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The present distribution and state of halophytic communities with *Hordeum geniculatum* in Slovakia

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Abstract: The paper provides information on the current occurrence of association *Hordeetum hystricis* Wendelbg. 1943 in Slovakia, where the community occurs at the northern border of its distribution range. The changes and vegetation state in the past and today are compared and discussed. The association is characterized by high cover of *Hordeum geniculatum* and is regarded as secondary community of relatively poorly salt-affected and nutrient rich solonetz soils. The occurrence of *Hordeetum hystricis* is related to intensively overgrazed sites in saline pastures. In Slovakia, the community was currently found near extinction and single locality was confirmed (Močenok, Siky farmstead). Due to the development trend and high dependence on sheep grazing the association is considered as critically endangered in Slovakia.

Keywords: *Hordeum geniculatum*, saline pastures, solonetz, Slovakia.

Introduction

Association *Hordeetum hystricis* Wendelbg. 1943 is regarded as secondary plant community developed on solonetz soils as a result of both anthropogenic and zoogenic factors. According to WENDELBERGER (1950) the association originated by nitrophilous degradation of the community *Puccinellietum limosae.* Association *Hordeetum hystricis* has arisen on most intensely grazed areas, particularly on strongly trampled sites or around sheep or cattle watering-places. Solonetz soil at those places is fine-grained, clay and heavily compacted. The soil surface swells by water and due to trampling it is mixed with livestock manure. This process produces a clay material, which after drying off and trodden down creates distinctive microrelief (MUCINA 1993, BORHIDI 2003).

The physiognomy is characterised by dominance of *Hordeum geniculatum* All. [syn. *Hordeum hystrix* Roth, *Hordeum marinum* Huds. subsp. *gussoneanum* (Parl.) Thell.]. Depending on soil salinisation and humidity regime, other halophytic species occur here, e.g. *Tripolium pannonicum*, *Puccinellia distans* agg., *Pholiurus pannonicus, Atriplex littoralis,* and *Lotus tenuis* grow at wetter soils, *Artemisia santonicum* subsp. *patens, Podospermum canum, Festuca pseudovina* or *Matricaria recutita* grow on dryer solonetz soils. Association *Hordeetum hystricis* is also characterized by grassland (mesophilic) species such as *Alopecurus pratensis*, *Poa bulbosa*, and *Lolium perenne.* Intensive grazing causes also occurrence of several ruderal plants such as *Taraxacum* sect. *Ruderalia*, *Echinochloa crus-gali*, or *Elytrigia repens* (BERNHARDT & HANDKE 1992, MUCINA 1993, POP 2002, BORHIDI 2003).

The dominant species *Hordeum geniculatum* occurs in a large area in Eurasia (CONERT 1998), but association *Hordeetum hystricis* has been documented only in central and south-eastern Europe. The association is relatively common in Hungary and northern Serbia and rare in southeastern Austria, southwestern Slovakia, southwestern and northwestern Romania and Bulgaria (VICHEREK 1973; MUCINA 1993; KOJIĆ et al. 1998; BORHIDI 2003; MOLNÁR & BORHIDI 2003; POP 2002, POPESCU 2005, TZONEV et al. 2009)

Materials and Methods

Phytosociological data sampling and analyses

The study was carried out from 2003 to 2010. Localities of *Hordeetum hystricis* were found in the field according to published data (KRIST 1940, VICHEREK 1973). The phytosociological relevés were sampled according to the Zürich-Montpellier approach using the adapted nine-grade Braun-Blanquet's scale (BARKMAN et al. 1964). All relevés with presence of *Hordeum geniculatum* recorded by us in Slovakia were used to compile the phytosociological table. Relevés were stored in the database using the TURBOVEG software (HENNEKENS 1996) and classified by divisive polythetic analysis using program TWINSPAN (HILL 1979).

The map was designed by program ArcGis, version 9.2. Coordinates of localities were obtained during field research using GPS equipment Garmin CS 60.

