

***Camphorosmetum annuae* RAPAICS ex Soó 1933 – vanishing plant community of saline habitats in Slovakia**

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Abstract: Association *Camphorosmetum annuae* was reported in the second half of 20th century from relatively large areas of south-western Slovakia. The community retreats in Slovakia nowadays due to conversion of saline soils to arable land. This work deals with recent distribution and condition of the community in Slovakia. Phytosociological relevés were sampled using the adapted Braun-Blanquet scale and classified by TWINSpan software. The results showed that the community has still occurred only on three sites near the villages of Veľké Kosihy, Iža and Kamenín, covering total area not larger than 70 m². However, typical *Camphorosmetum annuae* was found only in the Kamenínske slanisko Nature Reserve near the village of Kamenín where covered total area only 0.01-1 m². All other recent localities with occurrence of *Camphorosma annua* represent only secondary and disturbed habitats on more or less degraded saline soils. The vegetation cover on these localities is usually close to *Festucion pseudovinae* communities. The results documented that *Camphorosmetum annuae* is fast vanishing plant association in Slovakia and its survival and conservation is probably impossible without human impact.

Keywords: *Camphorosma annua*, conservation, pioneer saline vegetation, Slovakia.

Introduction

Inland halophytic plant communities are distributed on saline soils mainly in warm and dry lowland regions. In Slovakia, saline soils occupy the largest area on the Podunajská nížina Lowland, namely at the Žitný ostrov area and in the surrounding of the towns of Komárno, Nové Zámky and Štúrovo, with northernmost sites situated near the town of Nitra (KRIST 1940, KRIPPELOVÁ 1965, VICHEREK 1973, FEHÉR 2007). Far smaller areas with saline soils were published from the Východoslovenská nížina Lowland, especially near the villages of Kopčany, Malčice, and Raškovce (VICHEREK 1964, 1973).

Taking into account above mentioned publications, it is clear that relatively large areas of saline vegetation have occurred in Slovakia in the past. The saline vegetation cover was markedly reduced due to massive land reclamation during the last three decades of 20th century. For example, OSVAČILOVÁ & SVOBODOVÁ (1961) mentioned ca 8300 ha covered by saline plant communities in the Podunajská nížina Lowland. However, SÁDOVSKÝ et al. (2004b) found only ca 500 ha of saline vegetation, and habitats of initial salt marsh communities have been almost destroyed (ELIÁŠ jun. et al. 2003, 2008). Contemporary status of many saline species and their communities is unknown and detailed study is therefore needed.

Firstly, an overview in other European countries, based on literature data, is given. In the second part of the paper, the analysis of the data collected by the authors in Slovakia is presented. The results are discussed taking into account the nature conservation issues.

Syntaxonomy

Camphorosma annua participate as a dominant or subdominant in several plant communities (e.g. *Lepidio crassifolii-Camphorosmetum annuae* SOÓ 1947), but only *Camphorosmetum annuae* RAPAICS ex SOÓ 1933 occurs in Slovakia (e.g. VICHEREK 1973, VALACHOVIČ 2002, SÁDOVSKÝ et al. 2004a). Syntaxonomic treatments of this community are various depending on authors' concept. Usually it is included into alliance *Puccinellion limosae* (WENDELBERGER 1943, 1950, SOÓ 1964, MUCINA 1993, KOJIĆ et al. 1998, SANDA et al. 1999, POP 2002), but less frequently also to *Puccinellion convolutae* (MICEVSKI 1965), *Thero-Camphorosmion* (VICHEREK 1973) or *Camphorosmo-Suaedion corniculatae* (FREITAG et al. 2001). Recent syntaxonomic classifications of Hungarian alkali vegetation treat *Camphorosmetum annuae* within alliance *Salicornion prostratae* (BORHIDI 1996, BORHIDI 2003, MOLNÁR & BORHIDI 2003).

