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The Ecology and the Coenotic Characteristics of the Pholiuro pannonici-Plantaginetum tenuiflorae in the Pannonian Basin

By

Daniel DÍTĚ*), Pavol ELIÁŠ jun.**), Róbert ŠUVADA***) and

Nora SZOMBATHOVÁ****)

With 5 Figures

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Summary

DÍTĚ D., ELIÁŠ P. jun., ŠUVADA R. & SZOMBATHOVÁ N. 2010. Ecology and coenotic characteristics of the Pholiuro pannonici-Plantaginetum tenuiflorae in the Pannonian Basin. – *Phyton* (Horn, Austria) 49(2): 293–312, with 5 figures.

The Pholiuro pannonici-Plantaginetum tenuiflorae WENDELBERGER 1943 community is only known from the Pannonian region. The community has been reliably documented in Austria, Slovakia, Hungary, Serbia and Romania. Because this plant community is known only from a relatively small area, details about its synecology are inaccurate. To fill the relevant gaps in knowledge, the ecology and coenology of this community were studied in two countries within the Pannonian Basin (Hungary and Slovakia). A DCA analysis of 77 relevés from the Pannonian Plain confirmed that the community is characterised by the co-occurrence of both dominant plant

*) Dr. D. DÍTĚ, Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 9, 845 23, Bratislava, Slovak Republic; e-mail: daniel.dite@savba.sk

**) Ing. P. ELIÁŠ jun., Department of Botany, Slovak University of Agriculture, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic; e-mail: pelias@afnet.uniag.sk

***) Mgr. R. ŠUVADA, Administration of the Slovenský kras National Park, Hámosiho 188, 049 51, Brzotín, Slovak Republic; e-mail: robert.suvada@sopsr.sk

****) Ing. N. SZOMBATHOVÁ, Department of Pedology and Geology, Slovak University of Agriculture, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic; e-mail: nora.szombathova@uniag.sk

species with an abundance over 5%, although their individual abundances may reach values of up to 50%. The total area covered by vascular plants was relatively variable, ranging from 25 to 60%. The widespread presence of accessory species was dependent on the environmental conditions, in particular the moisture gradient. Our results also showed that while in Hungary the community occurs on across large areas, in Slovakia it is considered extinct. Extinction was likely caused by significant changes in the landscape structure, especially the land reclamation of alkali steppes (i.e., drainage, tillage). Secondary communities with both *Pholiurus pannonicus* and *Plantago tenuiflora* were created in damaged habitats, mainly in the deep tracks of rural roads. The occurrence of the above-mentioned species was dependent on occasional disturbance that eliminated competition from other plant species. Compared to the typical Pholiuro-Plantaginetum community, the secondary communities contain several ruderal and meadow species.

Zusammenfassung

DÍTĚ D., ELIÁŠ P. jun., ŠUVADA R. & SZOMBATHOVÁ N. 2010. Ecology and coenotic characteristics of the Pholiuro pannonici-Plantaginetum tenuiflorae in the Pannonian Basin. [Ökologie und coenologische Merkmale des Pholiuro pannonici-Plantaginetum tenuiflorae in der Pannonischen Tiefebene]. – Phytion (Horn, Austria) 49(2): 293–312, mit 5 Abbildungen.

Die Pholiuro pannonici-Plantaginetum tenuiflorae Gesellschaft ist nur aus Pannonien bekannt, mit zuverlässigen Dokumentationen aus Österreich, der Slowakei, Ungarn, Serbien und Rumänien. Da die Gesellschaft nur aus diesem relativ kleinen Gebiet bekannt ist, sind nur ungenaue Angaben über ihre Synökologie publiziert. Daher wurden Ökologie und Coenologie in zwei pannonischen Ländern untersucht (Ungarn, Slowakei). Die DCA-Analyse von 77 Vegetationsaufnahmen aus der Pannonischen Tiefebene bestätigt, dass die Gesellschaft durch das gemeinsame Vorkommen beider Dominanten mit mehr als 5% Deckung charakterisiert ist, obwohl die Arten eine Deckung bis 50% erreichen können. Die Gesamt-Deckungen der höheren Pflanzen reichen von 25 bis 60%. Das Auftreten von zusätzlichen Arten wurde durch unterschiedliche Standortseigenschaften bedingt, vor allem durch den Faktor Bodenfeuchte. Unsere Ergebnisse zeigen auch, dass die Gesellschaft in Ungarn noch weit verbreitet, in der Slowakei jedoch ausgestorben ist. Dies wurde durch landwirtschaftliche Maßnahmen, insbesondere die Rückgewinnung von Alkali-Steppen (Entwässerung, Bodenbearbeitung) verursacht. Eine sekundäre Gesellschaft mit den beiden Arten *Pholiurus pannonicus* und *Plantago tenuiflora* kann auf solcherart veränderten Lebensräumen, hauptsächlich in tiefen Spuren von Landstraßen, nachgewiesen werden. Das Vorkommen der beiden genannten Arten war hier abhängig von gelegentlichen Störungen, die zur Ausschaltung der Konkurrenz durch andere Pflanzenarten führen. Diese sekundäre Gesellschaft besitzt im Vergleich mit dem Pholiuro-Plantaginetum viele Arten von Ruderal- und Wiesenstandorten.

1. Introduction

In Central Europe halophyte plant communities develop on alkali soils in dry and arid regions. The centre of their occurrence is in the Pannonian Basin, mainly in the southwestern and eastern portions of Hungary (SZA-

BOLCS 1974). In the northwestern and northeastern part of the basin, the alkali steppe reaches the territories of Austria, Moravia and Slovakia (WENDELBERGER 1950, VICHEREK 1973). The largest studied area of saline vegetation was the Danube Lowland in Slovakia, where circa 8300 ha once existed (OSVAČILOVÁ & SVOBODOVÁ 1961). Presently, due to massive land reclamation during the communist era, only small fragments have survived, occupying an area of about 500 ha (SÁDOVSKÝ & al. 2004). Consequently, most of the halophytes and the halophytic communities are rare, or even missing and extinct.

The *Pholiuro pannonicum*-*Plantaginetum tenuiflorae* WENDELBERGER 1943 association develops on periodically flooded shallow depressions within saline soils. This community is characterised by the dominance and common occurrence of the annuals *Pholiurus pannonicus* and *Plantago tenuiflora*. *Ph. pannonicus* is more water-demanding, while *Pl. tenuiflora* is more tolerant to the soil salinity and desiccation and typically has a wider ecological amplitude (MUCINA 1993, BORHIDI 1996). Both of the species belong to a group of characteristic species from the Puccinellion limosae SOÓ 1933 alliance and the Festuco-Puccinellietea SOÓ 1968 class (MOLNÁR & BORHIDI 2003). The current distribution of these plant species is very scattered (KMEŤOVÁ 1997, ELIÁŠ jun. & al. 2009), and they are critically endangered in Slovakia (FERÁKOVÁ & al. 2001).

The *Pholiuro pannonicum*-*Plantaginetum tenuiflorae* community is only known from Pannonia. It has been reliably documented in Austria, Slovakia, Hungary, Serbia and Romania (WENDELBERGER 1950, VICHEREK 1973). The current main distribution area includes the eastern Hungarian alkali steppes in the Alföld region (SOÓ 1929, BORHIDI 2003) where the community is common. In Austria, Slovakia, Romania and Serbia, the community belongs to rare vegetation units (VICHEREK 1973, MUCINA 1993, IVEZIĆ & al. 1995, POPESCU 2005).

Very little reliable phytosociological material has been retained from the Slovak salt steppes. Several communities were mentioned only in the work of VICHEREK 1973, who also outlined the *Pholiuro pannonicum*-*Plantaginetum tenuiflorae* association. Historically, the distribution of the community coincided with the co-occurrence of the dominant species forming the association. It was sampled in the surroundings of Kamenín, Malý Jatov, Veľké Kosihy, Hájske, and Močenok in the Danube Lowland and near the villages of Malčice and Veľké Raškovce in the Východoslovenská nížina Lowland (VICHEREK 1973). It is likely that the older relevés of the community did not represent its total distribution in the Slovak saline habitats.