Nomenclature of flowering plants follows MARHOLD & HINDÁK (1998) and the names of syntaxa follow MOLNÁR & BORHIDI (2003). Diagnostic species follow JAROLÍMEK et al. (2008).

Soil analyses

Root-zone (0–25 cm) soil samples from two relevé plots taken at three different points were examined. Chemical parameters analysed and localities (relevé plots) of the samples are shown in Tab. 2. Base-exchange pH (pH_{KCl}) were analysed potentiometrically under the Slovak technical standard STN ISO 10390 in soil suspension prepared at five times its capacity of an aqueous solution of KCl (1 $mol.l^{-1}$). Exchange cations Ca, Mg, Na a K were evaluated in acidified soil extract of barium chloride buffer (pH 8.1) and triethanolamine by flame atomic absorption spectrometry (AAS-F) at a wavelength of the individual cations (STN ISO 13536). Organic carbon in the samples was determined according to STN ISO 10694 using dry way by method of dynamic combustion. Burning of the samples were at least 900℃ in a str eam of oxygen. Water-soluble salt content was determined by water extraction followed by evaporation of water extract and drying the residue at a temperature of 105℃ (R ICHARDS 1954).

Results and Discussion

During the survey of Slovak saline habitats in last decade, we found vegetation with more or less continuous presence of *Hordeum geniculatum* at only three locations (Tvrdošovce, Akomáň farmstead near Šurany, Siky farmstead near Močenok) in strongly degraded plant communities (Fig. 1). It is obvious, that the distribution of the community was more frequent in the past. We can conclude it from the occurrence of *H. geniculatum* – the species was reported from 11 localities by KRIST (1940) before the Second WW and later GRULICH & MAGLOCKÝ (1999) also gave eleven localities of the species. Moreover, VICHEREK (1973) published phytosociological relevés of association *Hordeetum hystricis* from six sites (Palárikovo, Malé Čiky farmstead east from Palárikovo, between villages of Tvrdošovce and Dolný Jatov, Šurany, Močenok and Hájske). Thus, it is obvious that this community was more frequent in the past and three recent localities confirmed in this study represent a rest of the previous distribution of the community in Slovakia.

The first locality was recorded in a small private goat pasture at northwestern edge of the Tvrdošovce village near the train station. The compact *H. geniculatum* vegetation was developed at several hundred square meters in 2004. In some places, monocoenoses with more than 80% dominance of *H. geniculatum* were recorded. However, *H. geniculatum* vegetation gradually

subsided due to the absence of grazing and the species completely disappeared in 2010.