Ecology, Threat and Distribution

Communities of *Camphorosma annua* prefer especially solonetz soils. Presence of the community indicates bare stand depressions (called "salt eyes") with highest salinity where the vegetation cover is sparse and species-poor (WENDELBERGER 1943, 1950, KRIPPELOVÁ 1965). Soil surface in the stands is covered by water for a prevailing part of the growing season and dry up in

summer. This character of water regime leads to the highest soil salinization in comparison to adjacent stands. Therefore, these "salt eyes" can be included to the most extreme habitats for vegetation in lowland conditions.

Camphorosma annua Pall. (*Chenopodiaceae*) belongs to the group of vanishing obligate halophytic plants in Central Europe. This species is endemic for Pontic-pannonian region and occurs from Austria, Hungary and countries of former Yugoslavia (Croatia, Serbia, Macedonia) to Ukraine, Romania and Bulgaria (BALL & AKEROYD 1964, AELLEN 1979). In Slovakia *C. annua* occurs only in the Podunajská nížina Lowland and it is considered as a phytogeographically important and border element of the Slovak flora (MAGLOCKÝ 1999). It was included in the Red lists of endangered taxa in Austria and Slovakia (NIKLFELD & SCHRATT-EHRENDORFER 1999, FERÁKOVÁ et al. 2001).

The *Camphorosmetum annuae* is distributed in Pontic-pannonian region (WENDELBERGER 1950, VICHEREK 1973). Reliable data about its occurrence were given from NE Austria (WENDELBERGER 1943, 1950, MUCINA 1993), SW Slovakia (e.g. KRIST 1940, VICHEREK 1973, VALACHOVIČ 2002), Hungary (e.g. SOÓ 1929, 1964, BODROGKÖZY 1962, 1980, BORHIDI 1996, MOLNÁR & BORHIDI 2003 etc.), NE Croatia (TOPIĆ et al. 2006), northern part of Serbia (SLAVNIĆ 1948, KOJIĆ et al. 1998), Macedonia (MICEVSKI 1965), Ukraine (BILIK 1937, 1963), Romania (ȚOPA 1939, POP 2002, POPESCU 2005) and Bulgaria (BONDEV et al. 1964, GANCHEV et al. 1971).

The association is widespread especially in Hungary where the main part of Pannonia occurs and where alkali habitats cover nearly 400,000 ha (MOLNÁR & BORHIDI 2003). In the Duna-Tisza köze region ca 3000 ha of salt bare spots vegetation was estimated (MOLNÁR & VAJDA 2000). The community was found also in SE and E Hungary (e.g. SOÓ 1929, 1964, BODROGKÖZY 1962, 1980, SOMOGYI 1965). Regardless of this wide distribution the association was proposed for protection and included to Red book of Hungarian plant communities (VARGA & VÁRGÁNE 1999).

Camphorosmetum annuae is scattered or rare in other parts of its range. In Austria it is distributed only at suitable habitats around the Neusiedler See (e.g. WENZL 1934, WENDELBERGER 1943, MUCINA 1993). According to TOPIĆ et al. (2006) current area of *Camphorosmetum annuae* in Croatia is not known exactly; well-known is only single locality near the town of Vukovar (E Croatia), where the saline vegetation covers surface ca 1-1.5 ha. Similar situation is in Macedonia. The halophytic vegetation is distributed in the eastern part of the country (ANDONOV et al. 2003). Micevski (1965) mentioned only two localities of *Camphorosmetum annuae* from this area. Occurrence of the association in Serbia is also very scattered. It was found only in the Banat and Bačka regions (SLAVNIĆ 1948, VUČKOVIĆ 1983, 1985, KNEŽEVIĆ 1980, 1994). Similarly, scattered distribution of the community is known from Romania. POPESCU (2005) pointed out its occurrence only from two districts in E part of the country (Muntenia and Moldova). The author estimated that total area covered by the association is not larger than 40-55 ha and the community needs protection. Ganchev et al. (1971) mentioned the community from several localities in SE Bulgaria. However, no

knowledge about current stage was published. In accordance with Tzonev (2008 in verb.) some of localities have survived, but many of them were destroyed and their structure was changed.

