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Phytosociological study of arable weed communities in Slovakia

Pflanzensoziologische Studien der Ackerunkraut-Gesellschaften in der Slowakei

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Abstract

A phytosociological survey of weed (segetal) vegetation in Slovakia was performed. A total of 508 relevés were sampled in 2002–2008. The aims of this study were to determine the actual distribution of the segetal communities, to analyze their floristic structure, and to evaluate their relationships to selected environmental factors.

Thirteen plant communities of the class *Stellarietea mediae* were distinguished by cluster analysis; 11 communities were included in the subclass *Violenea arvensis* (*Lathyro tuberosi-Adonidetum aestivalis*, *Consolido-Anthemidetum austriacae*, *Euphorbio exiguae-Melandrietum noctiflori*, *Veronicetum trilobae-triphyllidi*, *Lamio amplexicauli-Thlaspietum arvensis*, *Taraxacum* sect. *Ruderalia* community, *Spergulo arvensis-Scleranthetum annui*, *Myosotido-Sonchetum arvensis*, *Echinochloo-Setarietum pumilae*, *Galinsogo-Setarietum*, and *Stachyo annui-Setarietum pumilae*) and two in the subclass *Sisymbrienea* (*Portulacetum oleraceae* and *Setario viridis-Erigeronetum canadensis*). Communities were characterized by diagnostic, constant, and dominant species and their structure, ecology, and distribution were estimated. The species composition of these communities was documented in synoptic and association tables. DCA ordination and analysis of variance was used to determine the main environmental factors of floristic differentiation and to determine ecological and structural differences among the communities. The analyses showed that the most important factors affecting floristic composition and classification of the weed communities are their time of development (agroecophase), the type of crops and altitude.

Keywords: ordination, segetal communities, species composition, *Stellarietea mediae*, syntaxonomy, weed ecology

Erweiterte deutsche Zusammenfassung am Ende des Manuskripts

1. Introduction

The first interest in weed vegetation in Slovakia dates only from the period following World War II. The initial publication was a floristic study by FRANTOVA (1947), followed by ecological (OPLUŠTILOVÁ 1953) and phytosociological studies (ZAHRADNÍKOVÁ-ROŠETZKÁ 1955). More authors then became interested in segetal vegetation research (e.g. MOCHNACKÝ 1984b, PASSARGE & JURKO 1975, KROPÁČ & MOCHNACKÝ 2009, MÁJEKOVÁ et al. 2010);

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some authors concentrated on the ecology and distribution of segetal species (e.g. KRIPPELOVÁ 1974, ELIÁŠ & BARANEC 2005) or on the decline and extinction of more specialized weed species and communities (SKALICKÝ 1981). Several communities were described for the first time from the Slovak Republic. A full list of references about the research of segetal flora and vegetation in Slovakia is provided in the electronical Appendix S1.

Knowledge concerning segetal vegetation in Slovakia prior to 1996 was summarized and published by JAROLÍMEK et al. (1997) and by MOCHNACKÝ (1999). Although these authors characterized 21 communities from arable land, the data were not representatively distributed over Slovakia i.e., they originated from only a limited number of orographic units (approximately half of the area of Slovakia). These reports were at least 20 years old. While the study of segetal vegetation had continued in neighbouring countries (e.g. KROPÁČ 2006, LOSOSOVÁ et al. 2009, PINKE 2007, PINKE & PÁL 2008) in Slovakia the study of segetal vegetation significantly declined since the 1980s. Classical phytosociological research is changing to the study of diversity and changes in vegetation, and also to the impact of environmental factors on species' distribution (e.g. LOSOSOVÁ et al. 2004, PYŠEK et al. 2005, ŠILC & ČARNI 2005, FRIED et al. 2008, LOSOSOVÁ & SIMONOVÁ 2008, ANDREASEN & SKOVGAARD 2009, CIMALOVÁ & LOSOSOVÁ 2009, PINKE et al. 2010, 2012, PINKE & PÁL 2009, MÁJEKOVÁ et al. 2010).

The aims of this study are (1) to determine the actual distribution of the segetal communities in Slovakia, (2) to analyze the species composition of the communities (considering the life forms, species origin and invasiveness, representation of threatened species) and (3) to evaluate their relationships with selected environmental factors.

2. Materials and methods

2.1 Study area

The study area comprises the Slovak Republic (16°50´–22°34´ E, 47°44´–49°37´ N) and covers an area of 49,035 km^2. The altitude in the Slovak Republic ranges from 94 to 2,655 m a.s.l. This area is divided into three climatic regions: warm, moderately warm and cold (LAPIN et al. 2002). Almost half the total area of the country is used as agricultural land, which is mainly concentrated in the warm southern areas (STATISTICAL OFFICE OF THE SLOVAK REPUBLIC 2010).

2.2 Field sampling

The data set consisted of 508 phytosociological relevés (505 by the authors, 2 by I. Jarolímek and 1 by M. Janišová) made in arable land throughout the entire territory of Slovakia between 2002 and 2008. Sampling was random but focussed on orographic units with missing phytosociological material. Relevés were made from April to November over the whole altitude range of cultivated fields, at 98 to 928 m a.s.l. Relevés were made according to the Zürich-Montpellier school (BRAUN-BLANQUET 1964, WESTHOFF & VAN DER MAAREL 1978) using the 9-degree scale of abundance and dominance (BARKMAN et al. 1964). Plot size was mainly 10 × 10 m in broad-scale fields and 5 × 10 m in fine-scale private fields. Plots were situated in the inner part of the fields to avoid any effects from surrounding vegetation (OPLUŠTILOVÁ 1953, KROPÁČ & HEJNÝ 1975). The following types of cultivated fields were studied: cereals, cereal stubbles, root crops, fodder crops and also young fallow. Relevés were made only on those fields where weed cover was at least 25%, and the vegetation was of the *Stellarietea mediae* class.

2.3 Vegetation classification

Relevés were stored in a TURBOVEG database (HENNEKENS & SCHAMINÉE 2001). The following taxa were fused before the analysis: *Chenopodium album* agg. included *C. album*, *C. pedunculare* and *C. strictum*; *Papaver dubium* included *P. dubium* and *P. dubium* subsp. *austromoravicum*; *Vicia cracca* agg. included *V. cracca* and *V. cracca* agg. Cultivated crops, bryophytes and taxa determined only to the genus level were excluded from analysis. On the basis of detrended correspondence analysis (DCA; HILL & GAUCH 1980) in the programme CANOCO (TER BRAAK & ŠMILAUER 2002), one relevé was excluded as an outlier. The remaining 507 relevés were analyzed by cluster analysis using JUICE 7.0 (TICHÝ 2002) and SYN-TAX 2000 (PODANI 2001) programmes. The β-flexible method (β = -0.25) and Sorensen's similarity index were used in this analysis. The crispness of classification method proposed by BOTTA-DUKÁT et al. (2005) to identify the optimal number of clusters was applied. Each community was characterized by diagnostic, constant and dominant species. The diagnostic species were determined by calculating the fidelity of each species to each cluster, using the phi coefficient of association (SOKAL & ROHLF 1995, CHYTRÝ et al. 2002) in JUICE 7.0 programme (TICHÝ 2002). The phi coefficient was standardized to the equal relevé size of all groups (CHYTRÝ et al. 2006, TICHÝ & CHYTRÝ 2006) and Fisher's exact test was used (p < 0.001) for excluding non-significant fidelity values (CHYTRÝ et al. 2002, 2006). The threshold phi value where a species was considered diagnostic was set at 0.25. Constant species comprised those with a presence higher than 50%; and those with a presence higher than 80% are printed in bold type. The dominant species were defined as those having more than 50% cover in at least 3% of the relevés. Diagnostic, constant and dominant species in the text are ordered according to decreasing constancy.

In the association tables, the sequence of the relevés followed the cluster analysis results. Values 2m, 2a, 2b are shortened to m, a, b. Header data contain: relevé number, relevé area, altitude, total cover, moss layer cover, cover of crops, cover of weeds, height of herb layer and the number of species in the relevé. Species are ordered as follows: crops, diagnostic species of the community, species characteristic for alliance, order, subclass, and class, other species and bryophytes. Diagnostic species are ordered according to decreasing fidelity and the remaining species according to decreasing frequency.

The nomenclature of the taxa follows MARHOLD & HINDÁK (1998), except for the species ×*Triticosecale rimpaui* (Wittm.) Müntzing. The nomenclature of the syntaxa follows JAROLÍMEK et al. (1997) and JAROLÍMEK & ŠIBÍK (2008).

2.4 Environmental variables

The main environmental gradients of species composition were analysed by detrended correspondence analysis (DCA) in the programme CANOCO (TER BRAAK & ŠMILAUER 2002). For the ecological interpretation of ordination axes, the average nonweighted Ellenberg indicator values (EIV; ELLENBERG et al. 1992) for the relevés and Shannon-Wiener's index of diversity (HILL 1973) were plotted onto the DCA ordination diagram as supplementary environmental data.

The programme Statistica was used for correlation analyses and construction of Box-Whisker plots. Mean EIVs (ELLENBERG et al. 1992) per relevé, proportion of life forms (after DOSTÁL & ČERVENKA 1991, 1992), species richness, number of threatened species (after FERÁKOVÁ et al. 2001), native species, archaeophytes, neophytes, naturalized, invasive and casual species per relevé (after MEDVECKÁ et al. 2012), altitude, mean annual temperature and precipitation of the locality, month of relevé origin, and soil properties of the locality (soil reaction, content of sand – fraction 0.01–2.0 mm, silt – fraction 0.002–0.01 mm and clay – fraction < 0.002 mm in the topsoil) were compared among the communities using one-way ANOVA and subsequent Fisher LSD post-hoc test (p < 0.05) to determine homogenous groups. The variables with not-normal distributions by visually inspecting the distribution of the residuals (QUINN & KEOUGH 2002) were log-transformed at first.

The potential natural vegetation of the sites was defined after the Geobotanical map of Slovakia in a scale of 1 : 200,000 (MICHALKO et al. 1986).

National agricultural soil inventory maps in a 1 : 10,000 scale (NĚMEČEK et al. 1967) were used in the GIS to assign information on soil type, soil parent material and topsoil texture class to each relevé. Each relevé was then coupled with the closest soil profile from the AISOP soil profile database

(LINKEŠ et al. 1988, BIELEK et al. 2005) following both maximum distance and soil classification criteria. Soil profiles served as the data source for soil type, soil parent material, topsoil soil texture class and selected topsoil analytical characteristics in subsequent ecological analyses. Soil type and texture were classified according to WRB (IUSS WORKING GROUP WRB 2006).

Selected climatic factors were calculated in the GIS software. Air temperature and vertical atmospheric precipitation were produced from rasters of mean annual precipitations for the period 1961 to 1990. Source data was provided by the Slovak Hydro-meteorological Institute, and climatic regions were defined according to LAPIN et al. (2002).

3. Results

3.1 Numerical classification

We identified 13 communities from the class *Stellarietea mediae*. Cluster analysis results are summarized in the dendrogram (Fig. 1) and in the synoptic table (Table 1 in the supplement). Vegetation structure and environmental characteristics of the communities are shown in Figures 2–6.

Three main groups, (A, B and C), are distinguished in the dendrogram (Fig. 1). Grouping of the communities is partly by their syntaxonomic classification and partly derived from their ecological demands and time of development (seasonal optimum). Group A (*Portulacetum oleraceae* and *Setario viridis-Erigeronetum canadensis*) is separated at the highest level of dissimilarity. It consists of communities from the alliance *Eragrostion* of the mostly ruderal subclass *Sisymbrienea*. Both communities occur in the warm lowlands of Slovakia, where soils with a dominance of sand fraction in the topsoil are distributed, and they have low species diversity and are poor in threatened species (Figs. 4–6). They differ in nutrients demand and soil reaction. Species in the *Portulacetum* association require more nutrients and higher soil reaction than the *Setario-Erigeronetum* species (Fig. 2).

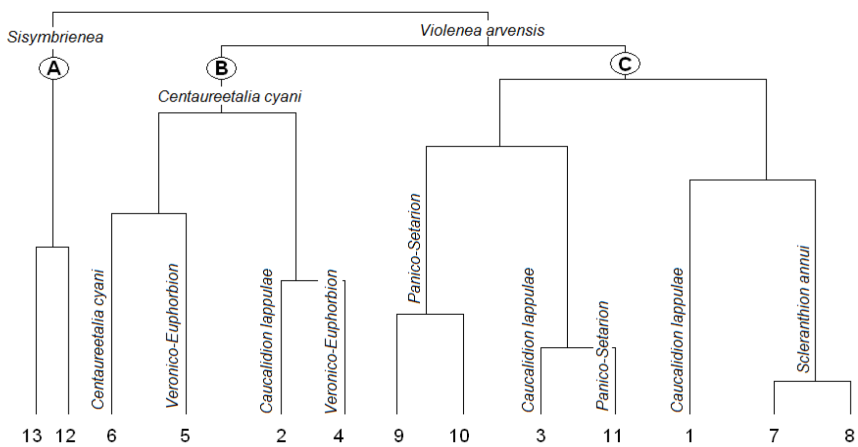


Fig. 1. Dendrogram of the numerical classification of the weed communities in Slovakia. The β-flexible method (β = -0.25) and Sorensen's similarity index were used. The community names (1–13) are given in Table 1 in the supplement.