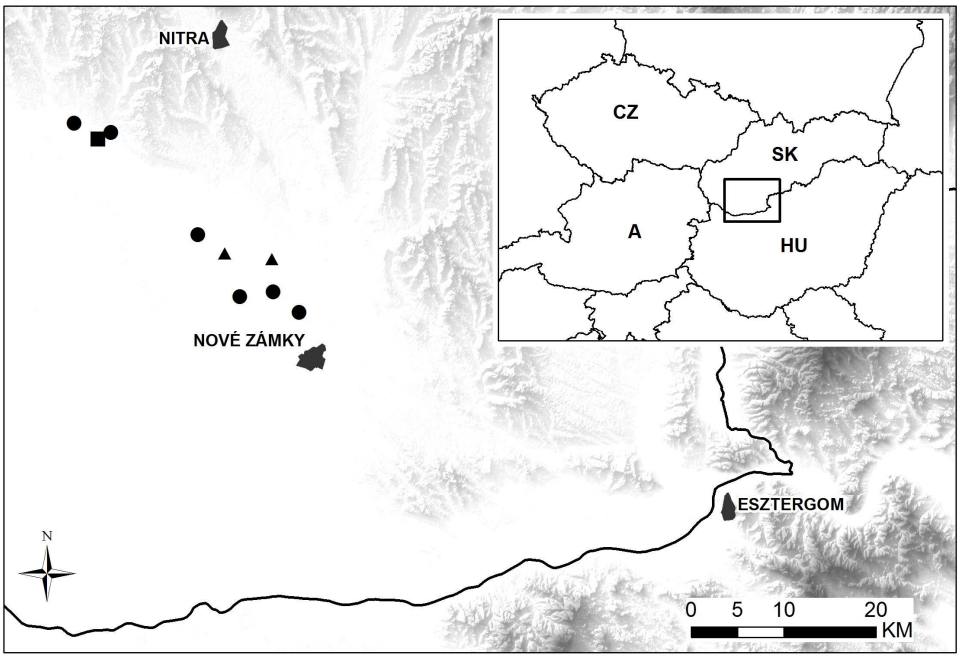

Fig. 1: Distribution of *Hordeum geniculatum* vegetation in Slovakia: ● – historical data of VICHEREK (1973), ▲ – current occurrence of vegetation with presence of *Hordeum geniculatum*, ■ – current occurrence of association *Hordeetum hystricis*.

Another site with *H. geniculatum* vegetation was recorded on degraded saline pastures in the Akomáň (also Okomáň) farmstead near Šurany in 2002. The vegetation covered rural road tracks passing through the edge of the pasture (SÁDOVSKÝ 2003). We have not confirmed the *H. geniculatum* vegetation in the following years (ELIÁŠ jun. & DÍTĚ ined.) until the vegetation was re-discovered here in 2010. It covered area only ca. 6 m^2 in the rest of intensive sheep grazing pasture near the farm buildings. Markedly ruderalised vegetation was hardly classifiable within a particular association (Tab. 1). Distinctive presence of *H. geniculatum* indicated the affinity to the association *Hordeetum hystricis*, which is for example confirmed by the presence of *Podospermum canum*. However, the dominance of *Festuca pseudovina* rather suggests that it was ruderalised vegetation of *Festucion pseudovinae* (Tab. 1, relevé no. 4).

The third current locality was recorded on intensively overgrazed salt pasture around the Siky farmstead near the Močenok village. The occurrence of *H. geniculatum* has been known here since thirties of the 20th century (DÍTĚ & ELIÁŠ jun. ined.). This is the largest and most vital known population in Slovakia now.

The vegetation is concentrated in surrounding of sheep stalls and strongly trampled areas in their neighbourhood (Fig. 2). Here are stands dominated by *H. geniculatum* with cover up to 70%, which were classified as association *Hordeetum hystricis* in this paper. This association is situated on a mosaic with other halophytic and sub-halophytic communities in the area of approximately 1.5 hectares. Except *H. geniculatum*, other (sub-)halophytic species as *Puccinellia distans* agg., *Matricaria recutita* and *Lepidium ruderale* were often recorded. Vegetation is also strongly ruderalised due to intensive grazing, which is typical for sites with this association in other parts of the Pannonian Basin (POP 2002, ELIÁŠ jun., DÍTĚ & ŠUVADA ined.). *Cynodon dactylon* or species from *Taraxacum* sect. *Ruderalia* were also recorded here (Tab. 1, relevés no. 5 – 7). Other weedy plants such as *Echinochloa crus-galli*, *Urtica dioica* and *Xanthium spinosum* were recorded outside of relevé plots.

Fig. 2: *Hordeetum hystricis* stands (brighter areas) on the Siky farmstead near Močenok in 2010.

The soil properties analyses showed that the community arose on slightly salinized solonetz soil (Tab. 2). The presence of a considerable number of ruderal species was related, in addition to the amount of salt in the soil, with higher nutrient content. Higher levels of the analysed elements in the substrate

(potassium, sodium, magnesium and calcium) as well as relatively high content of organic matter (Cox) were characteristic for the association. In the case of soil pH, we have found only very slightly alkaline soil reaction (Tab. 2). This is obviously due to the properties of the substrate, because solonetz and saline soils generally are alkaline (BRINKMAN 1988, HANES 2001).