The aims of this study were the following ones:

- a) to analyse the historical and recent stages of the community in Slovakia from a phytosociological and ecological point of view, and
- b) to compare the recent Slovak data with the data sampled in Hungary.

2. Material and Methods

2.1. Phytosociological Data Sampling

Fieldwork was carried out in the Pannonian Basin region of Slovakia and Hungary from 2003–2008 (Fig. 1). Phytosociological relevés were sampled according to the Zürich-Montpellier approach using the adapted nine-grade Braun-Blanquet's scale (BARKMAN & al. 1964). All of the relevés are stored in a database using TURBOVEG software (HENNEKENS 1996). The relevés were analysed using the JUICE program (TICHÝ 2002). For the ordination analysis we used CANOCO for Windows 4.5 (TER BRAAK & ŠMILAUER 1998). The nomenclature of the vascular plants follows MARHOLD & HINDÁK 1998, and the names of the syntaxa are in accordance with MOLNÁR & BORHIDI 2003.

2.2. Soil Sampling and Soil Analyses

Root-zone (0–25 cm) soil samples from 13 relevé plots taken at three different points were examined. The chemical parameters that were analysed and the localities (relevé plots) of the samples are shown in Tab. 4. The soil reaction was tested potentiometrically in H₂O (FIALA & al. 1999), and the total soil organic carbon (C_T) was estimated using the Tyurin method (ORILOV & GRIŠINA 1981).

2.3. Data Analyses

Numerical classification was performed using the modified TWINSpan (HILL & ŠMILAUER 2005) algorithm, with 6 pseudospecies cut levels (0, 2, 5, 10, 25, 50). We used 77 relevés taken from halophytic vegetation from the Pannonian Basin (Slovakia, Hungary); our main aim was the identification of the characteristic species in the *Pholiuro pannonicum*-*Plantaginietum tenuiflorae* association. The results of the numerical classification are summarised in a synoptic table (Tab. 2). We applied the *phi* coefficient with the Fisher's exact test at the level of significance of $P < 0.001$ as a fidelity measure. The diagnostic species shown in the synoptic table (Tab. 2) were selected subjectively, based on two selection rules: 1) the constancy of the diagnostic species was higher than 75% and 2) the fidelity was higher than 0.40. The diagnostic species in cluster number 4 (*Puccinellietum limosae* association) only were selected manually using only one selection rule for the diagnostic species: that the constancy was higher than 75%.

The relations between the phytosociological relevés of the contact vegetation and the studied association (*Pholiuro pannonicum*-*Plantaginietum tenuiflorae*) were displayed using detrended correspondence analysis (DCA; Fig. 2). We used 77 halophytic vegetation relevés from the Pannonian Basin that were grouped by the results of the numerical classification (Tab. 2). The ordination scores of the most important species (i.e., the species weight range) were more than 35%.

We used Principal components analysis (PCA) for the analysis of the typical vegetation in the *Pholiuro pannonicum*-*Plantaginietum tenuiflorae* community (Tab. 1) and for the classified relevés with the presence of either *Plantago tenuiflora* or *Pholurus pannonicus* from Slovakia (see Table 3). To display the data for inspection and to distinguish between the two groups of relevés, data attribute plots values (Fig. 3, Fig. 4) and LOESS visualisation regression modelling methods were used (Fig. 5) to exploit the identified quantitative data (pH, C_T, number of species).

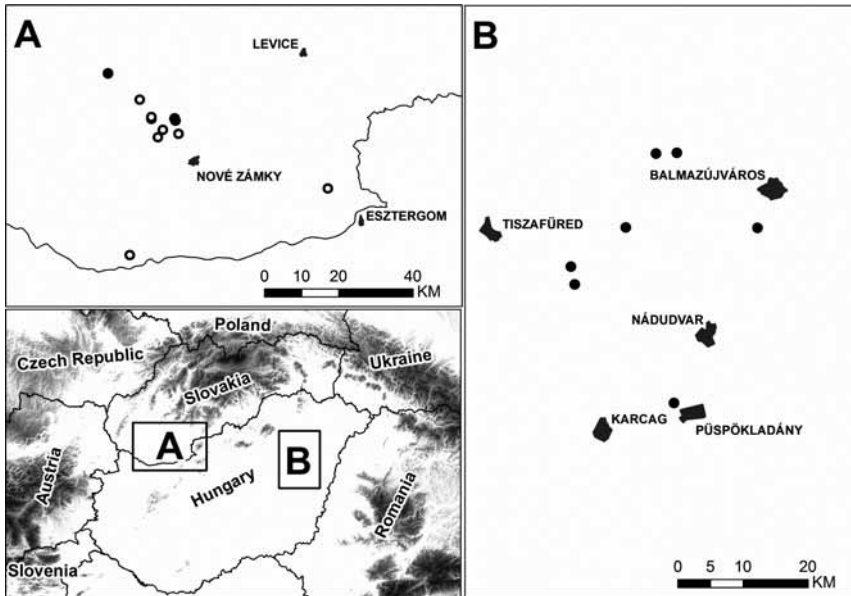


Fig. 1. Distribution of the relevés sampled during field research conducted between 2003–2008 in the Panonian Basin: ○ – secondary communities with occurrence of *Plantago tenuiflora* and/or *Pholiurus pannonicus*, ● – association of *Pholiuro pannonici*-*Plantaginetum tenuiflorae*.

2.4. Localities of Relevés in Tab. 1–4.

Relevés number, country code (HU – Hungary, SK – Slovakia, AU – Austria), detailed description of the locality, latitude, longitude, altitude, and the sampling date.

1. SK, Močenok, Siky farmstead, depression on edge of *Medicago sativa* field, E17°53'49.0", N48°13'17.8"; 116 m a. s. l., 15. 5. 2005.
2. SK, Šurany, Akomán farmstead, remains of saltpan – the deepest part, E18°07'12.5", N48°05'35.8"; 115 m a. s. l., 16. 6. 2004.
3. HU, Hortobágy National Park, Hortobágy E, depression in alkali steppe, E21°18'22.3", N47°33'38.7"; 92 m a. s. l.; 7. 6. 2008.
4. HU, Hortobágy National Park, Kocsiújfalu, depression in overgrazed alkali steppe, E20°54'52.6", N47°32'50.3"; 91 m a. s. l., 9. 6. 2008.
5. HU, Hortobágy National Park, Hortobágy E, depression in alkali steppe, E21°18'22.3", N47°33'38.7"; 92 m a. s. l.; 7. 6. 2008.
6. HU, Hortobágy National Park, Nagyiván, a long narrow groove in the alkali steppe, E20°54'59.9", N47°31'19.9"; 91 m a. s. l., 9. 6. 2008.
7. HU, Hortobágy National Park, Nagyiván, shallow depression, E20°54'59.9", N47°31'19.9"; 91 m a. s. l., 9. 6. 2008.
8. HU, Hortobágy National Park, Hortobágy E, depression in alkali steppe, E21°18'22.3", N47°33'38.7"; 92 m a. s. l.; 7. 6. 2008.
9. HU, Hortobágy National Park, depression in alkali steppe, E21°09'57.1", N47°40'54.0"; 93 m a. s. l., 8. 6. 2008.

