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Data for the botanical and pedological surveys of the Hungarian kurgans (Great Hungarian Plain, Hortobágy)

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Abstract: We undertook botanical and soil surveys on a mound called Csípő-halom (the Great Hungarian Plain). Alkaline and chernozem mosaics characterised the soil in the surrounding area of the mound and chernozem was typical of the top of the body of the mound. The floristic research can be well compared with the soil science examinations. The vast majority of species are weeds or species that tolerate disturbance well. Besides them we can find several plants belonging to the natural grassland associations as well. Among the dominant species, data on *Festuca rupicola, F. valesiaca* and *Agropyron pectiniforme* was previously published but only from one habitat from the area of Hortobágy. Despite its small territory it has a varied vegetation. Near the peak the *Agropyro-Kochietum porostratae* ZÓLYOMI 1958 association occurs. The larger part of the body of the mound is characterised by the dominant species of *Poa angustifolia* L. A subassociation of the silty grasslands, *Festuca valesiaca* also occurs wedged in the grass fields mentioned before. On the lower zone of the slope the contiguous association of the *Salvio-Festucetum rupicolae* (ZÓLYOM. 1958) SOÓ 1964 loess steppe areas can also be found, which is composed of *Festuca javorkae* besides the dominant *F. rupicola*. On the north-eastern side of the mound some discrete patches of the association *Artemisio-Festucetum pseudovinae* (MAGYAR 1928) SOÓ 1945 appear, which is typical of the surroundings of the mound.

Keywords: Kurgans, soil formation, palaeosoils, loess vegetation.

Introduction

The number of previously extensive sites of East European steppe landscapes has diminished in the Carpathian Basin, more specifically on the Great Hungarian Plain. The previously common steppe vegetation is of particular value belonging to the most rare associations of the Hungarian flora. Due to the expansion of land cultivation, mounds and burial hillock have become the last refuge for the protected steppe plants (PENKSZA & KAPOCSI 1998, PENKSZA 2000c, JOÓ 2003).

Burial mounds are the witnesses of ages past demonstrating the culture of our ancestors. In Hungary, they have been offered protection since the Law of Nature Protection (1996) was enacted but their protection is really as difficult as their classification and categorisation. For this reason, understanding their particular values and maintaining their present condition are considered very important.

The term burial mound is used as a collective term that includes all artificially created formations regardless of their function, origin and their time of origin. Based on this definition we can distinguish mounds as "tell" settlements, tumuli ("kurgans"), sentry mounds and hills for marking boundaries (TÓTH 1999, JOÓ & BARCZI 2001).

The soil required for the construction of kurgans was taken from the surrounding area (GENNADIJEV 1978, GENNADIJEV & IVANOV 1989). As a result of this, the parent material was exposed to the surface. On this parent rock new soil development could begin in the last few thousand years. The aim of our soil formation studies (BARCZI & JOÓ 2000) was to survey the several thousand-year-old soil buried under the mound and the soil in the distant surroundings of the mound. The buried soil may preserve the soil formation characteristics from the time of its formation, of its birth while the soil in the distant environment of the mound may show the marks of the soil-forming processes that have occurred since then (ALEXANDROVSKIY 1996).

The soil survey of the territory (BARCZI et al. 2001) requires a botanical one which is in close connection with the soil-forming processes. The different associations are closely related to the soil science parameters. It can be illustrated by Fehért-szirt of Kesztölc as well (PENKSZA et al. 1995). There can be correlations between the physical and the chemical features of the soil and its vegetation.

Our surveys of mounds have confirmed that the vegetation of the mounds of different age and that of the mounds being disturbed to a different extent is really varied. Some vegetation associations which cannot often be included into a transitional, coenosystem appear on them (JOÓ & BARCZI 2001, JOÓ 2003). Weeds are characteristic of the larger part of the ploughed land but the expansion of the original vegetation could also start on the territories.

SOÓ & MÁTHÉ (1938) collected the botanical data of the area of Tiszántúl and its environment. Since then there have not been any new data collections. It was also SOÓ (1933, 1947) who dealt with the vegetation of the territory of Hortobágy and he was the first to give information on several alkaline vegetations of this region, too.