Hordeum geniculatum has grown in these large pastures in Siky farmstead also in the contact communities, but only with coverage up to 5%. In shallow, muddy depressions, it was sampled in ruderalized *Heleochloetum schoenoides* association (Tab. 1, relevés no. 1, 2) or was found in sub-halophytic community *Pulicario vulgaris-Menthetum pulegium* (Tab. 1, relevé no. 3). The species was also sporadically found in the stands with the dominance of *Festuca pseudovina* (relevés not recorded).

Current vegetation of association *Hordeetum hystricis* is quite different comparing to published relevés of VICHEREK (1973). Several species mentioned by the author absented in our relevés – *Tripolium pannonicum* and *Taraxacum bessarabicum* (constancy value V) or *Atriplex litoralis* and *Dichodon viscidum* (constancy value IV). On the contrary, the current vegetation was represented by ruderal species with high stability (see above). Number of species also varied in the community. VICHEREK (1973) recorded about 10 species per relevé, we recorded 15 and more species per relevé (with one exception with 10 species). The number of species is related to the degree of ruderalisation and stands were also enriched by species of contact communities, although often only incidentally. It may be a considerable number of species, e.g. POP (2002) pointed out up to 82 vascular plant species in the association *Hordeetum hystricis* from Romania.

VICHEREK (1973) recorded *H. geniculatum* in many other Slovak halophytic communities. DÍTĚ et al. (2008, 2009) did not report this species in the vegetation of associations *Puccinellietum limosae* and *Camphorosmetum annuae* in Slovakia. However, in other parts of the Pannonian Basin, *H. geniculatum* was recorded in associations *Pholiuro pannonici-Plantaginetum tenuiflorae* and *Camphorosmetum annuae* (mostly up to 5%; DÍTĚ et al. 2008, 2010), as well as in *Artemisio santonici-Festucetum pseudovinae* (BODROGKÖZY & GYÖRFFY 1970, TÓTH & KERTÉSZ 1993).

Association *Hordeetum hystricis* is considered as secondary vegetation of the original vegetation of saline habitats, especially as. *Puccinellietum limosae* (e.g. WENDELBERGER 1950, VICHEREK 1973). Even VICHEREK (1973) considered this stands only as subassociation *Puccinellietum limosae hordeetosum hystricis*. Since *Hordeetum hystricis* stands are ecologically, physiognomically and also by species composition different from this association, we consider that it is a separate community. Depending on local conditions it can also develop from other original vegetation types, for example from some associations of alliance *Festucion pseudovinae* on less saline soils. This indicated also *Hordeum geniculatum* stand which we recorded on Akomáň site (see above).

Tab. 1. A table of relevés with presence of *Hordeum geniculatum* recorded in Slovakia.

Number of relevé	1	2	3	4	5	6	7
Area of relevé m^2	6	3	16	6	16	16	16
cover E_1 %	80	85	95	95	85	75	70
cover E_0 %	0	0	10	0	0	0	0
Number of species	16	10	19	18	19	17	15
Heleochloetum schoenoides							
Heleochloa schoenoides	4	5	.	.	.	.	.
Pholiurus pannonicus	+	r	.	.	.	.	.
Pulicario vulgaris-Menthetum pulegium							
Mentha pulegium	.	.	b	.	.	.	.
Pulicaria vulgaris	.	.	a	.	.	.	.
Agrostis stolonifera	.	.	a	.	.	.	.
Hordeetum hystricis							
Bromus hordeaceus	.	.	.	1	1	1	1
Lepidium ruderale	+	.	.	.	1	b	a
Podospermum canum	.	.	.	1	.	1	1
Matricaria recutita	.	.	.	1	1	1	.
Achillea millefolium	.	.	+	1	1	1	a
Other taxa							
Hordeum geniculatum	1	1	1	b	3	3	4
Cynodon dactylon	a	+	a	a	1	1	1
Polygonum aviculare	1	+	.	1	a	a	1
Puccinellia distans	1	1	.	.	+	a	a
Lolium perenne	+	+	1	.	1	1	1
Taraxacum sect. Ruderalia	r	.	+	+	+	1	1
*Plantago major * winteri*	r	.	+	.	+	.	r
Lotus tenuis	+	.	+	.	a	.	.
Trifolium bonannii	.	1	3	.	3	1	.
Festuca pseudovina	.	.	+	4	.	1	.
Echinochloa crus-galli	+	.	+	.	.	.	.
Juncus compressus	+	.	1	.	.	.	.
Plantago lanceolata	.	.	1	.	+	.	.
Capsella bursa-pastoris	.	.	.	+	+	.	.
Arenaria serpyllifolia	.	.	.	.	.	+	1
Veronica arvensis	.	.	.	1	.	.	r