Material and methods

The study was carried out during 2003–2007. Localities of *Camphorosmetum annuae* were being found in the field with the help of 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). Most of relevés was sampled on area to 3 m². All relevés were stored in the database, using the TURBOVEG software (HENNEKENS 1996). The relevés were classified by divisive cluster analysis using program TWINSpan (HILL 1979).

Nomenclature of flowering plants follows MARHOLD & HINDÁK (1998) and the names of syntaxa are according to MOLNÁR & BORHIDI (2003). Herbarium specimens collected during field research are stored in herbarium of Department of Botany, Slovak University of Agriculture, Nitra. The map was constructed using the map grid that was described by NIKLFELD (1971).

Results

Native bare spot stands of association *Camphorosmetum annuae* were found only on three localities during our study: Veľké Kosihy, Iža and Kamenín (Tab. 1, Fig. 1). All this stands are included to protected areas nowadays. Site near the Veľké Kosihy village has been situated in the Mostové Nature Reserve (named also Dérhídja in older literature). The community was developed only at five small bare spots in the north and south parts of the reserve; a total area was not larger than 20 m². Extreme stage was found at the second locality east of the Iža settlement. *Camphorosmetum annuae* has occurred in the west part of the Bokrošské slanisko Nature Reserve and covered only ca 5 m². However, it should be noted that the origin of bare spot depressions was mainly secondary – they have originated during soil mining for a brick production in sixties of 20th century. Finally, the largest area of *Camphorosmetum annuae* was found in the Kamenínske slanisko Nature Reserve near the village of Kamenín. Shallow depressions covered by the community have been centralized to north-western part of the reserve and their total surface was circa 35-45 m².

Vegetation of *Camphorosmetum annuae typicum* with absolute dominance of *C. annua* was sampled only in the Kamenínske slanisko Nature Reserve (Tab. 1, relevé 7); total area was not larger than 0.01-0.1 m² (!) depending on year. The site represents the last occurrence of this subassociation in Slovakia. Nevertheless, most of the *C. annua* vegetation cover on all above mentioned localities should be placed into subassociation *puccinellietosum limosae* that was described by VICHEREK (1973) from former Czechoslovakia. In contrast to *Camphorosmetum annuae typicum* this subassociation is characteristic by presence of some other plant species and the cover of *C. annua* can decrease

up to 15%. We recorded species *Puccinellia distans*, *Artemisia santonicum* subsp. *patens* and *Festuca pseudovina* almost in all relevés (Tab. 1). Average number of species per relevé was 6.8.

Besides native bare spots, we recorded communities with dominance of *Camphorosma annua* also on secondary habitats of saline soils (e.g. margins of rural roads and fields, man-made depressions). Six such localities were found in total: Tvrdošovce, Iža (the Bokrošské slanisko Nature Reserve), Velké Kosihy (the Mostové Nature Reserve), Kamenín (the Kamenínske slanisko Nature Reserve), Kamenný Most (the Čistiny Nature Reserve) and Šurany (Tab. 2, Fig. 1).