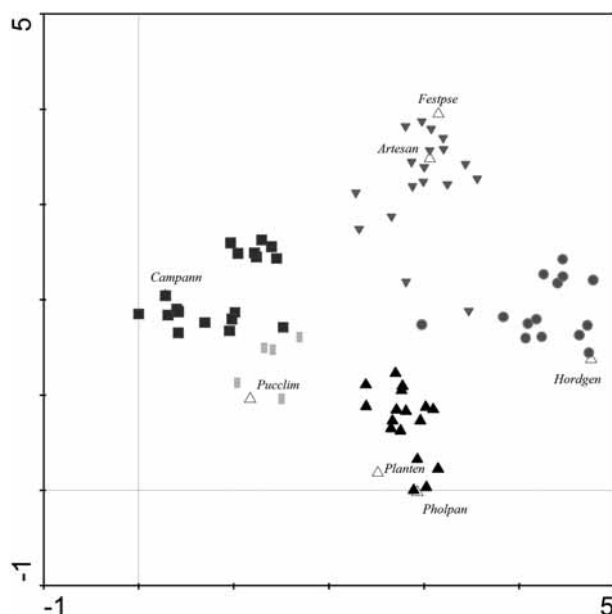


Fig. 2. Detrended correspondence analysis (DCA) ordination diagram of the 77 relevés of halophytic vegetation from the Pannonian Basin (Tab. 2). Group 1 (up-triangle) – *Pholiurus pannonicus*-*Plantago tenuiflora*; Group 2 (square) – *Camphorosmetum annuae*; Group 3 (circle) – *Hordeetum hystricis*; Group 4 (box) – *Puccinellietum limosae*; Group 5 (down-triangle) – *Artemisia santonici*-*Festucetum pseudovinae*. The eigenvalue for the first axis is 0.725 and 0.505 for the second axis. The length of the gradient for the first axis is 4.776 and 3.873 for the second axis. The ordination scores of the most important species (species weight range) are more than 35% (empty triangle). *Pholpan* = *Pholiurus pannonicus*, *Planen* = *Plantago tenuiflora*, *Festpse* = *Festuca pseudovina*, *Artesan* = *Artemisia santonicum*, *Hordgen* = *Hordeum geniculatum*, *Campann* = *Camphorosma annua*, *Pucclim* = *Puccinellia limosa*.

10. HU, Hortobágy National Park, Hortobágy E, depression in alkali steppe, E21°18'22.3", N47°33'38.7"; 92 m a. s. l.; 7. 6. 2008.
11. HU, Hortobágy National Park, Hortobágy E, depression in alkali steppe, E21°18'22.3", N47°33'38.7"; 92 m a. s. l.; 7. 6. 2008.
12. HU, Hortobágy National Park, Hortobágy W, shallow depression, E21°02'17.5", N47°35'22.9"; 93 m a. s. l., 8. 6. 2008.
13. HU, Hortobágy National Park, Újszentmargita, shallow depression in large alkali pastures, E21°07'24.0", N47°41'06.5"; 93 m a. s. l., 8. 6. 2008.
14. HU, Hortobágy National Park, Püspökladány NW, large depression in alkali pastures, E21°04'51.5", N47°20'14.9"; 89 m a. s. l., 10. 6. 2008.
15. HU, Hortobágy National Park, Hortobágy E, depression in alkali steppe, E21°18'22.3", N47°33'38.7"; 92 m a. s. l.; 7. 6. 2008.
16. HU, Hortobágy National Park, Újszentmargita, shallow depression in large alkali pastures, E21°07'24.0", N47°41'06.5"; 93 m a. s. l., 8. 6. 2008.

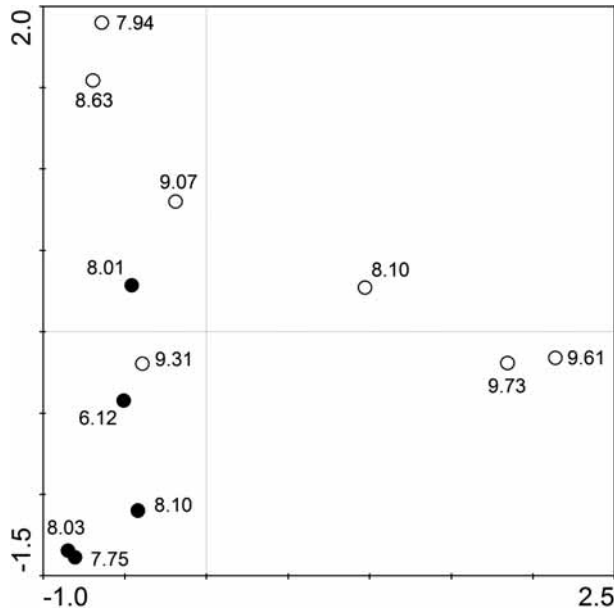


Fig. 3. Principal component analysis (PCA) projected for the 12 relevés, accounting for the presence of the species *Plantago tenuiflora* and *Pholiurus pannonicus* and the pH values. Group 1 (full circle) represents relevés classified by the association of *Pholiuro pannonici*-*Plantaginetum tenuiflorae*; Group 2 (empty circle) represents relevés with presence of *Plantago tenuiflora* and/or *Pholiurus pannonicus* species from Slovakia. The eigenvalue for the first axis is 0.318 and 0.228 for the second axis.

17. HU, Hortobágy National Park, Újszentmargita, shallow depression in large alkali pastures, E21°07'24.0", N47°41'06.5"; 93 m a. s. l., 8. 6. 2008.
18. SK, Veľké Kosihy, Mostové Nature Reserve, cart-road, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 6. 2008.
19. SK, Veľké Kosihy, Mostové Nature Reserve, cart-road, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 6. 2008.
20. SK, Veľké Kosihy, Mostové Nature Reserve, deep track of cart-road, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 5. 2005.
21. SK, Šurany, Malé Čiky farmstead, ploughed and abandoned field edge, E18°07'39.6", N48°03'16.5, 116 m a. s. l., 11. 5. 2008.
22. SK, Šurany, Malé Čiky farmstead, ploughed and abandoned field edge, E18°07'39.6", N48°03'16.5, 116 m a. s. l., 11. 5. 2008.
23. SK, Veľké Kosihy, Mostové Nature Reserve, cart-road, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 6. 2008.
24. SK, Veľké Kosihy, Mostové Nature Reserve, cart-road edge, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 8. 5. 2004.
25. SK, Veľké Kosihy, Mostové Nature Reserve, abandoned cart-road in south part of the reserve, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 6. 2008.
26. SK, Šurany, Akomán farmstead, remnant of saltpan, E18°07'12.5", N48°05'35.8", 114 m a. s. l., 13. 6. 2008.

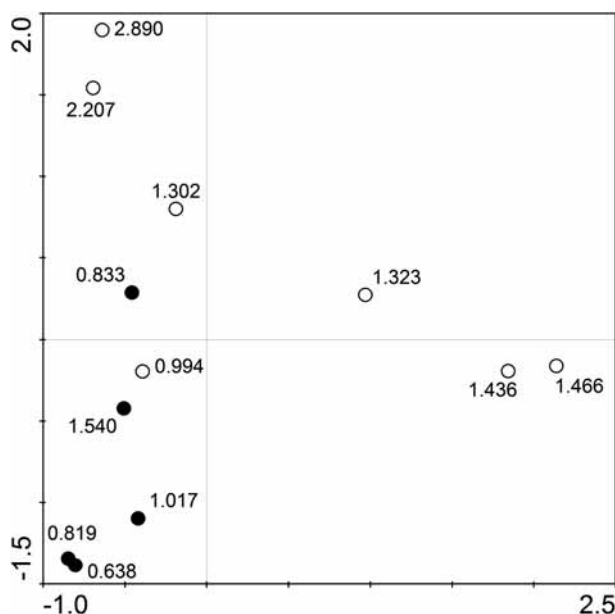


Fig. 4. Data attribute plot of CT values. Principal component analysis (PCA) projected for the 12 relevés with the presence of *Plantago tenuiflora* and *Pholiurus pannonicus* species with C_T values Group 1 (full circle) represents relevés classified as an association of *Pholiurus pannonicus*-*Plantaginetum tenuiflorae*. Group 2 (empty circle) represents relevés with the presence of *Plantago tenuiflora* and/or *Pholiurus pannonicus* species from Slovakia. The eigenvalue for the first axis is 0.318, 0.228 for the second axis.