Abb. 1. Dendrogramm der numerischen Klassifikation der Ackerunkraut-Gesellschaften in der Slowakei. Die „β-flexible method" (β = -0.25) und der „Sorensen Similarity Index" wurden verwendet. Zu den Namen der Gesellschaften 1–13, s. Tabelle 1, Beilage.

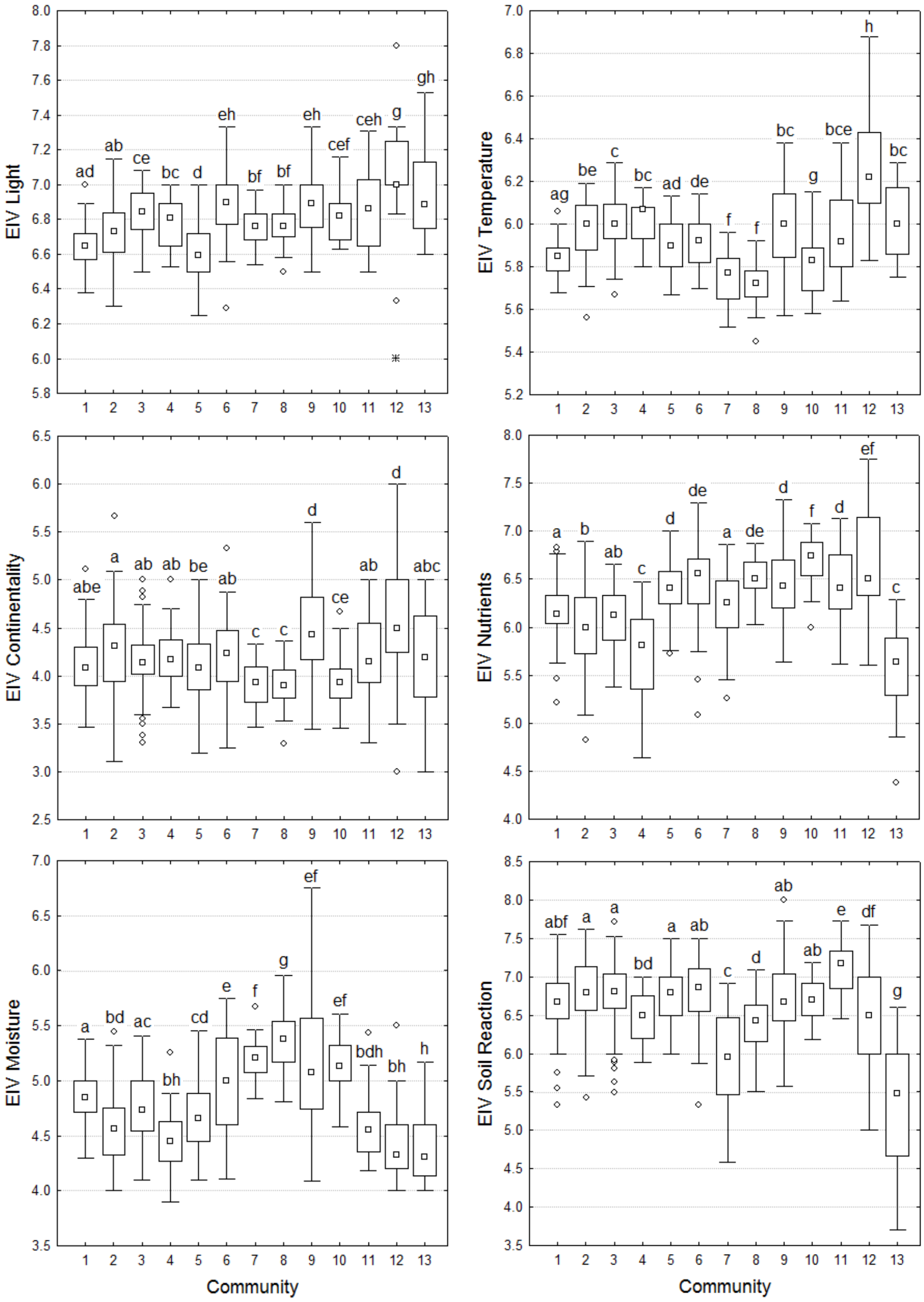


Fig. 2. Box-Whisker plots of the Ellenberg's indicator values for individual communities. Different letters indicate significant differences between communities. ANOVA and Fisher LSD post-hoc test, $p < 0.05$. Annotations: ▫ median, □ 25%–75%, I non-outlier range, ○ outliers, * extremes.

Abb. 2. Box-Whisker-Plots der Ellenberg-Zeigerwerte für die untersuchten Gesellschaften. Unterschiedliche Buchstaben kennzeichnen signifikante Unterschiede zwischen den Gesellschaften. ANOVA und Fisher LSD post-hoc test, $p < 0{,}05$. Anmerkungen: ▫ median, □ 25%–75%, I nicht im Ausreißer-Bereich, ○ Ausreißer, * Extreme Ausreißer.

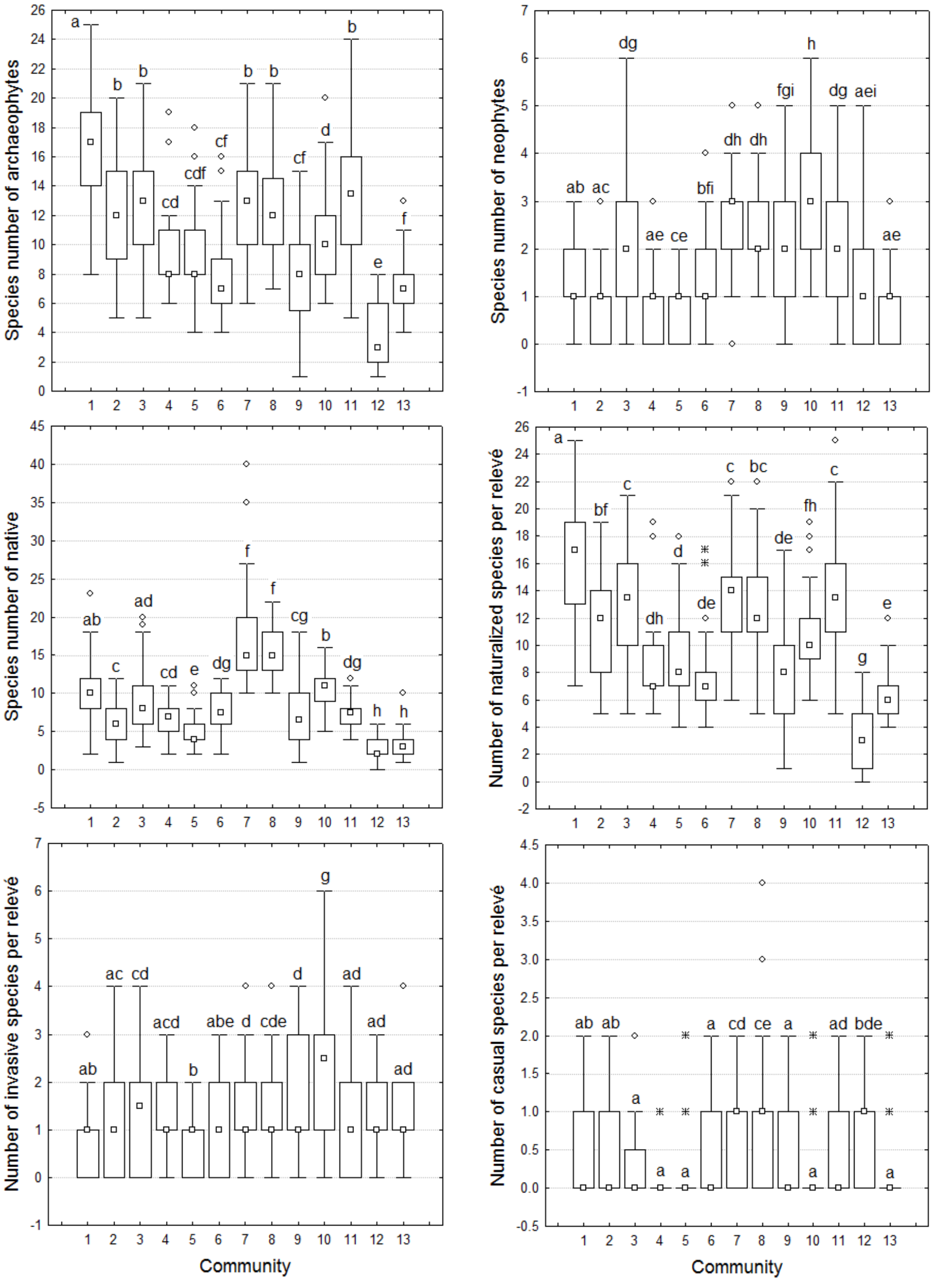


Fig. 3. Box-Whisker plots of the representation of archaeophytes, neophytes, native species, naturalised, invasive, and casual species in the individual communities. Different letters indicate significant differences between communities. ANOVA and Fisher LSD post-hoc test, $p < 0.05$. Annotations, see Figure 2.

Abb. 3. Box-Whisker-Plots des Vorkommens von Archäophyten, Neophyten, heimischen Arten, eingebürgerten, invasiven und unbeständigen Arten in den einzelnen Gesellschaften. Unterschiedliche Buchstaben kennzeichnen signifikante Unterschiede zwischen den Gesellschaften. ANOVA und Fisher LSD post-hoc test, $p < 0{,}05$. Anmerkungen, s. Abbildung 2.

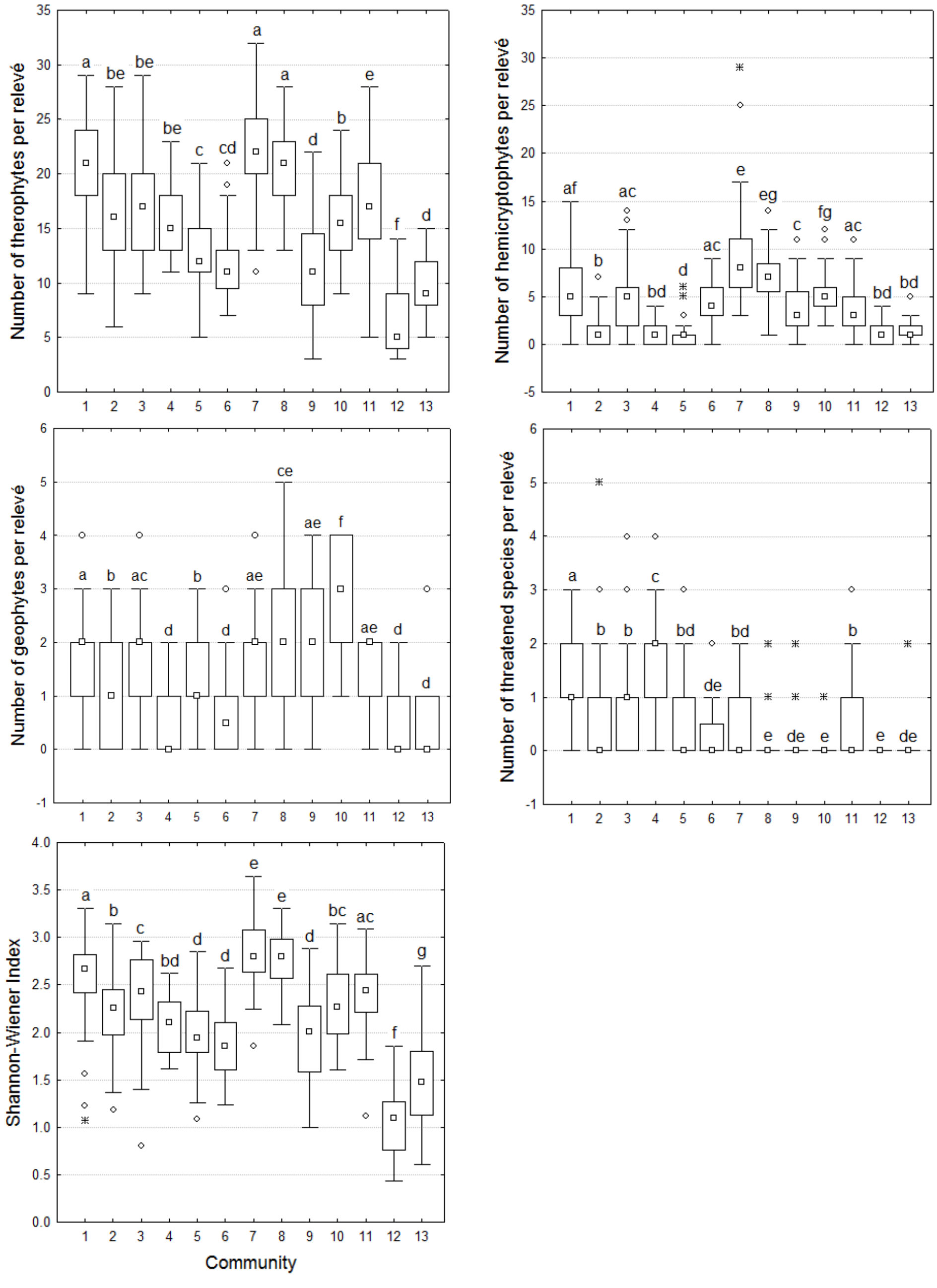


Fig. 4. Box-Whisker plots of the representation of therophytes, hemicryptophytes, geophytes, and threatened species in the individual communities, and species diversity of the communities. Different letters indicate significant differences between communities. ANOVA and Fisher LSD post-hoc test, $p < 0.05$. Annotations, see Figure 2.