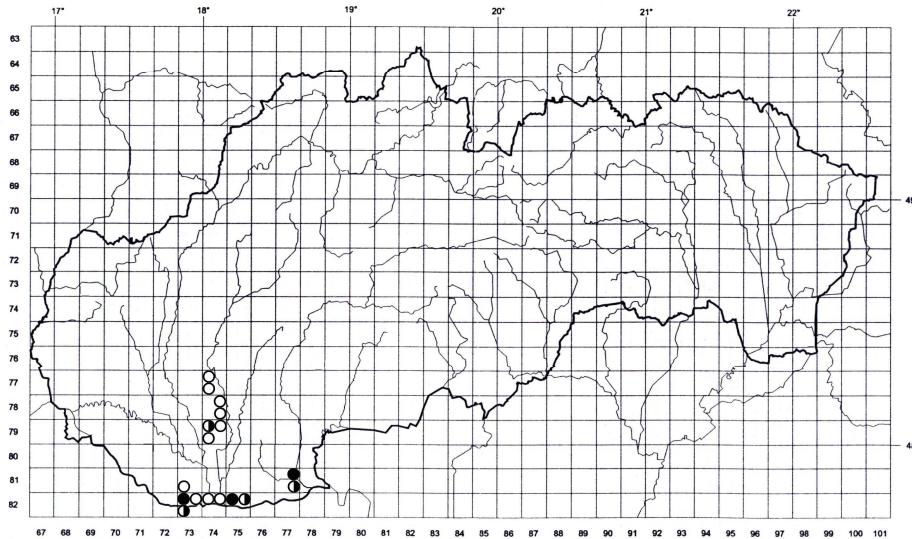


Fig. 1. Historical and recent distribution of *Camphorosmetum annuae* in Slovakia („○“ - the occurrence known in the past; „●“ - present occurrence on bare spots; „○” present occurrence on secondary habitats).

Survival of *Camphorosma annua* here was supported by disturbance of soil surface (single or periodical) which resulted to weaker competition of others plants. Salinity of soil was probably lower because we recorded higher number of species in average (8.9 species per relevé) and bryophytes were usually established (Tab. 2). Furthermore, in contrast to communities of natural bare spot depressions the vegetation cover of secondary *Camphorosma annua* habitats was characterized not only by higher occurrence of facultative halophytes (e.g. *Atriplex prostrata*, *Lepidium perfoliatum*, *Ranunculus pedatus*) but also some meadow and ruderal plants have been found frequently (e.g. *Capsella bursa-pastoris*, *Carduus acanthoides*, *Cirsium arvense*, *Holosteum umbellatum*, *Trifolium campestre*, *Vicia sativa*). Classification of these communities is problematic; only a few samples can be placed to more or less

modified/ruderalized *Camphorosmetum annuae* (Tab. 2, relevés 1, 10, 11). However, most of sampled communities were close to vegetation of alliance *Festucion pseudovinae* SOÓ 1933, namely to association *Artemisia santonici-Festucetum pseudovinae* SOÓ in MÁTHÉ 1933 corr. BORHIDI 1996. On the other hand, in some rare cases this vegetation was almost identical to *Camphorosmetum annuae* on bare spots such as several micro-stands in the Bokrošské slanisko Natural Reserve established by removing of vegetation cover and soil mining mentioned above (Tab. 1, relevés 1 and 2).

Tab. 1. Analytic table of current *Camphorosmetum annuae* vegetation on salt bare spots ("salt eyes") in Slovakia.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Relevé surface (m ²)	1	1	2	1	1	4	1	6	2	2	12	1	10	4	3	4	4
Coverage E ₁ %	25	30	15	30	30	20	90	80	90	50	70	30	85	15	20	20	35
Coverage E ₀ %	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of species per relevé	3	3	6	3	3	5	7	7	8	7	9	6	7	8	7	7	10
<i>Camphorosma annua</i>	b	b	a	a	b	a	5	4	4	3	b	b	4	1	a	1	1
<i>Puccinellia distans</i>	b	a	1	3	1	1	1	1	1	+	1	1	+	a	1	1	a
<i>Artemisia santonicum</i> ssp. <i>patens</i>	.	r	r	1	.	+	+	1	+	.	1	r	1	+	r	1	b
<i>Festuca pseudovina</i>	.	.	.	.	1	.	r	+	r	r	1	.	1	+	+	.	a
<i>Plantago maritima</i>	r	.	+	.	.	1	1	1	1	+	3	r	a	.	.	.	.
<i>Matricaria chamomilla</i>	.	.	.	.	.	.	r	3	1	b	1	a	.	.	1	.	.
<i>Limonium gmelinii</i>	.	.	.	.	.	.	.	1	r	r	1	+	1	.	.	.	.
<i>Cerastium dubium</i>	.	.	.	.	.	.	.	.	r	1	.	.	.	+	1	1	.
<i>Tripolium pannonicum</i>	.	.	+	.	.	.	.	.	.	.	.	.	.	+	r	.	+

