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| Phyton (Horn, Austria) | <b>Vol. 49</b> | Fasc. 2 | 221–234 | 29. 3. 2010 |
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## Is the Variability of *Salix cinerea*-carrs in Slovakia Influenced by Geographical or Ecological Factors?

By

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With 2 Figures

Received May 22, 2009

**Key words:** *Salix cinerea*, *Salicaceae*. – Detrended correspondence analysis, ecology, phytosociology, plant community distribution, Salicion cinereae, willow woodlands. – Vegetation of Slovakia, Europe.

### Summary

VALACHOVIČ M. & HRIVNÁK R. 2010. Is the variability of *Salix cinerea*-carrs in Slovakia influenced by geographical or ecological factors? – *Phyton* (Horn, Austria) 49 (2): 221–234, with 2 figures.

The paper refers to the relatively large ecological valence and geographical distribution of *Salix cinerea* (grey willow) carrs (Salicion cinereae) in Europe. The result of numerical classification and ordination do not allow to classify stands to one large association. On the other hand, the description of numerous local associations and temporary differences between them complicate the system of vegetation survey. The analyses based on 169 relevés resulted in the distinction of two associations: natural peat and wettest Salicetum pentandro-cinereae PASSARGE 1961, occurring predominantly in highlands, and semi-natural, slightly ruderalised and relatively dryer lowland willow stands of the Frangulo-Salicetum cinereae GRAEBNER & HUECK 1931. Differential taxa and description of ecological conditions are supplied with the distribution map of the associations.

### Zusammenfassung

VALACHOVIČ M. & HRIVNÁK R. 2010. Is the variability of *Salix cinerea*-carrs in Slovakia influenced by geographical or ecological factors? [Ist die Variabilität von *Salix cinerea*-Gebüsch in der Slowakei durch geographische oder ökologische Faktoren bedingt?] – *Phyton* (Horn, Austria) 49 (2): 221–234, mit 2 Abbildungen.

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Die vorliegende Arbeit behandelt die ökologische Amplitude und die geographische Verbreitung der *Salix cinerea*-Gesellschaften (Salicion cinereae) in Europa. Die Ergebnisse der numerischen Klassifikation bzw. der Ordination sprechen gegen die Vereinigung aller Bestände in einer Assoziation. Andererseits kompliziert die Unterscheidung zahlreicher lokal gültiger Assoziationen und Entwicklungsstadien den Überblick im System der Pflanzengesellschaften. Die Analyse von 169 pflanzensoziologischen Aufnahmen aus der Slowakei führte zur Unterscheidung von zwei Assoziationen: dem Salicetum pentandro-cinereae PASSARGE 1961 auf den nassesten Standorten über Torf, das vorwiegend in Hochlagen vorkommt und dem Frangulo-Salicetum cinereae GRAEBNER & HUECK 1931 auf leicht ruderalisierten und relativ trockenen Standorten der Niederung. Die Differentialarten und die Beschreibung der ökologischen Verhältnisse werden zusammen mit der geographischen Verteilung der Assoziationen präsentiert.

## 1. Introduction

The area of *Salix cinerea* agg. covers a large portion of the European continent, West Siberia and the eastern part of North America; it is also a highly invasive plant in Australia (CREMER 2003). Stands of grey willow are usually called "carrs". This term indicates stands of wet shrubs and alder woodlands (cf. KELLY & IREMONGER 1997). The development of willow carrs can start from various starting points e. g. marshes, mires, wet meadows, riverbanks or alluvial forest edges. From this point of view we might also expect a large spectrum in the structure and floristic diversity of plant communities with dominant grey willow. This fact is well known in Europe ranging from west to east. The question is how to deal with this variability from a syntaxonomical point of view, as the case may vary from one huge community to a plenty of strictly defined small vegetation units. Various different approaches are evident from the literature – let us have a look at some examples.

In Britain, RODWELL & al. 1991 distinguish only one community in a broad sense, the *Salix cinerea*-*Galium palustre* woodland. Later, in Cornwall, SOUTHALL & al. 2003 studied shrub of *Salix cinerea* subsp. *oleifolia* (SM.) MACREIGHT (syn. *S. atrocinerea* BROT.) along the succession gradient from poor fen and base-poor mires to woodlands and recognized eight understorey communities.

PASSARGE 1961 addressed this matter in northern Germany lowlands and claimed both aspects of stands variability - ecological and geographical. First, from a syntaxonomical point of view, the ecological variability was expressed at the lower level of subassociations and variants. Then, geographical variability was displayed at the higher level of associations. In contrary to the boreo-atlantic community Myrico-Salicetum cinereae (ALLORGE 1922) R. TX. & PASSARGE 1960, a typical Central-European association was proposed, in recent surveys named Salicetum pentandro-cinereae (PASSARGE 1961) OBERD. 1964. These stands were clas-

sified according to their ecological demands within a soft hierarchical structure of variants and subvariants. In addition to this highland community, SCHUBERT & al. 1995 also distinguished two further associations in Germany: the nitrophilous *Urtico-Salicetum cinereae* (ŠOMŠÁK 1963) PASSARGE 1968, and the *Salicetum cinereae* ZÓLYOMI 1931 – most typical however for lowland stands.

