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Classification of inland Bolboschoenus-dominated vegetation in Central Europe

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with 1 figure and 1 table

Abstract. Central European inland vegetation dominated by *Bolboschoenus* species was newly classified, based on current knowledge of taxonomic differentiation within the *Bolboschoenus maritimus*-complex. Altogether 225 phytosociological relevés from the Czech Republic, Slovakia, Poland, Germany and Austria were analysed. *Bolboschoenus*-dominated vegetation is found in a broad range of both freshwater and saline habitats. Individual *Bolboschoenus* species grow in different habitats with different species composition. The freshwater vegetation, dominated by *B. yagara, B. laticarpus* and *B. planiculmis*, reflects ecological differentiation of these species from base-poor to alkaline substrates, and from littoral habitats to temporarily flooded depressions. The following freshwater associations were distinguished: Phalarido arundinaceae-Bolboschoenetum laticarpi Passarge 1999 corr. Krumbiegel 2006, concentrated in large river floodplains, Bolboschoenetum yagarae Eggler 1933 corr. Hroudová et al. 2009, typical of the littoral zone of fishponds on base-poor bedrocks, and Tripleurospermo inodori-Bolboschoenetum planiculmis Hroudová et al. 2009, occurring mainly in temporarily flooded depressions on arable land. Saline vegetation is dominated by *Bolboschoenus maritimus* s. str. The alliance Cirsio brachycephali-Bolboschoenion compacti (Passarge 1978) Mucina in Balátová-Tuláčková et al. 1993, previously interpreted as vegetation of inland saline marshes, actually relates to freshwater *Bolboschoenus* vegetation. Therefore a new alliance, Meliloto dentati-Bolboschoenion maritimi Hroudová et al. 2009, is proposed here to include saline reed vegetation of continental areas.

Keywords: freshwater inland communities, phytosociology, saline vegetation, vegetation classification, wetlands.

Introduction

Recent studies of the morphological differentiation and taxonomy of *Bolboschoenus*-taxa on a worldwide scale (e.g., Egorova 1976, Browning et al. 1996, Smith & Kukkonen 1999, Browning & Gordon-Gray 2000, Egorova & Tatanov 2003, Tatanov 2003, Marhold et al. 2004) have distinguished five distinct *Bolboschoenus* species in Europe. Studies of their ecology (Hroudová et al. 1999) and distribution in Europe (Hroudová et al. 2007) revealed that some of them are confined to saline habitats (*B. maritimus* s. str.), some to freshwater habitats (*B. yagara, B. laticarpus*), and some may occur in both of these habitat types (*B. planiculmis*, *B. glaucus*). *B. glaucus* is distributed mainly in Southern Europe and does not occur in Central European plant communities. Understanding the niche differentiation patterns among the *Bolboschoenus* species enables clearer classification of *Bolboschoenus*-dominated vegetation, which has so far been burdened by the unresolved taxonomy of *Bolboschoenus*, although it has been obvious that the genus occupies and often even dominates a wide range of habitats, including coastal and inland salt marshes, littoral zones of freshwater bodies and temporarily flooded arable land.

Plant communities dominated by *Bolboschoenus* in Europe have been included in phytosociological alliances such as Scirpion maritimi Dahl & Hadač 1941, Cirsio brachycephali-Bolboschoenion Passarge ex Mucina in Balátová-Tuláčková et al. 1993, Scirpion maritimi-litoralis (Pignatti 1954) Borhidi 1970 (see Borhidi 1970) and several associations, and have been considered as subtypes of coastal or inland saline vegetation. This reflects the previous taxonomic classification of *Bolboschoenus* in Europe, which recognised only one broadly conceived species *B. maritimus* (L.) Palla, in some cases referred to as *Scirpus maritimus* L. (e.g., Norlindh 1972, Schultze-Motel 1980, Rothmaler 1982). Two subspecies differing in ecology were distinguished by some authors in Central Europe: *Bolboschoenus maritimus* subsp. *maritimus* and *B. maritimus* subsp. *compactus* (e.g. Dostál 1958, Foerster 1972, Casper & Krausch 1980). This taxonomic differentiation was supported by habitat differentiation of *Bolboschoenus* populations in this region, but it was rarely reflected in the classification of plant communities. In a few cases, however, freshwater *Bolboschoenus* communities were recognised besides the saline communities. Hejný & Husák (1978) mentioned the freshwater subassociation Glycerio fluitantis-Oenanthetum aquaticae (Eggler 1933)

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Hejný 1948 bolboschoenetosum maritimi Hejný in Hejný et Husák 1978 from South Bohemian ponds, and Zahlheimer (1979) described an association Bolboschoenetum maritimo-maritimi Zahlheimer 1979 prov. from the Danube floodplain in Bavaria. Recently, Oťaheľová (2001) included the association Bolboschoenetum maritimi Eggler 1933 among freshwater communities of the alliance Oenanthion aquaticae Hejný ex Neuhäusl 1959. This classification truly reflected the ecology of habitats described by Eggler (1933) from Wundschuh fishponds in Styria, where *Bolboschoenus* dominated a species-poor vegetation with freshwater plant species typical of fishponds.

The aim of the present paper was to analyse species composition and habitat affinities of *Bolboschoenus*-dominated vegetation in inland habitats of Central Europe, and to propose a phytosociological classification of this vegetation. We focused especially on freshwater communities, because their classification in Central Europe has not yet been satisfactorily solved.