Abb. 4. Box-Whisker-Plots des Vorkommens von Therophyten, Hemikryptophyten, Geophyten, bedrohten Arten in den einzelnen Gesellschaften und der Artenvielfalt der Gesellschaften. Unterschiedliche Buchstaben kennzeichnen signifikante Unterschiede zwischen den Gesellschaften. ANOVA und Fisher LSD post-hoc test, $p < 0,05$. Anmerkungen, s. Abbildung 2.

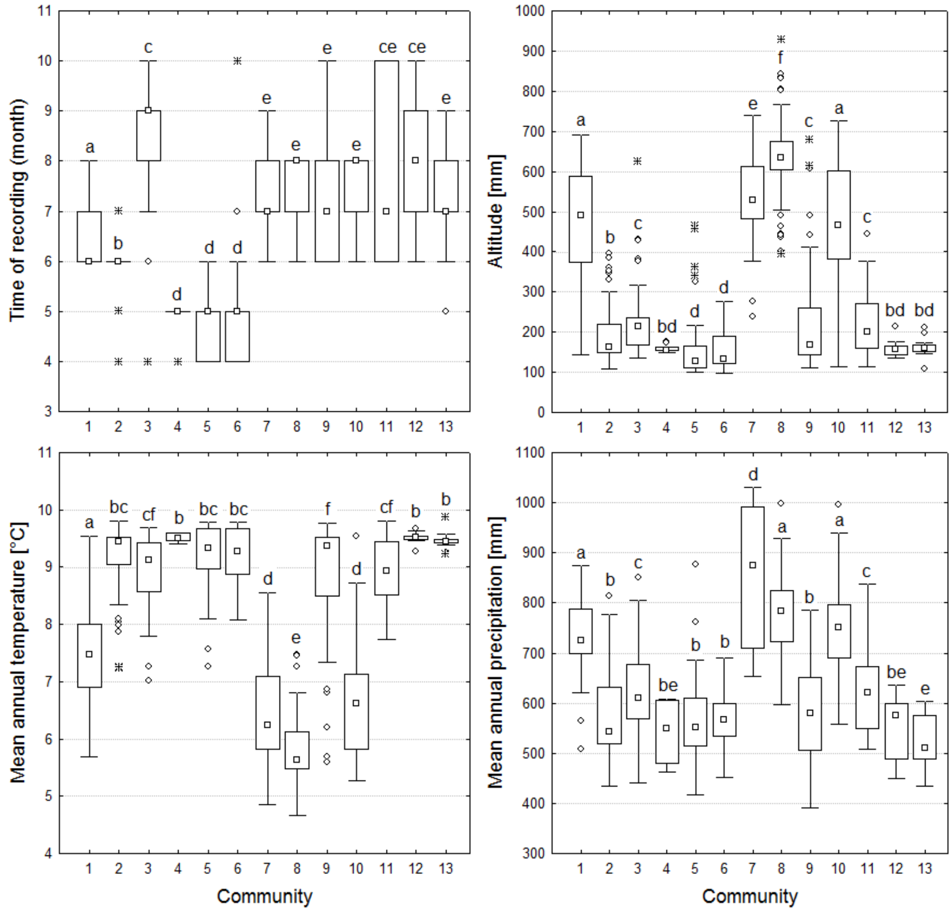


Fig. 5. Box-Whisker plots of the relationship of the individual communities to environmental factors. Different letters indicate significant differences between communities. ANOVA and Fisher LSD post-hoc test, $p < 0.05$. Annotations, see Figure 2.

Abb. 5. Box-Whisker-Plots der Beziehung zwischen den untersuchten Gesellschaften und Umweltfaktoren. Unterschiedliche Buchstaben kennzeichnen signifikante Unterschiede zwischen den Gesellschaften. ANOVA und Fisher LSD post-hoc test, $p < 0{,}05$. Anmerkungen, s. Abbildung 2.

Groups B and C (Fig. 1) include communities of the subclass *Violenea arvensis*, which contains typical arable weed communities (JAROLÍMEK et al. 1997). The second level of division is based on the type of agroecophases, i.e., in development time (Fig. 5). Group B communities are representatives of the spring and spring-summer agroecophase. Associations *Veronicetum trilobae-triphyllidi*, *Lamio amplexicauli-Thlaspietum arvensis* and *Taraxacum* sect. *Ruderalia* community develop as the first segetal communities in early spring. *Consolido-Anthemidetum austriacae* develops a little later and it replaces the *Veronicetum trilobae-triphyllidi* association. Therefore, these communities are placed beside each other in the dendrogram (Fig. 1). All communities in group B are widespread in the warm dry low-

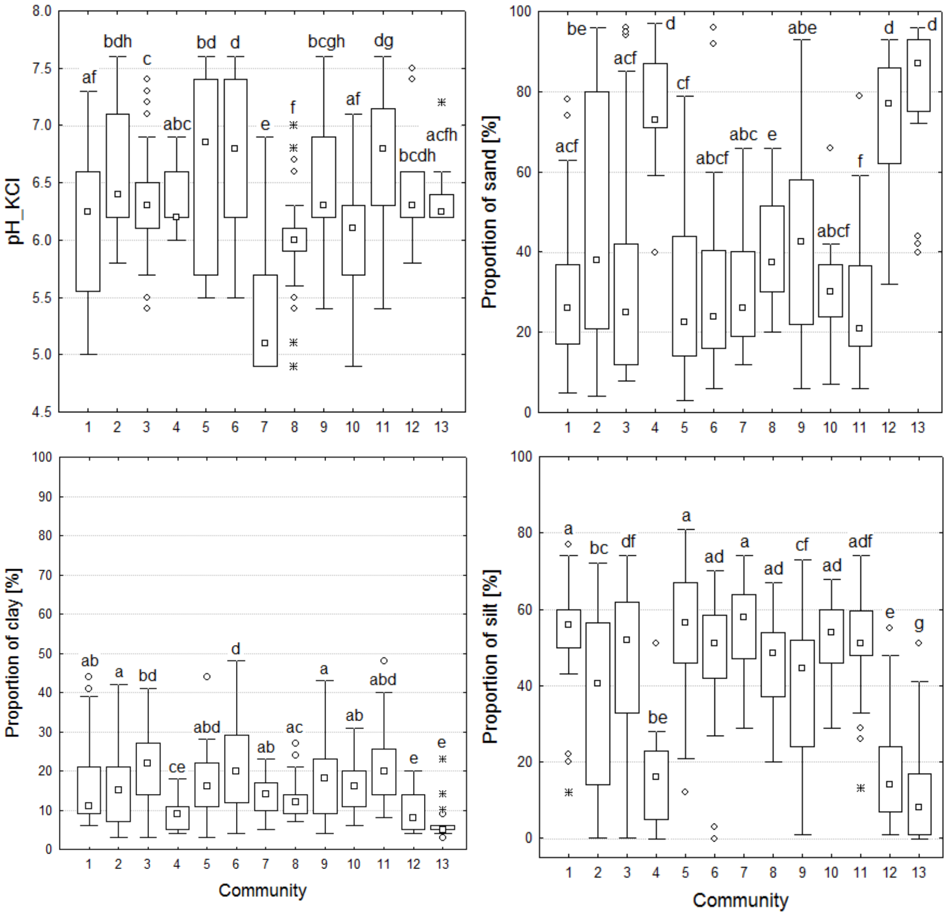


Fig. 6. Box-Whisker plots of the relationship of the individual communities to the soil characteristics. Different letters indicate significant differences between communities. ANOVA and Fisher LSD post-hoc test, $p < 0.05$. Annotations, see Figure 2.

Abb. 6. Box-Whisker-Plots der Beziehung der untersuchten Gesellschaften zu den Bodeneigenschaften. Unterschiedliche Buchstaben kennzeichnen signifikante Unterschiede zwischen den Gesellschaften. ANOVA und Fisher LSD post-hoc test, $p < 0{,}05$. Anmerkungen, s. Abbildung 2.

lands of Slovakia (Fig. 5). Stands of *Veronicetum* occur on coarse-textured sandy soils (Fig. 6). *Lamio-Thlaspietum* and *Taraxacum* sect. *Ruderalia* community comprise species with higher demands for soil nutrients than the other two communities (Fig. 2).

Communities in group C (Fig. 1) are typical for the summer and autumn agroecophase. In this studied vegetation, associations *Lathyro tuberosi-Adonidetum aestivalis*, *Spergulo arvensis-Scleranthetum annui*, and *Myosotido-Sonchetum arvensis* are spread at the highest altitudes; these localities are characterized by high precipitation and low temperature (Fig. 5). *Spergulo-Scleranthetum* and *Myosotido-Sonchetum* have the highest species diversity (Fig. 4), and the *Spergulo-Scleranthetum* association is bound to the most acidic substrates (Fig. 6). Stands of *Lathyro-Adonidetum* are typical for cereal fields, whereas the two other communities are typical for cereals and root crops.

The second part of group C (Fig. 1) includes communities at lower altitudes, except for the *Galinsogo-Setarietum* (Fig. 5). This association is more similar in ecological requirements to the previous part of group C, but the species composition is similar to the *Echinochloo-Setarietum pumilae* (Table 1 in the supplement). Therefore, it is next to *Echinochloo-Setarietum* in the dendrogram (Fig. 1). Both occur mainly in root crops. *Euphorbio exiguae-Melandrietum noctiflori* and *Stachyo annui-Setarietum pumilae* are typical for cereals and stubble, and therefore their species are less demanding on soil moisture (Fig. 2).

3.2 Gradient analysis

The communities of the segetal vegetation in the ordination diagram (DCA) are partly overlapping (Fig. 7). Nevertheless, a certain trend in the distribution of the communities is visible. The first axis was positively correlated with EIVs for light and temperature and negatively with diversity (Shannon-Wiener index). The second axis was positively correlated with EIV for moisture and negatively with EIV for soil reaction. On the left side of the ordination chart, relevés of the shade- and low temperature-tolerant species are plotted (mainly associations *Veronicetum* and *Lamio-Thlaspietum*). On the right side of the chart, relevés of species demanding light and high temperature are dispersed (e.g., associations *Stachyo-Setarietum* and *Portulacetum*). On the upper side, relevés of the association *Setario-Erigeronetum* formed mostly by acidophilous species are placed. The largest dispersion shows the association *Echinochloo-Setarietum*.

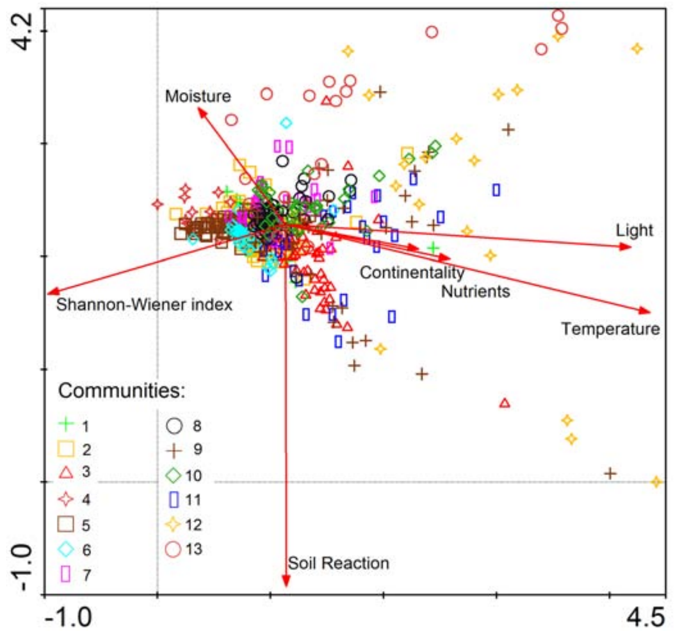


Fig. 7. Detrended Correspondence Analysis (DCA) of the segetal vegetation of Slovakia. Eigenvalues axis 1: 0.730, axis 2: 0.563. The average nonweighted Ellenberg indicator values were plotted onto the diagram as vectors. The community names (1–13) are given in chapter 3.3.

Abb. 7. Detrended Correspondence Analysis (DCA) der Segetalgesellschaften in der Slowakei. Eigenwerte: 1. Achse: 0,730; 2. Achse: 0,563. Die mittleren ungewichteten Ellenberg-Zeigerwerte sind als Vektoren in das Ordinationsdiagramm projiziert. Namen der Gesellschaften 1–13 s. Kap. 3.3.