In Austria, GEISSELBRECHT-TAFERNER & WALLNÖFER 1993 accepted only the latter mentioned association, partly attended by the nitrophilous *Phragmiti-Salicetum cinereae* WEISSER 1970. The newly published comprehensive study of FRANZ & WILLNER 2007 went much farther including all stands with *Salix cinerea* to one broad association, the *Frangulo-Salicetum cinereae* GRAEBNER & HUECK 1931. The problem of the ecological variability within the association was solved by the description of three subassociations – *urticetosum*, *typicum*, and *caricetosum elatae*. The co-dominance of *Frangula alnus* is sometimes considered as an important differentiating element between the above-mentioned associations (cf. SIMON 1960). However, it occurs only sporadically or even misses (WEBER 1989).

To comprehend the variability of willow stands in Slovakia, ŠOMŠÁK 1963 described narrowly defined associations mostly according to the ecological demands, especially moisture (duration of water table). Drier types, widespread all over Slovakia, were distinguished as the *Rubo-Salicetum cinereae* association. Wet types that rarely occur on lowlands and highlands of mainly Eastern Slovakia were published under the unique names, e. g. *Hydrocharo-Salicetum cinereae*, *Sphagno-Salicetum cinereae* and *Thelypteridi-Salicetum cinereae* (cf. ŠOMŠÁK 1963, JURKO 1964).

The reason to address this problem in Slovakia lay upon the answering of two questions: 1) Does the variability of willow carrs reflect rather the local ecological factors or the general distribution in Central Europe? 2) Is it more suitable to use the concept of several small associations or a broad one to illustrate the variability in the syntaxonomical system?

## 2. Methods

A total of 72 phytosociological relevés were carried out in 2003–2007 according to the Zürich-Montpellier School (BRAUN-BLANQUET 1964) and entered to the Turboveg database (HENNEKENS & SCHAMINÉE 2001). Having included the published data obtained from the Slovak National Database (<<http://ibot.sav.sk/cdf/index.html>>; cf. HEGEDŮŠOVÁ 2007) we have completed the final dataset of 169 relevés. The average plot area was 74 m<sup>2</sup> (almost 75% of all plots varied between 40–100 m<sup>2</sup>). All relevés fulfilled two conditions i) the cover of the shrub layer was more than 75 %, and ii) the moss layer was identified.

We have merged some narrowly defined species or subspecies as follows: *Agrostis stolonifera* agg. (*A. gigantea*, *A. stolonifera*), *Carex flava* agg. (*C. flava*, *C. tumidicarpa*), *Dactylorhiza majalis* s. lat. (*D. majalis*, *D. maculata*), *Dryopteris car-*

*thusiana* agg. (*D. carthusiana*, *D. dilatata*), *Eleocharis palustris* agg. (*E. palustris*, *E. uniglumis*), *Molinia caerulea* agg. (*M. caerulea*, *M. arundinacea*), *Myosotis scorpioides* agg. (*M. scorpioides*, *M. nemorosa*), *Plagiomnium affine* s. lat. (*P. affine*, *P. elatum*, *P. ellipticum*, *P. undulatum*, *P. rostratum*), *Quercus petraea* agg. (*Q. da-lechampii*, *Q. petraea*), and *Valeriana officinalis* agg. (*V. sambucina*, *V. officinalis*). For the cluster analysis (beta-flexible linkage method with the coefficient  $\beta = -0.25$  with the relative Sørensen's distance as a measure of dissimilarity), the same species, which occurred in different layers, had been merged and all species' percentage covers were square-root transformed. The construction of the clusters was performed with the PC-ORD 4-5 version using JUICE program (TICHÝ 2002). The crispness of the classification procedure (BOTTA-DUKÁT & al. 2005), as available in the JUICE program, was used to determine optimal number of clusters. The same program was used for manual table work. The grouping of taxa into the phytocoenological system followed the concept of MUCINA 1997, further amended by JAROLÍMEK & al. 2008.

The CANOCO 4.5 for Windows package (TER BRAAK & ŠMILAUER 2002) was used for the detrended correspondence analysis (DCA). Species data were square-root transformed, rare species were down-weighted. For the ecological interpretation of major gradients, the unweighted average ELLENBERG's indicator values of vascular plants (ELLENBERG & al. 1992) and the altitude of each sample were plotted onto the DCA ordination diagram as supplementary variables. Distribution maps were prepared using the DMAP program (MORTON 2005). Nomenclature of bryophytes and vascular plants followed KUBINSKÁ & JANOVICOVÁ 1998 and MARHOLD 1998.

### 3. Results

The species *Salix cinerea* covers in Slovakia suitable banks along watercourses and water bodies (oxbow lakes, ponds, pools) and is spread in depressions of wet meadows from lowlands to highlands (KOBÍLÍŽEK 2006). All areas manifest lacking surface drainage and different peat content. Favourable water conditions provide stands with good regeneration potential; even missing regular coppicing does not inhibit these stands to spread.

Preliminary analyses (TWINSPAN) and subsequently final cluster analysis brought very similar results - three stable clusters, which represented floristically and ecologically mutually well-differentiated groups. The essential synoptic table (Tab. 1) shows the principal differential taxa ordered into sociological groups. Although all relevés with a cover of the shrub layer below 30% were eliminated, the full cover of *Salix cinerea* in all three groups was not surprising. For the first cluster, the members of wet meadows (Calthion and Molinion species) are typical and due to the higher altitude, and sometimes to a specific type of substrate (fen) the species of the Scheuchzerio-Caricetea fuscae are more frequent. The dominant species *Salix cinerea* in shrub or tree layers is followed by subdominant *Salix pentandra* and *Alnus incana*.