Methods

We analysed a set of phytosociological relevés recorded by Z. Hroudová in the Czech Republic, Slovakia, Poland and Germany in 1974–2007, relevés published by Hrivnák (2002, 2003) from Slovakia and by Krumbiegel (2006) from Germany, a type relevé of Bolboschoenetum maritimi from Austria (Eggler (1933), a type relevé of Phalarido-Bolboschoenetum maritimi from Germany (Passarge 1999), and relevés from the Czech National Phytosociological Database (Chytrý & Rafajová 2003) made by S. Hejný, Š. Husák, J. Novák, J. Rydlo, K. Šumberová and J. Vicherek, in which *Bolboschoenus* species could be safely determined by comparison with revised herbarium specimens from the relevé localities (Ducháček et al. 2006, 2007). Only the relevés with *Bolboschoenus* cover >25 % were used for the analysis. Out of the total number of 255 relevés, 178 were from the Czech Republic, 42 from Germany, 18 from Slovakia, 16 from Poland and 1 from Austria. All the relevés were stored in a database using the TURBOVEG program (Hennekens & Schaminée 2001) and analysed in the JUICE program (Tichý 2002).

The nomenclature of plant species was unified according to Kubát et al. (2002) except for the genus *Bolboschoenus*, which followed Hroudová et al. (2007). We merged some narrowly defined species or subspecies as follows: *Agrostis stolonifera* agg. (*A. stolonifera* and *A. gigantea*), *Callitriche palustris* agg. (*C. palustris* and *C. cophocarpa*), *Eleocharis palustris* agg. (*E. palustris* and *E. uniglumis*), *Galium palustre* agg. (*G. palustre* and *G. elongatum*), *Galium mollugo* agg. (*G. mollugo* and *G. album*), *Juncus bufonius* agg. (*J. bufonius*, *J. ranarius* and *J. minutulus*), *Odontites vernus* agg. (*O. v.* subsp. *serotinus* and *O. v.* subsp. *vernus*), *Poa annua* agg. (*P. a.* subsp. *annua* and *P. a.* subsp. *mutabilis*), *Polygonum aviculare* agg. (*P. arenastrum*, *P. aviculare* and *P. rurivagum*) and *Xanthium albinum* agg. (*X. albinum* and *X. ripicola*). In the numerical classification, *Bolboschoenus* species (*B. laticarpus*, *B. maritimus*, *B. planiculmis* and *B. yagara*) were also merged into *B. maritimus* agg., in order to remove the effect of the taxonomic identity of *Bolboschoenus* on the structure of the resulting clusters. We did this in order to obtain a conservative test of whether different *Bolboschoenus* species occur in different plant communities. If different *Bolboschoenus* species were concentrated in clusters based on other species, our interpretation would be that there are different syntaxa dominated by different *Bolboschoenus* species. If, in contrast, occurrence of *Bolboschoenus* species did not follow the clusters based on other species, we would create a syntaxonomic classification on a different basis without considering dominance of individual *Bolboschoenus* species.

We classified the data using cluster analysis from the PC-ORD 4 program (McCune & Mefford 1999), with the relative Sørensen distance (= relative Manhattan distance; Faith et al. 1987) as a measure of dissimilarity and the beta-flexible linkage method with coefficient $\beta = -0.25$. Species percentage cover was square-root transformed. The crispness of classification procedure (Botta-Dukát et al. 2005), which is available in the JUICE program, was used to determine the optimal number of clusters. Diagnostic species for each cluster were determined using the phi coefficient of association with the size of all groups being standardised to an equal size (Tichý & Chytrý 2006). They were defined as species associated with the given cluster at $\Phi > 0.2$, provided that this association differed from random at $P < 0.01$ (Fisher´s exact test). Principal components analysis (PCA; centered by species) from the CANOCO 4.5 package (ter Braak & Šmilauer 2002) was used to explain major environmental gradients in species composition. PCA was selected because the first gradient length in detrended correspondence analysis was 1.964 SD units, indicating that a linear model of species response such as that included in PCA was appropriate for our data set. Species percentage cover was square-root transformed and rare species were downweighted. Unweighted Ellenberg indicator values (Ellenberg et al. 1992) and the Shannon-Wiener diversity index for relevés were plotted onto the PCA ordination diagram as supplementary variables (i.e. they did not influence computation of the ordination diagram). These values were correlated with the position of the relevés on the first two ordination axes (Pearson correlation coefficient was used) using the STATISTICA software (StatSoft 2001).

Results and discussion

Numerical classification of Bolboschoenus vegetation

Classification of all *Bolboschoenus*-dominated relevés resulted in five clusters, differing in the number of relevés, species richness and composition (Table 1). The fifth cluster represents the community of inland saline habitats, which corresponds with the association Astero pannonici-Bolboschoenetum compacti Hejný & Vicherek ex Oťaheľová & Valachovič 2001. We focus here on the freshwater communities (clusters 1 to 4) from fishponds, river banks, pools and oxbow lakes, wet arable land and other human-influenced habitats. The common feature of these four clusters is the occurrence of species typical of reed-beds and tall-sedge stands (class Phragmito-Magno-Caricetea, e.g., *Lythrum salicaria*, *Glyceria maxima*, *Carex acuta*, *Lycopus europaeus* and *Typha latifolia*), species of muddy habitats with a fluctuating water table (alliance Eleocharito palustris-Sagittarion sagittifoliae, e.g., *Oenanthe aquatica*, *Butomus umbellatus*, *Alisma plantago-aquatica* and *Eleocharis palustris* agg.) and annual species of ephemeral wetland habitats (*Bidens tripartita*, *B. frondosa*, *Persicaria hydropiper*, *P. lapathifolia* and *Rumex maritimus*). The clusters may contain more than one *Bolboschoenus* species, but the frequency of these species is clearly non-randomly distributed across the clusters. The clusters are characterised as follows:

Table 1. Synoptic table of inland vegetation dominated by *Bolboschoenus* species in Central Europe, based on cluster analysis of relevés, with percentage frequency (constancy) values: 1 and 2 – Phalarido arundinaceae-Bolboschoenetum laticarpi; 3 – Bolboschoenetum yagarae; 4 – Tripleurospermo inodori-Bolboschoenetum planiculmis; 5 – Astero pannonici-Bolboschoenetum compacti. Diagnostic species of clusters are in bold and ranked by decreasing fidelity, expressed through Φ values multiplied by 1000 (upper index; negative or non-significant values at $P = 0.01$ are not shown). Species are arranged by their affinity to higher syntaxa according to Chytrý & Tichý (2003). *Bolboschoenus* species are shaded. Habitats: B (rivers) also includes other permanent aquatic habitats in river floodplains such as oxbow lakes, dam reservoirs and brooks; C includes sand pits and sedimentation deposit basins; D includes temporarily flooded arable land, field depressions, meadows and drainage channels; prevailing habitat types are shaded.

Group no.	1	2	3	4	5
No. of relevés	104	80	40	22	9
No. of relevés from:					
A – fishponds	22	27	34	3	0
B – rivers	59	30	3	1	0
C – other permanent aquatic	14	2	0	0	0
D – temporary aquatic habitats	9	21	3	18	9
Diagnostic species of clusters					
Phalarido arundinaceae-Bolboschoenetum laticarpi					
Bolboschoenus laticarpus	**73** ^{294}	69 -	28 -	50 -	. -
Phalaris arundinacea	**30** ^{248}	5 -	12 -	18 -	. -
Xanthium albinum agg.	**12** ^{215}	4 -	2 -	. -	. -
Spirodela polyrhiza	6 -	**18** ^{305}	. -	. -	. -
Lemna minor	14 -	**26** ^{297}	5 -	. -	. -
Bidens connata	. -	**8** ^{247}	. -	. -	. -
Sagittaria sagittifolia	. -	**10** ^{240}	2 -	. -	. -
Typha angustifolia	. -	**9** ^{219}	2 -	. -	. -
Alisma plantago-aquatica	7 -	**31** ^{211}	28 -	14 -	. -
Bolboschoenetum yagarae					
Bolboschoenus yagara	8 -	14 -	**75** ^{660}	9 -	. -
Persicaria hydropiper	10 -	8 -	**65** ^{561}	18 -	. -
Alopecurus aequalis	. -	6 -	**50** ^{548}	9 -	. -
Carex bohemica	. -	2 -	**30** ^{477}	. -	. -
Bidens radiata	3 -	4 -	**25** ^{384}	. -	. -
Persicaria lapathifolia	12 -	22 -	**58** ^{378}	32 -	. -
Rorippa palustris	3 -	5 -	**38** ^{372}	18 -	. -
Gnaphalium uliginosum	. -	1 -	**18** ^{362}	. -	. -
Persicaria minor	. -	1 -	**18** ^{362}	. -	. -
Eleocharis ovata	. -	. -	**15** ^{352}	. -	. -
Juncus articulatus	. -	1 -	**25** ^{314}	14 -	. -
Juncus bufonius agg.	. -	1 -	**25** ^{314}	14 -	. -
Bidens cernua	1 -	2 -	**20** ^{313}	5 -	. -
Bidens tripartita	2 -	11 -	**35** ^{298}	23 -	. -
Callitriche palustris agg.	1 -	4 -	**12** ^{248}	. -	. -
Myosotis caespitosa	. -	. -	**8** ^{247}	. -	. -
Oenanthe aquatica	4 -	29 ^{162}	**32** ^{213}	18 -	. -
Tripleurospermo inodori-Bolboschoenetum planiculmis					
Tripleurospermum inodorum	1 -	10 -	8 -	**50** ^{528}	. -
Polygonum aviculare agg.	. -	6 -	. -	**36** ^{499}	. -
Stachys palustris	. -	2 -	. -	**32** ^{493}	. -
Plantago major	1 -	1 -	8 -	**36** ^{469}	. -
Cirsium arvense	. -	6 -	. -	**32** ^{456}	. -
Mentha arvensis	. -	4 -	2 -	**27** ^{411}	. -
Echinochloa crus-galli	12 -	10 -	18 -	**41** ^{336}	. -
Persicaria mitis	. -	. -	. -	**14** ^{335}	. -
Thlaspi arvense	1 -	. -	. -	**14** ^{318}	. -
Equisetum palustre	. -	1 -	. -	**14** ^{314}	. -
Alisma lanceolatum	. -	9 -	. -	**18** ^{283}	. -
Lactuca serriola	. -	1 -	2 -	**14** ^{277}	. -
Juncus inflexus	. -	. -	. -	**9** ^{272}	. -
Scutellaria galericulata	. -	. -	. -	**9** ^{272}	. -
Vicia tetrasperma	. -	. -	. -	**9** ^{272}	. -
Fallopia convolvulus	. -	. -	. -	**9** ^{272}	. -
Atriplex prostrata	. -	1 -	. -	**18** ^{252}	11 -
Rumex crispus	1 -	4 -	5 -	**32** ^{236}	33 -
Symphytum officinale	. -	6 -	. -	**18** ^{215}	11 -
Astero pannonici-Bolboschoenetum compacti					
Lotus tenuis	. -	. -	. -	5 -	**100** ^{972}
Juncus gerardii	. -	. -	. -	5 -	**100** ^{972}
Melilotus dentatus	. -	1 -	. -	9 -	**100** ^{940}
Agrostis stolonifera agg.	. -	9 -	12 -	32 ^{13}	**100** ^{753}
Potentilla anserina	. -	6 -	. -	32 ^{74}	**89** ^{729}
Aster tripolium subsp. *pannonicus*	. -	. -	. -	. -	**56** ^{707}
Bolboschoenus maritimus	1 -	5 -	. -	18 -	**56** ^{541}
Puccinellia distans	. -	. -	. -	. -	**33** ^{535}
Cirsium brachycephalum	. -	. -	. -	. -	**33** ^{535}
Pulegium vulgare	. -	. -	. -	. -	**22** ^{431}
Scorzonera parviflora	. -	. -	. -	. -	**22** ^{431}
Poa trivialis	. -	. -	2 -	9 -	**33** ^{426}
Elymus repens	. -	. -	2 -	23 ^{171}	**33** ^{336}
Trifolium hybridum	. -	1 -	12 -	14 -	**33** ^{324}
Plantago uliginosa	2 -	6 -	. -	41 ^{285}	**44** ^{330}
Ranunculus repens	2 -	9 -	. -	41 ^{237}	**56** ^{416}
Phragmito-Magno-Caricetea					
Bolboschoenus planiculmis	19 -	16 -	2 -	32 -	44 -
Lythrum salicaria	15 -	29 -	18 -	32 -	. -
Phragmites australis	10 -	16 -	5 -	14 -	44 -
Lycopus europaeus	7 -	15 -	12 -	18 -	. -
Glyceria maxima	4 -	12 -	12 -	23 -	. -
Eleocharis palustris agg.	5 -	11 -	2 -	9 -	11 -
Typha latifolia	6 -	10 -	8 -	14 -	. -
Butomus umbellatus	3 -	10 -	8 -	14 -	. -
Rorippa amphibia	9 -	15 -	8 -	. -	. -

