Alliance *Arrhenatherion elatioris* in West Bulgaria

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Abstract. Vegetation relating to the alliance *Arrhenatherion elatioris* has been studied in the central part of West Bulgaria. Classification and ordination of vegetation were performed. As a result of the analyses, four associations have been identified: *Ranunculo repentis-Alopecuretum pratensis, Tanaceto vulgaris-Arrhenatheretum elatioris, Pastinaco sativae-Arrhenatheretum elatioris* and *Ranunculo bulbosi-Arrhenatheretum elatioris*. In ass. *Ranunculo repentis-Alopecuretum pratensis,* two distinctive subgroups have been observed, differing in humidity of their substrate. The more humid one is the typical variation of the association, while the drier one is described as var. *Eryngium campestre*. The mode of vegetation use within the framework of the four associations is commented on.

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

Introduction

Mesophyllous vegetation of the class *Molinio-Arrhenatheretea* is very poorly studied in Bulgaria. The alliance *Arrhenatherion* was reported for the first time in Meshinev & al. (2005) and further commented in more details by Velev & al. (2010). All syntaxa published according to Braun-Blanquet approach for the country are summarized by Tzonev & al. (2009). Only one association and one plant community have been referred to alliance *Arrhenatherion*. Association *Arrhenatheretum elatioris* Br.-Bl. 1915 is reported for Sofia region (West Bulgaria), while the geographical variant of the association (Central Balkan Geographic Variant) is described from the Rhodopes (Apostolova & al. 2007). A plant community of the type *Poa pratensis-Dactylis glomerata* (Pavlov & al. 2006) is mentioned for the alliance, described from the northern slopes of the Central Balkan Range.

The purpose of the present study is to identify the syntaxonomic diversity of the alliance *Arrhenatherion elatioris* in the central part of West Bulgaria.

Material and methods

The study area lies in West Bulgaria, stretching over three administrative districts of the country: the region of Sofia City, Sofia district and Pernik district (Fig. 1). They cover an area of 10796 km^2, accounting approximately for one-tenth of the territory of the country. The physical and geographical characteristics of the studied region are presented by Velev & al. (2010). A total of 539 vegetation plots were sampled within the framework of three vegetation seasons (in the period 2007–2009). The plots have been laid out so as to cover uniformly the entire study area. We used a subset of 298 relevés which were previously classi-

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

fied as alliance *Arrhenatherion elatioris* (cf. Velev & al. 2010). Plot sampling was set up after the phytosociological approach of Braun-Blanquet (Braun-Blanquet 1965; Westhoff & van der Maarel 1973). Details on field data collection and soil sampling is given in Velev & al. (2010).

All relevés are stored in the TURBOVEG database (Hennekens & Schaminèe 2001). Classification was made with the help of Isopam method using Bray-Curtis distance measure (Schmidtlein & al. 2010) by JUICE 7.0 software package (Tichý 2002, Tichý & Holt 2006). The ordination method Indirect Gradient Analysis (Detrended Correspondence Analysis – DCA) was applied with the help of R-project (Ihaka & Gentleman 1996) and JUICE 7.0 software package (Tichý 2002, Tichý & Holt 2006).

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

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

Diagnostic species were assessed at the base of the fidelity. The threshold value for a species to be considered as diagnostic was set to Phi-coefficient ≥0.20. Species with cover ≥25 % in minimum 5 % of the relevés for any association have been accepted as dominant. Species which have been recorded in a minimum of 50 % of the relevés for any association were considered constant. The diagnostic, constant and dominant species are alphabetically arranged. Only species with constancy >5 % at least in one cluster, or >2 % when pointed out in the literature as characteristic, are included in the synoptic table.

The taxonomy of species follows Kozhuharov (1992) and Delipavlov & Cheshmedjiev (2003). The diagnostic species and established syntaxa are in compliance with Ellmauer & Mucina (1993), Ellmauer (1995), Mucina (1997), Chytrý & Vicherek (2003), Kaligaric & al. (2003), Hájková (2007), Hájková & al. (2007), Uhliarová & al. (2007), Škodová & Janišová (2008) and Janišová & al. (2010).

Environmental conditions in the habitats were assessed by means of the Ellenberg Indicator Values for species (EIV), according to Ellenberg & al. (1992). All variables (EIV, total cover, altitude, and species richness) are summarized and presented in nine 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. Homogeneity (equality) of variance assumption was tested by Levene's test (Levene 1960). A multiple comparison of the summarized variables is presented, in order to show which of them manifests a significant statistical difference among the studied vegetation units (Table 3).

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

Results and Discussion

As a result of the conducted analyses, four distinct groups of relevés were obtained. These are the associations *Ranunculo repentis-Alopecuretum pratensis, Tanaceto vulgaris-Arrhenatheretum elatioris, Pastinaco sativae-Arrhenatheretum elatioris*, and *Ranunculo bulbosi-Arrhenatheretum elatioris*. The association *Ranunculo repentis-Alopecuretum pratensis* is represented by two distinct subgroups in relation to the

humidity of substrate. The more humid subgroup of 27 relevés represents the typical form of the association – var. typicum. The drier subgroup (var. *Eryngium campestre*) of 49 relevés is a deviation from the typical form.

So far in the literature there are different concepts about the volume and syntaxonomical diversity of the alliance *Arrhenatherion elatioris*. Päzolt & Jansen (2004) indicate only one association for the alliance – *Arrhenatheretum elatioris* Br.-Bl. 1915. According to other authors (Ellmauer & Mucina 1993; Hájková & al. 2007; Uhliarová & al. 2007) the syntaxonomical diversity within this alliance is considerably higher. Our results allow us to adopt the opinion of the latter authors who support the idea of a greater diversity within alliance *Arrhenatherion*.