The most common willow carrs in Slovakia occur under dryer, slightly ruderalised and nitrophilous conditions. This is supported by species of

Table 1. The abridged synoptic table of grey willow carrs vegetation in Slovakia, based on the cluster analysis of 169 relevés/517 species, with percentage frequency values: 1 – *Salicetum pentandro-cinereae*, 2 – *Frangulo-Salicetum cinereae*, drier variant, 3 – *Frangulo-Salicetum cinereae*, wetter variant.

Abbreviations in alphabetic order: AG – *Alnetea glutinosae*, aln – *Alnion glutinosae*, cal – *Calthion palustris*, GU – *Galio-Urticetea*, LE – *Lemnetea*, MA – *Molinio-Arrhenatheretea*, MC – *Montio-Cardaminetea*, Mol – *Molinietalia*, PM – *Phragmito-Magnocaricetea*, RP – *Rhamno-Prunetea*, SC – *Scheuchzerio-Caricetea fuscae*.

| Number of cluster<br>Number of relevés                                                             |                                   | Layer                | 1<br>51    | 2<br>82    | 3<br>36    |
|----------------------------------------------------------------------------------------------------|-----------------------------------|----------------------|------------|------------|------------|
| Phaneorograms (classes <i>Alnetea glutinosae</i> , <i>Franguletea</i> and <i>Rhamno-Prunetea</i> ) |                                   |                      |            |            |            |
|                                                                                                    | <i>Salix cinerea</i>              | E <sub>3</sub>       | 10         | 5          | .          |
|                                                                                                    | <b><i>Salix cinerea</i></b>       | <b>E<sub>2</sub></b> | <b>100</b> | <b>100</b> | <b>100</b> |
|                                                                                                    | <i>Salix cinerea</i>              | E <sub>1</sub>       | 25         | 44         | 17         |
|                                                                                                    | <i>Salix pentandra</i>            | E <sub>2</sub>       | 25         | 4          | 8          |
|                                                                                                    | <i>Frangula alnus</i>             | E <sub>2</sub>       | 12         | 4          | 14         |
|                                                                                                    | <i>Alnus glutinosa</i>            | E <sub>2</sub>       | 2          | 1          | 19         |
|                                                                                                    | <i>Populus tremula</i>            | E <sub>2</sub>       | 4          | 1          | 3          |
|                                                                                                    | <i>Salix purpurea</i>             | E <sub>2</sub>       | 20         | 10         | .          |
|                                                                                                    | <i>Prunus padus</i>               | E <sub>2</sub>       | 12         | 2          | .          |
|                                                                                                    | <i>Viburnum opulus</i>            | E <sub>2</sub>       | 14         | 5          | .          |
|                                                                                                    | <i>Viburnum opulus</i>            | E <sub>1</sub>       | 14         | 12         | .          |
|                                                                                                    | <i>Prunus spinosa</i>             | E <sub>1</sub>       | 2          | 23         | .          |
|                                                                                                    | <i>Crataegus monogyna</i>         | E <sub>1</sub>       | 4          | 21         | .          |
|                                                                                                    | <i>Sambucus nigra</i>             | E <sub>1</sub>       | 2          | 20         | .          |
| Diagnostic taxa of individual clusters                                                             |                                   |                      |            |            |            |
| AG                                                                                                 | <i>Alnus incana</i>               | E <sub>2</sub>       | 20         | .          | .          |
|                                                                                                    | <i>Crepis paludosa</i>            | E <sub>1</sub>       | 55         | .          | .          |
| SC                                                                                                 | <i>Valeriana simplicifolia</i>    | E <sub>1</sub>       | 35         | .          | .          |
| Mol                                                                                                | <i>Galium uliginosum</i>          | E <sub>1</sub>       | 24         | .          | .          |
| cal                                                                                                | <i>Caltha palustris</i>           | E <sub>1</sub>       | 90         | 16         | .          |
| cal                                                                                                | <i>Filipendula ulmaria</i>        | E <sub>1</sub>       | 78         | 10         | .          |
|                                                                                                    | <i>Plagiomnium affine</i> s. lat. | E <sub>0</sub>       | 41         | 9          | .          |
| cal, MC                                                                                            | <i>Myosotis scorpioides</i> agg.  | E <sub>1</sub>       | 45         | 6          | .          |
| cal, MC                                                                                            | <i>Geum rivale</i>                | E <sub>1</sub>       | 38         | 1          | .          |
| aln, MC                                                                                            | <i>Cardamine amara</i>            | E <sub>1</sub>       | 27         | 1          | .          |
| aln, cal, MC                                                                                       | <i>Chaerophyllum hirsutum</i>     | E <sub>1</sub>       | 27         | 1          | .          |
| aln                                                                                                | <i>Equisetum sylvaticum</i>       | E <sub>1</sub>       | 22         | 2          | .          |
| AG                                                                                                 | <i>Rubus caesius</i>              | E <sub>1</sub>       | 4          | 44         | .          |
| MA                                                                                                 | <i>Carex hirta</i>                | E <sub>1</sub>       | 8          | 39         | .          |
| GU                                                                                                 | <i>Cucubalus baccifer</i>         | E <sub>1</sub>       | 2          | 27         | .          |
| GU                                                                                                 | <i>Geum urbanum</i>               | E <sub>1</sub>       | 2          | 24         | .          |
|                                                                                                    | <i>Cirsium arvense</i>            | E <sub>1</sub>       | 2          | 20         | .          |
| RP                                                                                                 | <i>Cornus sanguinea</i>           | E <sub>1</sub>       | .          | 22         | .          |
| GU                                                                                                 | <i>Glechoma hederacea</i> agg.    | E <sub>1</sub>       | .          | 22         | .          |