Species recorded in one relevé only: *Artemisia santonicum* subsp. *patens* 2a (6); *Bolboschoenus maritimus* agg. + (2); *Bromus japonicus* + (4); *B. sterilis* + (7); *Bupleurum tenuissimum* + (1); *Carex stenophylla* + (1); *Cerastium subtetrandrum* 1 (4); *Cichorium intybus* r (5); *Convolvulus arvensis* 1 (4); *Coronopus squamatus* r (5); *Dichodon viscidum* + (7); *Elytrigia intermedia* + (6); *Eryngium campestre* r (4); *Galium verum* 1 (4); *Geranium pusillum* 1 (4); *Chenopodium album* r (1); *Leontodon autumnalis* + (3); *Medicago lupulina* 1 (5); *Poa annua* 1 (5); *P. pratensis* + (3); *Taraxacum bessarabicum* + (3); *Trifolium campestre* 2a (4); *T. repens* + (3); *T. retusum* 2a (4);

Localities of relevés:

1, 2. Močenok, Siky farmstead, depressions in overgrazed saline pastures, 17°53´81.2´´; 48°13´30.10´´, 120 m n. m., 24. 8. 2010. **3.** Močenok, Siky farmstead, edge of overgrazed saline pasture, 17°53´51.68´´; 48°13´18.42´´, 120 m n. m., 24. 9. 2010. **4.** Šurany, Akomáň farmstead, overgrazed sheep pasture near farm buildings, 117 m n. m., 18°07´50.80´´; 48°05´07.50´´, 120 m n. m., 24. 9. 2010. **5. – 7.** Močenok, Siky farmstead, overgrazed saline pasture near stalls, 17°53´49.00´´; 48°13´17.70 ´´, 120 m n. m., 13. 6. 2008.

Tab. 2. Chemical properties of analysed soil samples. Numbers of relevés are identical with those presented in Tab. 1.

Number of relevé	Salts (%)	Cox (%)	pH_{KCl}	Ca (cmol+/kg)	Na (cmol+/kg)	K (cmol+/kg)	Mg (cmol+/kg)
5	0.142	2.639	7.80	14.46	1.098	1.89	0.93
6	0.151	2.264	7.74	16.57	2.701	1.68	5.71

Vegetation of association *Hordeetum hystricis* had specific origin in the track of rural roads, where it was developed in continuous, narrow strips in the middle of other plant communities. As we mentioned above, this type of vegetation was known from the site Akomáň in Slovakia. This is a normal occurrence in the Pannonian Basin, which we recorded on a number of sites, e.g. in the northern Voyvodina (Serbia) in surrounding of Horgos and Rančevo or on saline pastures in the Hungarian national parks Hortobágy and Kiskunság. These stands were characteristic by dominance of trampling-tolerant species such as *Poa annua* or *Scrolochloa dura* (DÍTĚ, ELIÁŠ jun. & ŠUVADA ined.).