Molinio-Arrhenatheretea Tüxen 1937
Arrhenatheretalia elatioris Tüxen 1931
Arrhenatherion elatioris Luquet 1926

Ass. *Ranunculo repentis-Alopecuretum pratensis* (Eggler 1933) Ellmauer in Mucina & al. 1993

Diagnostic species: *Alopecurus pratensis, Carex hirta, C. vulpina, Cirsium canum, Holcus lanatus, Lysimachia nummularia, Potentilla reptans, Ranunculus acris, R. repens, Trifolium pratense.*

Constant species: *Achillea millefolium, Agrimonia eupatoria, Cirsium ligulare, Convolvulus arvensis, Dactylis glomerata, Daucus carota, Festuca pratensis, Galium verum, Geranium dissectum, Leontodon hispidus, Lotus corniculatus, Plantago lanceolata, Poa pratensis, Ranunculus acris, Trifolium pratense, T. repens, Taraxacum officinale, Vicia grandiflora, V. cracca.*

Dominant species: *Arrhenatherum elatius, Festuca pratensis.*

Total cover: 65–100 %.

Soil pH range: from medium acidic to very slightly alkaline (5.03–7.16).

Altitude range: 677-913 m a.s.l.

Base rock: silicate.

The substrates on which this association is developed are rich in nutrients, which is in conformity with statements for the other parts of its distribution (Hájková 2007, Uhliarová & al. 2007). Its habitats are among the best water-supplied, as compared to the other three associations (Figs 2, 3; Table 3). Vegetation that formed this association was determined as mesophylous to hygrophilous (Chytrý & Vicherek 2003). Similar vegetation type is classified in Czech Republic and Slovak Republic as ass. *Poo trivialis-Alopecuretum pratensis* Regel 1925 within alliance *Deschampsion caespitosae* Horvatić 1930 (Hájková 2007, Uhliarová &

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.

Syntaxa	*Ranunculo repentis-Alopecuretum pratensis* variant *typicum*		*Ranunculo repentis-Alopecuretum pratensis* variant *Eryngium campestre*		*Tanaceto vulgaris-Arrhenatheretum elatioris*		*Pastinaco sativae-Arrhenatheretum elatioris*		*Ranunculo bulbosi-Arrhenatheretum elatioris*	
Number of relevés	27		49		47		37		138	
Fidelity / Constancy	**Phi**	%	**Phi**	%	**Phi**	%	**Phi**	%	**Phi**	%
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Ranunculo-Alopecuretum										
Carex vulpina	**58.5**	44	**...**	.	**...**	4	**...**	.	**...**	.
Cirsium canum	**49.4**	59	**...**	2	**...**	13	**...**	22	**...**	4
Ranunculus repens	**39.4**	30	**...**	.	**...**	2	**...**	8	**...**	1
R. acris (Arrh)	**37.9**	81	**...**	39	**...**	32	**...**	41	**...**	27
Potentilla reptans	**31.3**	67	**...**	8	**...**	32	**18.2**	54	**...**	22
Trifolium pratense (Arrh)	**30.4**	93	**...**	67	**...**	26	**...**	62	**5.8**	69
Alopecurus pratensis (Arrh)	**30.1**	78	**...**	31	**...**	47	**11.8**	59	**...**	24
Carex hirta	**27**	30	**...**	.	**...**	15	**...**	14	**...**	2
Lysimachia nummularia	**22.5**	11	**...**	.	**...**	2	**...**	3	**...**	.
Holcus lanatus (Arrh)	**18.9**	22	**22.6**	24	**...**	2	**...**	3	**...**	1
Cerastium holosteoides (Arrh)	**16.7**	48	**19.7**	51	**...**	4	**...**	32	**...**	27
Festuca pratensis (Arrh)	**16.8**	93	**13.3**	90	**...**	57	**19.2**	95	**...**	60
Poa trivialis	**12.8**	26	**...**	.	**...**	19	**18**	30	**...**	7
Lychnis flos-cuculi	**15.1**	11	**...**	2	**...**	4	**...**	5	**...**	1
Centaurea jacea	**...**	11	**...**	.	**...**	2	**...**	8	**...**	8
Glechoma hederacea	**…**	4	**…**	.	**…**	.	**…**	.	**…**	.
Sanguisorba officinalis	**…**	.	**…**	2	**…**	.	**…**	.	**…**	.
Tanaceto-Arrhenatheretum										
Artemisia vulgaris	**...**	4	**...**	2	**38.4**	34	**...**	5	**...**	7