Materials and methods

The first step of our survey was to seek a territory where the soil forming processes could be reconstructed. The sampling area we chose had developed on loess or loess-like sediment, it was relatively undisturbed (cultivated, afforested or built-up) and could be characterized by undisturbed soil formation conditions (prevented from floods, low human interference and protection). The botanical study and that of the soil-vegetation interrelations require mounds covered with almost natural vegetation. After visiting and surveying more than fifty kurgans, we chose Csípő-halom (Fig. 1). The aim of the present research is to reveal the results of the pedological and botanical studies of the mound.

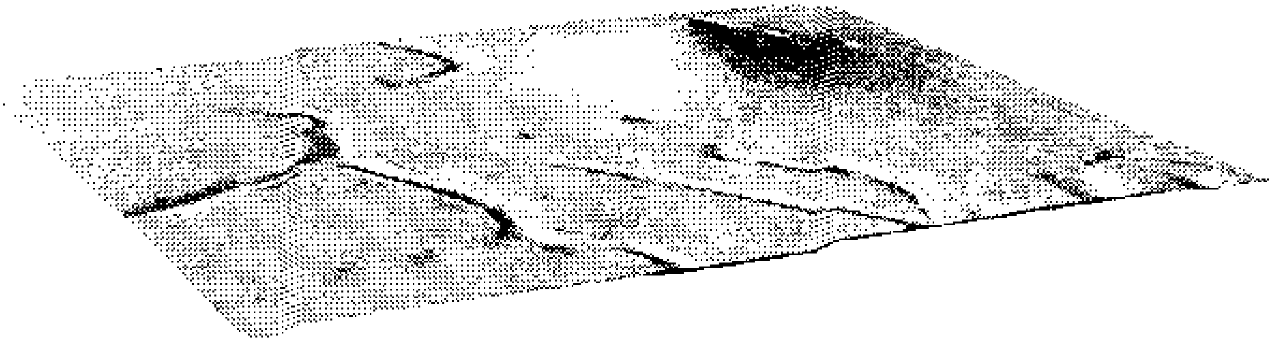

Fig. 1. 3D GIS model of Csípő-halom

Csípő-halom can be found on Hortobágy, near Lakes Derzsi, along the road connecting Road 33 to Ohat. It is bounded on the North by a road for 200-300 m long, bounded on the East by Nyugati-főcsatorna and bounded on the South by waters of a smaller channel. It is a mound having a nice shape in relatively good condition with well-preserved characteristics. Its vegetation being close to the natural one, the original one also shows how valuable a kurgan can be on Hortobágy. According to radiocarbon dating, the mound was built in the Bronze Age and its age is estimated at 6040±100 BP years.

We did the pedological sampling of the surroundings of the mound with a Pürckhauer-pricking rod soil sampler (Finnern et al. 1994) collecting the main morphological features and the results of the simpler on-site studies. It made certain one-metre-deep samplings possible without disturbing the soil too much examining their soil type, colour, texture, humidity and their content of carbonate and pH.

The instrument we used for the pedological study and the sampling of the body of the mound was a Styl double-armed auger. The principle of the sampling was the so-called Birks and Birks palaeoecological network mapping drilling taking the dimensions of time and space (Birks & Birks 1980) into consideration.

Besides the pedological studies, we also did botanical ones and we prepared the list of species of the mound. On the typical sites we made recordings with the Braun-Blanquet (1951) method in plots by 2 x 2 m² indicating the value of coverage of the species in percentage. The name of the species follows the nomenclature of Simon (2000) and the syntaxa of Borhidi (1996) is taken as a basis for the names of associations. Species occurring in the coenological relevés were classified coenosystematically also on the basis of Simon (2000). Detached vegetation patches were classified into associations on the basis of Borhidi (1996) and, in the case of units below associations, of Soó (1964). Those vegetation patches that could not be clearly classified into associations or subassociations were signed separately. Vegetation patches were separated one by one on the basis of their dominant species, considering both the number of species and the rate of species belonging to each coenosystematical groups.

Results

The flora of the sampling area

Despite the fact that the territory is not extensive, several different types of vegetation are found here and as a result of this, the number of species is also relatively high. During our studies of Csípő-halom and its close environment, we noted 72 species (Tab. 1). Among them we found numerous species that were registered either as weeds or as species tolerating strong degradation and disturbance. The area gives shelter to some rare and protected floral species as well.