| Number of cluster                                                                        |                                   |                | 1  | 2  | 3  |
|------------------------------------------------------------------------------------------|-----------------------------------|----------------|----|----|----|
| AG, PM                                                                                   | <i>Thelypteris palustris</i>      | E <sub>1</sub> | 4  | 1  | 72 |
| AG, PM                                                                                   | <i>Calamagrostis canescens</i>    | E <sub>1</sub> | 2  | 1  | 53 |
| AG, PM                                                                                   | <i>Peucedanum palustre</i>        | E <sub>1</sub> | 2  | 1  | 44 |
| PM                                                                                       | <i>Typha angustifolia</i>         | E <sub>1</sub> | .  | 6  | 44 |
| PM                                                                                       | <i>Carex pseudocyperus</i>        | E <sub>1</sub> | .  | 2  | 61 |
|                                                                                          | <i>Persicaria amphibia</i>        | E <sub>1</sub> | .  | 6  | 33 |
|                                                                                          | <i>Eurhynchium schleicheri</i>    | E <sub>0</sub> | .  | 1  | 31 |
| PM                                                                                       | <i>Cicuta virosa</i>              | E <sub>1</sub> | .  | .  | 47 |
|                                                                                          | <i>Rumex hydrolapathum</i>        | E <sub>1</sub> | .  | .  | 39 |
|                                                                                          | <i>Hygrohypnum</i> sp.            | E <sub>0</sub> | .  | .  | 33 |
| LE                                                                                       | <i>Salvinia natans</i>            | E <sub>1</sub> | .  | .  | 33 |
| LE                                                                                       | <i>Hydrocharis morsus-ranae</i>   | E <sub>1</sub> | .  | .  | 28 |
| LE                                                                                       | <i>Stratiotes aloides</i>         | E <sub>1</sub> | .  | .  | 28 |
| SC                                                                                       | <i>Menyanthes trifoliata</i>      | E <sub>1</sub> | .  | .  | 25 |
| Diagnostic taxa of the alliances <i>Calthion palustris</i> and <i>Molinion caeruleae</i> |                                   |                |    |    |    |
|                                                                                          | <i>Angelica sylvestris</i>        | E <sub>1</sub> | 47 | 20 | .  |
|                                                                                          | <i>Poa trivialis</i>              | E <sub>1</sub> | 39 | 39 | .  |
|                                                                                          | <i>Scirpus sylvaticus</i>         | E <sub>1</sub> | 41 | 12 | .  |
|                                                                                          | <i>Mentha longifolia</i>          | E <sub>1</sub> | 16 | 5  | .  |
|                                                                                          | <i>Cirsium oleraceum</i>          | E <sub>1</sub> | 25 | 5  | .  |
|                                                                                          | <i>Cirsium rivulare</i>           | E <sub>1</sub> | 10 | 7  | .  |
|                                                                                          | <i>Equisetum palustre</i>         | E <sub>1</sub> | 51 | 26 | 3  |
|                                                                                          | <i>Cirsium palustre</i>           | E <sub>1</sub> | 29 | 4  | 11 |
|                                                                                          | <i>Agrostis stolonifera</i>       | E <sub>1</sub> | 12 | 28 | 8  |
|                                                                                          | <i>Cardamine pratensis</i> agg.   | E <sub>1</sub> | 14 | 6  | 14 |
| Diagnostic taxa of the class <i>Molinio-Arrhenatheretea</i>                              |                                   |                |    |    |    |
|                                                                                          | <i>Ranunculus repens</i>          | E <sub>1</sub> | 31 | 37 | 3  |
|                                                                                          | <i>Lysimachia nummularia</i>      | E <sub>1</sub> | 16 | 35 | 6  |
|                                                                                          | <i>Symphytum officinale</i>       | E <sub>1</sub> | 6  | 35 | 17 |
|                                                                                          | <i>Mentha aquatica</i>            | E <sub>1</sub> | 2  | 5  | 6  |
|                                                                                          | <i>Deschampsia cespitosa</i>      | E <sub>1</sub> | 41 | 26 | .  |
|                                                                                          | <i>Lychnis flos-cuculi</i>        | E <sub>1</sub> | 18 | 13 | .  |
|                                                                                          | <i>Brachythecium salebrosum</i>   | E <sub>0</sub> | 18 | 41 | .  |
|                                                                                          | <i>Valeriana officinalis</i> agg. | E <sub>1</sub> | 22 | 17 | .  |
|                                                                                          | <i>Primula elatior</i>            | E <sub>1</sub> | 20 | 4  | .  |
|                                                                                          | <i>Juncus effusus</i>             | E <sub>1</sub> | 20 | 9  | .  |
|                                                                                          | <i>Brachythecium rutabulum</i>    | E <sub>0</sub> | 16 | 9  | .  |
|                                                                                          | <i>Acetosa pratensis</i>          | E <sub>1</sub> | 16 | 9  | .  |
|                                                                                          | <i>Lathyrus pratensis</i>         | E <sub>1</sub> | 16 | 5  | .  |
|                                                                                          | <i>Ajuga reptans</i>              | E <sub>1</sub> | 14 | 4  | .  |
|                                                                                          | <i>Ranunculus acris</i>           | E <sub>1</sub> | 12 | 10 | .  |
|                                                                                          | <i>Heracleum sphondylium</i>      | E <sub>1</sub> | 12 | 5  | .  |
|                                                                                          | <i>Galium mollugo</i> agg.        | E <sub>1</sub> | 12 | 1  | .  |
|                                                                                          | <i>Dactylis glomerata</i> agg.    | E <sub>1</sub> | 10 | 9  | .  |
|                                                                                          | <i>Cirsium canum</i>              | E <sub>1</sub> | 2  | 10 | .  |
|                                                                                          | <i>Vicia cracca</i> agg.          | E <sub>1</sub> | 2  | 17 | .  |