27. SK, Šurany, Akomán farmstead, remnant of saltpan, E18°07'12.5", N48°05'35.8", 114 m a. s. l., 13. 6. 2008.
28. SK, Šurany, Akomán farmstead, remnant of saltpan, E18°07'12.5", N48°05'35.8", 114 m a. s. l., 13. 6. 2008.
29. SK, Šurany, Akomán farmstead, cart-road track, E18°07'20.5", N48°05'14.6", 118 m a. s. l., 13. 6. 2008.
30. SK, Veľké Kosihy, Mostové Nature Reserve, ploughed and abandoned site, cart-road track, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 6. 2008.
31. SK, Šurany, Malé Čiky farmstead, salt pan in ploughed and abandoned alkali steppe, E18°03'05.5", N48°03'05.5", 116 m a. s. l., 11. 5. 2008.
32. SK, Tvrdošovce, deep track in cart-road northwest from railway station, E18°02'08.3", N48°05'53.9", 117 m a. s. l., 27. 6. 2008.
33. SK, Šurany, Akomán farmstead, ruderalised depression surrounded by vegetation with dominance of *Elytrigia repens*, E18°07'12.5", N48°05'35.8", 114 m a. s. l., 16. 6. 2004.
34. SK, Šurany, Akomán farmstead, depression surrounded by *Festucion pseudovinae* vegetation, E18°07'12.5", N48°05'35.8", 114 m a. s. l., 16. 6. 2004.
35. SK, Horný Jatov, Čierny vršok site, shallow depression, E18°00'04.3", N48°08'53.5", 113 m a. s. l., 12. 5. 2005.

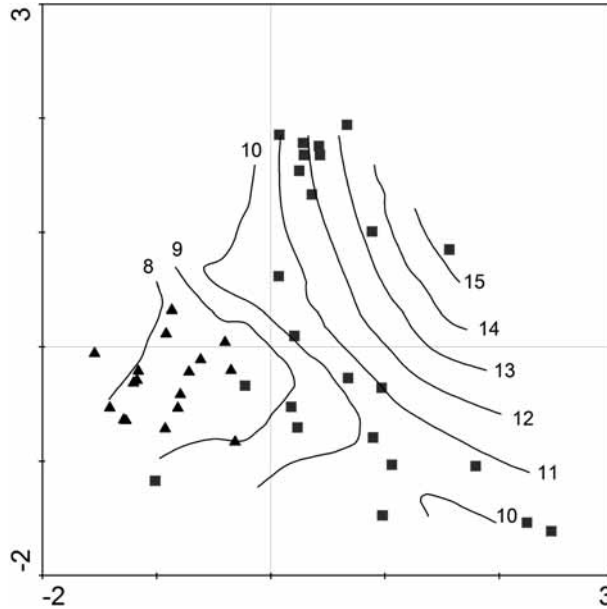


Fig. 5. Data attribute plot for the number of species in the relevés determined with the LOESS visualisation method of regression modelling. Principal component analysis (PCA) projected for the 41 relevés with the presence of *Plantago tenuiflora* and *Pholiurus pannonicus*. Group 1 (triangle) represents all of the relevés classified as the association of *Pholiurus pannonicus*-*Plantaginietum tenuiflorae* (Tab. 1). Group 2 (square) represents all the other relevés with a presence of *Plantago tenuiflora* and/or *Pholiurus pannonicus* species from Slovakia (Tab. 3). The eigenvalue for the first axis is 0.187 and 0.150 for the second axis.

36. SK, Horný Jatov, Čierny vršok site, deep tractor track, E18°00'04.3", N48°08'53.5", 113 m a. s. l., 12. 5. 2005.
37. SK, Horný Jatov, Čierny vršok site, depression in alkali steppe, E18°00'04.3", N48°08'53.5", 113 m a. s. l., 12. 5. 2005.
38. SK, Tvrdošovce, north from the village, disturbed cart-road in alkali steppe, E18°02'09.1", N48°06'09.4, 109 m a. s. l., 12. 5. 2005.
39. SK, Kamenínske slanisko Nature Reserve, small shallow depression, E18°38'41.5", N47°526'44.00, 109 m a. s. l., 2. 7. 2008.
40. SK, Palárikovo, degraded saltpan near railway station, E18°04'20.9", N48°04'06.00", 110 m a. s. l., 21. 7. 2004.
41. SK, Palárikovo, degraded saltpan near railway station, E18°04'20.9", N48°04'06.00", 110 m a. s. l., 21. 7. 2004.
42. SK, Kamenín, Kamenínske slanisko Nature Reserve, E18°38'41.5", N47°526'44.00, 109 m a. s. l., 14. 9. 2003.
43. SK, Kamenín, Kamenínske slanisko Nature Reserve, E18°38'41.5", N47°526'44.00, 109 m a. s. l., 8. 5. 2004.
44. SK, Kamenín, Kamenínske slanisko Nature Reserve, E18°38'41.5", N47°526'44.00, 109 m a. s. l., 8. 5. 2004.

45. SK, Kamenín, Kamenínske slanisko Nature Reserve, E18°38'41.5", N47°526'44.00, 109 m a. s. l., 8. 5. 2004.
46. HU, Kiskunság National Park, Miklapuszt, E19°08'45.0", N46°41'26.1, 95 m a. s. l., 12. 5. 2006.
47. HU, Kiskunság National Park, Miklapuszt, E19°08'45.0", N46°41'26.1, 95 m a. s. l., 12. 5. 2006.
48. HU, Kiskunság National Park, Dunatetőten, E19°09'52.6", N46°46'45.3, 95 m a. s. l., 12. 5. 2006.
49. HU, Kiskunság National Park, Dunatetőten, E19°09'52.6", N46°46'45.3, 95 m a. s. l., 12. 5. 2006.
50. HU, Kiskunság National Park, Dunatetőten, E19°09'52.6", N46°46'45.3, 95 m a. s. l., 12. 5. 2006.
51. HU, Hortobágy National Park, Nyírólapos, 85 m a. s. l., 9. 7. 2007.
52. HU, Hortobágy National Park, Nyírólapos, 85 m a. s. l., 9. 7. 2007.
53. HU, Hortobágy National Park, Nyírólapos, 85 m a. s. l., 9. 7. 2007.
54. HU, Hortobágy National Park, Balmazújváros, E21°20'49.3", N47°35'06.9", 86 m a. s. l., 7. 11. 2007.
55. HU, Hortobágy National Park, Balmazújváros, E21°20'49.3", N47°35'06.9", 86 m a. s. l., 7. 11. 2007.
56. HU, Hortobágy National Park, Hajdúböszörmény, near Kispród farmstead, E21°23'18.3", N47°43'11.2, 100 m a. s. l., 12. 7. 2007.
57. HU, Hortobágy National Park, Hajdúböszörmény, near Kispród farmstead, E21°23'18.3", N47°43'11.2, 100 m a. s. l., 12. 7. 2007.
58. HU, Hortobágy National Park, Hajdúböszörmény, near Kispród farmstead, E21°23'18.3", N47°43'11.2, 100 m a. s. l., 12. 7. 2007.
59. HU, Hortobágy National Park, Hajdúböszörmény, near Kispród farmstead, E21°23'18.3", N47°43'11.2, 100 m a. s. l., 12. 7. 2007.
60. HU, Kiskunság National Park., Alsószenttamás farmstead NE, E19°10'08.0", N46°56'58.7", 96 m a. s. l., 11. 6. 2008.
61. SK, Tvrdšovce, edge of track-road, E18°02'08.3", N48°05'53.9, 114 m a. s. l., 10. 5. 2008.
62. HU, Hortobágy National Park, Nagyiván, E20°54'18.0", N47°28'44.7" 93 m a. s. l., 9. 7. 2008.
63. SK, Tvrdšovce N, E18°02'09.1", N48°06'09.4, 109 m a. s. l., 12. 5. 2005.
64. SK, Kamenný Most, Čistiny Nature Reserve, E18°38'08.5", N47°51'53.10, 109 m a. s. l., 13. 5. 2005.
65. HU, Hortobágy National Park, Kocsiújfalu E20°54'52.6", N47°32'50.3", 92 m a. s. l., 9. 6. 2008.
66. HU, Hortobágy National Park, Kocsiújfalu E20°54'52.6", N47°32'50.3", 92 m a. s. l., 9. 6. 2008.
67. HU, Hortobágy National Park, Kocsiújfalu E20°54'52.6", N47°32'50.3", 92 m a. s. l., 9. 6. 2008.
68. HU, Hortobágy National Park, Kocsiújfalu E20°54'52.6", N47°32'50.3", 92 m a. s. l., 9. 6. 2008.
69. SK, Močenok, Siky farmstead, E17°53'52.2", N48°13'18.6", 113 m a. s. l., 13. 6. 2008.
70. SK, Močenok, Siky farmstead, E17°53'52.2", N48°13'18.6", 113 m a. s. l., 13. 6. 2008.
71. SK, Močenok, Siky farmstead, E17°53'52.2", N48°13'18.6", 113 m a. s. l., 13. 6. 2008.
72. HU, Hortobágy National Park, Balmazújváros, E21°20'42.4", N47°35'27.9", 86 m a. s. l., 8. 6. 2008.