Table 1. Continuation

1	2	3	4	5	6	7	8	9	10	11
Cirsium arvense	...	19	**14.3**	47	**29.9**	62	...	27	...	13
Convolvulus arvensis	...	37	...	71	**20.6**	89	...	78	...	77
Dactylis glomerata	...	44	...	78	**20.6**	91	...	84	...	69
Elymus repens	...	48	...	39	**15.3**	70	...	65	...	53
Cichorium intybus	...	15	...	35	...	47	...	49	...	43
Tanacetum vulgare	...	4	...	6	...	9	...	5	...	4
Melilotus officinalis	...	.	...	.	...	6	...	.	...	5
Linaria vulgaris	...	.	...	4	...	2	...	.	...	1
Pastinaco-Arrhenatheretum										
Trisetum flavescens (Arrh)	...	30	...	20	...	28	**26.9**	65	**12.4**	51
Bromus mollis	...	4	...	4	...	4	**26.7**	27	**12.2**	18
Galium album (Arrh)	...	15	...	4	**13.5**	36	**24.9**	46	...	22
Tragopogon pratensis	...	4	...	10	...	19	...	19	...	14
Pastinaca sativa	...	.	...	.	...	4		3	...	.
Ranunculo-Arrhenatheretum										
Festuca rubra agg. (Arrh)	...	7	...	2	...	13	...	27	**32.7**	44
Coronilla varia	...	.	...	6	...	.	...	24	**32.3**	35
Potentilla argentea	...	7	...	35	...	4	...	8	**28.1**	41
Filipendula vulgaris	...	.	...	.	...	.	...	3	**23.9**	10
Knautia arvensis (Arrh)	...	4	...	6	...	21	...	16	**22.7**	33
Lotus corniculatus (Arrh)	...	52	**19.3**	69	...	19	...	41	**19.5**	70
Leucanthemum vulgare (Arrh)	...	22	...	12	...	15	...	19	**20.8**	38
Plantago media (Arrh)	...	19	...	18	...	15	...	30	**20.1**	42
Avenula pubescens (Arrh)	...	.	...	.	...	.	...	.	**18.7**	4
Salvia pratensis	...	.	...	.	...	9	...	11	**18.3**	17
Briza media	...	.	...	10	...	6	...	.	**16.1**	14
Anthoxanthum odoratum (Arrh)	...	22	...	.	...	.	...	11	**15.6**	20
Clinopodium vulgare	...	.	...	2	...	.	...	.	**15.4**	5
Veronica chamaedrys (Arrh)	...	.	...	.	...	4	...	11	**12.8**	11
Plantago lanceolata (Arrh)	...	74	...	61	...	47	...	81	**12.6**	80
Achillea millefolium	...	67	...	90	...	62	...	92	**12.3**	90
Rumex acetosa (Arrh)	...	15	...	4	...	9	...	14	**10.6**	19
Galium verum	...	44	...	69	...	57	...	73	**10.1**	73
Fragaria vesca	...	11	...	2	...	4	...	8	**10**	13
Tragopogon orientalis	...	11	...	6	...	4	...	5	...	12
Ranunculus bulbosus	...	4	...	.	...	2	...	.	...	1
Festuca rupicola	...	.	...	.	...	4	...	8	...	2
Carex caryophyllea	...	4	...	.	...	.	...	.	...	1
Bromus erectus	...	.	...	.	...	.	...	3	...	1
Campanula patula	...	.	...	2	...	.	...	.	...	1
Carex montana	...	.	...	.	...	.	...	.	...	1
Arrhenatherion										
Daucus carota	...	30	**39**	84	...	45	...	35	...	31
Leontodon hispidus	...	15	**37.1**	73	...	21	...	30	**11.3**	49
Arrhenatherum elatius	...	22	...	63	**34**	94	...	65	...	58
Silene vulgaris	...	.	...	.	...	23	...	3	**27.9**	28
Medicago lupulina	...	41	...	27	...	15	...	59	**24.2**	65
Trifolium campestre	...	22	...	63	...	30	...	46	**22.9**	69
Bromus arvensis	**16.2**	48	...	27	...	21	...	41	...	28
Crepis biennis	...	44	...	2	...	45	...	51	**9.5**	47
Poa pratensis	...	89	...	96	...	91	...	97	...	83
Rhinanthus minor	...	22	...	12	...	2	...	5	...	15
Trifolium dubium	...	7	...	.	...	.	...	8	...	5
Molinio-Arrhenatheretea										
Trifolium hybridum	...	33	**34.1**	57	...	21	...	16	...	7
Cynosurus cristatus	**34**	56	...	22	...	.	**10.6**	35	...	16
Juncus effusus	**30.2**	11	...	.	...	.	...	.	...	.
Trifolium repens	...	63	**29**	86	...	21	...	59	...	56
T. patens	**28.5**	19	...	2	...	2	...	3	...	2
Equisetum arvense	...	7	...	.	**25**	23	...	11	...	4
Plantago major	...	26	...	14	...	13	**22.5**	38	...	9

Table 1. Continuation

1	2	3	4	5	6	7	8	9	10	11
Prunella vulgaris	**22**	22	**...**	8	**...**	.	**...**	11	**...**	6
Carex ovalis	**20.8**	11	**...**	.	**...**	2	**...**	3	**...**	1
C. panicea	**20.3**	7	**...**	2	**...**	.	**...**	.	**...**	.
Vicia sepium	**...**	4	**...**	.	**...**	.	**20**	11	**...**	3
Juncus compressus	**19.1**	7	**...**	.	**...**	.	**...**	3	**...**	.
Lolium perenne	**15.4**	48	**...**	33	**...**	13	**18.8**	51	**...**	23
Taraxacum officinale	**...**	63	**...**	69	**...**	60	**18.4**	84	**...**	57
Ononis arvensis	**18.2**	19	**...**	2	**...**	.	**...**	14	**...**	8
Mentha longifolia	**...**	26	**...**	10	**6**	26	**17.9**	35	**...**	7
Stellaria graminea	**17.6**	59	**...**	24	**...**	28	**...**	54	**...**	44
Leontodon autumnalis	**...**	4	**...**	14	**...**	2	**16.7**	19	**...**	7
Deschampsia caespitosa	**16.6**	15	**...**	4	**...**	6	**...**	5	**...**	2
Vicia tetrasperma	**15.9**	56	**...**	39	**...**	26	**...**	43	**...**	37
Rumex crispus	**13.8**	30	**15**	31	**...**	19	**...**	5	**...**	9
Vicia cracca	**...**	48	**...**	69	**...**	49	**...**	68	**...**	57
Lathyrus pratensis	**...**	33	**...**	31	**...**	32	**...**	24	**...**	26
Vicia hirsuta	**...**	19	**...**	2	**...**	17	**...**	22	**...**	20
Phleum pratense	**...**	11	**...**	4	**...**	13	**...**	14	**...**	7
Poa annua	**...**	11	**...**	6	**...**	.	**...**	11	**...**	4
Colchicum autumnale	**...**	4	**...**	.	**...**	4	**...**	5	**...**	5
Veronica serpyllifolia	**...**	7	**...**	.	**...**	.	**...**	5	**...**	1
Festuco-Brometea										
Eryngium campestre	**...**	.	**53.8**	63	**...**	4	**...**	3	**12.8**	30
Hieracium bauchinii	**...**	.	**50.3**	43	**...**	4	**...**	.	**...**	9
Sanguisorba minor	**...**	4	**...**	10	**...**	2	**...**	.	**46.8**	41
Centaurea rhenana	**...**	.	**...**	.	**...**	.	**...**	.	**34.6**	14
Thymus glabrescens	**...**	4	**...**	.	**...**	.	**...**	.	**34.5**	19
Echium vulgare	**...**	.	**33.9**	31	**...**	11	**...**	.	**...**	9
Onobrychis arenaria	**...**	.	**...**	.	**...**	15	**...**	11	**33.4**	33
Teucrium chamaedrys	**...**	4	**...**	4	**...**	9	**...**	5	**29.7**	28
Hypericum perforatum	**...**	4	**27.5**	39	**...**	17	**...**	5	**...**	24
Festuca valesiaca	**...**	26	**...**	63	**...**	36	**...**	49	**26.6**	77
F. dalmatica	**...**	.	**...**	.	**...**	.	**...**	8	**25**	15
Trifolium montanum	**...**	.	**24.9**	12	**...**	.	**...**	.	**...**	4
Chondrilla juncea	**...**	.	**24.4**	20	**...**	6	**...**	.	**...**	11
Linum austriacum	**...**	.	**...**	.	**...**	.	**...**	.	**23**	7
Centaurea scabiosa	**...**	.	**...**	.	**...**	.	**...**	.	**23**	7
Koeleria macrantha	**...**	.	**...**	2	**...**	.	**...**	.	**21.3**	8
Medicago falcata	**...**	.	**...**	2	**...**	2	**...**	14	**20.3**	17
Fragaria viridis	**...**	.	**...**	.	**...**	.	**...**	3	**20.2**	8
Salvia verticillata	**...**	.	**...**	.	**...**	2	**...**	5	**17.9**	10
Dorycnium herbaceum	**...**	.	**...**	.	**...**	.	**...**	.	**17.1**	4
Viola hirta	**...**	.	**...**	.	**...**	.	**...**	.	**17.1**	4
Euphorbia seguerana	**...**	.	**...**	.	**...**	.	**...**	.	**15.3**	3
Scabiosa ochroleuca	**...**	.	**...**	.	**...**	.	**...**	3	**14.2**	5
Euphorbia cyparissias	**...**	4	**...**	8	**...**	9	**...**	.	**...**	12
Other species										
Vicia villosa	**...**	7	**57.5**	63	**...**	11	**...**	3	**...**	9
Lathyrus nissolia	**...**	7	**53.2**	61	**...**	6	**...**	5	**...**	16
Xeranthemum annuum	**...**	.	**48.9**	43	**...**	2	**...**	3	**...**	10
Taeniatherum caput-medusae	**...**	.	**48.2**	33	**...**	.	**...**	.	**...**	4
Hordeum secalinum	**43.1**	22	**...**	.	**...**	.	**...**	.	**...**	.
Chamomilla recutita	**...**	7	**38.3**	33	**...**	2	**...**	3	**...**	4
Myosotis arvensis	**...**	30	**33.6**	59	**...**	21	**...**	16	**...**	17
Lathyrus sylvestris	**...**	.	**33.5**	16	**...**	2	**...**	.	**...**	.
Alopecurus myosuroides	**...**	4	**33.6**	22	**...**	4	**...**	.	**...**	1
Salvia nemorosa	**...**	.	**...**	2	**...**	28	**...**	30	**33.4**	49
Knautia drymeja	**...**	.	**...**	.	**...**	.	**...**	3	**33.1**	17
Odontites verna	**...**	.	**32.5**	20	**...**	.	**...**	.	**...**	7
Lathyrus tuberosus	**...**	.	**32.4**	18	**...**	.	**...**	.	**...**	5
Carex echinata	**31.2**	48	**...**	16	**...**	23	**...**	19	**...**	4