Achillea collina	*Euphorbia cyparissias*
A. setacea	*Festuca javorkae*
Agrimonia eupatoria	*F. pseudovina*
Agropyron pectiniforme	*F. rupicola*
Ajuga genevensis	*F. valesiaca*
Alopecurus pratensis	*Galium aparine*
Arabidopsis thaliana	*G. mollugo*
Arrhenatherum elatius	*G. verum*
Artemisia absinthium	*Geranium pusillum*
A. santonicum	*Holosteum umbellatum*
Bromus mollis	*Hypericum perfoliatum*
Capsella bursa-pastoris	*Knautia arvensis*
Carduus acanthoides	*Koeleria cristata*
Carex praecox	*Lamium amplexicaule*
C. stenophylla	*L. purpureum*
Centaurea pannonica	*Lathyrus tuberosus*
Cerastium semidecandrum	*Lepidium draba*
Convolvulus arvensis	*L. perfoliatum*
Cruciata pedemontana	*Lotus corniculatus*
Daucus carota	*Medicago falcata*
Elymus repens	*M. lupulina*
Erodium ciconium	*Myosotis sticta*
E. cicutarium	*Ornithogalum umbellatum*
Erophila verna	*Phlomis tuberosa*
Eryngium campestre	*Picris hiecracioides*

Pimpinella saxifraga	*T. pratense*
Plantago lanceolata	*T. striatum*
Poa angustifolia	*Valerianella lacusta*
Podospermum canum	*Verbena officinalis*
Potentilla argentea	*Verbascum phlomoides*
Ranunculus pedatus	*Veronica arvensis*
Silene viscosa	*V. prostrata*
Sonchus asper	*V. triphyllos*
Stachys germanica	*Vicia angustifola*
Trifolium angulatum	*V. hirsuta*
T. arvense	*V. tetrasperma*

Tab. 1. The list of the species of the area (on the basis of Joó 2003).

The pedological study of the mound and its surroundings

In the surroundings of the mound, late Pleistocene and Holocene types of sediment can be found on the surface. Loess silt gets mixed up with young alluvial deposit in some places, the River Tisza mingled it with loess. The dominant basic rock is loess-like sediment.

The relief of the territory was formed by the changes of bed of the River Tisza and by the movement of materials under the influence of the wind as well.

A population could settle down on the outstanding mounds elevating to a drier and higher level. Taking its hydrography into consideration it is a territory without any water flows and draining the high level of ground water. The ground water on some sites is above 2 m but generally moves and is stored at 2-4 m deep, that is why during the wetter periods the danger of drainage can be really significant. The mean yearly temperature of the territory is between 10 and 10.2 °C and the mean rainfall is 520-580 mm (Marosi & Somogyi 1990). Considering both major climatic elements and microclimate, the area presently can be classified into forest steppe climate zone.

There are differences between the various soil types of the area due to the water table and micromorphology. Because of the high salt content of the ground water and the nearby channels, the influence of water can also be experienced by making the lower territories swampy, they become alkaline soil. This process is due to the high salt content of the ground water, which is getting closer and closer to the surface providing the soil primarily with Na^+ making the expansion of plants which tolerate salt less impossible.

Water-soluble salts, mainly Na-salts play an important role in the formation of soils belonging to the main category of alkaline soils. Na^+ mainly occurs in soil solutions in dissolved form, if they are solid in the form of crystallized salt or in the form of ions adsorbed on the surface of colloids. The quantity, the quality and the proportion of these three forms define the nature of the alkaline process and features of the soil.

The typical soil of water flows, special eroded surfaces ("padka") and lower territories is meadow solonetz, a kind of alkaline soil, whose salt accumulation maximum is at a deeper level with its eroded A-horizon. Over long periods of time they have been substantially eroded because of the special soil-forming process of the eroded surfaces. The traces of the stronger effect of water can be identified in its basic rock (gley spots), which was also loess-like sediment.