73. HU, Hortobágy National Park, Balmazújváros, E21°20'42.4", N47°35'27.9", 86 m a. s. l., 8. 6. 2008.
74. HU, Kiskunság National Park, Pozsáros farmstead near Apaj, E19°06'58.7", N47°03'01.9", 94 m a. s. l., 11. 6. 2008.
75. HU, Hortobágy National Park, Püspökladány, E21°04'51.5", N47°20'14.9", 84 m a. s. l., 10. 6. 2008.
76. HU, Hortobágy National Park, Karcag, E20°49'36.1", N47°16'10.8", 91 m a. s. l., 7. 6. 2008.
77. HU, Hortobágy National Park, Karcag, E20°49'36.1", N47°16'10.8", 91 m a. s. l., 7. 6. 2008.
78. HU, Hortobágy National Park, Karcag, E20°49'36.1", N47°16'10.8", 91 m a. s. l., 7. 6. 2008.
79. HU, Hortobágy National Park, Szandalik W, E21°07'24.0", N47°41'06.5", 91 m a. s. l., 11. 6. 2008.
80. SK, Kráľová nad Váhom, Juhásove slance site, E17°52'49.00", N48°13'54.6, 96 m a. s. l., 9. 5. 2004.
81. SK, Kráľová nad Váhom, Juhásove slance site, E17°52'49.00", N48°13'54.6, 96 m a. s. l., 9. 5. 2004.
82. SK, Kráľová nad Váhom, Juhásove slance site, E17°52'49.00", N48°13'54.6, 96 m a. s. l., 9. 5. 2004.
83. HU, Hajdúböszörmény, Kispród farmstead, E21°23'18.3", N47°43'11.2, 100 m a. s. l., 12. 7. 2007.
84. SK, Komjatice, Ružový dvor farmstead, E18°07'32.5", N48°09'03.00", 126 m a. s. l., 12. 5. 2005.
85. SK, Palárikovo, N from the railway station, E18°04'20.9", N48°04'06.00", 110 m a. s. l., 21. 7. 2004.
86. SK, Veľké Kosihy, Mostové Nature Reserve, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 3. 9. 2003.
87. SK, Veľké Kosihy, Mostové Nature Reserve, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 8. 5. 2004.
88. SK, Veľké Kosihy, Mostové Nature Reserve, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 5. 2005.
89. SK, Veľké Kosihy, Mostové Nature Reserve, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 6. 2008.
90. SK, Veľké Kosihy, Mostové Nature Reserve, E17°54'08.5", N47°46'21.1", 107 m a. s. l., 12. 6. 2008.
91. SK, Šurany, Malé Čiky farmstead, E21°04'51.5", N47°20'14.9", 112 m a. s. l., 11. 5. 2008.
92. SK, Šurany, Malé Čiky farmstead, E21°04'51.5", N47°20'14.9", 112 m a. s. l., 11. 5. 2008.
93. SK, Šurany, Malé Čiky farmstead, E21°04'51.5", N47°20'14.9", 112 m a. s. l., 11. 5. 2008.
94. SK, Tvrdošovce, N, E18°02'09.1", N48°06'09.4, 109 m a. s. l., 12. 5. 2005.
95. SK, Tvrdošovce NW, field edge, E18°02'08.3", N48°05'53.9, 114 m a. s. l., 10. 5. 2008.
96. AU, Neusiedler National Park., Illmitz, E16°47'13.5", N47°45'56.5, 113 m a. s. l., 17. 9. 2008.
97. SK, Močenok, pastures at Siky farmstead, E17°53'52.2", N48°13'18.6", 113 m a. s. l., 9. 5. 2004.
98. HU, Hortobágy National Park, Hortobágy W, E21°02'17.5", N47°35'22.9", 97 m a. s. l., 8. 6. 2008.

99. HU, Hortobágy National Park, Hortobágy W, E21°01'50.3", N47°35'20.0", 100 m a.s. l., 7. 6. 2008.
100. SK, Kamenín, Kamenínske slanisko Nature Reserve, E18°38'41.5", N47°52'44.00, 109 m a. s. l., 8. 5. 2004.
101. HU, Hortobágy National Park, Püspökladány, E21°05'17.7", N47°19'56.0", 89 m a. s. l., 10. 7. 2007.

3. Results

Association: *Pholiuro pannonicum-Plantaginetum tenuiflorae* WENDELBG 1943

Synonyms: (see also VICHEREK 1973, MUCINA 1993, KOJIĆ & al. 1998, BORHIDI 2003): *Pholiuro-Plantaginetum tenuiflorae* VICHEREK 1973; *Pholiuro-Plantaginetum tenuiflorae* VICHEREK 1973 *myosuretosum* BODROGK. 1964; *Pholiuro-Plantaginetum tenuiflorae* (VICHEREK 1973) *puccinellietosum limosae* BODROGK. 1964; *Plantagini tenuiflorae-Pholiuretum pannonicum* (SOÓ 1933) WENDELBG. 1943; *Pholiuro-Plantaginetum tenuiflorae* (RAPCS. 1927) WENDELBG. 1943; *Pholiuro-Plantaginetum tenuiflorae* (RAPCS. 1927) WENDELBG. 1943 *eleocharetosum uniglumis* BODROGK. & GYÖRFFY 1970; *Pholiuro-Plantaginetum tenuiflorae* (RAPCS. 1927) WENDELBG. 1943 *typicum* BODROGK. 1965 (syn. *polygonetosum* SLAVNÍČ 1948); *Pholiuro-Plantaginetum tenuifoliae* (RAPCS. 1927) WENDELBG. 1943; *Pholiuro-Plantaginetum tenuifoliae* (RAPCS. 1927) WENDELBG. 1943 *camphorosmetosum annuae* SLAVNÍČ 1948; *Pholiuro-Plantaginetum tenuifoliae* (RAPCS. 1927) WENDELBG. 1943 *lytretosum* VUČKOVIĆ 1985; *Pholiuro-Plantaginetum tenuifoliae* (RAPCS. 1927) WENDELBG. 1943 *polygono-matricarietosum chamomillae* SLAVNÍČ 1948; *Pholiuro-Plantaginetum tenuifoliae* (RAPCS. 1927) WENDELBG. 1943 *ranunculo-myosuretosum minimus* SLAVNÍČ 1948.