| Number of cluster                                                 |                | 1  | 2  | 3  |
|-------------------------------------------------------------------|----------------|----|----|----|
| Diagnostic taxa of the class <i>Scheuchzerio-Caricetea fuscae</i> |                |    |    |    |
| <i>Aulacomnium palustre</i>                                       | E <sub>0</sub> | 8  | .  | 14 |
| <i>Calliergon cordifolium</i>                                     | E <sub>0</sub> | 6  | .  | 14 |
| <i>Sphagnum squarrosum</i>                                        | E <sub>0</sub> | 2  | .  | 19 |
| <i>Agrostis canina</i>                                            | E <sub>1</sub> | 4  | 1  | 6  |
| Diagnostic taxa of the class <i>Lemnetea</i>                      |                |    |    |    |
| <i>Lemna minor</i>                                                | E <sub>1</sub> | 2  | 6  | 36 |
| <i>Lemna trisulca</i>                                             | E <sub>1</sub> | .  | 2  | 22 |
| Diagnostic taxa of the class <i>Phragmito-Magnocaricetea</i>      |                |    |    |    |
| <i>Lythrum salicaria</i>                                          | E <sub>1</sub> | 14 | 40 | 67 |
| <i>Galium palustre</i>                                            | E <sub>1</sub> | 31 | 27 | 47 |
| <i>Equisetum fluviatile</i>                                       | E <sub>1</sub> | 27 | 4  | 33 |
| <i>Lycopus europaeus</i>                                          | E <sub>1</sub> | 22 | 34 | 81 |
| <i>Scutellaria galericulata</i>                                   | E <sub>1</sub> | 10 | 16 | 67 |
| <i>Phragmites australis</i>                                       | E <sub>1</sub> | 6  | 18 | 61 |
| <i>Iris pseudacorus</i>                                           | E <sub>1</sub> | 2  | 23 | 19 |
| <i>Carex acuta</i>                                                | E <sub>1</sub> | 6  | 17 | 22 |
| <i>Typha latifolia</i>                                            | E <sub>1</sub> | 6  | 9  | 44 |
| <i>Carex elata</i>                                                | E <sub>1</sub> | 2  | 2  | 36 |
| <i>Poa palustris</i>                                              | E <sub>1</sub> | 8  | 2  | 3  |
| <i>Carex acutiformis</i>                                          | E <sub>1</sub> | 2  | 28 | 6  |
| <i>Epilobium palustre</i>                                         | E <sub>1</sub> | 4  | .  | 14 |
| <i>Phalaris arundinacea</i>                                       | E <sub>1</sub> | .  | 22 | 3  |
| <i>Stachys palustris</i>                                          | E <sub>1</sub> | .  | 11 | 22 |
| <i>Glyceria maxima</i>                                            | E <sub>1</sub> | .  | 10 | 50 |
| <i>Carex riparia</i>                                              | E <sub>1</sub> | .  | 18 | 31 |
| <i>Oenanthe aquatica</i>                                          | E <sub>1</sub> | .  | 2  | 19 |
| <i>Sium latifolium</i>                                            | E <sub>1</sub> | .  | 2  | 19 |
| <i>Sparganium erectum</i>                                         | E <sub>1</sub> | .  | 2  | 17 |
| <i>Rorippa amphibia</i>                                           | E <sub>1</sub> | .  | 1  | 17 |
| <i>Alisma plantago-aquatica</i>                                   | E <sub>1</sub> | .  | 1  | 11 |
| Diagnostic taxa of the class <i>Alnetea glutinosae</i>            |                |    |    |    |
| <i>Lysimachia vulgaris</i>                                        | E <sub>1</sub> | 67 | 55 | 75 |
| <i>Solanum dulcamara</i>                                          | E <sub>1</sub> | 6  | 51 | 64 |
| <i>Carex elongata</i>                                             | E <sub>1</sub> | 8  | 1  | 33 |
| <i>Dryopteris carthusiana</i> agg.                                | E <sub>1</sub> | 4  | 1  | 6  |
| <i>Calystegia sepium</i>                                          | E <sub>1</sub> | .  | 30 | 22 |
| Diagnostic and constant taxa of the class <i>Galio-Urticetea</i>  |                |    |    |    |
| <i>Urtica dioica</i>                                              | E <sub>1</sub> | 39 | 52 | .  |
| <i>Galium aparine</i> agg.                                        | E <sub>1</sub> | 29 | 50 | .  |
| <i>Aegopodium podagraria</i>                                      | E <sub>1</sub> | 25 | 4  | .  |
| <i>Impatiens noli-tangere</i>                                     | E <sub>1</sub> | 14 | 1  | .  |
| <i>Anthriscus sylvestris</i>                                      | E <sub>1</sub> | 10 | 6  | .  |
| <i>Alliaria petiolata</i>                                         | E <sub>1</sub> | 2  | 7  | .  |
| <i>Geranium robertianum</i>                                       | E <sub>1</sub> | 6  | 2  | .  |
| <i>Chaerophyllum aromaticum</i>                                   | E <sub>1</sub> | 4  | 2  | .  |
| <i>Humulus lupulus</i>                                            | E <sub>1</sub> | 6  | 20 | .  |
| <i>Eupatorium cannabinum</i>                                      | E <sub>1</sub> | 10 | 9  | 3  |