The vegetation of the sampling area

The vegetation of the mound and its surroundings also shows the pedological mosaic-likeness. On the wet territories the vegetation outlines the patches where the water can stand and in some places the depressions under the average level of the relief covered with alkaline vegetation. On the lower zone of the foot of the mound and its surroundings there are smaller areas of alkali pastures e.g. *Artemisio-Festucetum pseudovinae* (MAGYAR 1928) SOÓ 1945. But the alkaline vegetation is not unified. There are loess-meadows and on certain areas they get contracted. The alkaline vegetation is also supported by erosion because as it is not unified, the water in the depressions makes the soil rich in organic materials disappear, it is taken away by water and the soil layers of high salt content and of columned structure come to the surface reducing the possibility of the existence of loess vegetation. As opposed to this the presence of small heaps of loess is indicated by the patches of loess-meadows, which are typical of drier steppes and by the great number of *Phlomis tuberosa.*

The botanical and soil survey of the mound

Csípő-halom elevating from its mosaic-like alkaline environment defeats its micro-relief features. The alkaline vegetation cannot cope with the slopes of the artificial elevations and the ground water of high salt content does not influence the soil forming processes either. It confirmed our experience gained through the pedological examination of certain previously disturbed mounds. On the basis of that, the mounds, regardless of the fact whether the mound elevates from an alkaline or chernozem environment, soil formation took place from the direction of steppe (chernozem) soil formation. The typical chernozem marks, e.g., the long earthworm-hole networks, such other types of tunnels of animals and lime fluctuation in the profile, show us what the soil formation of the Great Hungarian Plain could be on areas exempt from water.

Soils that belong to the main type of chernozem soils are characterised by humus accumulation, formations of crumby structures and the two-way movement of the soil solution saturated by calcium, which are the results of the soil formation under the grass vegetation. Human activities had an effect also on the mound and its surroundings. On the one hand, creating canals along the western and southern side of the mound can be considered as an intervention into the life of the landscape, and on the other hand, surroundings of the mound were grazed by animals extensively until the 1970-1990 years. The latter one did not have a significant effect on soil generation, since land use remained in accordance with landscape potential. The area has been under nature protection in recent years and its surroundings are mown by Directorate of Hortobágy National Park once a year, excluding the vegetation of higher loess meadows containing protected plant species and the body of mound.

Despite the small extension of the mound, different types of vegetation could develop. Among the dominant species, data on *Festuca rupicola*, *F. valesiaca* and *Agropyron pectiniforme* was previously published only in connection with Hajdúnánás, from the territory of Hortobágy (SOÓ & MÁTHÉ 1938). But data on

Festuca javorkae was published only by Penksza (2000a, 2000b) from the southern part of Tiszántúl and by Penksza & Malatinszky (2001) from the Putnok hills.

Basically Csípő-halom has two types of vegetation. Loess vegetation is characteristic of the dominant part of the mound and in smaller proportions, mainly on lower territories, patches of alkaline vegetation can also be found (Fig. 2).

On the peak region of the mound pioneer vegetation of open loess areas mainly belonging to the *Agropyro-Kochietum prostratae* Zólyomi 1958 association has developed (Tab. 2). But the other dominant species, the *Bassia prostrata* giving its name to the association is missing. The *Agropyron pectiniforme* has a great proportion of covering. It is nearly contiguous. *Festuca pseudovina* also occurs, which is typical of the alkali pastures. *F. valesiaca* and *Poa angustifolia* being present in nearly all vegetation patches can be found as well.

The dominant species of the meadow near the peak region and which can reach to the foot of the mound in some places is *Poa angustifolia*. This type of vegetation is similar to the strongly degraded grasslands that can be found on the territories of former loess grasslands. However, many species of the association listed by Soó (1933) are missing e.g., *Cynodon dactylon*, *Lolium perenne*, *Festuca pseudovina*. The vegetation type is usually poor, consisting of 10-15 species. It is also typical that certain species in some patches may have a great proportion of covering. On the basis of this we can identify Elymus repens, *Elymus repens* and *Carex praecox, Verbascum phoeniceum,* and *Verbascum phoeniceum* and *Carex praecox*. The coenological structure of the site of *Elymus repens* is the following:

***Querco-Fagetea & Quercetea pubescentis-petreae* species**
Galium mollugo 3
***Festucetalia valesiacae* species**
Myosotis stricta 1
***Festuco-Brometea* species**
Elymus repens 20, *Agrimonia eupatoria* 1, *Poa angustifolia* 20
***Chenopodietea & Secalietea* species**
Euphorbia cyparissias 5, *Galium aparine* 2, *Lamium purpureum* 2, *Lepidium draba* 2,*Veronica arvensis* 3.