Table 1. Continuation

1	2	3	4	5	6	7	8	9	10	11
Juncus articulatus	**30.2**	11	**...**	.	**...**	.	**...**	.	**...**	.
Trifolium incarnatum	**...**	11	**...**	18	**...**	15	**...**	27	**30**	50
Galium divaricatum	**...**	.	**28.9**	10	**...**	.	**...**	.	**...**	.
Agrimonia eupatoria	**...**	30	**28.1**	76	**...**	28	**...**	46	**11.2**	59
Medicago minima	**...**	.	**...**	.	**...**	.	**...**	.	**27.7**	9
Potentilla neglecta	**...**	4	**...**	6	**...**	2	**...**	5	**27.6**	33
Cirsium ligulare	**...**	11	**27.4**	73	**...**	30	**...**	57	**13.4**	59
Ranunculus arvensis	**...**	.	**27.4**	10	**...**	.	**...**	.	**...**	1
Vulpia myurus	**...**	.	**26.9**	12	**...**	.	**...**	.	**...**	3
Trifolium arvense	**...**	.	**26.1**	10	**...**	.	**...**	.	**...**	1
Allium scorodoprasum	**...**	11	**...**	.	**25.8**	21	**...**	3	**...**	3
Astragalus glycyphyllos	**...**	.	**...**	2	**12.7**	21	**25.4**	30	**...**	11
Carex distans	**24.5**	7	**...**	.	**...**	.	**...**	.	**...**	.
Gaudinia fragilis	**24.5**	7	**...**	.	**...**	.	**...**	.	**...**	.
Polygonum aviculare	**24.5**	7	**...**	.	**...**	.	**...**	.	**...**	.
Thesium simplex	**...**	.	**...**	.	**...**	.	**...**	.	**24.3**	7
Euphorbia esula	**...**	.	**...**	.	**...**	6	**...**	.	**23.7**	13
Potentilla inclinata	**...**	.	**...**	.	**...**	2	**...**	.	**23.7**	9
Rosa canina juv.	**...**	4	**23.5**	33	**...**	9	**...**	14	**...**	20
Cardaria draba	**...**	.	**...**	2	**...**	6	**23.5**	16	**...**	3
Anchusa officinalis	**...**	.	**...**	.	**...**	.	**...**	.	**23**	7
Lathyrus aphaca	**...**	19	**22.9**	35	**...**	13	**...**	14	**...**	7
Ornithogalum nutans	**22.9**	7	**...**	.	**...**	.	**...**	.	**...**	1
Astragalus glycyphylloides	**...**	.	**...**	.	**22.7**	6	**...**	.	**...**	.
Conium maculatum	**...**	.	**...**	.	**22.7**	6	**...**	.	**...**	.
Bidens tripartita	**…**	.	**…**	.	**…**	…	**22.6**	8	**…**	1
Melampyrum arvense	**...**	.	**22**	14	**...**	2	**...**	3	**...**	5
Bromus sterilis	**...**	7	**21.8**	33	**...**	13	**...**	22	**...**	8
Viola tricolor	**...**	.	**21.8**	10	**...**	2	**...**	.	**...**	2
Arenaria serpyllifolia	**...**	.	**...**	2	**...**	4	**...**	.	**21.6**	12
Trifolium ochroleucon	**21.4**	7	**...**	.	**...**	.	**...**	.	**...**	1
Geranium dissectum	**9.8**	48	**21.1**	59	**...**	32	**...**	38	**...**	16
Dipsacus laciniatus	**13.8**	41	**20.6**	47	**...**	28	**...**	16	**...**	10
Carex muricata	**...**	15	**...**	.	**...**	4	**20.4**	22	**...**	7
Rorippa thracica	**20.2**	11	**...**	6	**...**	.	**...**	.	**...**	1
Urtica dioica	**...**	4	**...**	.	**...**	11	**20**	16	**...**	1
Geum urbanum	**...**	7	**...**	16	**...**	4	**19.8**	24	**…**	6
Rubus caesius juv.	**...**	7	**19.8**	14	**...**	.	**...**	.	**...**	5
Crepis pulchra	**…**	.	**…**	…	**18.5**	4	**…**	.	**…**	.
Poa compressa	**...**	.	**19.3**	16	**...**	4	**...**	3	**...**	10
Trifolium striatum	**...**	15	**19.2**	35	**...**	11	**...**	5	**15.6**	32
Vicia pannonica	**...**	15	**...**	2	**...**	9	**19.2**	27	**...**	17
Artemisia absinthium	**…**	.	**…**	.	**…**	.	**19**	5	**…**	1
Tragopogon dubius	**...**	.	**...**	16	**18.7**	32	**...**	16	**...**	24
Thymus callieri	**...**	.	**...**	.	**...**	.	**...**	.	**18.7**	4
Poa bulbosa	**...**	.	**...**	4	**...**	.	**...**	11	**18.3**	14
Veronica arvensis	**...**	7	**18.1**	24	**...**	6	**...**	14	**...**	11
Rumex obtusifolius	**...**	.	**18.1**	4	**...**	.	**...**	.	**...**	.
Vicia varia	**...**	.	**18.1**	4	**...**	.	**...**	.	**...**	.
Anthriscus cerefolium	**...**	.	**...**	.	**...**	2	**18.1**	8	**...**	2
Rhinanthus rumelicus	**...**	41	**17.7**	55	**...**	21	**...**	27	**...**	46
Mentha spicata	**...**	4	**...**	.	**17.7**	11	**...**	3	**...**	2
Geranium pusillum	**...**	.	**...**	.	**...**	.	**...**	5	**17.7**	9
Galium aparine	**...**	15	**...**	.	**17.5**	23	**10.6**	19	**...**	3
Polygala vulgaris	**...**	.	**...**	.	**...**	2	**...**	3	**17.1**	8
Cirsium vulgare	**...**	11	**...**	8	**17**	28	**...**	16	**...**	14
Carlina acanthifolia	**...**	.	**...**	.	**...**	.	**...**	3	**15.8**	6
Pastinaca hirsuta	**...**	.	**...**	2	**...**	.	**...**	5	**15.5**	9
Oenanthe banatica	**15.3**	7	**...**	.	**...**	.	**...**	5	**...**	.
Hieracium caespitosum	**...**	.	**...**	.	**...**	.	**...**	.	**15.3**	3
Nonea pulla	**...**	.	**...**	.	**...**	.	**...**	.	**15.3**	3