Group no.	1	2	3	4	5
Galium palustre agg.	2 -	10 -	2 -	9 -	. -
Carex acuta	10 -	2 -	5 -	5 -	. -
Sparganium erectum	2 -	5 -	5 -	9 -	. -
Leersia oryzoides	2 -	2 -	12 -	5 -	. -
Glyceria fluitans	1 -	6 -	8 -	5 -	. -
Alisma gramineum	1 -	8 -	2 -	5 -	. -
Acorus calamus	1 -	2 -	2 -	9 -	. -
Schoenoplectus lacustris	. -	8 196	2 -	. -	. -
Berula erecta	1 -	1 -	. -	5 -	. -
Carex riparia	1 -	1 -	. -	5 -	. -
Sium latifolium	. -	5 -	2 -	. -	. -
Carex vulpina	. -	1 -	. -	5 -	. -
Sparganium emersum	1 -	1 -	. -	. -	. -
Iris pseudacorus	1 -	1 -	. -	. -	. -
Aquatic species (Lemnetea and Potametea)					
Potamogeton trichoides	1 -	4 -	. -	. -	. -
Potamogeton pectinatus	1 -	2 -	2 -	. -	. -
Potamogeton lucens	1 -	1 -	2 -	. -	. -
Batrachium aquatile	. -	1 -	2 -	. -	. -
Nuphar lutea	2 -	1 -	. -	. -	. -
Ceratophyllum demersum	1 -	1 -	. -	. -	. -
Myriophyllum spicatum	1 -	1 -	. -	. -	. -
Potamogeton natans	1 -	1 -	. -	. -	. -
Isoëto-Nanojuncetea					
Cyperus fuscus	1 -	. -	10 199	5 -	. -
Peplis portula	1 -	1 -	8 -	. -	. -
Elatine hydropiper	. -	2 -	5 -	. -	. -
Veronica anagalloides	. -	2 -	. -	5 -	. -
Potentilla supina	1 -	. -	. -	5 -	. -
Eleocharis acicularis	. -	4 -	2 -	. -	. -
Spergularia rubra	1 -	. -	2 -	. -	. -
Elatine triandra	. -	1 -	2 -	. -	. -
Bidentetea tripartitae					
Bidens frondosa	21 -	28 -	12 -	27 -	. -
Rumex maritimus	4 -	8 -	18 -	14 -	. -
Ranunculus sceleratus	. -	4 -	15 112	14 -	11 -
Other species					
Persicaria amphibia	11 -	32 184	10 -	27 -	11 -
Lysimachia vulgaris	6 -	6 -	5 -	18 -	. -
Veronica anagallis-aquatica	. -	2 -	5 -	14 -	11 -
Schoenoplectus tabernaemontani	. -	2 -	. -	5 -	22 -
Poa palustris	. -	4 -	8 -	14 -	. -
Calystegia sepium	3 -	6 -	. -	14 -	. -
Myosoton aquaticum	2 -	8 -	2 -	5 -	. -
Myosotis palustris	. -	9 160	2 -	5 -	. -
Juncus compressus	. -	. -	. -	5 -	11 -
Sonchus asper	. -	. -	. -	5 -	11 -
Lycopus exaltatus	. -	. -	. -	5 -	11 -
Carex otrubae	. -	. -	. -	5 -	11 -
Mentha aquatica	. -	6 -	5 -	. -	. -
Poa pratensis	. -	. -	2 -	9 -	. -
Potentilla reptans	. -	1 -	. -	9 -	. -
Lythrum virgatum	. -	1 -	. -	9 -	. -
Atriplex patula	. -	1 -	. -	5 -	. -
Centaurium pulchellum	. -	1 -	. -	9 -	. -
Chenopodium glaucum	1 -	2 -	. -	5 -	. -
Xanthium strumarium	1 -	. -	2 -	5 -	. -
Cirsium palustre	. -	1 -	2 -	5 -	. -
Carex hirta	1 -	2 -	. -	5 -	. -
Carex secalina	1 -	1 -	. -	5 -	. -
Veronica catenata	2 -	. -	. -	5 -	. -
Chenopodium polyspermum	. -	5 -	2 -	. -	. -
Sonchus arvensis	. -	2 -	. -	5 -	. -
Salix triandra	6 -	1 -	. -	. -	. -
Conyza canadensis	. -	. -	2 -	5 -	. -
Trifolium repens	. -	. -	2 -	5 -	. -
Solanum dulcamara	4 -	2 -	. -	. -	. -
Chenopodium rubrum	. -	4 -	2 -	. -	. -
Artemisia vulgaris	. -	1 -	. -	5 -	. -
Anagallis arvensis	. -	1 -	. -	5 -	. -
Epilobium hirsutum	. -	1 -	. -	5 -	. -
Epilobium ciliatum	. -	1 -	. -	5 -	. -
Symphytum bohemicum	. -	1 -	. -	5 -	. -
Capsella bursa-pastoris	. -	1 -	. -	5 -	. -
Taraxacum sect. *Ruderalia*	. -	1 -	. -	5 -	. -
Sonchus palustris	. -	1 -	. -	5 -	. -
Urtica dioica	3 -	. -	2 -	. -	. -
Zea mays	1 -	4 -	. -	. -	. -
Rorippa sylvestris	2 -	1 -	. -	. -	. -
Setaria viridis	1 -	2 -	. -	. -	. -
Chenopodium album	. -	1 -	2 -	. -	. -
Juncus effusus	. -	1 -	2 -	. -	. -
Amaranthus species	1 -	1 -	. -	. -	. -
Pulicaria vulgaris	1 -	1 -	. -	. -	. -