Species in one or two relevés only

Species recorded in two relevés only: *Atriplex tatarica* + (16), 1 (17), *Bromus mollis* r (6), r (14), *Cynodon dactylon* + (16), 1 (17), *Chenopodium urticum* 1 (14), + (15).

Species recorded in one relevé only: *Achillea collina* + (17), *Bromus commutatus* r (7), *Inula britannica* r (17), *Polygonum rurivagum* r (11), *Taraxacum* sect. *Ruderalia* + (17), *Tetragonolobus maritimus* r (3), *Veronica arvensis* r (11).

Localities of relevés

Note: For relevés, the header data are listed in the following order: number of relevé, locality, exposition, elevation, altitude, sampling date.

1. Iža, the Bokrošské slanisko Nature Reserve, W part, secondary developed depression near the waste dump, exp. S, elev. ca 1°, 115 m a. s. l., 1. 10. 2006. 2. Iža, the Bokrošské slanisko Nature Reserve, W part, secondary developed depression near the waste dump, exp. S, elev. ca 1°, 115 m a. s. l., 1. 10. 2006. 3. Iža, the Bokrošské slanisko Nature Reserve, W part, pit in salt meadow near the waste dump, 115 m a. s. l., 1. 10. 2006. 4. Veľké Kosihy, the Mostové Nature Reserve, N part, degraded bare spot, 117 m a. s. l., 12. 5. 2005. 6. Veľké Kosihy, the Mostové Nature Reserve, bare spot, exp. S, elev. ca 5°, 117 m a. s. l., 13. 9. 2003. 5., 11., 12., Kamenín, the Kamenínske slanisko Nature Reserve, NW part, 112 m a. s. l., 13. 5. 2005. 7.-10. Kamenín, the Kamenínske slanisko Nature Reserve, NW part, 112 m a. s. l., 8. 5. 2004. 13. Kamenín, the Kamenínske slanisko Nature Reserve, NW part, 112 m a. s. l., 14. 9. 2003. 14., 15. Veľké Kosihy, the Mostové Nature Reserve, N part, bare spot near a deer-stand, 117 m a. s. l., 12. 5. 2005. 16. Veľké Kosihy, the Mostové Nature Reserve, N part, partially rutted bare spot, 117 m a. s. l., 14. 9. 2005. 17. Veľké Kosihy, the Mostové Nature Reserve, S part, partially missing bare spot, 117 m a. s. l., 13. 9. 2003.

Tab. 2. Analytic table of current communities with *Camphorosma annua* on anthropogenically disturbed habitats in Slovakia.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Relevé surface (m ²)	2	1	4	2	1	8	2	12	1	1	1	1	1	10	10
Coverage E ₁ %	30	60	25	70	50	50	30	70	60	50	70	50	30	95	85
Coverage E ₀ %	0	10	0	3	20	3	2	20	0	10	50	10	90	20	10
Number of species per relevé	4	3	7	6	8	15	12	18	6	7	9	13	10	9	8
<i>Camphorosma annua</i>	3	b	1	b	b	a	a	b	b	3	3	b	1	+	a
<i>Puccinellia distans</i>	b	3	b	.	1	3	1	a	a	1	1	1	.	b	1
<i>Artemisia santonicum ssp. patens</i>	.	+	1	a	1	b	a	b	.	1	.	1	a	a	4
<i>Plantago maritima</i>	.	.	b	.	1	1	1	a	.	+	1	1	a	4	a
<i>Festuca pseudovina</i>	.	.	.	3	+	1	1	3	1	.	.	+	1	.	a
<i>Matricaria chamomilla</i>	.	.	.	.	a	a	a	3	1	b	3	b	1	.	.
<i>Cerastium dubium</i>	r	.	.	.	.	+	+	a	+	+	a	1	.	.	.
<i>Limonium gmelinii</i>	.	.	.	.	.	.	.	.	.	.	+	+	1	1	a
<i>Achillea collina</i>	.	.	.	.	+	.	.	.	.	.	.	.	+	a	1