3.3 List and description of the segetal communities

Class *Stellarietea mediae* R. Tx., Lohmeyer et Preising in R. Tx. ex von Rochow 1951
Subclass *Violenea arvensis* Hüppe et Hofmeister ex Jarolímek et al. 1997
Order *Centaureetalia cyani* R. Tx., Lohmeyer et Preising in R. Tx. ex von Rochow 1951
All. *Caucalidion lappulae* (R. Tx. 1950) von Rochow 1951
Ass. 1 *Lathyro tuberosi-Adonidetum aestivalis* Kropáč et Hadač in Kropáč et al. 1971
Ass. 2 *Consolido-Anthemidetum austriacae* Kropáč et Mochnacký 1990
Ass. 3 *Euphorbio exiguae-Melandrietum noctiflori* G. Müller 1964
All. *Veronico-Euphorbion* Sissingh ex Passarge 1964
Ass. 4 *Veronicetum trilobae-triphyllidi* Slavnić 1951
Ass. 5 *Lamio amplexicauli-Thlaspietum arvensis* Krippelová 1981
Other communities of the order *Centaureetalia cyani*
Comm. 6 *Taraxacum* sect. *Ruderalia* community
Order *Atriplici-Chenopodietalia albi* R. Tx. (1937) Nordhagen 1940
All. *Scleranthion annui* (Kruseman et Vlieger 1939) Sissingh in Westhoff et al. 1946
Ass. 7 *Spergulo arvensis-Scleranthetum annui* Kuhn 1937
Ass. 8 *Myosotido-Sonchetum arvensis* Passarge in Passarge et Jurko 1975
All. *Panico-Setarion* Sissingh in Westhoff et al. 1946
Ass. 9 *Echinochloo-Setarietum pumilae* Felföldy 1942 corr. Mucina 1993
Ass. 10 *Galinsogo-Setarietum* (R. Tx. et Beck. 1942) R. Tx. 1950
Ass. 11 *Stachyo annui-Setarietum pumilae* Felföldy 1942 corr. Mucina 1993
Subclass *Sisymbrienea* Pott 1992
Order *Eragrostietalia* J. Tx. ex Poli 1966
All. *Eragrostion* R. Tx. ex Oberd. 1954
Ass. 12 *Portulacetum oleraceae* Felföldy 1942
Ass. 13 *Setario viridis-Erigeronetum canadensis* Šomšák 1976

Ass. 1: *Lathyro tuberosi-Adonidetum aestivalis* (Appendix S2, Fig. 9a)

Diagnostic species: *Cyanus segetum, Lapsana communis, Neslia paniculata, Myosotis arvensis, Lithospermum arvense, Papaver rhoeas, Vicia hirsuta, Galium aparine, Lathyrus tuberosus, Galium spurium*

Constant species: ***Tripleurospermum perforatum***, ***Viola arvensis***, ***Myosotis arvensis***, ***Galium aparine***, ***Fallopia convolvulus***, *Stellaria media, Cirsium arvense, Convolvulus arvensis, Capsella bursa-pastoris, Polygonum aviculare* agg., *Lapsana communis, Apera spica-venti, Elytrigia repens, Cyanus segetum, Veronica persica, Papaver rhoeas, Chenopodium album* agg., *Vicia hirsuta, Sonchus arvensis*

Dominant species: *Apera spica-venti, Tripleurospermum perforatum, Cyanus segetum, Papaver rhoeas*

This community is typical for cereal fields in the summer agroecophase (June–July). More basiphilous species (e.g., *Galium spurium*, *Lathyrus tuberosus*, *Lithospermum arvense*, *Neslia paniculata*) are frequent in the community. The community occurs mainly in the colline (seldom lowland and submontane) belt in the moderately warm climatic region. It is typical for fine-scale fields in the hillside settlement areas of western and central Slovakia (Fig. 8; Biele Karpaty Mts, Borská nížina Lowland, Horehronské podolie, Javorie Mts, Krupinská planina Plain, Liptovská kotlina Basin, Malé Karpaty Mts, Myjavská pahorkatina Hills, Ostrôžky Mts, Poľana Mts, Popradská kotlina Basin, Slovenský kras Karst, Stolické vrchy Mts, Štiavnické vrchy Mts, Tríbeč Mts, and Turčianska kotlina Basin). The potential natural vegetation of these localities is mostly Carpathian oak-hornbeam woods, submontane and montane floodplain woods and beech woods with forb-rich undergrowth. The soil parent material is mostly in-situ weathered or transported intermediate igneous rocks, sedimentary rocks, and alluvial sediments. Dominant soil types are Cambisols (Eutric), Haplic Fluvisols (Eutric), and Rendzic Phaeozems, with prevailingly siltic soils.

This association was described from the Czech Republic by KROPÁČ et al. (1971), and it has been determined in Slovakia (KROPÁČ 1981, MOCHNACKÝ 1984b, 1996, 1998, 1999, JAROLÍMEK et al. 1997, ZALIBEROVÁ et al. 2004, ZALIBEROVÁ & JAROLÍMEK 2005, KROPÁČ & MOCHNACKÝ 2009) and also in the Czech Republic (KOBLIHOVÁ 1989, OTÝPKOVÁ 2001, LOSOSOVÁ 2004, KROPÁČ 2006, LOSOSOVÁ et al. 2009).

Ass. 2: *Consolido-Anthemidetum austriacae* (Appendix S3)

Diagnostic species: *Papaver rhoeas*, *Cota austriaca*, *Consolida regalis*

Constant species: ***Fallopia convolvulus***, ***Viola arvensis***, *Tripleurospermum perforatum*, *Polygonum aviculare* agg., *Stellaria media*, *Papaver rhoeas*, *Consolida regalis*, *Apera spica-venti*, *Chenopodium album* agg., *Cirsium arvense*, *Galium aparine*, *Capsella bursa-pastoris*

Dominant species: *Tripleurospermum perforatum*, *Cota austriaca*, *Papaver rhoeas*

This community is typical for the summer agroecophase (June–July). It develops mainly in cereals and more rarely on abandoned fields. The community is spread throughout the warm climatic region in the lowlands and to a lesser extent in the colline belt (Fig. 8; Borská nížina Lowland, Biele Karpaty Mts, Hronská pahorkatina Hills, Ipeľská kotlina Basin, Malé Karpaty Mts, Nitrianska pahorkatina Hills, Podunajská rovina Flat, Považský Inovec Mts, Rožňavská kotlina Basin, Slovenský kras Karst, Stolické vrchy Mts, and Trnavská pahorkatina Hills). Potential natural vegetation in these localities is mainly: elm floodplain woods, submontane and montane floodplain woods and Carpathian and Pannonian oak-hornbeam woods. Soil parent materials are mostly alluvial sediments, eolian sands, and loess, with mollic soil types dominant (Mollic Fluvisols, Haplic Chernozems) – together with initial soils [Haplic Arenosols (Eutric), Haplic Fluvisols (Eutric)]. Here, coarse and medium arenic, siltic, and loamy textured soils prevail.

This association has been recorded only in Slovakia and in areas of the Czech Republic (KROPÁČ 1981, 2006, MOCHNACKÝ 1996, 1998, 1999, 2005, KROPÁČ & MOCHNACKÝ 1990, JAROLÍMEK et al. 1997 and ZALIBEROVÁ et al. 2004).

Ass. 3: *Euphorbio exiguae-Melandrietum noctiflori* (Appendix S4, Fig. 9b)

Diagnostic species: *Anagallis arvensis*, *Setaria pumila*, *Tithymalus exiguus*, *Silene noctiflora*, *Kickxia elatine*, *Pastinaca sativa*

Constant species: ***Anagallis arvensis***, ***Tripleurospermum perforatum***, ***Polygonum aviculare* agg.**, ***Cirsium arvense***, ***Fallopia convolvulus***, ***Chenopodium album* agg.**, *Viola arvensis*, *Setaria pumila*, *Veronica persica*, *Convolvulus arvensis*, *Taraxacum* sect. *Ruderalia*, *Silene noctiflora*, *Elytrigia repens*, *Echinochloa crus-galli*

Dominant species: *Setaria pumila*, *Anagallis arvensis*

Although this community occurs also in cereal fields, its optimum growth is on stubble. It was found from June to November, but the majority of relevés come from August to September. It mainly consists of two layers; the lower layer is created by low and prostrate species that do not overgrow the mown cereal stems. The physiognomy of these stands differs due to alternating frequent and dominant species. Several species of bryophytes were also present. This community mainly occurs in the warm climatic region in the lowlands and colline belt in central and western Slovakia (Fig. 8; Borská nížina Lowland, Ipeľská kotlina Basin, Ipeľská pahorkatina Hills, Krupinská planina Plain, Malé Karpaty Mts, Nitrianska pahorkatina Hills, Podunajská rovina Flat, Považské podolie, Strážovské vrchy Mts, Tríbeč Mts, Trnavská pahorkatina Hills, Zvolenská kotlina Basin, and Žitavská pahorkatina Hills). Potential natural vegetation is mainly elm floodplain woods, Carpathian and Pannonian oak-hornbeam woods. Soil parent materials are alluvial sediments, polygenetic loess-like hillslope sediments, eolian sands, and loess, with dominant soil types being Cutanic Luvisols, Mollic Fluvisols, Haplic Fluvisols (Eutric), and Haplic Cambisols (Eutric). Medium textured loamy and siltic soils prevail.

The association was described from Germany by MÜLLER (1964). It is widespread in Slovakia (KROPÁČ 1974, 1981, KRIPPELOVÁ 1981, MOCHNACKÝ 1996, 1998, 1999, JAROLÍMEK et al. 1997, ZALIBEROVÁ & JAROLÍMEK 2005, KROPÁČ & MOCHNACKÝ 2009), in the Czech Republic (KOBLIHOVÁ 1989, OTÝPKOVÁ 2001, 2004, LOSOSOVÁ 2004, KROPÁČ 2006, LOSOSOVÁ et al. 2009), in Austria (HOLZNER 1973, MUCINA 1993), in Germany (SCHUBERT & MAHN 1968, HILBIG 1973, SCHUBERT 1995, 2001), in Poland (KUŹNIEWSKI 1975) and also in Denmark (LAWESSON 2004).

Ass. 4: *Veronicetum trilobae-triphyllidi* (Appendix S5)

Diagnostic species: *Veronica triphyllos, Papaver dubium, Veronica sublobata, V. hederifolia, Erophila verna, Papaver argemone, Descurainia sophia, Holosteum umbellatum, Anthemis ruthenica*

Constant species: ***Viola arvensis*, *Veronica hederifolia*, *Capsella bursa-pastoris*, *Veronica triphyllos*,** *V. sublobata, Descurainia sophia, Apera spica-venti, Stellaria media, Fallopia convolvulus, Elytrigia repens, Consolida regalis, Tripleurospermum perforatum, Polygonum aviculare* agg., *Papaver dubium*

Dominant species: *Veronica hederifolia, Descurainia sophia, Viola arvensis, Stellaria media*

This is a spring community fully developed in April and May. Stands are typical for winter cereals, but could also develop on young fallow. Winter and annual species from the class *Stellarietea mediae* and also *Sedo-Scleranthetea* are typical for the community. The association is recently recorded only in the warm climatic region of the Borská nížina Lowland in western Slovakia (Fig. 8). Pannonian oak-hornbeam woods are potential natural vegetation in this locality. Soil parent materials are alluvial sediments and eolian sands, with dominant soil types of Haplic Arenosols, Mollic Fluvisols, and Endogleyic Chernozems. Coarse and medium textured arenic and loamy soils prevail.

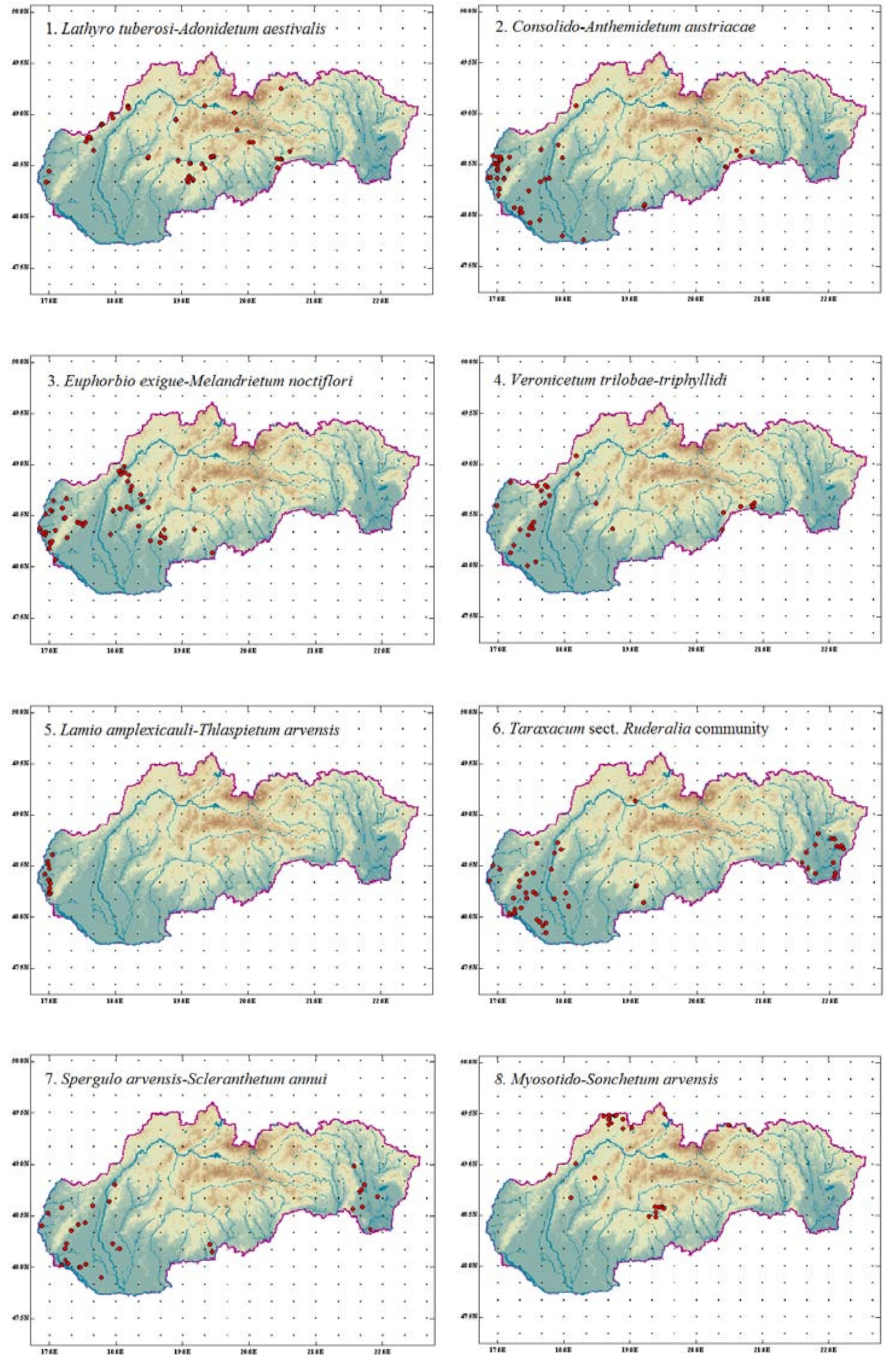
The community was described from the former Yugoslavia by SLAVNIĆ (1951). Authors have recorded it in Slovakia (MOCHNACKÝ 1986, 1996, 1998, 1999, JAROLÍMEK et al. 1997, MÁJEKOVÁ 2004, ZALIBEROVÁ et al. 2004, MÁJEKOVÁ et al. 2010), in the Czech Republic (KROPÁČ 1981, 1997, 2006, LOSOSOVÁ 2004, LOSOSOVÁ et al. 2009), in Austria (HOLZNER 1973, MUCINA 1993), in Hungary (BORHIDI et al. 2012), and also in Slovenia (ŠILC 2005, ŠILC & ČARNI 2005, 2007).