Appendix 1 – Species in one cluster only (in alphabetical order):
Acer negundo cluster 2: constancy 1 %, *Agrostis canina* 3: 2, *Althaea officinalis* 4: 5, *Apera spica-venti* 3: 2, *Aster novi-belgii 4: 5, Atriplex sagittata* 4: 5, *Batrachium circinatum* 2: 1, *Batrachium trichophyllum* 2: 4, *Beta vulgaris* 2:1, *Bidens* sp. 3: 2, *Calamagrostis epigejos* 3: 2, *Carex acutiformis* 4: 5, *Carex disticha* 4: 5, *Carex pairae* 4: 5, *Carex vesicaria* 3: 2, *Cicuta virosa* 1: 2, *Cichorium intybus* 2: 1, *Coleanthus subtilis* 3: 2, *Convolvulus arvensis* 2: 1, *Crypsis aculeata* 5: 11, *Deschampsia cespitosa* 4: 5, *Digitaria ischaemum* 2: 1, *Drepanocladus* sp. 1: 1, *Elatine alsinastrum* 4: 5, *Elatine* sp. 3: 2, *Epilobium palustre* 3: 2, *Epilobium roseum* 3: 2, *Equisetum arvense* 1: 1, *Equisetum fluviatile* 2: 1, *Filipendula ulmaria* 4: 5, *Galinsoga parviflora* 2: 1, *Galinsoga quadriradiata* 2: 1, *Galium aparine* 1: 1, *Galium mollugo* agg. 4: 5, *Geranium dissectum* 2: 1, *Geum urbanum* 3: 5, *Heleochloa alopecuroides* 3: 2, *Holcus lanatus* 3: 2, *Hottonia palustris* 2: 1, *Chara* sp. 2: 2, *Chenopodium ficifolium* 4: 5, *Inula britannica* 4: 5, *Isolepis setacea* 3: 2, *Juncus atratus* 4: 5, *Juncus bulbosus* 3: 2, *Lathyrus pratensis* 4: 5, *Lemna gibba* 2: 2, *Lemna turionifera* 1: 1, *Limosella aquatica* 3: 5, *Lolium perenne* 4: 5, *Lotus uliginosus* 2: 1, *Lythrum hyssopifolia* 2: 1, *Matricaria recutita* 4: 5, *Matricaria* sp. 3: 5, *Mentha* sp. 2: 1, *Najas marina* 1: 1, *Nymphaea alba* 2: 1, *Odontites vernus* agg. 4: 5, *Poa annua* agg. 4: 5, *Polygonum* sp. 3: 2, *Populus nigra* 1: 2, *Potamogeton crispus* 2: 1, *Potentilla norvegica* 3: 5, *Puccinellia limosa* 4: 5, *Ranunculus lateriflorus* 4: 5, *Raphanus raphanistrum* 4: 5, *Ricciocarpos natans* 2: 1, *Rubus caesius* 2: 1, *Rubus idaeus* 1: 1, *Rubus* sp. 3: 2, *Rumex stenophyllus* 5: 11, *Salix alba* 1: 2, *Salix viminalis* 1: 2, *Sinapis arvensis* 4: 5, *Solanum lycopersicum* 2: 2, *Spergularia maritima* 4: 5, *Sphagnum* sp. 3: 2, *Taraxacum bessarabicum* 4: 5, *Thalictrum lucidum* 4: 5, *Trifolium fragiferum* 5: 11, *Tussilago farfara* 2: 1, *Typha* sp. 2: 1, *Utricularia australis* 2: 1, *Veronica beccabunga* 2: 2, *Veronica peregrina* 3: 2, *Veronica persica* 2: 1, *Veronica scutellata* 3: 5, *Xanthium* sp. 2: 1, *Zannichellia palustris* 2: 1.