| Number of cluster                                                                  |                | 1   | 2   | 3   |
|------------------------------------------------------------------------------------|----------------|-----|-----|-----|
| Constant taxa of the alliance <i>Alnion incanae</i>                                |                |     |     |     |
| <i>Athyrium filix-femina</i>                                                       | E <sub>1</sub> | 14  | 5   | .   |
| <i>Fraxinus excelsior</i>                                                          | E <sub>1</sub> | 10  | 4   | .   |
| Other species presented at least in two clusters with one frequency value >10%+A29 |                |     |     |     |
| <i>Equisetum arvense</i>                                                           | E <sub>1</sub> | 18  | 27  | .   |
| <i>Potentilla erecta</i>                                                           | E <sub>1</sub> | 14  | 4   | .   |
| <i>Petasites hybridus</i>                                                          | E <sub>1</sub> | 11  | 4   | .   |
| <i>Cruciata glabra</i>                                                             | E <sub>1</sub> | 11  | 3   | .   |
| <i>Ranunculus auricomus</i> s. lat.                                                | E <sub>1</sub> | 11  | 5   | .   |
| <i>Brachythecium velutinum</i>                                                     | E <sub>0</sub> | 2   | 10  | .   |
| <i>Calliergonella cuspidata</i>                                                    | E <sub>0</sub> | 29  | 9   | 14  |
| <i>Brachythecium rivulare</i>                                                      | E <sub>0</sub> | 6   | .   | 22  |
| <i>Marchantia polymorpha</i>                                                       | E <sub>0</sub> | 7   | .   | 14  |
| <i>Bidens cernua</i>                                                               | E <sub>1</sub> | .   | 3   | 19  |
| <i>Leucanthemella serotina</i>                                                     | E <sub>1</sub> | .   | 1   | 11  |
| Number of other hidden species                                                     |                | 233 | 107 | 33  |
| Total number of species                                                            |                | 340 | 323 | 100 |

**Cluster 1** (51 relevés): (18) these authors (unpubl.); (14) Kontriš J. 1981. Biol. Pr., Bratislava, 27/3: 1–164; (3) Špániková A. & Zaliberová M. 1982. Vegetácia ČSSR, B5, Bratislava, 302 pp.; (1) Urbanová V. & Zaliberová M. 1996. Vlast. Zb. Považia, Žilina, 18: 143–174; (1) Šoltés R. 2000. Ochr. Prír., 18: 41–49; (4) Šoltés R. & Novák A. 2001. Bull. Slov. Bot. Spoločn., 23: 51–56; (1) Háberová I. 2004. Príroda Nízkych Tatier, Banská Bystrica, 1: 89–95; (1) Hrivnák R., Šoltés R. & Rajtarová N. 2004. Ochr. Prír., 23: 163–181; (1) Kontriš J. & al. 2005. Acta Fac. Ecol., TU Zvolen, 13: 5–9; (2) Michalková D. 2006. Bull. Slov. Bot. Spoločn., Suppl. 2 (14): 59–90; (1) Fajmonová E. (unpubl.); (3) Watzka R. Diploma Thesis (unpubl.); (1) Staníková M. Diploma Thesis (unpubl.);

**Cluster 2** (82 relevés): (54) these authors (unpubl.); (10) Šomšák L. 1963. Acta Fac. Rer. Nat. Univ. Com. Botanica, 8: 229–302; (1) Fraňo A. 1971: Acta Fac. Rer. Nat. Univ. Com. Botanica, 19: 3–193; (6) Zaliberová M. 1994: Ekologia, Bratislava, Suppl. 1: 107–114; (1) Hrivnák R. 1999: Ochr. Prír., 17: 73–88; (4) Zlinská J. & Kubalová S. 2001: Acta Enviromen. Univ. Com. 11: 1–120; (3) Watzka R. Diploma Thesis (unpubl.); (1) Ripka J. Diploma Thesis (unpubl.); (2) Staníková M. Diploma Thesis (unpubl.);

**Cluster 3** (36 relevés): (25) Šomšák L. 1963. Acta Fac. Rer. Nat. Univ. Com. Botanica, 8: 229–302. (11) Berta J. 1970: Vegetácia ČSSR, B1, Bratislava, 371 pp.

the class Rhamno-Prunetea, as well as sciophilous and nitrophilous herbs such as *Carex hirta*, *Glechoma hederacea*, *Geum urbanum*, *Galium aparine*, and *Urtica dioica* (class Galio-Urticetea, see Tab. 1, cluster 2).