Ass. 5: *Lamio amplexicauli-Thlaspietum arvensis* (Appendix S6)

Diagnostic species: *Lamium amplexicaule, Veronica hederifolia, Consolida regalis*

Constant species: ***Stellaria media*, *Capsella bursa-pastoris*, *Tripleurospermum perforatum*, *Viola arvensis*, *Galium aparine*, *Cirsium arvense*,** *Consolida regalis, Lamium amplexicaule, Veronica hederifolia, V. persica, Apera spica-venti*

Dominant species: *Stellaria media, Viola arvensis, Veronica hederifolia*


1. Lathyro tuberosi-Adonidetum aestivalis
2. Consolido-Anthemidetum austriacae
3. Euphorbio exigue-Melandrietum noctiflori
4. Veronicetum trilobae-triphyllidi
5. Lamio amplexicauli-Thlaspietum arvensis
6. Taraxacum sect. Ruderalia community
7. Spergulo arvensis-Scleranthetum annui
8. Myosotido-Sonchetum arvensis

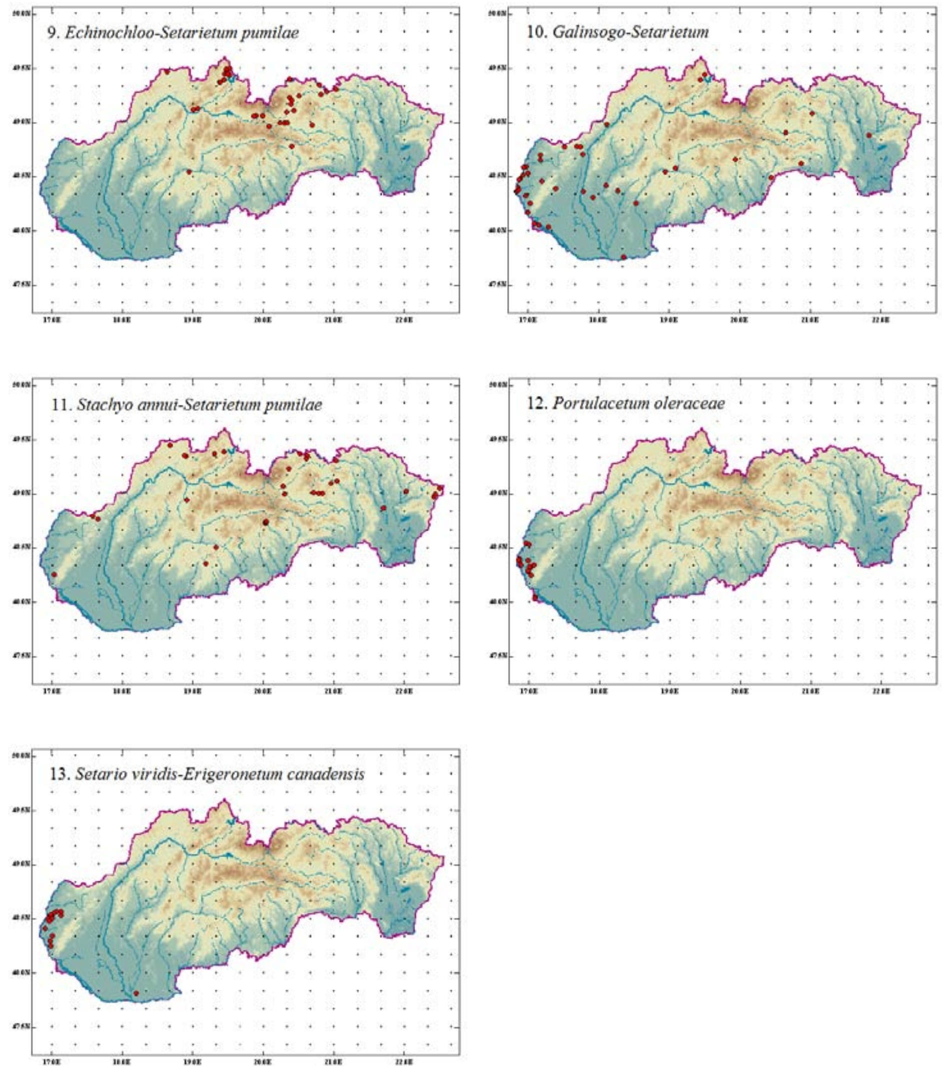


Fig. 8. Distribution of the segetal communities in Slovakia.

Abb. 8. Die Verbreitung der Segetalgesellschaften in der Slowakei.

This community forms a spring aspect in cereal fields. Annuals from the class *Stellarietea mediae* are the most frequent, and these dominate the vegetation. Stands are bound to warm climatic regions in eastern and southwestern Slovakia. They occur in the lowlands and hills of: Borská nížina Lowland, Ipeľská kotlina Basin, Krupinská planina Plain, Myjavská pahorkatina Hills, Nitrianska pahorkatina Hills, Podunajská rovina Flat, Považský Inovec Mts, Trnavská pahorkatina Hills, Turčianska kotlina Basin, Východoslovenská pahorkatina Hills, Východoslovenská rovina Flat, and Zemplínske vrchy Mts (Fig. 8). Potential natural vegetation of the localities comprises elm and willow-poplar floodplain woods and Carpathian and Pannonian oak-hornbeam woods. Soil parent materials are mostly alluvial sediments, polygenetic loess-like hillslope sediments and loess. The dominant soil types are Haplic Fluvisols (Eutric), Haplic Chernozems (Calcaric), Mollic Fluvisols (Calcaric) and Albic Cutanic Luvisols, with prevailingly medium textured siltic soils.

The association was described from eastern Slovakia by KRIPPELOVÁ (1981), and the community was documented by MOCHNACKÝ (1984a) in Slovakia and by OTÝPKOVÁ (2001) in the Czech Republic.

Comm. 6: *Taraxacum* sect. *Ruderalia* community (Appendix S7, Fig. 9c)

Diagnostic species: *Taraxacum* sect. *Ruderalia*, *Lactuca serriola*, *Stenactis annua*, *Veronica polita, Stellaria media*

Constant species: ***Stellaria media***, ***Capsella bursa-pastoris***, ***Taraxacum* sect. *Ruderalia***, ***Tripleurospermum perforatum***, *Lactuca serriola*, *Veronica polita, Elytrigia repens, Veronica persica*

Dominant species: *Capsella bursa-pastoris*, *Stellaria media*, *Viola arvensis*, *Tripleurospermum perforatum*, *Taraxacum* sect. *Ruderalia, Raphanus raphanistrum, Elytrigia repens*

This community is typical for perennial fodder crops; mainly lucerne. Its seasonal optimum is in the spring agroecophase (April–May), before the first removal of the crop. Species of the class *Stellarietea mediae* are well represented in the vegetation, but species of *Artemisietea vulgaris* are also frequent, as the fodder crops are grown in the same place for several years. The community occurs in a warm climatic region in the lowlands of western and eastern Slovakia (Fig. 8; Beskydské predhorie Foothills, Borská nížina Lowland, Ipeľská kotlina Basin, Nitrianska pahorkatina Hills, Podunajská rovina Flat, Považský Inovec Mts, Trnavská pahorkatina Hills, Východoslovenská pahorkatina Hills, and Východoslovenská rovina Flat). Potential natural vegetation in these localities is mainly elm floodplain woods and Carpathian and Pannonian oak-hornbeam woods. Soil parent material is mostly alluvial sediments, loess, and hillslope sediments. Dominant soil types are Mollic Fluvisols (Calcaric), Haplic Chernozems (Calcaric), Eutric Fluvisols (Calcaric), and Cutanic Luvisols, with medium textured siltic soils prevailing.

The *Taraxacum* sect. *Ruderalia* community was described only from warm regions of the Czech Republic by KROPÁČ (2006).

Ass. 7: *Spergulo arvensis-Scleranthetum annui* (Appendix S8, Fig. 9d)

Diagnostic species: *Anthemis arvensis*, *Stellaria graminea*, *Galeopsis tetrahit*, *Trifolium repens*, *Filaginella uliginosa*, *Galinsoga urticifolia*, *Persicaria maculosa*, *Hylotelephium maximum* agg., *Galeopsis bifida*, *Scleranthus annuus*, *Vicia hirsuta, Gypsophila muralis*, *Achillea millefolium* agg., *Myosotis arvensis*, *Ranunculus repens*, *Spergula arvensis*, *Xanthoxalis stricta, Chaerophyllum aromaticum, Agrostis gigantea, Vicia angustifolia*

Constant species: ***Fallopia convolvulus***, ***Chenopodium album* agg.**, ***Stellaria media***, ***Galeopsis tetrahit***, ***Myosotis arvensis***, ***Trifolium repens***, ***Viola arvensis***, ***Capsella bursa-pastoris***, ***Anthemis arvensis***, ***Cirsium arvense***, *Polygonum aviculare* agg., *Persicaria maculosa*, *Galium aparine*, *Vicia hirsuta*, *Galinsoga urticifolia*, *Taraxacum* sect. *Ruderalia*, *Elytrigia repens*, *Plantago uliginosa*, *Persicaria lapathifolia, Galeopsis bifida*

Dominant species: *Stellaria media*, *Tripleurospermum perforatum, Galinsoga urticifolia*, *Cyanus segetum*

This is a summer community with optimum development in July and August, and it is typical for both root-crops such as potatoes and for cereals. Several acidophilous, hygrophilous and nitrophilous species form this community's composition. It is widespread in both moderately warm and moderately cold climatic regions in the colline and submontane belt. It is typical for small fields in hillside settlement areas in central and northern Slovakia (Fig. 8; Biele Karpaty Mts, Jablunkovské medzihorie, Javorie Mts, Javorníky Mts, Kysucká vrchovina Upland, Kysucké Beskydy Mts, Ľubovnianska vrchovina Upland, Nitrianska pahorkatina Hills, Ostrôžky Mts, Pieniny Mts, Podbeskydská brázda Furrow, Poľana Mts, Považské podolie, Strážovské vrchy Mts, Turzovská vrchovina Upland, Veporské vrchy Mts, and Zvolenská kotlina Basin). Potential natural vegetation consists of beech and fir woods with forb-rich undergrowth, submontane beech woods with forb-rich undergrowth and Carpathian oak-hornbeam woods. Soil parent materials are mostly in-situ weathered or transported clastic sedimentary rocks and acid igneous rocks and polygenetic hillslope sediments. Dominant soil types are Haplic Cambisols (Eutric) and Haplic Stagnosols (Eutric), with prevailingly medium textured siltic and loamy soils.

The association was described from southern Germany by KUHN (1937) and it has also been recorded in Slovakia (MOCHNACKÝ 1996, 1998, 1999, JAROLÍMEK et al. 1997, KROPÁČ & MOCHNACKÝ 2009), in the Czech Republic (KROPÁČ 2006, OTÝPKOVÁ 2001, 2004, LOSOSOVÁ 2004, LOSOSOVÁ et al. 2009), and in Austria (MUCINA 1993).

Ass. 8: *Myosotido-Sonchetum arvensis* (Appendix S9, Fig. 9e)

Diagnostic species: *Matricaria discoidea*, *Galeopsis tetrahit*, *Persicaria hydropiper*, *Galeopsis bifida*, *Potentilla anserina*, *Poa annua*, *Persicaria lapathifolia*, *Mentha arvensis*, *Sonchus arvensis*, *Myosotis arvensis*, *Tithymalus helioscopia*, *Stachys palustris*, *Galium aparine*, *Lapsana communis*, *Geranium dissectum*, *Trifolium repens*, *Veronica arvensis*

Constant species: ***Fallopia convolvulus***, ***Tripleurospermum perforatum***, ***Galium aparine***, ***Viola arvensis***, ***Elytrigia repens***, ***Galeopsis tetrahit***, ***Polygonum aviculare* agg.**, ***Myosotis arvensis***, ***Chenopodium album* agg.**, ***Veronica persica***, ***Stellaria media***, ***Cirsium arvense***, ***Sonchus arvensis***, *Capsella bursa-pastoris*, *Persicaria lapathifolia*, *Stachys palustris*, *Mentha arvensis*, *Veronica arvensis*, *Matricaria discoidea*, *Tithymalus helioscopia*, *Trifolium repens*, *Equisetum arvense*

Dominant species: *Tripleurospermum perforatum*, *Fallopia convolvulus*, *Chenopodium album* agg.