Table 1. Continuation

1	2	3	4	5	6	7	8	9	10	11
Digitalis lanata	...	.	...	.	...	2	...	.	**15.2**	5
Hordeum murinum	**15.2**	11	...	4	...	2	...	5	...	1
Lactuca serriola	...	4	...	2	**15.1**	15	**12.4**	14	...	1
Dasypyrum villosum	...	4	...	.	...	2	...	8	**14.7**	12
Centaurea cyanus	...	.	...	2	**14.1**	6	...	3	...	.
Capsella bursa-pastoris	...	11	...	6	...	.	**14**	14	...	2
Berteroa incana	...	4	...	.	...	.	...	3	**13.9**	7
Crataegus monogyna juv.	...	.	**13.5**	14	...	2	...	14	...	7
Centaurea solstitialis	...	.	...	.	...	2	...	.	**13.5**	4
Trifolium michelianum	...	4	...	.	...	.	**13.4**	5	...	.
Centaurea phrygia	...	4	...	.	...	.	**13.4**	5	...	.
Agrostis canina	...	4	**13.3**	8	...	4	...	.	...	1
Arctium lappa	...	7	...	2	...	11	**12.7**	14	...	1
Avena fatua	...	4	**12.2**	6	...	2	...	.	...	.
Cruciata laevipes	...	22	...	4	...	11	...	19	**10.9**	24
Vicia grandiflora	...	59	...	55	...	51	...	70	...	62
Ranunculus polyanthemos	...	22	...	12	...	32	...	32	...	33
Rhinanthus angustifolius	...	30	...	.	...	13	...	24	...	19
Vicia angustifolia	...	19	...	16	...	11	...	16	...	10
Ajuga genevensis	...	.	...	10	...	13	...	3	...	6
Anthemis arvensis	...	.	...	4	...	6	...	11	...	4
Clematis vitalba	...	.	...	2	...	11	...	5	...	4
Geranium columbinum	...	4	...	2	...	6	...	.	...	8
Lathyrus hirsutus	...	7	...	4	...	4	...	5	...	5
Melissa officinalis	...	4	...	4	...	4	...	3	...	6
Agrostis capillaris	...	7	...	8	...	.	...	.	...	5
Anthriscus caucalis	...	4	...	.	...	4	...	8	...	5
Consolida regalis	...	.	...	4	...	4	...	5	...	4
Erodium cicutarium	...	.	...	.	...	6	...	3	...	7
Falcaria vulgaris	...	.	...	.	...	9	...	5	...	4
Pyrus pyraster juv.	...	.	...	6	...	2	...	3	...	5
Thesium bavarum	...	.	...	2	...	6	...	.	...	6
Viola arvensis	...	.	...	6	...	4	...	.	...	4
Melilotus officinalis	...	.	...	.	...	6	...	.	...	5
Petrorhagia prolifera	...	.	...	2	...	.	...	3	...	5
Potentilla erecta	...	.	...	8	...	.	...	.	...	4
Valerianella dentata	...	.	...	.	...	6	...	3	...	4
Rumex patientia	...	4	...	.	...	6	...	5	...	1
Poa sylvicola	...	7	...	4	...	5	...	.	...	.