Recently, we confirmed the existence of the *Pholiuro pannonicum-Plantaginetum tenuiflorae* community at two localities in Slovakia (in the Danube Lowland). The first one was found near the Akomán farmstead around the town of Šurany in 2004 (Tab. 1, rel. 2). At this location we observed well-developed stands of *Pholiuro pannonicum-Plantaginetum tenuiflorae* with relatively abundant populations of both dominant species. Soil desalination and the absence of exploitation have caused a gradual disappearance of the community. The two dominant species are close to extinction at present, and the community has been replaced by vegetation that is dominated by *Festuca pseudovina* (see Tab. 3). The second locality was documented in 2005. The *Pholiuro pannonicum-Plantaginetum tenuiflorae* association occurred in a stand located in a shallow depression on the edge of a *Medicago sativa* field near the Siky farmstead (Tab. 1, rel. 1). Unfortunately, the site was ploughed the following year, and the community was lost. The revalidation of the localities in the Východoslovenská nížina Lowland was unsuccessful because the sites have been destroyed. We therefore regard the community as extinct in Slovakia at present. There was, however, a typical vegetation of this community in the Hortobágy

Table 1. Relevés classified as the *Pholiuro pannonicum*-*Plantaginietum tenuiflorae* association (17 relevés from Hungary and Slovakia). The abundance of both dominant species (*Plantago tenuiflora* and *Pholiurus pannonicus*) is higher than 5%.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Relevé surface (m ²)	6	6	16	16	16	10	6	16	9	12	16	6	8	16	12	12	16
Coverage E ₁ %	40	60	50	25	40	50	50	45	35	55	45	40	60	30	35	45	60
Coverage E ₀ %	30	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0	0
Number of species per relevé	10	8	6	7	8	11	11	13	12	10	7	9	8	8	7	6	6
<i>Pholiurus pannonicus</i>	b	a	3	b	3	b	a	b	B	a	a	3	b	b	3	3	3
<i>Plantago tenuiflora</i>	a	a	3	a	a	3	a	a	A	a	b	b	b	a	A	b	b
<i>Puccinellia distans</i> agg.	1	3	1	+	a	a	b	1	A	1	a	1	1	.	1	+	3
<i>Artemisia santonicum</i>	.	.	.	.	r	+	1	r	1	1	1	1	+	+	R	+	+
<i>Carex stenophylla</i>	.	b	.	.	+	+	a	b	+	b	.	.	3	1	.	.	.
<i>Gypsophila muralis</i>	.	.	+	.	1	.	.	+	+	1	+	.	.	+	1	.	.
<i>Hordeum geniculatum</i>	.	.	.	+	r	+	.	+	.	+	.	r	.	+	.	.	.
<i>Matricaria recutita</i>	.	.	.	.	1	.	.	+	+	a	1	.	.	1	1	.	.
<i>Polygonum aviculare</i>	1	a	.	1	.	.	.	+	1	1	.	+	1	1	1	1	1
<i>Podospermum canum</i>	.	.	.	.	.	+	r	+	.	.	.	.	+	.	.	r	.
<i>Dichodon viscidum</i>	.	.	.	.	.	.	1	1	+	1	+	.	.	.	.	.	.
<i>Alopecurus pratensis</i>	.	1	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.
<i>Festuca pseudovina</i>	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1
<i>Eleocharis uniglumis</i>	.	.	.	1	.	1	.	+	.	.	.	.	.	.	.	.	.
<i>Trifolium angulatum</i>	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.
<i>Poa bulbosa</i>	.	.	.	.	.	.	+	.	+	.	.	1	.	.	.	.	.

Species recorded in two relevés only: *Beckmannia eruciformis* + (4), 1 (7); *Lepidium ruderales* + (9), + (12); Species recorded in one relevé only: *Bolboschoenus maritimus* 1 (1); *Tripleurospermum inodorum* 1 (1); *Myosurus minimus* + (1); *Epilobium tetragonum* + (1); *Juncus bufonius* + (1); *Rumex crispus* + (1); *Chenopodium album* 1 (2); *Rorippa kernerii* + (3); *Nostoc commune* 5 (6); *Juncus compressus* 1 (6); *Lepidium perfoliatum* + (9); *Limonium gmelinii* r (12)

National Park territory (south-east Hungary, Tab. 1, rels. 3–17) where it was widespread.

We recorded vegetation and the occurrence of both *Plantago tenuiflora* and *Pholiurus pannonicus* in destroyed and abandoned saline sites in Slovakia (Tab. 3). These secondary habitats are generally created by human activities. The wheels of heavy agricultural machinery create deep tracks in the moist soil, and similar depressions are formed during field cultivation. These relatively deep hollows and depressions are flooded with water in the spring and then stay wet for a long period and dry up during the summer. The occurrence of both *Plantago tenuiflora* and *Pholiurus pannonicus* depends on the occasional disturbance and elimination of competition from other plant species. The current vegetation, compared with the typical *Pholiuro-Plantaginietum* community, was enriched by several ruderal species (e.g., *Echinochloa crus-galli*, *Elytrigia repens* and *Chenopodium album*) as well as by some meadow plants (e.g., *Alopecurus*

Table 2. Synoptic table of the percentage of Pholiuro-Plantaginetum and other closely related contact communities.

Group No.: No. of relevés:	A 1-17	B 42-64	C 65-78	D 79-83	E 84-101
<i>Plantago tenuiflora</i>	100	9	7	7	17
<i>Pholiurus pannonicus</i>	100	.	7	.	.
<i>Camphorosma annua</i>	.	100	.	40	.
<i>Hordeum geniculatum</i>	41	4	100	.	.
<i>Puccinellia distans</i> agg.	94	65	43	100	28
<i>Festuca pseudovina</i>	18	22	71	.	100
<i>Artemisia santonicum</i>	76	22	64	20	100
<i>Dichodon viscidum</i>	29	22	29	40	61
<i>Plantago maritima</i>	.	22	7	.	44
<i>Podospermum canum</i>	29	4	43	.	44
<i>Veronica arvensis</i>	.	4	7	.	39
<i>Matricaria recutita</i>	41	35	57	40	33
<i>Puccinellia distans</i>	.	22	36	.	28
<i>Erophila verna</i>	.	9	.	.	28
<i>Tripolium pannonicum</i>	.	.	7	60	22
<i>Elytrigia repens</i>	.	.	21	.	22
<i>Bromus hordeaceus</i>	.	.	64	.	17
<i>Cynodon dactylon</i>	.	9	29	.	17
<i>Poa pratensis</i>	.	.	21	.	17
<i>Bupleurum tenuissimum</i>	.	.	7	.	17
<i>Galium aparine</i>	.	.	.	.	22
<i>Limonium gmelinii</i>	6	13	7	.	17
<i>Myosotis stricta</i>	.	.	.	.	17
<i>Bromus japonicus</i>	.	4	.	.	17
<i>Bromus racemosus</i>	.	4	.	.	11
<i>Agropyron intermedium</i>	.	.	36	.	11
<i>Trifolium campestre</i>	.	.	7	.	11
<i>Atriplex tatarica</i>	.	.	14	.	11
<i>Achillea millefolium</i>	.	.	57	.	11
<i>Alopecurus pratensis</i>	18	.	57	.	11
<i>Poa bulbosa</i>	18	9	.	.	6
<i>Plantago lanceolata</i>	.	.	14	.	6
<i>Centaurea pratensis</i>	.	.	7	.	6
<i>Lamium purpureum</i>	.	.	.	.	6
<i>Lepidium perfoliatum</i>	6	9	36	.	6
<i>Capsella bursa-pastoris</i>	.	.	29	.	6
<i>Gypsophila muralis</i>	47	.	29	.	6
<i>Carex stenophylla</i>	53	.	21	.	6
<i>Polygonum aviculare</i>	70	.	50	.	.