The first cluster mainly contains relevés dominated by *Bolboschoenus laticarpus* from littoral habitats along rivers and water bodies in river floodplains (e.g., oxbow lakes), and partly from fishponds and other secondary wetland habitats (e.g., arable field depressions with prolonged periods of flooding or flooded sand pits). The stands are species-poor and most diagnostic species of this cluster are typical of river-bank habitats.

The second cluster represents species-poor stands dominated mainly by *B. laticarpus*, and in some cases also by *B. planiculmis* or *B. yagara*. They occur in variable habitats with shallow water, such as fishponds and other types of man-made water reservoirs, riverine habitats and flooded depressions in arable fields. The presence of aquatic plants, reeds and species adapted to fluctuating water levels is typical of this cluster.

The third cluster represents fishpond communities with well developed *B. yagara* stands, sometimes mixed with *B. laticarpus* or dominated by *B. laticarpus*. Diagnostic species include annual species of ephemeral wetlands. Most of the relevés are from fishponds on acid, base-poor bedrocks, frequently on sand.

The fourth cluster contains the relevés dominated by *B. laticarpus* and *B. planiculmis*, and is distinguished from the preceding clusters by the occurrence of agricultural weeds, which reflect the main habitat – wet depressions on arable land. It also includes stands from mineral nutrient-rich habitats, in some cases created on sites of former saline vegetation.

Relationships between Bolboschoenus species and habitats

There is a strong ecological differentiation within the genus *Bolboschoenus* in Europe (Hroudová et al. 1999). Halophilous *Bolboschoenus maritimus* occupies one extreme of the ecological range; *B. planiculmis* frequently occurs on mineral-rich alkaline soils in warmer regions, but extends to mesotrophic habitats on neutral soils; *B. laticarpus* inhabits a wide range of freshwater habitats (meso- to eutrophic) and *B. yagara* is associated with the opposite ecological extreme – habitats on acid, base-poor soils. This differentiation may be, however, modified by the effects of other environmental factors, competition and human impact. Therefore niches of some species overlap and real habitat differentiation is not so clear. In some cases mixed stands may occur at a single site: *Bolboschoenus laticarpus* was found together with *B. yagara* or *B. planiculmis*, and *B. planiculmis* with *B. maritimus*, but *B. yagara* never occurred together with *B. maritimus*.

This differentiation is reflected in the frequency of *Bolboschoenus* species in individual clusters (Table 1). *Bolboschoenus maritimus* is concentrated in saline habitats (cluster 5), but it also occurs in some relevés of cluster 4 – mainly those from arable land on formerly saline sites. In clusters 1 and 2 it occurs rarely in man-made habitats. In Central Europe *B. planiculmis* occurs nearly exclusively in man-made habitats, such as arable land, drainage channels, small fishponds or other reservoirs, and flooded sand pits. It is mostly found as a weed in crop fields (cluster 4), but it also occurs in the vegetation of shallow littoral habitats (clusters 1 and 2); in contrast, it is nearly absent from fishponds (cluster 3). It is also able to persist in some types of saline habitats of cluster 5. *B. laticarpus* inhabits a wide range of habitats, and appears to be the most frequent freshwater *Bolboschoenus* species in Central Europe (Krumbiegel 2006, Hroudová et al. 2007). This species is typical of rivers and river floodplains (clusters 1 and 2), but it also occurs frequently in still water (fishponds, dam reservoirs, sand pits – cluster 2 and 3), and has recently spread to be a weed of arable land (cluster 4). *B. yagara* is well adapted to fishponds, and it only occasionally occurs in other habitats, such as river oxbow lakes. In Central Europe it predominates in fishpond littorals on acid, base-poor bedrocks (cluster 3). Relevés with *B. yagara* in clusters 1, 2 and 4 also originate from fishpond habitats.

The major gradient in species composition of Central European *Bolboschoenus* vegetation is correlated with the Ellenberg indicator value for soil reaction (Fig. 1). Along the first PCA axis, there is an apparent change from cluster 5 (with *Bolboschoenus maritimus* dominance) to cluster 3 (with *B. yagara* dominance) with decreasing Ellenberg reaction value. Along the second PCA axis communities are ordered from intermittently wet and alkaline to the wettest habitats in the freshwater littoral zone, i.e. from cluster 5 to clusters 1–2 (with *B. laticarpus* dominance). The position of *Bolboschoenus* species in the diagram indicates their affinity to plant communities in specialised habitats (halophyte communities in the case of *Bolboschoenus maritimus*, fishponds on mineral-poor grounds in *B. yagara* and littoral habitats in river floodplains in *B. laticarpus*) or the occurrence in a wider community range and a closer relationship to halophyte communities in *B. planiculmis*.