Arrh - Diagnostic species for alliance *Arrhenatherion*

Table 3. Multiple comparison of environmental factors among studied associations 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 = soil reaction obtained using Ellenberg Indicator Values, rich = species richness, T = temperature.

	Ranunculo-Alopecuretum var. *Eryngium campestre*	*Tanaceto-Arrhenatheretum*	*Pastinaco-Arrhenatheretum*	*Ranunculo-Arrhenatheretum*
Ranunculo-Alopecuretum var. *typicum*	Cov; pH; L; M; N	Rich; pH; M	Cov; pH; Cont; M	Cov; Rich; pH; A; L; T; Cont; M; N
Ranunculo-Alopecuretum var. *Eryngium campestre*		Cov; Rich; A; M; N	Cov; A; L; M; N	A; Cont; M; N
Tanaceto-Arrhenatheretum			Rich	Cov; Rich; A; T; Cont; M; N
Pastinaco-Arrhenatheretum				L; T; M; N
Ranunculo-Arrhenatheretum				

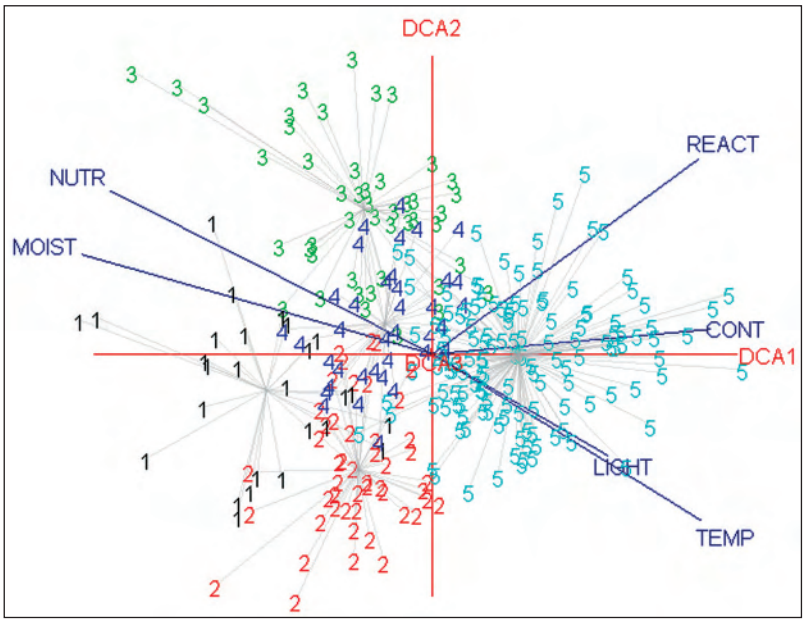

Fig. 2. Indirect gradient analysis. Biplot diagram of DCA. The vectors represent the Ellenberg Indicator Values.
Abbreviations: **REACT** = reaction, **CONT** = continentality, **TEMP** = temperature, **MOIST** = moisture, **NUTR** = nutrients.
1 = *Ranunculo repentis-Alopecuretum pratensis* var. *typicum*
2 = *Ranunculo repentis-Alopecuretum pratensis* var. *Eryngium campestre*
3 = *Tanaceto vulgaris-Arrhenatheretum elatioris*
4 = *Pastinaco sativae-Arrhenatheretum elatioris*
5 = *Ranunculo bulbosi-Arrhenatheretum elatioris*

al. 2007). In the studied area, ass. *Ranunculo repentis-Alopecuretum pratensis* is represented by two variants differing in humidity of their substrate.

There are no reasons to define distinct subassociations yet. We propose two variants considering the ecology and management of the grasslands. The typical variation of the association – var. *typicum* is poorly represented. The drier variant *Eryngium campestre* is more widely distributed. It is characterised with many diagnostic species for the class *Festuco-Brometea: Agrimonia eupatoria, Chondrilla juncea, Echium vulgare, Eryngium campestre, Hieracium bauchinii, Hypericum perforatum, Trifolium montanum,* etc. Characteristically, a number of species indicating ruderalisation and disturbance of habitats are also present: *Dipsacus laciniatus*, *Cirsium ligulare*, *Lathyrus aphaca*, *L. nissolia*, *Taeniatherum caput-medusae*, *Vicia villosa*, *Xeranthemum annuum,* etc. (Table 1). This deviation from the typical variant of the association is due to most intensive land-use (Fig. 4). Vegetation within the framework of var. *Eryngium campestre* is subject to a higher rate of grazing and combined use – grazing and hay-making. Intensive grazing in the communities of ass. *Ranunculo repentis-Alopecuretum pratensis* is also mentioned by Lüth & al. (in press). Disturbances caused by the grazing and trampling of animals favour the advent of ruderal elements and drying out of the habitats. A similar type of changes has been also observed for other vegetation types in the study area (Todorova & Tzonev 2010). A detailed study in relation to the insetting changes in ass. *Ranunculo repentis-Alopecuretum pratensis* under the impact of grazing is presented by Gselman & al. (2003). Vegetation of the typical variant was mainly used for hay-making, while the grazing was not so active (Fig. 4).

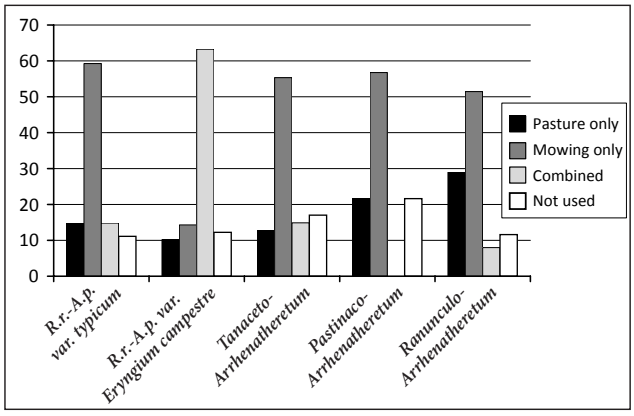

Fig. 4. The mowing/grazing management of the studied vegetation types.