A) Pholiuro pannonicum-Plantaginetum tenuiflorae (17 relevés, numbers 1-17)

B) Camphorosmetum annuae (23 relevés, numbers 42-64)

C) Hordeetum hystricis (14 relevés, numbers 65-78)

D) Puccinellietum limosae (5 relevés, numbers 79-83)

E) Artemisio santonici-Festucetum pseudovinae (18 relevés, numbers 84-101)

pratensis, *Bromus hordeaceus* and *Poa pratensis*). The occurrence of these plants indicated a lower soil salinity (Tab. 3, rels. 18–25). In the stands located at the edges of arable fields (Tab. 3, rels. 21 and 22), some species that are typical of salt marshes (e.g., *Tripolium pannonicum* and *Dichodon viscidum*) have survived. The vegetation in the abandoned depressions (i.e., not cultivated, Tab. 3, rels. 35–37) or in the gradually degraded saline sites (Tab. 3, rels. 38 and 39) was rather similar to the Pholiuro-Plantaginetum community.

Due to its broad ecological amplitude, *Plantago tenuiflora* rarely survives on former salt pans. At these sites, the original Camphorosmetum annuae association was degraded and replaced by Artemisio santonici-Festucetum pseudovinae vegetation with a dominance of the *Artemisia santonicum* species of up to 75% (Tab. 3, rels. 40 and 41). Moreover, we also found *Pl. tenuiflora* in communities of Puccinellietum limosae, Camphorosmetum annuae, and Artemisio santonici-Festucetum pseudovinae (Tab. 2). Similarly, *Pholiurus pannonicus* was infrequently sampled in Hordeetum hystricis and Artemisio santonici-Festucetum pseudovinae communities (Tab. 2). It is interesting that *Ph. pannonicus* was usually found together with *Pl. tenuiflora* but that a single occurrence was very rare.

Despite the ecological plasticity of both dominant species and their occurrence in other plant communities, the DCA analysis of the 77 relevés from the Pannonian Basin distinguished the Pholiuro pannonici-Plantaginetum tenuiflorae association very well from other contact communities (Fig. 2). The association has been characterised by the co-occurrence of both dominants with an abundance of more than 5%, while their individual abundance may reach values up to 50%. The total cover of vascular plants was relatively variable, ranging from 25 to 60%. In addition to the characteristic species, the obligate halophytes of *Artemisia santonicum* and *Puccinellia limosa* were regularly present (often with higher abundances); *Hordeum geniculatum* was rarely recorded. Some facultative halophytes were recorded as well (e.g., *Polygonum aviculare*, *Carex stenophylla*, *Gypsophila muralis* etc.; Tab. 1). Non-vascular plants (E_0) are generally not present in typical stands of the association; however, we found *Nostoc commune* on rare occasions. Therefore, *Polygonum aviculare* was not confirmed as the diagnostic species of the community.

The PCA of the soil pH (Fig. 3, Tab. 4) demonstrated a distinct grouping of the typical Pholiuro pannonici-Plantaginetum tenuiflorae association and vegetation with presence of *Ph. pannonicus* and *Pl. tenuiflora* that developed in secondary habitats. The results of the PCA analysis showed that the communities typically developed on occupied sites with lower active soil pH values. The average pH value in the secondary vegetation was 9.1; in the case of the typical Pholiuro-Plantaginetum community, this value was significantly lower, measuring only 7.8. Similarly, the primarily developed vegetation association was typically characterised by

Table 3. Analytic table of secondary communities with the occurrence of both *Pholiurus pannonicus* and/or *Plantago tenuiflora* in Slovakia.

Relevé number	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Relevé surface (m ²)	2	6	5	16	16	10	10	3	6	6	1	1	1	16	2	16	1	9	2	2	8	1	3	16
Coverage E ₁ %	35	20	50	45	40	45	85	25	75	70	30	5	70	80	35	85	60	80	50	80	50	35	70	70
Coverage E ₀ %	0	5	5	0	0	0	40	0	5	0	0	0	10	10	10	0	0	10	20	3	3	90	60	50
Number of species per relevé	16	16	9	10	12	8	10	19	8	8	7	7	11	6	8	12	9	15	15	15	15	8	10	19
<i>Echinochloa crus-galli</i>	1	1	.	+	1	r	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Polygonum rivivagum</i>	b	1	a	.	.	3	a	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Lepidium ruderales</i>	+	+	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Tripleurospermum perforatum</i>	1	1	1	+	+	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.
<i>Lolium perenne</i>	1	+	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
<i>Atriplex littoralis</i>	.	.	.	1	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Carex stenophylla</i>	.	.	.	.	.	.	1	3	a	b	+	+	+	+	a	.	.	.	.	.	.	.	.	.
<i>Pholiurus pannonicus</i>	.	.	.	.	.	.	+	1	+	1	+	1	.	b	a	3	.	.	.	.	1	.	.	.
<i>Alopecurus pratensis</i>	.	.	.	.	.	.	.	+	+	.	.	.	.	.	1	1	.	.	1	.	.	.	.	.
<i>Poa pratensis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.
<i>Puccinellia distans</i> agg.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	a	a	a	b	3	.	.	.	.
<i>Triplolium pannonicum</i>	.	.	.	a	b	.	.	.	.	.	.	.	.	a	.	.	b	1	1	1	.	.	.	.
<i>Myosurus minimus</i>	.	.	.	.	.	a	.	.	.	.	.	.	.	+	.	.	1	a	a	.	.	.	.	.
<i>Festuca pseudovina</i>	.	.	.	.	.	.	.	a	3	+	.	+	4	.	4	.	3	a	1	1	1	.	1	.
<i>Bupleurum tenuissimum</i>	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	1	.
<i>Myosotis stricta</i>	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
<i>Inula britannica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	+	.
<i>Elytrigia repens</i>	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
<i>Vicia tetrasperma</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	.	a	a	.
<i>Plantago tenuiflora</i>	a	a	3	3	b	a	b	a	a	1	.	.	a	r	1	+	.	a	b	b	1	a	a	r
<i>Matricaria recutita</i>	1	1	1	a	b	.	1	+	.	.	+	1	+	.	.	.	a	+	+	a	1	.	.	.
<i>Puccinellia distans</i>	1	.	.	1	1	+	.	.	1	+	1	+	a	1	1	.	.	.	.	.	.	1	1	.
<i>Artemisia santonicum</i>	.	.	.	.	.	.	r	.	.	.	.	3	3	1	1	+	.	r	.	b	a	4	4	.
<i>Dichodon viscidum</i>	.	.	.	1	1	.	.	.	.	.	.	.	.	.	1	+	a	a	1	+	.	1	1	.
<i>Polygonum aviculare</i>	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	1	+	a	3	.	.	.	.
<i>Podospermum canum</i>	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	1	+	.	.	.	.	1	1	.
<i>Chenopodium album</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	a	.	.	.	.	.	.	.
<i>Bromus hordeaceus</i>	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	a	1	.	r	.	.	.	.
<i>Juncus compressus</i>	.	+	.	.	.	.	1	.	.	+	.	a	.	.	.	3	.	.	.	.	.	.	+	.
<i>Plantago major</i> subsp. <i>winteri</i>	+	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Trifolium repens</i>	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	.	r	.	.	.	.	.
<i>Cynodon dactylon</i>	.	1	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
<i>Elytrigia trichophora</i>	.	+	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Plantago maritima</i>	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	r	.	1	.	.	.	.