The ecological differentiation determines the distribution ranges of *Bolboschoenus* species in Europe, and the proportion of relevés originating from different areas roughly corresponds to the actual regional abundance of individual species. Most of the analysed relevés were from the Czech Republic, because the fishpond communities dominated by *B. yagara* and *B. laticarpus* are concentrated there; other relevés were recorded in the fishpond basins in Upper Lusatia (Germany) and SW Poland. *B. yagara* was not found in Slovakia, but other freshwater communities were recorded there. The western limit of *B. planiculmis* is the western border of Bohemia (see distribution maps in Hroudová et al. 2007), thus relevés with *B. planiculmis* are lacking from Germany.

Syntaxonomy and nomenclature of freshwater Bolboschoenus vegetation

Matching our classification to the established phytosociological system of Central European vegetation was difficult because most of the previously described vegetation units are based on relevés that did not distinguish individual *Bolboschoenus* species. Thus their differentiation into saline and freshwater communities was based only on other species and habitat characteristics. Most vegetation surveys recognised saline communities dominated by *Bolboschoenus maritimus* (Tüxen 1937, Soó 1957, Tüxen & Hülbusch 1971, Krisch 1974, Pott 1995, Borhidi 1996, Rennwald 2000, Berg et al. 2004, Matuszkiewicz 2007). Freshwater *Bolboschoenus* communities may have been included in the subassociation Bolboschoenetum maritimi typhoidetosum arundinaceae described from the Elbe river in Germany (Tüxen & Hülbusch 1971). Bolboschoenetum maritimi Tüxen 1937 was described as a species-poor halophile reed-bed community occurring along rivers and their mouths (Tüxen 1937); nevertheless, some *Bolboschoenus maritimus*-dominated communities in secondary habitats that were included in this syntaxon probably also represented freshwater communities (e.g., Oberdorfer 1992).

So far only two associations that include the freshwater *Bolboschoenus*-dominated vegetation have been described from Europe: Bolboschoenetum maritimi Eggler 1933 and Phalarido-Bolboschoenetum laticarpi Passarge 1999 corr. Krumbiegel 2006. The syntaxonomical and nomenclatural interpretation according to the International Code of

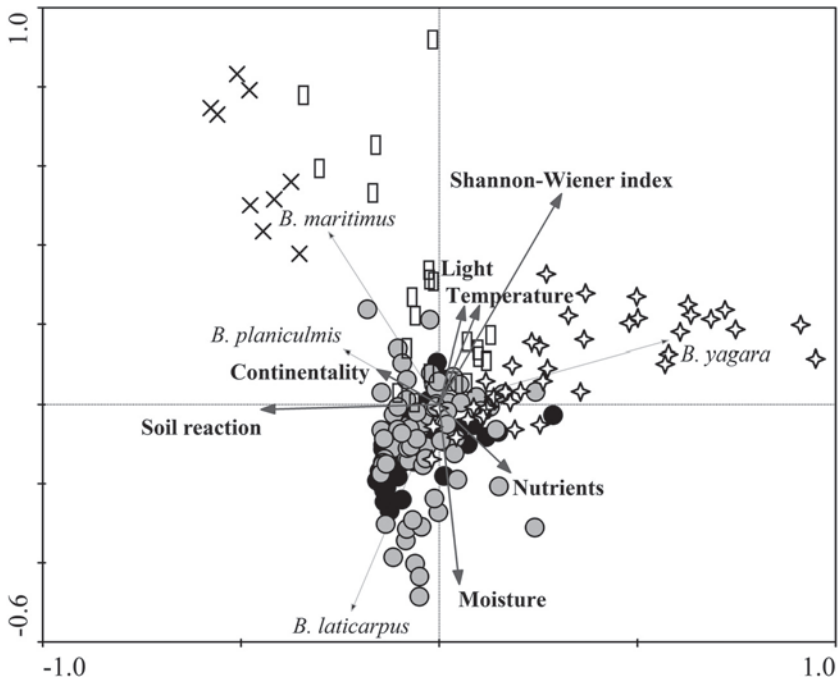

Fig. 1 – Principal components analysis (PCA) ordination diagram of relevés (eigenvalues of the first two axes are 0.078 and 0.073). Average Ellenberg indicator values and the Shannon-Wiener diversity index for relevés were plotted onto the PCA ordination diagram as supplementary variables (the cumulative percentage variance of the species–environment relation for the first two axes is 23.8 % and 47.1 %). *Bolboschoenus* species were plotted onto the PCA diagram as supplementary species. Pearson correlation coefficients with the first two PCA axes (* $P < 0.01$; ns: $P > 0.01$): Shannon-Wiener index (0.309* and 0.529*), Light (0.063^{ns} and 0.246*), Temperature (0.101^{ns} and 0.247*), Continentality (–0.158^{ns} and 0.088^{ns}), Moisture (0.051^{ns} and –0.454*), Soil reaction (–0.449* and –0.013^{ns}), Nutrients (0.181* and –0.172*). Circles – Phalarido arundinaceae-Bolboschoenetum laticarpi (full – cluster 1, shaded – cluster 2); stars – Bolboschoenetum yagarae; boxes – Tripleurospermo inodori-Bolboschoenetum planiculmis; crosses – Astero pannonici-Bolboschoenetum compacti.