This community is typical for the late summer agroecophase (July–August) and it develops both in root-crops and cereals. Several therophytes and also hemicryptophytes are represented among the diagnostic species; stands are noticeable mostly by the yellow inflorescences of *Sonchus arvensis*. Hygrophilous and nitrophilous species are common in the community. Private fine-scale fields are typical biotopes for this community, which develops in the moderately cold climatic region and occasionally in moderately warm areas in the colline to submontane belt (Fig. 8; Hornádska kotlina Basin, Levočské vrchy Mts, Liptovská kotlina Basin, Ľubovnianska vrchovina Upland, Nízke Tatry Mts, Ondavská vrchovina Upland, Oravská kotlina Basin, Podbeskydská brázda Furrow, Podbeskydská vrchovina Upland, Popradská kotlina Basin, Spišská Magura Mts, Spišsko-šarišské medzihorie, Štiavnické vrchy Mts, Turčianska kotlina Basin, Turzovská vrchovina Upland, and Volovské vrchy Mts). The potential natural vegetation is mainly submontane and montane floodplain woods and fir and fir-spruce woods. Soil parent materials are mostly in-situ weathered or transported clastic sedimentary rocks and alluvial and polygenetic hillslope sediments. The dominant soil types are Haplic Cambisols (Eutric), Haplic Fluvisols (Eutric), and Haplic Stagnosols (Eutric), with prevailingly medium textured siltic and loamy soils.

The association was described from Slovak territory by PASSARGE & JURKO (1975), and it was also recorded in Slovakia by MOCHNACKÝ (1996, 1998, 1999) and by JAROLÍMEK et al. (1997). However, it has not been reported in other countries.

Ass. 9: *Echinochloo-Setarietum pumilae* (Appendix S10)

Diagnostic species: *Xanthium albinum*, *Aster lanceolatus*, *Echinochloa crus-galli*

Constant species: ***Chenopodium album* agg.**, ***Cirsium arvense***, *Elytrigia repens*, *Polygonum aviculare* agg., *Echinochloa crus-galli*, *Fallopia convolvulus*, *Convolvulus arvensis*, *Tripleurospermum perforatum*

Dominant species: *Tripleurospermum perforatum*, *Setaria pumila*, *Echinochloa crus-galli*, *Convolvulus arvensis*, *Chenopodium polyspermum*

Although this community is typical for the summer agroecophase from June to August, it could remain on the fields until October. It develops in different types of agricultural stands: in root-crops, cereals, stubble, fallow and field depressions. Heterogeneity of the crop is reflected in the heterogeneity of the weed vegetation and its structure. Diagnostic species are poorly represented, except for *Echinochola crus-galli* which is also constant and dominant species on some stands. Several neophytes are frequent in this vegetation (e.g., *Amaranthus blitoides*, *A. powellii*, *A. retroflexus*, *Ambrosia artemisiifolia*, *Aster lanceolatus*, and *Xanthium albinum*). The community is dispersed throughout Slovakia, but mainly occurs in the warm climatic region, in the lowland and colline belt, and occasionally in the submontane belt and orographic units: Bachureň, Borská nížina Lowland, Hornádska kotlina Basin, Hronská pahorkatina Hills, Chvojnická pahorkatina Hills, Ipeľská pahorkatina Hills, Malé Karpaty Mts, Myjavská pahorkatina Hills, Nitrianska pahorkatina Hills, Oravská kotlina Basin, Podunajská rovina Flat, Považské podolie, Slovenský kras Karst, Stolické vrchy Mts, Štiavnické vrchy Mts, Trnavská pahorkatina Hills, Východoslovenská pahorkatina Hills, Zvolenská kotlina Basin, and Žitavská pahorkatina Hills (Fig. 8). The altitude ranges from 112 to 679 m a.s.l. Potential natural vegetation is elm floodplain woods, submontane and montane floodplain woods and Carpathian oak-hornbeam woods. The soil parent material is

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Fig. 9. Stands of the following communities **a)** *Lathyro tuberosi-Adonidetum aestivalis* with flowering aspect of *Papaver rhoeas*, *Cyanus segetum* and *Cota austriaca* in the cereal field (*Secale cereale*) in the Krupinská planina Plain; **b)** *Euphorbio exiguae-Melandrietum noctiflori* with aspect of *Anagallis arvensis* and *Sherardia arvensis* in a stubble field; **c)** *Taraxacum* sect. *Ruderalia* community in a lucerne (*Medicago sativa*) field with dominance of *Capsella bursa-pastoris* in the Podunajská nížina Lowland; **d)** *Spergulo arvensis-Scleranthetum annui* in a private oat (*Avena sativa*) field with dominant *Galeopsis tetrahit*; **e)** *Myosotido-Sonchetum arvensis* in a small private potato field in the Liptovská kotlina Basin; **f)** *Galinsogo-Setarietum* with dominant *Galinsoga parviflora* and *G. urticifolia* in a small private potato field; **g, h)** *Stachyo annui-Setarietum pumilae* with dominant *Setaria pumila* in a stubble field (Photos: Jana Májeková).

Abb. 9. Bestände der folgenden Gesellschaften **a)** *Lathyro tuberosi-Adonidetum aestivalis* mit Blühaspekt von *Papaver rhoeas*, *Cyanus segetum* und *Cota austriaca* im Getreidefeld (*Secale cereale*) im Krupinská planina Flachland; **b)** *Euphorbio exiguae-Melandrietum noctiflori* (Aspekt von *Anagallis arvensis* und *Sherardia arvensis*) in einem Stoppelfeld; **c)** *Taraxacum* sect. *Ruderalia*-Gesellschaft in einem Luzerne-Feld (*Medicago sativa*) mit *Capsella bursa-pastoris* als dominanter Art in der Podunajská nížina Tiefebene; **d)** *Spergulo arvensis-Scleranthetum annui* in einem privaten Hafer-Feld (*Avena sativa*) mit dominantem *Galeopsis tetrahit*; **e)** *Myosotido-Sonchetum arvensis* in einem kleinen privaten Kartoffel-Feld im Liptovská kotlina-Becken; **f)** *Galinsogo-Setarietum* mit den dominanten Arten *Galinsoga parviflora* und *G. urticifolia* in einem kleinen privaten Kartoffel-Acker; **g, h)** *Stachyo annui-Setarietum pumilae* mit dominanter *Setaria pumila* im Stoppelfeld (Fotos: Jana Májeková).


a)
b)
c)
d)
e)
f)
g)
h)

mostly alluvial and proluvial sediments, eolic sands, and loess. Dominant soil types are Haplic Fluvisols (Eutric), Mollic Fluvisols (Eutric), Haplic Chernozems (Calcaric) and Cutanic Luvisols, with prevailingly medium textured loamy soils.

This association was common in Slovakia in the past (KRIPPELOVÁ 1981, MOCHNACKÝ 1996, 1998, 1999, 2005, JAROLÍMEK et al. 1997, ZALIBEROVÁ et al. 2004, ZALIBEROVÁ & JAROLÍMEK 2005). It was described from Hungary by FELFÖLDY (1942), and besides Hungary (SOÓ 1961, BORHIDI 1996, PINKE 2000, 2007, PINKE & PÁL 2008, BORHIDI et al. 2012) it is widespread in the Czech Republic (LOSOSOVÁ 2004, KROPÁČ 2006, LOSOSOVÁ et al. 2009), Austria (MUCINA 1993) and also in Slovenia (ŠILC 2005, ŠILC & ČARNI 2005, 2007).

Ass. 10: *Galinsogo-Setarietum* (Appendix S11, Fig. 9f)

Diagnostic species: *Galinsoga urticifolia*, *G. parviflora*, *Sonchus arvensis*, *Equisetum arvense*, *Stachys palustris*, *Lamium purpureum*, *Symphytum officinale*, *Armoracia rusticana*, *Geranium dissectum*, *Persicaria lapathifolia*

Constant species: ***Chenopodium album* agg.**, ***Cirsium arvense***, ***Convolvulus arvensis***, ***Veronica persica***, ***Sonchus arvensis***, ***Lamium purpureum***, *Stellaria media*, *Fallopia convolvulus*, *Capsella bursa-pastoris*, *Galium aparine*, *Galinsoga parviflora*, *Elytrigia repens*, *Equisetum arvense*, *Stachys palustris*, *Galinsoga urticifolia*, *Echinochloa crus-galli*, *Persicaria lapathifolia*, *Tripleurospermum perforatum*, *Taraxacum* sect. *Ruderalia*

Dominant species: *Galinsoga urticifolia*, *G. parviflora*, *Echinochloa crus-galli*, *Equisetum arvense*

This is a summer association typical for stands in small potato fields. Its optimum is in July and August when diagnostic species are in bloom. While the neophytes *Galinsoga parviflora* and *G. urticifolia* determine vegetation physiognomy (Fig. 9f), the community also contains nitrophilous and hygrophilous species. It is widespread in orographic units in the colline and submontane belt, in moderately warm and moderately cold climatic regions: Bachureň, Borská nížina Lowland, Bukovské vrchy Mts, Hornádska kotlina Basin, Javorie Mts, Krupinská planina Plain, Kysucká vrchovina Upland, Laborecká vrchovina Upland, Myjavská pahorkatina Hills, Ondavská vrchovina Upland, Oravská kotlina Basin, Pieniny Mts, Podbeskydská vrchovina Upland, Popradská kotlina Basin, Spišská Magura Mts, Spišsko-šarišské medzihorie, Stolické vrchy Mts, Turčianska kotlina Basin, Turzovská vrchovina Upland, and Východoslovenská pahorkatina Hills (Fig. 8). Potential natural vegetation is mainly submontane and montane floodplain woods and Carpathian oak-hornbeam woods. Soil parent materials are mostly alluvial sediments and in-situ weathered or transported clastic sedimentary rocks. Dominant soil types are Haplic Fluvisols (Eutric), Haplic Cambisols (Eutric), Haplic Stagnosols (Eutric), and Rendzic Phaeozems, with prevailingly medium textured siltic soils.

The association was previously recorded in Slovakia by ELIÁŠ (1974) and MOCHNACKÝ (1984b). It is also spread in Poland (Fijałkowski 1975, ANIOŁ-KWIATKOWSKA & KĄCKI 2006, RZYMOWSKA & SKRZYCZYŃSKA 2006, MATUSZKIEWICZ 2007, NOWAK 2007), in Germany (PASSARGE 1955, HILBIG 1973, HÜPPE & HOFMEISTER 1990, SCHUBERT 2001), in Denmark (LAWESSON 2004), and in the Ukraine (SOLOMAKHA et al. 1992, SOLOMAKHA 1995).

Ass. 11: *Stachyo annui-Setarietum pumilae* (Appendix S12, Fig. 9g, h)

Diagnostic species: *Tithymalus falcatus*, *Sonchus oleraceus*, *Stachys annua*, *Anagallis arvensis*, *Reseda lutea*, *Kickxia spuria*, *K. elatine*, *Linaria vulgaris*, *Anagallis foemina*, *Medicago lupulina*, *Amaranthus retroflexus*, *Solanum nigrum*, *Convolvulus arvensis*, *Atriplex patula*

Constant species: ***Viola arvensis***, ***Chenopodium album* agg.**, ***Cirsium arvense***, ***Capsella bursa-pastoris***, ***Convolvulus arvensis***, ***Anagallis arvensis***, *Tripleurospermum perforatum*, *Elytrigia repens*, *Stellaria media*, *Polygonum aviculare* agg., *Sonchus oleraceus*

Dominant species: *Chenopodium album* agg., *Tripleurospermum perforatum*, *Artemisia vulgaris*, *Apera spica-venti*

This community occurs in summer (June–July) in cereal fields and occasionally in root crops, and in autumn (September–October) it is found in stubble. The stands are physiognomically different with no common dominant species. In addition to annual species from the class *Stellarietea mediae*, perennials from the class *Artemisietea vulgaris* are also frequently present. The community occurs mainly in the warm climatic region and occasionally also in moderately warm climes. It is spread in the western and southern parts of Slovakia (Fig. 8; Biele Karpaty Mts, Bodvianska pahorkatina Hills, Borská nížina Lowland, Dolnomoravský úval, Hornonitrianska kotlina Basin, Ipeľská pahorkatina Hills, Košická kotlina Basin, Myjavská pahorkatina Hills, Podunajská rovina Plain, Slovenský kras Karst, Strážovské vrchy Mts, and Trnavská pahorkatina Hills). Potential natural vegetation is Carpathian and Pannonian oak-hornbeam woods. Soil parent materials are mostly alluvial sediments, loess, and loess-like polygenetic hillslope sediments. Dominant soil types are Haplic Chernozems (Calcaric), Cutanic Luvisols, Haplic Fluvisols (Eutric) and Mollic Fluvisols (Eutric), with prevailingly medium textured siltic soils.

The association was described from Hungary by FELFÖLDY (1942). It has been recorded in Slovakia (MOCHNACKÝ 1996, 1998, 1999, JAROLÍMEK et al. 1997, KROPÁČ & MOCHNACKÝ 2009), in Hungary (PINKE 2007, PINKE & PÁL 2008, 2009, BORHIDI et al. 2012), in the Czech Republic (KROPÁČ 2006, LOSOSOVÁ et al. 2009) and also in Austria (MUCINA 1993).