Ass. *Tanaceto vulgaris-Arrhenatheretum elatioris* Fischer ex Ellmauer in Mucina & al. 1993

Diagnostic species: *Artemisia vulgaris, Cirsium arvense, Convolvulus arvensis, Dactylis glomerata.*
Constant species: *Achillea millefolium, Arrhenatherum elatius, Dactylis glomerata, Convolvulus arvensis, Cirsium arvense, Elymus repens, Festuca pratensis, Galium verum, Poa pratensis, Taraxacum officinale, Vicia grandiflora.*
Dominant species: *Arrhenatherum elatius, Elymus repens.*
Total cover: 60–100 %.
Soil pH range: from medium acidic to very slightly alkaline (5.51–7.04).

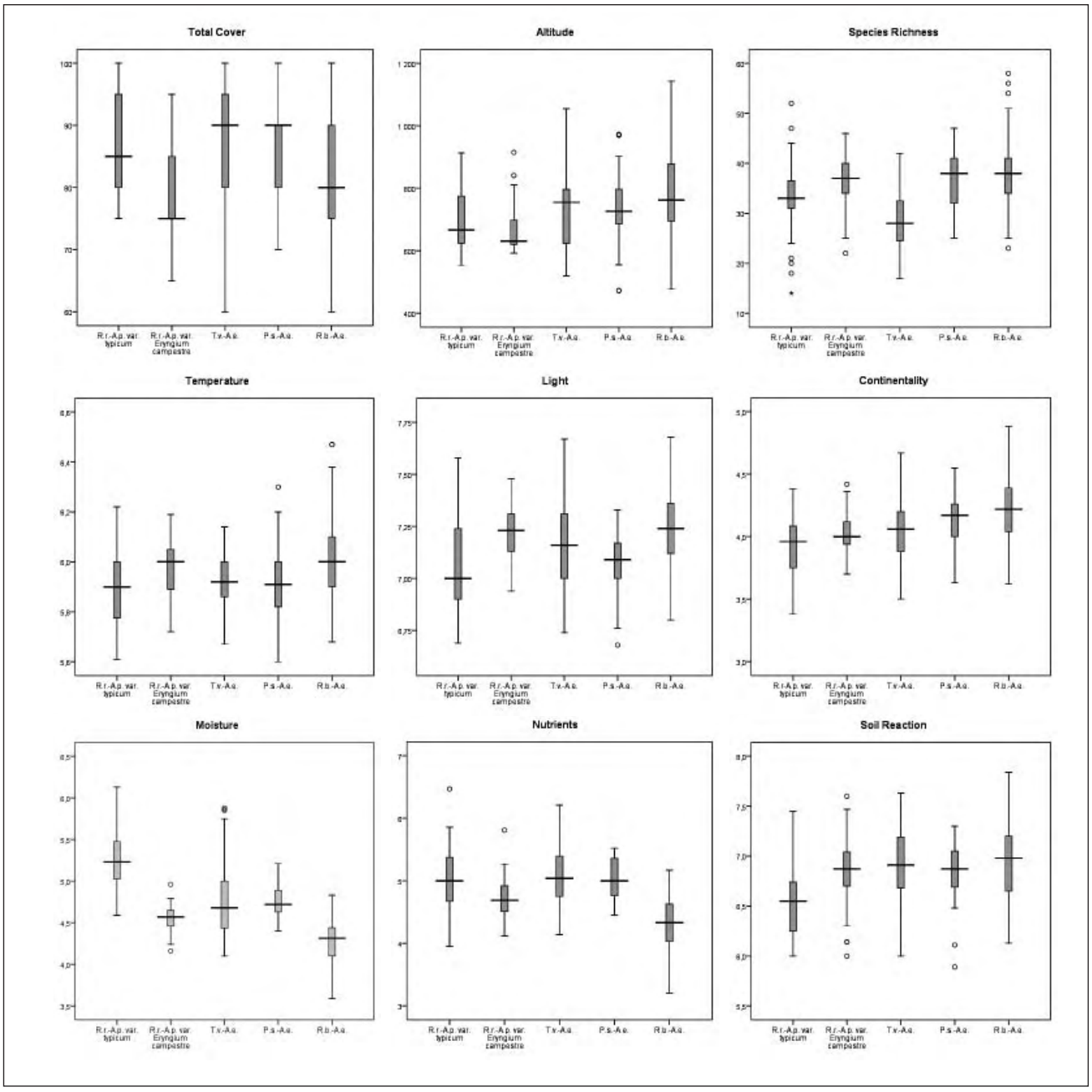

Fig. 3. Box and whiskers plots of the most important variables.

Altitude range: 520–1055 m a.s.l.
Base rock: silicate – 98 %, limestone – 2 %.

This mesophyllous vegetation characteristically has a number of diagnostic species for the class *Artemisietea vulgaris* Lohmeyer & al. ex von Rochow 1951, such as *Artemisia vulgaris, Cichorium intybus, Cirsium vulgare, Elymus repens, Lactuca serriola, Melilotus officinalis*, *Tanacetum vulgare,* etc. These species were mentioned at the same time as diagnostic for the association (Ellmauer & Mucina 1993; Dierschke 1997). Ecologically, the association is close to *Pastinaco sativae-Arrhenatheretum elatioris.* Fischer & al. (1985) characterize its communities as a transitional vegetation type between the associations *Arrhenatheretum elatioris (=Pastinaco sativae-Arrhenatheretum elatioris)* and *Tanaceto-Artemisietum*. In comparison with the other three associations in the investigated area, *Tanaceto vulgaris-Arrhenatheretum elatioris* is the association with the lowest species diversity, and at the same time with a high total cover (Table 2, Fig. 3). Association *Tanaceto vulgaris-Arrhenatheretum elatioris* is mainly used for hay-making (Fig. 4).