Species in one, two or three relevés only

Species recorded in three relevés only: *Cynodon dactylon* r (1), + (3), 1 (4), *Elytrigia repens* + (4), + (7), 1 (8), *Erophila verna* + (6), 1 (11), a (13).

Species recorded in two relevés only: *Achillea millefolium* r (7), + (8), *Tripolium pannonicum* 1 (6), 1 (14), *Atriplex patula* 1 (7), r (8), *Bromus japonicus* r (11), + (12), *B. mollis* r (6), r (10), *Cirsium arvense* r (8), r (12), *Cruciata pedemontana* r (6), r (12), *Lactuca serriola* r (6), r (8), *Lamium amplexicaule* r (7), r (8), *Lepidium perfoliatum* 1 (9), r (11), *Veronica arvensis* + (8), r (12).

Species recorded in one relevé only: *Allium vineale* r (15), *Capsella bursa-pastoris* r (12), *Carduus acanthoides* r (8), *Epilobium tetragonum* + (13), *Galium aparine* r (8), *Galium verum* a (14), *Holosteum umbellatum* r (5), *Myosurus minimus* + (7), *Odontites vulgaris* + (14), *Plantago tenuiflora* 1 (6), *Podospermum canum* + (8), *Polygonum rurivagum* 1 (8), *Ranunculus pedatus* r (13), *Trifolium campestre* + (6), *Vicia sativa* r (6).

Localities of relevés

Note: For relevés, the header data are listed in the following order: number of relevé, locality, exposition, elevation, altitude, sampling date.

1. Tvrdošovce, N, rutted rural road, 112 m a. s. l., 12. 5. 2005. 2. Iža, the Bokrošské slanisko Nature Reserve, N part, secondary developed depression near the waste dump, 115 m a. s. l., 1. 10. 2006. 3. Iža, the Bokrošské slanisko Nature Reserve, W part, secondary developed depression near the waste dump, exp. S, elev. ca 1^o, 115 m a. s. l., 1. 10. 2006. 4. Veľké Kosihy, the Mostové Nature Reserve, depression in groove of rural road, 117 m a. s. l., 13. 5. 2005. 5., 13 - 15. Kamenín, the Kamenínske slanisko Nature Reserve, SE part, overgrown shallow depression, 112 m a. s. l., 13. 5. 2005. 6. Tvrdošovce, N, rutted rural road, 112 m a. s. l., 12. 5. 2005. 7. Šurany, Okomáň site, W part, groove of rural road, 120 m a. s. l., 12. 5. 2005. 8. Šurany, Okomáň site, W part, rutted bare spot, 120 m a. s. l., 12. 5. 2005. 9. - 12. Kamenný Most, the Čistiny Nature Reserve, rutted rural road on east part of the site, 111 m a. s. l., 13. 5. 2005.

Discussion

In Slovakia, the occurrence of *Camphorosmetum annuae* coincides with the distribution area of *Camphorosma annua* which is restricted to the warmest and driest regions of the Podunajská nížina Lowland (SW Slovakia). It reaches the north-western border of distribution there.

