. 2010. Mountain hay meadows. – In: **Biserkov, V.** (ed.): Red Data Book. Republic of Bulgaria. Vol. 3. Habitats., Sofia, BAS & MOEW, Electronic edition (in Bulgarian).

Rozbrojová, Z., Hájek, M. & Hájek, O. 2010. Vegetation diversity of mesic meadows and pastures in the West carpatians. – Preslia, **82**: 307-332.

Sanda, V., Popescu, A. & Barabaş, N. 1998. Syntaxonomy and Characteristics of Romanian Vegetation. Edit. "I. Borcea", Bacău (in Romanian).

Sanda, V., Öllerer, K. & Burescu, P. 2008. The Phytocoenoses of Romania. Syntaxonomy, Structure, Dynamics and Development. Edit. Ars Docendi, Univ. Bucharest.

Sarbu, A., Coldea, G., Negrean, G., Cristea, V., Hanganu, J. & Veen, P. 2004. Grasslands of Romania. Final report on National Grasslands Inventory 2000 – 2003. Univ. Bucharest.

Schmidtlein, S., Tichý, L., Feilhauer, H. & Faude, U. 2010. A brute-force approach to vegetation classification. – J. Veg. Sci., **21**: 1162-1171.

Šegulja, N. 2005. Vegetation of grassland, moor and swamp habitats in the National Park Plitvice Lakes. – Nat. Croat., **14**(2): 1-194.

Stančić, Z. 2000. Grasslands of class *Molinio-Arrhenatheretea* in the Northwestern Croatia. PhD Thesis. Univ. of Zagreb (in Croatian).

Stančić, Z. 2008. Classification of mesic and wet grasslands in northwest Croatia. – Biologia, **63**(6): 1089-1103.

ter Braak, C. & Šmilauer, P. 2002. CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithaca, New York.

Tichý, L. 2002. JUICE, software for vegetation classification. – J. Veg. Sci., **13**: 451-453.

Trinajstić, I. 2008. Plant Communities of Croatia. Acad. Sci. Forest. Zagreb.

Tzonev, R., Dimitrov, M., & Roussakova, V. 2009**.** Syntaxa according to the Braun-Blanquet approach in Bulgaria. – Phytol. Balcan., **15**(2): 209-233.

Uhliarová, E., Janišová, M. & Ujházy, K. 2007. *Arrhenatherion elatioris* Luquet 1926. – In: **Janišová, M.** (ed.), Grassland Vegetation of the Slovak Republic – Electronic Expert System for Identification of Syntaxa, pp. 91-94. SAV, Bratislava.

Velev, N., Apostolova, I., Rozbrojová, Z. & Hájková, P. 2010. The alliances *Arrhenatherion*, *Cynosurion* and *Trifolion medii* in Western Bulgaria – environmental gradients and ecological limitations. – Hacquetia, **9**(2): 207-220.

Wendelberger, G. 1965. Zur Vegetationsgliederung Südosteuropas. – Mitt. Naturwiss. Vereines Steiermark, **95**: 245-286.

Westhoff, V. & **van der Maarel, E.** 1973. The Braun-Blanquet approach. 2-nd ed. – In: **Whittaker**, **R.** (ed.), Classification of Plant Communities. Pp. 287-399. Junk, The Hague.

Zuidhoff, C., Rodwell, S. & Schaminée, H.J. 1995. The *Cynosurion cristati* Tx. 1947 of Central, Southern and Western Europe: a tentative overview, based on the analysis of individual relevés. – Ann. Bot., **53:** 25-47.