Based on our data we can conclude that *Hordeetum hystricis* is currently extremely rare plant community in Slovakia. It has limited occurrence to only single known locality and its survival requires intensive grazing and livestock trampling. Therefore, we regarded the association *Hordeetum hystricis* as critically endangered.

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References

BARKMANN J. J., DOING H. & SEGAL S. (1964): Kritische Bemerkungen und Vorschläge zur quantitativen Vegetationsanalyse. – Acta Bot. Neerl. 13: 394-419.

BERNHARDT K. G. & HANDKE K. (1992): Successional dynamics on newly created saline marsh soils. – Ekologia (CSFR) 11:139-152.

BODROGKÖZY GY. & GYÖRFFY B. (1970): Ecology of the halophilic vegetation of the Pannonicum VII. Zonation study along the Bega-Backwaters in the Voivodina (Yugoslavia). – Acta Biol. Szeged 17: 25-42.

BORHIDI A. (1996): An annotated checklist of the Hungarian plant communities. I. The non-forest vegetation. – In: BORHIDI, A. (ed.): Critical revision of the Hungarian plant communities, Janus Pannonius Univ. Pécs, pp. 43-94.

BORHIDI A. (2003): Magyarország növénytársulásai. – Akadémiai Kiadó, Budapest, 610 p.

BRINKMAN R. (1988): Saline and sodic soils. Land Reclamation and Water Management. – *ILRI publication* (Wageningen) 27: 62-68.

CONERT HJ. (1998): *Hordeum* L. In: CONERT H.J., ECKEHART J.J., KADEREIT J.W., SCHULTZE-MOTEL W., WAGNITZ G., WEBER H.E. (eds.), G. Hegi, Illustrierte Flora von Mittel-Europa. – Blackwell Wissenschafts, München, pp. 802 – 832.

DÍTĚ D., ELIÁŠ jun. P. & SÁDOVSKÝ M. (2008): *Camphorosmetum annuae* RAPAICS ex SOÓ 1933 – vanishing plant community of saline habitats in Slovakia. – Thaiszia 18: 9-20.

DÍTĚ D., ELIÁŠ jun. P. & ŠUVADA R. (2009): The current distribution and status of community *Puccinellietum limosae* in Slovakia. – Thaiszia - J. Bot., Košice, 19: 63-70.

DÍTĚ D., ELIÁŠ P. jun., ŠUVADA R. & SZOMBATHOVÁ N. (2010): Ecology and coenotic characteristics of the *Pholiuro pannonici-Plantaginetum tenuiflorae* WENDELBERGER 1943 in the Pannonian Basin. – Phyton (Horn), 49/2: 293-313.

ELIÁŠ P. jun., DÍTĚ D. & SÁDOVSKÝ M. (2003): Rastie *Acorellus pannonicus* (Jacq.) Palla na Slovensku? – Ochr. Prír., Banská Bystrica, 22: 23-25.

ELIÁŠ P. jun., DÍTĚ D., GRULICH V. & SÁDOVSKÝ M. (2008): Distribution and communities of *Crypsis aculeata* and *Heleochloa schoenoides* in Slovakia. – Hacquetia 7: 5-20.

GRULICH V. & MAGLOCKÝ Š. (1999): *Hordeum geniculatum* All. – In: ČEŘOVSKÝ J. et al., Červená kniha ohrozených a vzácnych druhov rastlín a živočíchov ČR a SR. Vol. 5. Vyššie rastliny. Príroda, Bratislava, p. 188.

HANES J. (2001): Solonetz in region of village Močenok (Slovak Republic). – Poľnohospodárstvo 47(3): 173-187.

HENNEKENS S. M. (1996): User's guide to TURBOVEG: A software package for input, processing, and presentation of phytosociological data. – IBN-DLO, Wageningen and Lancaster.

HILL M. O. (1979): TWINSPAN. A Fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. – Cornell Univ., Ithaca, 90 pp.