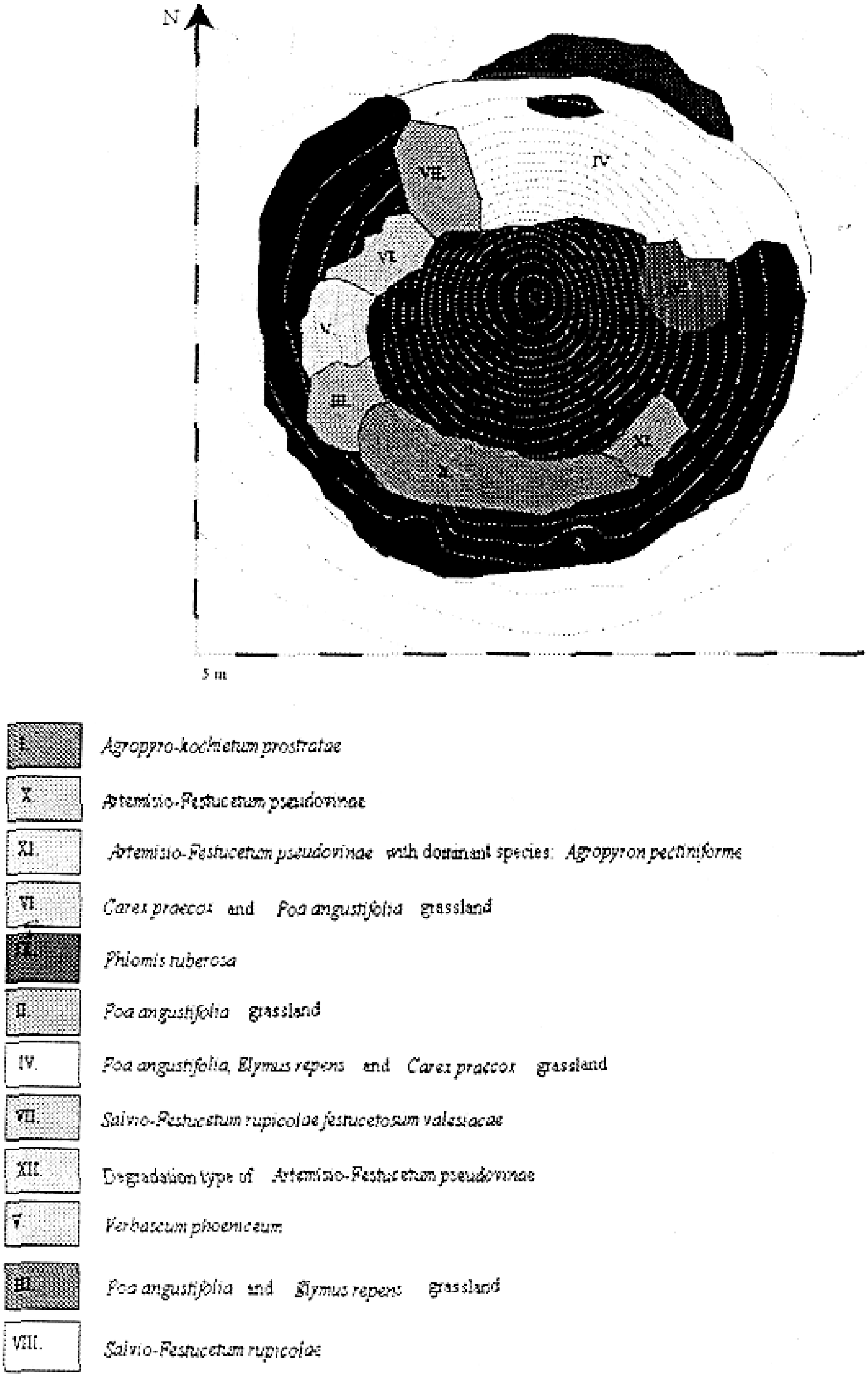

Fig. 2. Vegetation map of Csípő-halom (Joó 2003)