Conspicuous difference is visible in the third cluster, where the presence of phanerogams (shrubs and their saplings) is much lower, restricted to the taxa, which are able to grow in deeper water. From the syntaxonomical point of view, this cluster is an artefact, because the difference is based on the temporary occurrence of aquatic plants. The species from the

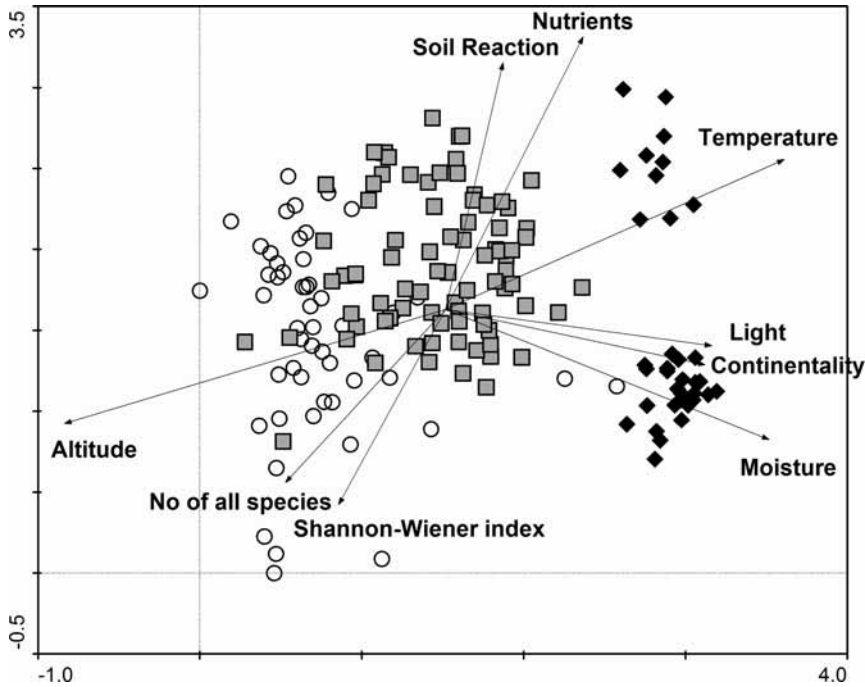


Fig. 1. Detrended correspondence analysis ordination diagram of relevés (total inertia 5.794, eigenvalues of the first two axes are 0.467 and 0.244). The average ELLENBERG's indicator values and altitude for relevés were plotted onto DCA ordination diagram as supplementary variables (cumulative percentage variance of species-environment relation for the first two axes are 29.4 % and 41.6 %). Weighted correlations between first two axes and environmental variables: Light – 0.5520 and –0.1389, Temperature – 0.6747 and 0.2633, Continentality – 0.5410 and –0.1806, Moisture – 0.6830 and –0.3620, Soil reaction – 0.0836 and 0.5419, Nutrients – 0.2442 and 0.5828 and Altitude – –0.7663 and –0.1732.

Circles: *Salicetum pentandro-cinereae* – shaded squares: *Frangulo-Salicetum cinereae*, drier variant – full rhomboids: *Frangulo-Salicetum cinereae*, wetter variant.

classes *Lemnetea* and *Potametea* cannot be considered important for the definition of new units.

Apart from numerous diagnostic taxa of individual groups (Tab. 1), there are many common species that connect the two or all three clusters. The expectation of simple differentiation on the association level is therefore exaggerated. Using ELLENBERG's indicator values, the result of the DCA (Fig. 1) shows that the first axes explain the moisture gradient, and the right part of the graph manifests grouped relevés from flooded stands (cluster 3). The opposite part contains clumped relevés where the less wet substratum facilitates the large amount of accidental species. Here the

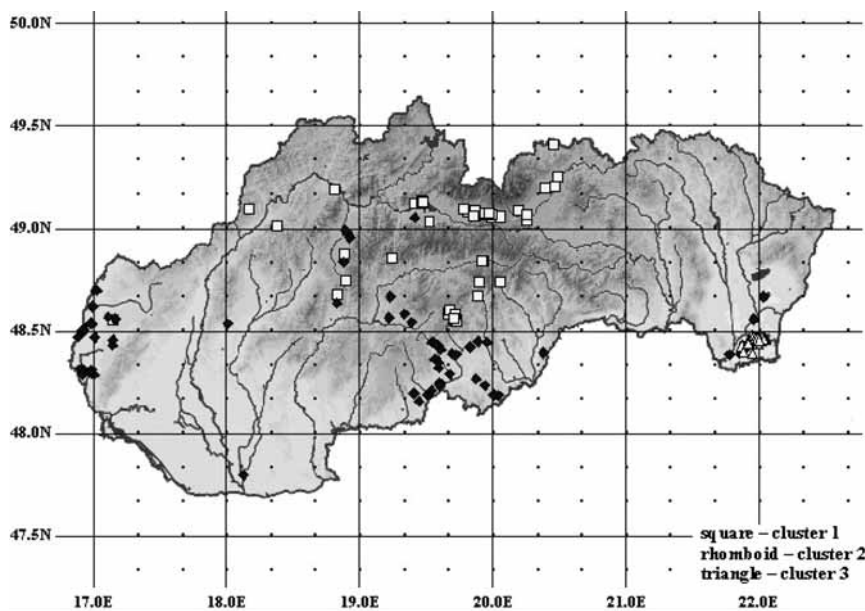


Fig. 2. Distribution map of grey willow carrs vegetation in Slovakia.

highest species numbers occur. The first DCA axis explains correlation with the altitude in the best possible way, where samples are arranged from higher to lower altitudes. The content of nutrients is significant for the explanation of variability along the second DCA axis. This factor provides some effect on the internal variability in all three vegetation types, e. g. in all groups of existing stands more or less influenced by nutrients. Their contents in most cases depend on the distance to a source (agricultural fields, manure meadows, strongly polluted water bodies etc). However, this fact cannot be automatically transferred into classification.