JAROLÍMEK I., ŠIBÍK J., TICHÝ L. & KLIMENT J. (2008): Diagnostic, constant and dominant species of the higher vegetation units of Slovakia, pp. 9–294. – In: JAROLÍMEK I. & ŠIBÍK J. (eds). Diagnostic, constant and dominant species of the higher vegetation units of Slovakia. Veda, Bratislava.

KOJIĆ M, POPOVIĆ R, KARADŽIĆ B. (1998): Sintaksonomski pregled vegetacije Srbije (Syntaxonomical survey of Serbian vegetation). Institut za biološka istraživanja „Siniša Stanković“, Beograd.

KRIST V. (1940): Halofytní vegetace jz. Slovenska a severní části Malé Uherské nížiny. – Práce Mor. Přír. Společn., Brno, 12/10: 1-100.

MARHOLD K. & HINDÁK F. (eds) (1998): Zoznam nižších a vyšších rastlín Slovenska. – Veda, Bratislava, 687 pp.

MOLNÁR ZS. & BORHIDI A. (2003): Hungarian alkali vegetation: Origins, landscape history, syntaxonomy, conservation. – Phytocoenologia 33: 377-408.

MUCINA L. (1993): *Puccinellio-Salicornietea,* pp. 522-549. – In: MUCINA L., GRABHERR G. & ELLMAUER T. (eds), Die Pflanzengesellschaften Österreichs. Teil 1, Anthropogene Vegetation. Fischer, Stuttgart & New York.

POP I. (2002): Vegetatia solurior saraturoase den Romania. – Contrib. Bot., Cluj, 35(2): 287-332

POPESCU A. (2005): Pajişti ponto-panonice de *Hordeum hystrix*. – In: DONIŁĂ, N., POPESCU A., PAUCĂ-COMĂNESCU M., MIHĂILESCU S., BIRIS I.A.: Habitatele din România. Edit. Tehnică Silvică, Bucuresti, p. 53.

RICHARDS L. A. (1954): Diagnosis and Improvement of Saline and Alkali Soils. – U.S. Salinity Laboratory Staff, Washington, p. 159.

SÁDOVSKÝ M. (2003): *Hordeum geniculatum*. [Report]. – In: Mráz, P. (ed.): Zaujímavejšie floristické nálezy. – Bull. Slov. Bot. Spoločn., Bratislava, 25: 252.

SÁDOVSKÝ M., ELIÁŠ P. ml. & DÍTĚ D. (2004): Historické a súčasné rozšírenie slaniskových spoločenstiev na juhozápadnom Slovensku. – Bull. Slov. Bot. Spoločn., Bratislava, Supl. 10: 127-129.
STN ISO 13536 (2001): Kvalita pôdy. Stanovenie katiónovej výmennej kapacity a obsahu vymeniteľných katiónov za použitia tlmivého roztoku chloridu bárnatého s hodnotou pH 8,1. SÚTN, Bratislava.
STN ISO 10694 (2001): Kvalita pôdy. Stanovenie organického a celkového uhlíka po suchom spaľovaní (elementárna analýza). SÚTN, Bratislava.
STN ISO 10390 (2005): Kvalita pôdy. Stanovenie pH. SÚTN, Bratislava.
TÓTH T. & KERTÉSZ M. (1993): Mapping the degradation of solonetzic grassland. – Agrokémia és Talajtan 42: 43–54
TZONEV R. T., DIMITROV M. A. & ROUSSAKOVA, V. H. (2009): Syntaxa according to the Braun-Blanquet approach in Bulgaria. Phytologia Balcanica 15: 209–233.
VICHEREK J. (1973): Die Pflanzengsellschaften der Halophyten und Subhalophytenvegetation der Tschechoslowakei. – Vegetace ČSSR, ser. A, Praha, 5: 79-90.
WENDELBERGER G. (1950): Zur Soziologie der kontinentalen Halophytenvegetation Mitteleuropas. – Abh. Akad. Wiss. Wien, Math.-Nat. Kl. 108: 1-180 + Tab.

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