Species recorded in two relevés only: *Achillea collina* + (38), + (41), *Agrostis stolonifera* **2a** (24), **3** (25), *Atriplex patula* + (27), **r** (28), *Camphorosma annua* **2a** (38), **1** (39), *Erophila verna* **1** (35), + (38), *Poa angustifolia* **1** (33), + (41), *Rumex stenophyllus* + (32), **r** (36), *Sclerochloa dura* + (18), **r** (20), *Solidago* sp. + (21), **1** (22), *Taraxacum* sect. *Ruderalia* **r** (18), **1** (24), *Trifolium campestre* + (38), + (41), Species recorded in one relevé only: *Achillea millefolium* **r** (18), *Alopecurus geniculatus* **2b** (20), *Atriplex tatarica* + (23), *Bromus japonicus* + (22), *Bromus racemosus* + (41), *Centaurea jacea* subsp. *pratensis* **1** (25), *Cirsium arvense* **r** (19), *Convolvulus arvensis* **r** (18), *Cruciata pedemontana* **r** (38), *Dactylis glomerata* **1** (35), *Daucus carota* + (19), *Epilobium tetragonum* **1** (25), *Heleochoa schoenoides* **2a** (23), *Chenopodium* sp. **r** (41), *Lactuca* sp. **r** (38), *Limonium gmelinii* + (40), *Lotus corniculatus* + (37), *Nostoc commune* **4** (39), *Plantago lanceolata* **r** (24), *Plantago major* + (25), *Plantago uliginosa* **1** (20), *Poa annua* + (19), *Poa compressa* + (25), *Potentilla argentea* **r** (37), *Potentilla reptans* + (19), *Pulegium vulgare* **1** (25), *Rorippa kernerii* **1** (25), *Rubus caesius* **r** (19), *Silene multiflora* **r** (41), *Trifolium fragiferum* subsp. *bonannii* + (24), *Trifolium pratense* **r** (30), *Vicia sativa* **r** (38).

a lower rate of CT content in the soil (Tab. 4, average value 1.16) compared with the vegetation on secondary habitats (Tab. 4, average value 1.66).

Table 4. Chemical properties of analysed soil samples / relevés. Numbers of relevés are identical with those presented in Tab. 1 and Tab. 3.

Number of relevé	1	10	12	14	15	19	21	22	26	28	30	32
pH _{H2O}	8.10	8.01	8.03	6.12	7.75	8.10	9.73	9.61	7.94	8.63	9.07	9.31
CT [%]	1.017	0.833	0.819	1.540	0.638	1.323	1.436	1.466	2.890	2.207	1.302	0.994

Lastly, a higher species number per relevé was confirmed by the PCA analysis in the secondary stands compared to stands of the typical *Pholiuro pannonici-Plantaginetum tenuiflorae* (Fig. 5). The vegetation of the typical *Pholiuro pannonici-Plantaginetum tenuiflorae* community has, on average, 8.6 species per relevé (max. 13 species), while the number of species in secondary stands was on average 11.4 taxa per relevé (max. 19 species), and some ruderal species were present (e.g., *Chenopodium album*, *Tripleurospermum perforatum*).

4. Discussion

The *Pholiuro pannonici-Plantaginetum tenuiflorae* is an alkaline species association that occupies muddy depressions in the transitory zone of solonetz, the meadow soils transitional to solonetz and the muddy bottom of solonetz (BODROGKÖZY 1965b, BODROGKÖZY & GYÖRFFY 1970, DAJIC-STE-VANOVIC & al. 2008). VICHEREK 1973 suggested that the association was created as a secondary community on alkaline, nitrified and frequently trampled soils. The development of the *Pholiuro pannonici-Plantaginetum tenuiflorae* association was closely related with strong human interference on the natural saline vegetation (e.g., rural roads tracked out by the wheels of carriages and trails trampled by livestock), particularly in the areas where associations with *Puccinellion limosae* are present. By contrast, most other authors have considered the community to exist primarily in alkaline habitats (WENDELBERGER 1950, BODROGKÖZY 1965b, MUCINA 1993, BORHIDI 2003, MOLNÁR & BORHIDI 2003). These habitats have developed as a result of water erosion from the short grass steppes of *Festucion pseudovinae* Soó 1933 and the muddy habitats of *Puccinellion limosae* Soó 1933 (WENDELBERGER 1950, BORHIDI 2003). BODROGKÖZY 1965a and VARGA-SIPOS 1984 mentioned that the succession of *Pholiuro pannonici-Plantaginetum tenuiflorae* community in the Hortobágy region can be deduced from *Agrostio-Beckmannietum eruciformis* RAPAICS ex Soó 1930, *Agrostio-Glycerietum poiformis* MAGYAR ex Soó 1933 or *Agrostio-Alopecuretum pratensis* (Soó 1933) Soó 1947 (*Scorzonero-Juncion gerardii* alliance) and is the result of drying and graduate alkalisation. On the basis of our results,

we assume that the native vegetation of the association was present in Slovakia in the past. This statement was confirmed by samples of vanishing fragments of the association near the Akomáň farmstead surrounding of Šurany. The distribution of this vegetation type was not restricted to places affected by human activities; it was also developed in shallow depressions in primary alkaline habitats similar to those that we recently sampled in the well-preserved saline localities in the Hortobágy National Park (south-east Hungary). However, the community recently became extinct in Slovakia, and an exact reconstruction of its native distribution is impossible.

The *Pholiuro pannonici-Plantaginetum tenuiflorae* association is a relatively species-poor community. In published works (SLAVNÍČ 1948, WENDELBERGER 1943, 1950, BODROGKÖZY 1965a, b, BODROGKÖZY & GYÖRFFY 1970, VICHÉREK 1973) as well as in our results (Tab. 1, Fig. 5), the number of species ranged from 3 to 13 species per relevé. However, we recorded higher numbers of species per relevé (11.4 species in average, max. 19 species) in the vegetation of secondary habitats with the presence of both species (Tab. 3). In those relevés, significant numbers of species occurring outside of the saline habitats too, were recorded (e.g., *Chenopodium album*, *Vicia tetrasperma*, *Trifolium repens*). The difference in species numbers was caused by changes in the ecological conditions, especially soil desalination and drainage. Salt-tolerant plants almost always lost their competitive advantages, and they were held back by other species. The same results were obtained during the study of *Camphorosmetum annuae*, *Heleo-chloetum schoenoidis* and *Crypsidetum aculeatae* in Slovakia (DÍTĚ & al. 2008, ELIÁŠ jun. & al. 2008). In addition, VICHÉREK 1973 and MUCINA 1993 mentioned that *Polygonum rurivagum* was a diagnostic species for the association. Our analysis did not confirm this claim. The community was particularly characterised by the co-occurrence of both dominants – *Plantago tenuiflora* and *Pholiurus pannonicus*.

The *Pholiuro-Plantaginetum* community was separated into nine sub-associations, depending upon the duration of spring inundation by sub-soil water and the degree of soil alkalinity (see SLAVNÍČ 1948, WENDELBERGER 1943, 1950, BODROGKÖZY 1965a, BODROGKÖZY & GYÖRFFY 1970, VICHÉREK 1973). These sub-associations, however, are not differentiated in the most recent literature (MUCINA 1993, POP 2002, BORHIDI 2003). In our opinion, this is a correct statement because the *Pholiuro-Plantaginetum* sub-associations represent only the sub-dominant occurrence of some floristic elements (e.g., *Myosurus minimus*) together with the characteristic species, and therefore their differentiation is not necessary. In addition, MICEVSKI 1965 reported a *Pholiuro-Plantaginetum balcanicum*, an association endemic to Macedonia, which developed in small depressions in Ovče Polje site. The author described this community on the basis of the occurrence of the species *Puccinellia convoluta*, *Crypsis aculeata*, *Heleo-*

chloa schoenoides and *Suaeda maritima*, which are not present in the Pholiuro-Plantagnetum community described in Central Europe. A revision of these data is necessary in the future because it could be another community or an altogether new community.

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