Ass. 12: *Portulacetum oleraceae* (Appendix S13)

Diagnostic species: *Panicum miliaceum*, *Digitaria sanguinalis*, *Setaria viridis*, *Datura stramonium*, *Echinochloa crus-galli*

Constant species: ***Chenopodium album* agg.**, *Echinochloa crus-galli*, *Digitaria sanguinalis*

Dominant species: *Chenopodium album* agg., *Panicum miliaceum*, *Echinochloa crus-galli*, *Datura stramonium*, *Raphanus raphanistrum*, *Conyza canadensis*, *Ambrosia artemisiifolia*, *Amaranthus retroflexus*

This association is the floristically poorest of all recorded segetal communities. It is typical for summer and autumn agroecophases (June–October) and predominantly develops in root-crops and to a lesser extent in cereals, stubblefields and fallow land. The community is characterized by thermophilous annual species which demand high soil nitrogen content. The physiognomy of the vegetation is not united, with several species alternating in dominance. The community was recorded only in western Slovakia (Fig. 8; Borská nížina Lowland and Podunajská rovina Flat) in the warm climatic region. Potential natural vegetation is elm floodplain woods. Soil parent materials are mostly fluvial (alluvial and terrace) sediments and eolian sands. Dominant soil types are Haplic Arenosols and Mollic Fluvisols (Calcaric), with prevailingly coarse and medium textured arenic and loamy soils.

The association has also been recorded in other parts of Slovakia (ELIÁŠ 1982a, MOCHNACKÝ 1984b, 1996, 1998, 1999, JAROLÍMEK et al. 1997), in the Czech Republic (KROPÁČ 1981, 2006, LOSOSOVÁ et al. 2009) and also in Hungary (FELFÖLDY 1942, BORHIDI 1996, BORHIDI et al. 2012).

Ass. 13: *Setario viridis-Erigeronetum canadensis* (Appendix S14)

Diagnostic species: *Digitaria sanguinalis*, *Anthemis ruthenica*, *Conyza canadensis*, *Raphanus raphanistrum*, *Trifolium arvense*

Constant species: ***Fallopia convolvulus***, ***Viola arvensis***, ***Chenopodium album* agg.**, ***Digitaria sanguinalis***, *Elytrigia repens*, *Conyza canadensis*, *Apera spica-venti*

Dominant species: *Digitaria sanguinalis*, *Raphanus raphanistrum*, *Conyza canadensis*, *Sinapis arvensis*, *Apera spica-venti*

This community is one of the floristically poorest types on arable land. Although it is spread in cereals and on stubble, young fallows are the optimal biotope for its development. It has a rather modified structure in agrocoenoses, with optimum development in summer and autumn when the diagnostic and dominant species of *Digitaria sanguinalis* and *Conyza canadensis* are in bloom. The community's central occurrence is in the warm climatic region in the Borská nížina Lowland, but in one case it was recorded in the Hronská pahorkatina Hills (Fig. 8). Potential natural vegetation is mostly Pannonian oak-hornbeam woods and oak woods with *Potentilla alba*. Soil parent materials are mostly eolian sands. Dominant soil types are Haplic Arenosols and Endogleyic Chernozems (Arenic, Calcaric), with prevailingly coarse textured arenic soils.

The association was described by ŠOMŠÁK (1976) as a typical community in young pine plantations, and it has been recorded only in the Borská nížina Lowland of western Slovakia (JAROLÍMEK et al. 1997).

3.4 Species composition and environmental factors

The weed vegetation was represented by 407 plant taxa, with 26 of these bryophytes and 381 vascular plants. Therophytes were dominant (57%), followed by hemicryptophytes (36%), geophytes (4%), phanerophytes (juvenile stage) (2%), and chamaephytes (1%). Native species (56%) prevailed over aliens (44%), and archaeophytes (34%) over neophytes (10%). Most alien flora species were naturalised (82%), followed by invasive (9%) and casual species (9%). There were 32 threatened vascular plant species and four threatened species of bryophytes recorded in the communities (Table 2).

The highest species diversity was recorded in the associations of *Spergulo-Scleranthetum* and *Myosotido-Sonchetum* (Fig. 4). These also constituted the highest number of native species (Fig. 3). In contrast, *Portulacetum* and *Setario-Erigeronetum* registered the lowest species diversity (Fig. 4). The highest number of archaeophytes was recorded in the association *Lathyro-Adonidetum* and the lowest in *Portulacetum*. Neophytes were not strongly represented in the communities. Naturalized species prevailed in *Lathyro-Adonidetum* and invasives prevailed in *Galinsogo-Setarietum*. The number of casuals in all communities was poor (Fig. 3). Therophytes were the most abundant in the associations *Lathyro-Adonidetum*, *Spergulo-Scleranthetum*, and *Myosotido-Sonchetum*, but there were less in *Portulacetum oleraceae*. The highest number of threatened species was recorded in the *Veronicetum* association (Fig. 4).

The association *Portulacetum* contained the most thermophilous species, while *Spergulo-Scleranthetum* and *Myosotido-Sonchetum* species had the lowest demand for temperature (Fig. 2). The *Myosotido-Sonchetum* was spread in the coldest areas, followed by communities *Spergulo-Scleranthetum*, *Galinsogo-Setarietum*, and *Lathyro-Adonidetum*. These communities were typical at the highest altitudes, with segetal vegetation requiring the highest precipitation (Fig. 5).

Table 2. Threatened species in the segetal communities (1–13) in Slovakia (according to FERÁKOVÁ et al. 2001 and KUBINSKÁ et al. 2001). Each species is presented by its presence (%) in each community. Endangerment categories (Endang.) are according to IUCN: CR – critically endangered, EN – endangered, VU – vulnerable, LR:nt – lower risk: near threatened, DD – data deficient.

Tabelle 2. Gefährdete Arten in den Segetalgesellschaften (1–13) in der Slowakei (nach FERÁKOVÁ et al. 2001 und KUBINSKÁ et al. 2001). Jede Art ist durch ihre Stetigkeit (%) in jeder Gesellschaft repräsentiert. Gefährdungskategorien (Endang.) richten sich nacher Klassifikation der IUCN: CR – vom Aussterben bedroht, EN – stark gefährdet, VU – gefährdet, LR:nt – gering gefährdet, DD – keine ausreichenden Daten.

Taxon	Endang.	Community number												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Vascular plants														
Adonis aestivalis	LR:nt	2	4	5	–	–	–	–	–	2	–	–	–	–
Agrostemma githago	CR	7	9	–	–	–	–	–	–		–	–	–	–
Aphanes arvensis	EN	4	–	2	6	4	–	–	–	–	–	–	–	–
Arenaria leptoclados	VU	–	–	2	–	–	–	–	–	–	–	–	–	–
Bifora radians	DD	–	–	2	–	–	–	–	–	–	–	–	–	–
Bolboschoenus maritimus	EN	–	–	2	–	–	–	–	–	–	–	–	–	–
Bromus commutatus	VU	–	2		–	–	–	–	–	–	–	–	–	–
Bromus secalinus	EN	2	–	–	–	–	–	–	2		–	–	–	–
Centaurium pulchellum	VU	–	–	4	–	–	–	–	–	–	–	–	–	–
Chamaepitys chia subsp. *trifida*	LR:nt	–	–	2	–	–	3	–	–	2	–	10	–	–
Cyanus segetum	LR:nt	63	23	4	–	15	3	37	8	7	3	3	–	6
Dichodon viscidum	VU	–	–	–	6	2	9	–	–	–	–	–	–	–
Hibiscus trionum	VU	–	–	–	–	–	–	–	–	2	–	–	–	–
Kickxia elatine	LR:nt	–	2	21	–	–	3	–	–	–	–	23	–	–
Kickxia spuria	VU	2	–	20	–	–	–	–	–	2	–	23	–	–
Logfia minima	VU	–	–	–	–	–	–	–	–	–	–	–	–	6
Lolium temulentum	CR	–	–	–	–	–	–	2	4	2	–	–	–	–
Lythrum hyssopifolia	VU	–	–	2	–	–	–	–	–	2	–	–	–	–
Misopates orontium	VU	4	–	2	–	–	–	–	–	–	–	10	–	–
Myosurus minimus	VU	–	2	–	12	7	3	–	–	–	–	–	–	–
Papaver argemone	VU	2	2	–	35	–	3	–	–	–	–	–	–	6
Papaver dubium	LR:nt	2	–	–	–	–	–	–	–	–	–	–	–	–
Papaver dubium subsp. *austromoravicum*	LR:nt	–	4	–	53	4	–	–	–	–	–	–	–	–
Pulicaria dysenterica	LR:nt	–	–	2	–	–	–	–	–	–	–	–	–	–
Ranunculus arvensis	LR:nt	14	4	2	–	6	–	2	–	–	–	–	–	–
Rumex stenophyllus	VU	2	–	2	–	–	3	2	–	5	–	–	–	–
Spergula morisonii	EN	–	–	–	–	–	–	–	–	–	–	–	–	6
Tithymalus tommasinianus	DD	2	–	–	–	–	–	–	–	–	–	–	–	–
Veronica agrestis	EN	5	–	–	–	–	–	2	6	–	3	–	–	–
Veronica anagalloides	EN	–	–	–	–	–	–	–	–	2	–	–	–	–
Veronica triloba	EN	–	2	–	–	6	–	–	–	–	–	–	–	–
Veronica triphyllos	VU	2	19	–	76	9	–	–	–	–	–	–	–	–
Bryophytes														
Anthoceros agrestis	LR:nt	–	–	–	–	–	–	2	–	–	–	–	–	–
Eurhynchium praelongum	VU	–	–	–	–	–	3	–	–	–	–	–	–	–
Pottia davalliana	LR:nt	–	–	2	–	–	–	–	–	–	–	–	–	–
Weissia longifolia	LR:nt	–	–	2	–	–	3	5	–	–	–	–	–	–

Continental species were most abundant in *Echinochloo-Setarietum* and *Portulacetum*. The most acidophilous species were represented in the associations *Spergulo-Scleranthetum* and *Setario-Erigeronetum* (Fig. 2), with *Spergulo-Scleranthetum* also occurring in localities with the lowest soil pH (Fig. 6). Species with a low demand for nutrients were most abundant in the associations *Veronicetum* and *Setario-Erigeronetum* (Fig. 2).

The associations *Veronicetum*, *Portulacetum*, and *Setario-Erigeronetum* were typical for sandy soils (Fig. 6).

4. Discussion

Although JAROLÍMEK et al. (1997) published 21 associations in arable land in Slovakia, we did not distinguish all of them. Possible reasons for this discrepancy are: (i) their occurrence was not equally confirmed in the past (for example, ELIÁŠ (1982b) published the occurrence of *Tribulo-Tragetum* without any relevés), (ii) their distribution was very rare or quite localized in the past [*Misopateto-Galeopsietum ladani* was described only from one mountain (KROPÁČ & HEJNÝ 1975) and *Cannabio ruderalis-Silenetum noctiflorae* from one lowland in Slovakia (MOCHNACKÝ 1989)] and (iii) agricultural intensification in the past decades caused huge changes in weed composition (KROPÁČ 1977, 1997, HOLZNER 1978, SKALICKÝ 1981, KROPÁČ & KOPECKÝ 1987, OTÝPKOVÁ 2003, PYŠEK et al. 2005, LOSOSOVÁ & SIMONOVÁ 2008, PINKE & PÁL 2008). On the other hand, it is possible that we did not record all types of vegetation in all types of agrocoenoses, and therefore some rare communities may not have been distinguished in the analyses, and the relevés were assigned to other clusters. For example, we certainly assumed the occurrence of *Erophilo-Arabidopsietum* in Slovakia, but there was insufficient data on this association to be reported in our study.

In addition, we also recorded some communities not characterized by JAROLÍMEK et al. (1997). Although the association *Lamio amplexicauli-Thlaspietum arvensis* was described from eastern Slovakia as a vernal community (KRIPPELOVÁ 1981), this community was not confirmed in further analyses (JAROLÍMEK et al. 1997). Our relevés had similar floristic structure and ecological preferences as the community described from eastern Slovakia and also from the Czech Republic (OTÝPKOVÁ 2001). Although this association had some species in common with *Veronicetum trilobae-triphyllidi*, numerical analysis had explicitly divided these stands. It appears that these associations are ecological vicariants. *Veronicetum* is spread in western Slovakia only in the Borská nížina Lowland where the parent soil material is sandy and poor in nutrients and moisture. *Lamio-Thlaspietum* is mainly typical for other Slovak lowlands, such as in eastern Slovakia. In the past, *Veronicetum* was recorded in both the west and east of the country (MOCHNACKÝ 1986, 1996, 1998, JAROLÍMEK et al. 1997, MÁJEKOVÁ 2004, MÁJEKOVÁ et al. 2010). However, we did not record it recently in the east, and the reason is possibly due to increased intensive agriculture in this area. Moreover, the application of herbicides caused decreases in sensitive species; and this is one reason why *Veronicetum* had more threatened species than *Lamio-Thlaspietum*. It is possible that the association *Lamio-Thlaspietum* is an impoverished form of *Veronicetum* caused by intensive chemical management.

We recorded the *Taraxacum* sect. *Ruderalia* community as being novel for Slovakia, where it forms a well-developed and stable community in perennial fodder crops. This community was described from the Czech Republic in similar biotopes (KROPÁČ 2006).