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
Ranunculo-Alopecuretum var. typicum	27	121	32.96	18.52	8.2	22.01	1
Ranunculo-Alopecuretum var. Eryngium campestre	49	120	36.65	19.71	11.32	30.23	1
Tanaceto-Arrhenatheretum	47	102	28.26	13.99	3.98	8.53	1
Pastinaco-Arrhenatheretum	37	135	36.41	18.57	3.96	5.87	1
Ranunculo-Arrhenatheretum	138	234	38.2	11.3	6.08	22.6	1

Ass. *Pastinaco sativae-Arrhenatheretum elatioris* Passarge 1964

Diagnostic species: *Bromus mollis*, *Galium album, Trisetum flavescens*.
Constant species: *Achillea millefolium, Alopecurus pratensis, Arrhenatherum elatius, Dactylis glomerata, Cirsium ligulare, Convolvulus arvensis, Crepis biennis, Elymus repens, Festuca pratensis, Galium verum, Lolium perenne, Medicago lupulina, Plantago lanceolata, Poa pratensis, Potentilla reptans, Stellaria graminea, Taraxacum officinale, Trifolium pratense, T. repens, Trisetum flavescens, Vicia grandiflora, V. cracca*.
Dominant species: *Alopecurus pratensis.*
Total cover: 70–100 %.
Soil pH range: from medium acidic to very slightly alkaline (5.21–7.32).
Altitude range: 472–973 m a.s.l.
Base rock: silicate – 86 %, limestone – 14 %.

This association represents the most typical vegetation of the mesic grasslands. The species diversity is high, but consisting mainly of generalist species, which explains the low Sharpness Index (Table 2). This association was reported for the study area by Apostolova & al. (2007) with the synonym *Arrhenatheretum elatioris* Br.-Bl. 1915. Our study has extended the distribution of its communities in the West Bulgaria and confirmed the higher altitude prevalence mentioned by Apostolova & al. (2007), as compared to Central Europe. Uhliarová & Janišová (2007) reported this vegetation type as one of the widest distributed both in Slovakia and in the other countries of Central Europe. Within the framework of the investigated region, it turned out that this association was more poorly represented (37 relevés), as compared to the other established associations. The communities were mainly used for hay-making. However, the greatest number of abandoned terrains was found there (Fig. 4).

Ass. *Ranunculo bulbosi-Arrhenatheretum elatioris* Ellmauer in Mucina & al. 1993

Diagnostic species: *Coronilla varia, Festuca rubra agg., Filipendula vulgaris, Knautia arvensis, Potentilla argentea.*
Constant species: *Achillea millefolium, Agrimonia eupatoria, Arrhenatherum elatius, Cirsium ligulare, Convolvulus arvensis, Dactylis glomerata, Elymus repens, Festuca pratensis, F. valesiaca, Galium verum, Lotus corniculatus, Medicago lupulina, Poa pratensis, Plantago lanceolata, Taraxacum officinale, Trifolium campestre, T. pratense, T. repens, Trisetum flavescens, Vicia grandiflora, V. cracca.*
Dominant species: *Arrhenatherum elatius.*
Total cover: 60–100 %.
Soil pH range: from medium acidic to very slightly alkaline (5.03–7.42).
Altitude range: 477–1143 m a.s.l.
Base rock: silicate – 84 %, limestone – 16 %.

This is the widest distributed association within the study area, falling into the range of alliance *Arrhenatherion.* The habitats were characterized by low humidity values and low nutritive substances in the substrate (Fig. 3). As compared to the other three associations, *Ranunculo bulbosi-Arrhenatheretum elatioris* develops in habitats with more intensive light and higher temperature. This is why we consider this type of vegetation as mesoxerophytic. It comprises many diagnostic species for the class *Festuco-Brometea* (Table 1). These species are differential for the distinction from *Pastinaco sativae-Arrhenatheretum elatioris* (Ujházy & al. 2007). Owing to this, *Ranunculo bulbosi-Arrhenatheretum elatioris* has a high Sharpness index (Table 2). The association is best distinguished in the ordination space. This is connected with the higher values of the factors light, temperature and continentality (Fig. 2, Table 3). Continentality is a complex factor, reflecting the lower values of moisture and the higher thermal characteristics of the region at microhabitat level. This is the reason for the presence of many thermophile species in this association. Similar situation is observed also in Central Europe (Uhliarová & al. 2007). Vegetation of the ass. *Ranunculo bulbosi-Arrhenatheretum*

elatioris is mainly used for hay-making, but in many cases combined use (hay-making and grazing) was observed. Stančić (2008) reported that in Croatia this type of grasslands is disappearing, because of the abandoning of hay mowing. In Bulgaria, such terrains are still mowed for hay and the percentage of abandoned land was comparatively small (Fig. 4).

Investigation of a large region of Bulgaria has shown that within alliance *Arrhenatherion* diversity of the vegetation has been presented by four associations. These syntaxa have been known for Central Europe for a long time, but three of them are reported for the first time for Buglaria. The analyses have shown that mesophyllous vegetation from alliance *Arrhenatherion* does not show any specificity on a regional level. The plant communities were poor in endemic species. This invited the conclusion that the Balkan Peninsula, which is rich in specific vegetation (cf. Horvat & al. 1974), in relation to mesic grasslands seems closer to Central Europe. The latter is due to the great number of generalist species, which have a wide geographical area. Another factor determining the similarity of plant communities of that type in a broad geographical range is the mode of their use. Traditionally, the plant communities of alliance *Arrhenatherion* have been used for hay-making. Such management ensures the presence of species adapted to recurrent mowing, but not suitable for intensive grazing. The abandonment of mowing as a land use mode has led to changes in these communities. More xerophytic conditions in Bulgaria, as compared to Central Europe, determine the presence of more diagnostic species for the class *Festuco-Brometea* in mesic grasslands. The transition from hay-making to grazing observed in some places would speed up the processes of xerophytisation. Another process observed in the vegetation of mesic grasslands is the increasing presence of ruderal species, as a consequence of the combined land use (both for hay-making and for grazing) as well as the fragmentation of habitats.

The vegetation of alliance *Arrhenatherion* has considerable floristic richness (a total of 411 higher plant species and mosses have been registered in the relevés). It is also important as a high-quality fodder resource. Lowland hay meadows are subject to protection under Directive 92/43 EEC. In our opinion, measures aimed at retaining the traditional land use would guarantee the protection of this type of vegetation in its overall synaxonomic diversity.

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