Salvio-Festucetum rupicolae (Zólyomi 1957) Soó 1964 appears on the north-western slope of the body of the mound (Tab. 3), whose dominant species is *Festuca valesiaca* identified as the subassociation of *Festucetosum valesiacae*. Besides *Festuca valesiaca*, some tussocks of *Festuca javorkae* also occur confirming its separation from the typical association. The composition is as follows:

Agropyro-Kochietum chr. **species**
Agropyron pectiniforme 15
Festucetalia valesiacae **species**
Festuca javorkae 5, *F. valesiaca* 25
Arrhenatheretea **species**
Ornithogalum umbellatum 3
Festuco-Brometea **species**
Koeleria cristata 4, *Galium verum* 5, 1, *Medicago falcata* 3, *M. lupulina* 2, *Picris hieracioides* 1, *Poa angustifolia* 10, *Potentilla argentea* 2,
Chenopodietea & Secalietea **species**
Cardus acanthoides 3, *Euphorbia cyparissias* 2, *Lepidium draba* 1, *Sonchus asper* 1, *Trifolium arvense* 2, *Veronica arvensis* 3, *Vicia tetrasperma* 1.

Loess steppe becomes characteristic of the lower part of the slope. On the north-eastern slope of the mound and on certain areas in its surroundings *Phlomis tuberosa*, our prominent botanical heritage, forms large, contiguous patches, sites. The highest number of species among the vegetation types was here. But none of the name-giving associations (*Salvia*) occurred in the community. *Salvia* species can be found only far from the mound and are characteristic of the areas of loess meadows in alkaline environment.

A crucial role in the differentation of vegetation may be played by the fact that the top of the mound can be considered as the driest point, since precipitation washes towards deeper areas fast. This contributes to the erosion of the mound, that is also can be considered as an influencing factor.

Considering occurrence of vegetation and its differentiation from the top region, humidity of soil may be the crucial factor. Although the whole body of the mound is characterised by chernozem topsoil, soils in the lower zones take in still more moist and surface run-off is less, therefore these conditions give possibility for the occurrence of the vegetation type. In the near future, we wish to lay a bigger emphasis on revealing soil-plant-microclimate connections more accurately.

On the lower zone of the foot of the mound and its surroundings there are smaller degraded areas of alkali pastures with *Artemisio-Festucetum pseudovinae* (Magyar 1928) Soó 1963 (Tab. 4). We illustrated three patches on the map. The vegetation of the first spot consists of basically alkaline species and species tolerating disturbance well. Besides *Artemisia santonicum*, which gives 30% of coverage, we also identified the area where not only the species characteristic of alkaline pastures but species registered as that of loess steppes, *Agropyron pectiniforme* (Simon 2000). In the lower region of the mound we could identify strongly degraded weedy alkaline areas.

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Tab. 2-4 on next pages.

Tab. 2. The phytosociological table of *Agropyro-Kochietum prostratae* Zólyomi 1958 association (May 25, 2001).

Plot number	*1*	*2*	*3*	*4*	*A-D*	*K*
Coverage %	**80**	**80**	**80**	**75**		
Agropyro-Kochietum chr. **species**						
Agropyron pectiniforme	70	70	60	65	60-75	4/4
Festucetalia valesiacae **species**						
Festuca valesiaca	2			3	3-3	2/4
Festucion pseudovinae & Cynodonti pseudovinae **species**						
Festuca pseudovina	2	5	3	1	1-5	4/4
Trifolium striatum				1	1	1/4
Corynephoretalia **species**						
Trifolium arvense			1			1/4
Festuco-Brometea **species**						
Koeleria cristata			6	3	3-6	2/4
Holosteum umbellatum		1			1	1/4
Medicago lupulina	1	2	3	2	1-3	4/4
Chenopodietea & Secalietea **species**						
Capsella bursa-pastoris		2			2	1/4
Carduus acanthoides	3				3	1/4
Euphorbia cyparissias			2			1/4
Poa angustifolia	2	2	2		2-3	3/4
Veronica arvensis			1	1	1	2/4

Tab. 3. The phytosociological table of *Salvio-Festucetum rupicolae* (Zólyomi 1958) Soó 1964 association (May 25, 2001).