In the past *Camphorosmetum annuae* was found on ca 25-30 localities in surroundings of the settlements of Zlatná na Ostrove, Okoličná na Ostrove,

Zemianska Olča, Komárno, Palárikovo, Tvrdošovce, Dolný Jatov, Šurany, Rastislavice, Komjatice, Sládečkovce (now Močenok), Hájske, Kamenný Most and Kamenín (KLIKA & VLACH 1937, KRIST 1940, ŠMARDA 1952, KRIPPELOVÁ 1965, VICHEREK 1973). Typical stands of the association often covered large areas of saline depressions and partly also sites disturbed by human activities. This pioneer vegetation overgrew around free centre of bare spot and the coverage of *C. annua* in such ring-shaped stands reached up to 100%. *Matricaria chamomilla* subsp. *bayeri* was a frequent subdominant species during spring months of growing season (KRIST 1940, KRIPPELOVÁ 1965, VICHEREK 1973).

Recently occurrence of the association was reported only from six localities in bare spots near the villages of Tvrdošovce, Močenok, Kamenný Most and Kamenín (SVOBODOVÁ & ŘEHOŘEK 1985, 1988, 1992, SVOBODOVÁ 1990, 1993, VALACHOVIČ 1995). Four relevés of the community were published by ZLINSKÁ (ZLINSKÁ 2003, 2005) from two protected areas near the municipalities of Veľké Kosihy and Iža (the Mostové Nature Reserve and the Bokrošské slanisko Nature Reserve).

The results of the present study suggest that recultivation of landscape (e.g. ploughing, drying of wet saline soils, planting of *Populus* forests) has caused a strong reduction of *Camphorosmetum annuae* vegetation in Slovakia. We argue that above mentioned human activities (mainly land drainage) have led to the soil salinity decrease which has caused that saline vegetation with dominance of *Camphorosma annua* is currently close to extinction. Destruction of existing habitats seems to be irreversible and rapid in present conditions (continuous land recultivation, weak or absent management of protected areas with halophytic vegetation etc.). It is alarming that some stands of our relevés published in this work are being destroyed nowadays.

Only three *Camphorosmetum annuae* localities still exist and the total area of these habitats is up to 70 m². However, the bare spots covered in the past by a few obligate halophytic plants were changed markedly as a result of soil desalination – the plant diversity increased and the structure and species composition of communities was changed. We did not record any stands of *Camphorosmetum annuae typicum* sensu VICHEREK (1973) during our study except ca 0.01-0.1 m² in central parts of saline depressions on the Kamenínske slanisko Natural Reserve. VICHEREK (1973) pointed out that the community was characteristic by absolute dominance of *Camphorosma annua* (coverage 50-75%), total absence of bryophytes and presence of only a few other species (especially *Matricaria chamomilla* and *Puccinellia distans*). Number of species per relevé was usually one or two. On the basis of our phytosociological data recent Slovak *Camphorosmetum annuae* is represented mainly by subassociation *puccinellietosum limosae* (TOPA 1939) VICHEREK 1973. However, the average number of species per relevé was approximately double (6.8 species per relevé) in comparison to data of VICHEREK (1973). The author mentioned only 3.8 species per relevé in this subassociation. We regard increasing plant diversity of bare stands as a result of decreasing soil salinity caused by negative human impact.

All other recent Slovak localities of communities with *Camphorosma annua* are represented only by secondary and disturbed habitats on more or less degraded saline soils. The vegetation cover is usually close to communities of alliance *Festucion pseudovinae* SOÓ 1933. On the other hand occurrence of *Camphorosma annua* on these habitats showed that the species is able to occupy micro sites with lower soil salinity if other competitors are not abundant. This fact is important for the practical species protection. We suppose in accordance with Zs. MOLNÁR (2007 in verb.) that removing vegetation cover and creating artificial depressions can help *Camphorosma annua* to survive in Slovakia. It is likely that the vegetation cover of *Camphorosmetum annuae* would develop on such spare sites made by humans similarly to depressions in the Bokrošské slanisko Nature Reserve. Future investigations will show whether this management provides satisfying and long-term results.

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