The groups' distribution is well demonstrated by the map (Fig. 2). The altitudinal gradient displays two basic types of stands. The first type of stands (cluster 1) differentiated by the presence of some mountain taxa, e. g. *Crepis paludosa*, *Valeriana simplicifolia*, *Chaerophyllum hirsutum*, *Geum rivale*, and *Alnus incana* is distributed at higher altitudes, especially in basins and the sub- to montane belts of the Western Carpathians. The second one (clusters 2 and 3) generally occurs in lowlands and south-central Slovakia basins from the Borská nížina in the western part of Slovakia to the Potiská nížina in the eastern part of Slovakia. While the first stand occurs close to riparian forests (the alliance *Alnion incanae*), the lowland type resembles to patterns of communities growing nearby alder swamp woods (the alliance *Alnion glutinosae*).

#### 4. Discussion

Heterogeneous species composition of both moss and herb layers on one side, homogeneous however in structure, determined by the absolute dominance of *Salix cinerea* on the other side, are typical features of old willow stands. Probably, this was the reason why LIBBERT 1933 decided to analyse only the shrub layer. LIBBERT l. c. gave up the idea of one large association, proposed by GRAEBNER & HUECK 1931. He was convinced, that all stands represent succession stages towards alder carrs.

This synusial approach based on the evaluation of the shrub layer also later used by FOUCAULT & JULVE 2001 is not accepted. Beside the herb layer, bryophytes also play a prominent role in ecology of willow carrs. Moss species generally are distributed in a huge area, having though a relatively strict relation to actual ecological conditions – mosses are good indicators of moisture patterns and shade intensity.

PASSARGE 1961 considered stands with *Salix cinerea* in Pannonia as a poor offshoot of one huge association, however, local communities were also previously described in Hungary by ZÓLYOMI 1931 and SOÓ 1954. The geographical aspect was actually suppressed by this approach. Much later, ŠILC 2002 in Slovenia used ZÓLYOMI's old name *Salicetum cinereae* and proposed within this frame three subassociations with respect to the ground water table: i) subass. *calthetosum* (far the most flooded), ii) subass. *typicum* (moderate), and iii) subass. *leucojetosum aestivi* (the most dry), representing succession stages to alder woodland. From the nomenclatorial point of view, ŠILC l. c. disregarded the fact, that the relevés by ZÓLYOMI 1931 were rather problematic (plot area of 1 m<sup>2</sup>) and the description of the association does not follow the ICPN code. According to WEBER 1998, this was the reason for the rejection of this name and we do agree with him. We also consider the ranking of the alliance and the order within the class *Franguletea* as correct, in contrary to the ranking of shrubs into the forest class *Alnetea glutinosae*.

According to our results, the first cluster in Table 1 belongs to the association *Salicetum pentandro-cinereae*. Diagnostic taxa are typical for wet meadows and spring vegetation, with more frequent occurrence of typical marsh species or nitrophilous plants as well as the species of sub- and montane belts. The other two clusters 2 and 3 belong to *Frangulo-Salicetum cinereae*. They represent the drier and wetter variant, respectively. Within this association, typical marsh species, some nitrophilous and meadows species are diagnostic for the drier variant, and some fen and aquatic species for the wetter variant (Tab. 1). Both variants are known from the southern lowlands and basins of West to East Slovakia.

The final syntaxonomical structure of the alliance in Slovakia is therefore stated as follows:

Class: Franguletea DOING 1962

Order: Salicetalia auritae DOING 1962

Alliance: Salicion cinereae Th. MÜLLER & GÖRS ex PASSARGE 1961

Association: Salicetum pentandro-cinereae PASSARGE 1961

Syn.: Salicetum cinereae ZÓLYOMI 1931 p.p.

Association: Frangulo-Salicetum cinereae GRAEBNER & HUECK 1931

Syn.: Salicetum cinereae ZÓLYOMI 1931 p.p., Calamagrostio-Salicetum cinereae SOÓ 1955; Rubo-Salicetum cinereae ŠOMŠÁK 1963; Sphagno-Salicetum cinereae ŠOMŠÁK 1963; Hydrocharo-Salicetum cinereae ŠOMŠÁK 1963; Thelypterido-Salicetum cinereae ŠOMŠÁK 1963; Phragmiti-Salicetum cinereae WEISSER 1970; Urtico-Salicetum cinereae auct.

Besides the numerous above-mentioned communities described by ŠOMŠÁK 1963, in Slovakia the name Salicetum cinereae ZÓLYOMI 1931 was also applied (cf. JAROLÍMEK & al. 2008). We include the majority of them into a broader unit – the Frangulo-Salicetum cinereae. Despite of the fact that WEBER 1998 incorporated the association Rubo-Salicetum cinereae ŠOMŠÁK 1963 into the Salicetum pentandro-cinereae, in our opinion it is better to consider these stands as a part of the Frangulo-Salicetum cinereae, namely of the subass. urticetosum dioicae.

FRANZ & WILLNER 2007 cope with the problem of transition from one type to another by the acceptance of only one association, in this case, the Frangulo-Salicetum cinereae. The types with peat species were all included into the Frangulo-Salicetum auritae. This model is not applicable in our case because of the absolute absence of *Salix aurita* in our data.

## 5. Acknowledgements

Authors are grateful to our colleagues Drahoš BLANÁR, Judita KOCHJAROVÁ, Helena OTAHEL'OVÁ, Rudolf ŠOLTĚS, Mária ZALIBEROVÁ, for the assistance during the fieldwork, to Anna KUBINSKÁ and Rudolf ŠOLTĚS for the determination of mosses. Natalia JEGOROV'OVA kindly reviewed our English. The research was supported by the VEGA Slovak Grant Agency grants no. 2/0672/08 and no. 2/4349/07.

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