Plot number	*1*	*2*	*3*	*4*	*A-D*	*K*
Coverage %	70	90	70	85		
Aceri-Quercion **species**						
Phlomis tuberosa			5	25	5-25	2/4
Festucetalia valesiacae **species**						
Festuca javorkae		2	5		2-5	2/4
Festuca rupicola	20	40	10	20	10-40	4/4
Myosotis stricta	2		1		2	2/4
Ranunculus pedatus	1				1	1/4
Veronica prostrata		3			3	1/4
Arrhenatheretea **species**						
Arrhenatherum elatius		3				1/4
Daucus carota		2		1	1-2	2/4
Knautia arvensis		2			2	1/4
Lotus corniculatus		2			2	1/4
Ornithogalum umbellatum	3				3	1/4
Pimpinella saxifraga		2			2	1/4
Agrostion albae **species**						
Alopecurus pratensis			3	2	2-3	2/4
Festucion pseudovinae & Cynodonti pseudovinae **species**						
Stachys germanica			2		2	1/4
Festuco-Brometea **species**						
Achillea collina		1		3	1-3	2/4
Agrimonia eupatoria		3	3	2	2-3	3/4
Ajuga genevensis			4	3	3	2/4
Carex praecox	10	5	4	3	3-10	4/4
Elymus repens	10	2	8	3	2-10	4/4
Eryngium campestre		2			2	1/4
Galium verum	15		15		15	2/4
Hypericum perforatum		2			2	1/4
Medicago lupulina				1	1	1/4
Picris hieracioides		2	2		2	2/4
Poa angustifolia	10	3	2	10	2-10	4/4
Potentilla argentea		3			3	1/4
Vicia angustifolia		3			3	1/4
Chenopodietea & Secalietea **species**						
Carduus acanthoides		2			2	1/4
Convolvulus arvensis		3	2	5	2-5	3/4
Euphorbia cyparissias	3				3	1/4
Lathyrus tuberosus		2			2	1/4
Lepidium draba	1				1	1/4
Trifolium arvense	1				1	1/4
Verbena officinalis				2	2	1/4
Vicia hirsuta				8	8	1/4
Vicia tetrasperma	4	10	10		4-15	3/4

Tab. 4. The phytosociological table of *Artemisio-Festucetum pseudovinae* (MAGYAR 1928) SOÓ 1963 association (May 25, 2001).

Plot number	*1*	*2*	*3*	*A-D*	*K*
Coverage %	**85**	**80**	**95**		
Artemisio-Festucetum pseudovinae chr. **species**					
Artemisia santonicum	30	30	30	30	3/3
Agropyro-Kochietum chr. **species**					
Agropyron pectiniforme		3	3	3	2/3
Festucetalia valesiacae **species**					
Achillea setacea	5	2	5	2-5	3/3
Carex stenophylla	2	1	2	1-2	3/3
Myosotis stricta	2	1	2	1-2	3/3
Silene viscosa		1	3	1-3	2/3
Festucion pseudovinae & Cynodonti pseudovinae **species**					
Festuca pseudovina	15	15	15	15	3/3
Lepidium perfoliatum		1		1	1/3
Trifolium angulatum	3	2	3	2-3	3/3
Festuco puccinellietea **species**					
Podospermum canum		2		2	1/3
Arrhenatheretea **species**					
Plantago lanceolata	2	2	2	2	3/3
Festuco-Brometea & Arrhenatherete **species**					
Bromus mollis	2	3	3	2-3	3/3
Aphanion **species**					
Arabidopsis thalina	1			1	1/3
Corynephoretalia canancensis **species**					
Cerastium semidecandrum		1	2	1-2	2/3
Agrostion albae **species**					
Alopecurus pratensis			2	2	1/3
Festuco-Brometea **species**					
Elymus repens	2			2	1/3
Erophila verna	1	1	1	1	3/3
Eryngium campestre	2	1	2	1-2	3/3
Galium verum	2	2		2	2/3
Koeleria cristata	3	2	3	2-3	3/3
Medicago lupulina	1			1	1/3
Poa angustifolia	1	2		1-2	2/3
Potentilla argentea	4			4	1/3
Chenopodietea & Secalietea **species**					
Artemisia absinthium	3		2	2-3	2/3
Convolvulus arvensis		1		1	1/3
Erodium cicutarium			1	1	1/3
Lamium amplexicaule	1			1	1/3
Lepidium draba	3	3	4	3-4	3/3
Veronica arvensis	10	15	10	1-15	3/3