While that author classified it in the alliance *Caucalidion lappulae*, *Caucalidion* species are very poorly represented in our material. Therefore, we classified this only at the order level.

The association *Galinsogo-Setarietum* was described by TÜXEN (1950), but he synonymized it with *Echinochloo-Setarietum pumilae* (as also did JAROLÍMEK et al. 1997 and KROPÁČ 2006). JAROLÍMEK et al. (1997) also characterized stands with the dominant species *Galinsoga parviflora* as a variant of *Echinochloo-Setarietum*. In our analyses, these communities are placed side by side, but they are strictly divided. *Galinsogo-Setarietum* forms typical growths in potato fields with the dominant species *Galinsoga parviflora* and *G. urticifolia*. *Galinsogo-Setarietum* occurs at higher altitudes in colder climates with higher precipitations and more acidic soil than *Echinochloo-Setarietum*. Diversity and representation of archaeophytes, neophytes and also native species is also higher in the *Galinsogo-Setarietum*. Meanwhile, KRIPPELOVÁ (1981) characterized the association *Echinochloo-Setarietum* as a thermophilous community.

Although associations *Euphorbio-Melandrietum* and *Stachyo-Setarietum* are floristically similar, their syntaxonomical classification is different. They are typical for stubble or cereal fields in autumn, but they are identified also in summer agroecophases. The floristic composition of some relevés overlaps, making their classification very difficult. Our community *Euphorbio-Melandrietum* is very similar to the original description by MÜLLER (1964), with the exception of *Setaria pumila* which exhibits high presence and abundance in our relevés. In contrast, this species is typical for the *Stachyo-Setarietum* (FELFÖLDY 1942), and this grass has expanded in Slovakia in the last decades. The community *Stachyo-Setarietum* is also similar to the association *Kickxietum spuriae* Krusem. et Vlieg. 1939 described from The Netherlands (KRUSEMAN & VLIEGER 1939, HAVEMAN et al. 1998) and also from Poland (MATUSZKIEWICZ 2007), Slovenia (ŠILC & ČARNI 2007), Croatia (HULINA 2002), Denmark (LAWESSON 2004), and from Germany (OBERDORFER 1983). Therefore, these stubble-field communities should be revised on a broader scale range.

The association *Lathyro tuberosi-Adonidetum aestivalis* described by KROPÁČ et al. (1971) was dominated by *Adonis aestivalis*. However, the representation of *A. aestivalis* in our relevés is very poor. There has been a remarkable decline in this species in countries under herbicide pressure and seed cleaning during the last decades (KUŹNIEWSKI 1975, KOBLIHOVÁ 1989, HULINA 2002, 2005, OTÝPKOVÁ 2003). It is still relatively frequent at field margins and in abandoned places in warm parts of Slovakia, but is rare in arable field vegetation. It appears that *Adonis aestivalis* was replaced by *Cyanus segetum* in this community. This species is still very common and abundant in some regions of Slovakia, and it is possibly resistant to herbicide application.

Recorded stands of the *Portulacetum oleraceae* are not in their typical form, but represent only an impoverished form of the community. *Portulaca oleracea* thrives on root crop fields on sandy soils (DEYL 1964). But intensively cultivated maize fields are now increasingly more under chemical treatment than mechanical disturbance, and as dicotyledonous herbicides are used, *Portulaca oleracea* is inhibited and weed grasses prosper. The nomenclature of this community is thus not clear and definitive mainly due to high representation of the species *Digitaria sanguinalis* and *Panicum miliaceum*.

Numerical analysis of our data follows partly syntaxonomical hierarchy and partly ecological preferences of the species. The highest level of dissimilarity separates the subclasses *Sisymbrienea* and *Violenea arvensis*, but the lower division levels do not reflect exactly the syntaxonomic system. The second level of division separates communities by their time of development (i.e., spring and spring-summer communities vs. summer and autumn communities). This is confirmed also by ordination analysis, where spring communities can be found on the left side of the chart, whereas summer and autumn on the right. Such a trend was recorded also by PINKE & PÁL (2008) in Hungary. Other important factors in the classification of segetal vegetation in Slovakia appeared to be the type of crops and altitude. Different studies suggest that the most important factors for classification of weed vegetation are: sowing season, crop type, soil pH, soil texture, climatic factors and altitude (LOSOSOVÁ et al. 2004, 2006, FRIED et al. 2008, PINKE & PÁL, 2008, ANDREASEN & SKOVGAARD 2009, CIMALOVÁ & LOSOSOVÁ 2009, PINKE et al. 2010, 2011, 2012).

The alliance *Caucalidion lappulae* is most divided and dispersed in different parts in the dendrogram. The alliance includes thermophilous weed species, with a focus occurrence in winter cereals; they occupy basic habitats and are at the edge of their distribution in central Europe (ŠILC et al. 2014). Classification of the associations into this alliance is variable in different countries. For example, the association *Veronicetum trilobae-triphyllidi* is classified in the alliance *Caucalidion* in the Czech Republic, whereas in Slovakia, Hungary, Austria and Slovenia in the alliance *Veronico-Euphorbion*. Similarly, the association *Stachyo annui-Setarietum pumilae* is included in the alliance *Caucalidion* in the Czech Republic and Hungary, but in the alliance *Panico-Setarion* in Slovakia and Austria (cf. MUCINA 1993, JAROLÍMEK et al. 1997, ŠILC & ČARNI 2007, LOSOSOVÁ et al. 2009, BORHIDI et al. 2012).

Classification of the weed (segetal) vegetation is sometimes ambiguous because the species composition is markedly influenced by agricultural management, mainly by huge utilization of herbicides and fertilizers. Therefore, classification is more hindered than in natural vegetation. Although weed vegetation is unfavourable in the crop production, these communities have an important role in the landscape – from the view of diversity and conservation, since they host several threatened plant species and offer refuge for the fauna.

Erweiterte deutsche Zusammenfassung

Einleitung – Die ersten Untersuchungen zur Segetalvegetation in der Slowakei sind erst nach dem 2. Weltkrieg durchgeführt worden. Seitdem haben sich verschiedene Autoren mit der Untersuchung dieser Vegetationstypen beschäftigt, dieses Interesse schwand jedoch seit den 1980er Jahren.

Die Ziele dieser Arbeit sind, folgende Aspekte zu untersuchen und zu analysieren: (i) die aktuelle Verbreitung der Segetal-Pflanzengesellschaften in der Slowakei, (ii) die floristische Zusammensetzung der Pflanzengesellschaften (Lebensformen, Herkunft der Sippen und Fragen nach dem Status als invasive Arten, Vorhandensein von gefährdeten Sippen) sowie (iii) ihre Beziehungen zu ausgewählten Umweltfaktoren.

Material und Methoden – Das Untersuchungsgebiet umfasst die gesamte Fläche der Slowakischen Republik (Zentraleuropa). Die Datengrundlage umfasst 508 pflanzensoziologische Aufnahmen, die zwischen den Jahren 2002 und 2008 mit den Methoden der Zürich-Montpellier Schule (BRAUN-BLANQUET 1964, WESTHOFF & VAN DER MAAREL 1978) durchgeführt wurden. Hierbei ist die 9-stufige Skala zur Artmächtigkeit von BARKMAN et al. (1964) verwendet worden. Die Probeflächen-Größe war meistens 10 × 10 m (großflächigen Felder) und 5 × 10 m in kleinen privaten Feldern. Die pflanzensoziologischen Aufnahmen wurden mit der Clusteranalyse ausgewertet unter Verwendung der Programme JUICE 7.0 und SYN-TAX 2000. Die “β-flexible method” (β = -0.25) und „Sorensen’s similarity index” wurden verwendet. Für Korrelationsanalysen und die Erstellung von „Box-Whisker Plots“ verwendeten wir das Programm Statistica. Folgende Daten wurden zwischen den Gesellschaften verglichen und statistisch geprüft (ANOVA und “subsequent Fisher LSD post-hoc test”, $p < 0.05$): mittlere Ellenberg-Indikatorwerte; Anteil der Lebensformen; Artenreichtum; Zahl gefährdeter Arten, einheimischer Arten, Archaeophyten, Neophyten, eingebürgerter, invasiver und nur gelegentlich auftretender Arten pro Aufnahme, ferner Höhenlage, mittlere Jahrestemperatur und Niederschläge im engeren

Gebiet, Aufnahmezeitpunkt (Monat), Bodeneigenschaften (Reaktion, Sand-, Lehm-, Tongehalt im Oberboden). Die Hauptgradienten der Umweltfaktoren wurden mit Hilfe der DCA (Detrended Correspondence Analysis) mit Hilfe des Programms CANOCO (TER BRAAK & ŠMILAUER 2002) dargestellt. Wir verwendeten die mittleren ungewichteten Ellenberg Indikatorwerte (ELLENBERG et al. 1992) und den Diversitätsindex von Shannon-Wiener als ergänzende Daten.

Ergebnisse und Diskussion – Wir identifizierten 13 Pflanzengesellschaften der Klasse *Stellarietea mediae*; 11 Gesellschaften wurden der Unterklasse *Violenea arvensis* zugeordnet: *Lathyro tuberosi-Adonidetum aestivalis*, *Consolido-Anthemidetum austriacae*, *Euphorbio exiguae-Melandrietum noctiflori*, *Veronicetum trilobae-triphyllidi*, *Lamio amplexicauli-Thlaspietum arvensis*, *Taraxacum* sect. *Ruderalia*-Gesellschaft, *Spergulo arvensis-Scleranthetum annui*, *Myosotido-Sonchetum arvensis*, *Echinochloo-Setarietum pumilae*, *Galinsogo-Setarietum*, *Stachyo annui-Setarietum pumilae* und 2 der Unterklasse *Sisymbrienea*: *Portulacetum oleraceae*, *Setario viridis-Erigeronetum canadensis.* Einige der Gesellschaften sind neu für die synanthrope Vegetation der Slowakei, wenn man das zusammenfassende Werk JAROLÍMEK et al. (1997) heranzieht; dieses sind die folgenden Typen: *Lamio amplexicauli-Thlaspietum arvensis*, *Galinsogo-Setarietum*, *Taraxacum* sect. *Ruderalia*-Gesellschaft.

Die Ergebnisse der Clusteranalyse wurden im Dendrogramm und in der synoptischen Tabelle dargestellt, desweiteren sind die Gesellschaften mit ihren diagnostischen, konstanten und dominanten Arten sowie ihre Struktur, Ökologie und Verbreitung gekennzeichnet worden. Das Ergebnis dieser Spezifizierung zeigte, dass die wichtigsten Faktoren, die die floristische Zusammensetzung und die Klassifikation der Segetalvegetation beeinflussen, die Zeit ihrer Entwicklung (sog. Agroökophase), die Art der Feldfrucht und die Meereshöhe sind.

Die Segetalvegetation dieser Untersuchung wird durch 407 verschiedene Pflanzensippen gekennzeichnet, darunter 26 Vertreter der Moose und 381 Gefäßpflanzen. Unter diesen Sippen sind Therophyten dominant (57 %), gefolgt von Hemikryptophyten (36%), Geophyten (4 %), Phanerophyten (Juvenilstadien) (2 %) und Chamaephyten (1%) (DOSTÁL & ČERVENKA 1991, 1992). Einheimische Arten überwiegen (56%) im Vergleich zu Nicht-Einheimischen (44%). Archäophyten sind stärker vertreten (34 %) als Neophyten (10 %). Die meisten der Nicht-einheimischen sind eingebürgert (82 %), gefolgt von invasiven Arten (9 %) und nur gelegentlich vorkommenden (9%) (MEDVECKÁ et al. 2012). Es konnten 32 gefährdete Gefäßpflanzen und 4 gefährdete Moosarten (FERÁKOVÁ et al. 2001, KUBINSKÁ et al. 2001) nachgewiesen werden.

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Supplements and Appendices

Supplement 1. Table 1. Abridged synoptic table of the segetal communities in Slovakia.

Beilage 1. Tabelle 1. Gekürzte Stetigkeitstabelle der Ackerunkraut-Gesellschaften in der Slowakei.

Additional supporting information may be found in the online version of this article.

Zusätzliche unterstützende Information ist in der Online-Version dieses Artikels zu finden.

Appendix S1. List of references about the research of segetal flora and vegetation in Slovakia.

Anhang S1. Literaturübersicht zur Erforschung der Segetalflora und –vegetation in der Slowakei.

Appendix S2–S14. Relevés of the studied communities.

Anhang S2–S14. Vegetationsaufnahmen der untersuchten Pflanzengesellschaften.

S2. *Lathyro tuberosi-Adonidetum aestivalis.*
S3. *Consolido-Anthemidetum austriaceae.*
S4. *Euphorbio exigue-Melandrietum noctiflori.*
S5. *Veronicetum trilobae-triphyllidi.*
S6. *Lamio amplexicauli-Thlaspietum arvensis.*
S7. *Taraxacum* sect. *Ruderalia* community.
S8. *Spergulo arvensis-Scleranthetum annui.*
S9. *Myosotido-Sonchetum arvensis.*
S10. *Echinochloo-Setarietum pumilae.*
S11. *Galinsogo-Setarietum.*
S12. *Stachyo annui-Setarietum pumilae.*
S13. *Portulacetum oleraceae.*
S14. *Setario viridis-Erigeronetum canadensis.*

Appendix S15: Localities of the relevés in Appendices S2–S14.

Anhang S15: Lokalitäten der pflanzensoziologischen Aufnahmen in den Anhängen S2–S14.

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