Phytosociological Nomenclature (ICPN; Weber et al. 2000) of the clusters from Table 1 is as follows:

Bolboschoenus laticarpus vegetation of river corridors (cluster 1)

Cluster 1 corresponds to the association Phalarido-Bolboschoenetum laticarpi Passarge 1999 corr. Krumbiegel 2006, which is a community of river banks, oxbow lakes and other water bodies connected with river systems. Krumbiegel (2006) published relevés from the middle Elbe river in Germany, but this community probably occurs over a wider Central European area, especially in floodplains of large rivers. Zahlheimer (1979) described this vegetation from the Danube floodplain in Bavaria under the provisional association name Bolboschoenetum maritimo-maritimi. The inclusion of cluster 1 into the association Phalarido-Bolboschoenetum laticarpi is clearly supported by the fact that the nomenclature type relevé by Passarge (1999), as well as most of the relevés by Krumbiegel (2006), were placed in this cluster. This association belongs to the Phragmition australis Koch 1926 alliance, as most of its stands contain species of reed beds.

Passarge (1999) described this association as "Phalarido-Bolboschoenetum maritimi Vahle in Prsg. et al. 1990". However, Vahle (in Preising et al. 1990) indicated the name "Phalarido-Bolboschoenetum maritimi Zonneveld 1960", which was not published by Zonneveld (1960). Instead, Zonneveld (1960) published relevés of different vegetation with *Scirpus triqueter* and *Bolboschoenus* (probably *B. maritimus* s. str.) under the names "Gemeenschap van *Scirpus maritimus* and *Phalaris arundinacea*" or "Scirpetum triquetri et maritimi phalaridetosum". Thus, Phalarido-Bolboschoenetum maritimi attributed to Zonneveld (1960) is a phantom name (sensu Mucina 1993), and the same name attributed to Vahle in Preising et al. (1990) is invalid, because there is no nomenclature type relevé given in that publication. The valid description of this name was only published by Passarge (1999) who published it with a holotype. However, Krumbiegel (2006) pointed out that the stands described by Passarge (1999) did not contain *Bolboschoenus maritimus* or *B. maritimus* subsp. *compactus*, but *B. laticarpus.* Therefore Krumbiegel corrected this association name to Phalarido-Bolboschoenetum laticarpi Passarge 1999 corr. Krumbiegel 2006, according to ICPN Art. 43. The

question is whether use of names *Bolboschoenus maritimus* and *B. maritimus* subsp. *compactus* by Passarge (1999) can be considered a taxonomic error according to Art. 43, because *B. laticarpus* was only described five years later (Marhold et al. 2004). We suggest that it may be an error, because Example 3 for Art. 43 (Weber et al. 2000) features exactly the same situation (J.-P. Theurillat, personal comm.): in this example the association name Cytiso purgantis-Genistetum cinerascentis Rivas-Martínez 1970 was corrected to Cytiso oromediterranei-Genistetum cinerascentis Rivas-Martínez 1970 corr. Rivas-Martínez et Canto 1987 although *Cytisus oromediterraneus* was only described in 1984 (Rivas-Martínez et al. 1984). Therefore we accept this association name in its corrected form and have added an epithet for *Phalaris arundinacea* according to ICPN Recomm. 10C, to give Phalarido arundinaceae-Bolboschoenetum maritimi Passarge 1999 corr. Krumbiegel 2006.

Bolboschoenus laticarpus vegetation of littoral habitats (cluster 2)

Cluster 2 mostly comprises relevés from various types of littoral habitats which are species-poor and lack a distinctive species composition. Except for *Bidens connata*, which is an alien plant spreading along rivers, other diagnostic species of this cluster are shared with clusters 1 and 3. This cluster corresponds to transitional habitats between the littorals of oxbow lakes and pools connected with streams and those of standing water, such as fishponds and other artificial reservoirs. We included the relevés of cluster 2 in the same association as relevés of cluster 1, i.e. Phalarido arundinaceae-Bolboschoenetum laticarpi, for the following two reasons: (1) the habitats are heterogeneous as in cluster 1 (including fishponds, small reservoirs or sand pits close to streams); (2) the presence of *Bidens connata* and the high frequency of *Bolboschoenus laticarpus* indicate the connection to river systems (*B. laticarpus* is a typical species of river floodplains, see Krumbiegel 2006, Hroudová et al. 2007).

Bolboschoenus yagara vegetation of fishponds on base-poor bedrock (cluster 3)

Cluster 3 represents vegetation of meso- to eutrophic habitats dominated by *Bolboschoenus yagara*, occurring mostly in fishponds and other reservoirs with a fluctuating water level, but never in saline habitats. It is characterised by a group of ephemeral wetland species, typical of the temporal stage of water-level decrease, and is clearly distinct from the other clusters. This vegetation was first described by Eggler (1933) from Wundschuh fishponds near Graz in Styria as association Bolboschoenetum maritimi Eggler 1933, and its nomenclatural type relevé (Eggler 1933: 154) was assigned to cluster 3 in our analysis. However, van Langendonck (1931) validly described a different association, Scirpetum maritimi, from Dutch coastal saline habitats. As *Scirpus maritimus* L. is the basionym of *Bolboschoenus maritimus* (L.) Palla, the association name Bolboschoenetum maritimi Eggler 1933 should be considered as a younger homonym of Scirpetum maritimi van Langendonck 1931, and thus rejected as an illegitimate name (ICPN, Art. 31). When revising specimens of *Bolboschoenus* collected by Eggler in Wundschuh fishponds in the herbarium of Karl-Franzens-Universität in Graz (GZU), Z. Hroudová found specimens related to Eggler's relevés no. 488 and 490, both from 12 July 1927, which was the date the type relevé was recorded. Relevé numbers were not given in Eggler's (1933) paper, nevertheless, all the herbarium specimens in GZU from Wundschuh fishponds belonged to *B. yagara* (Hroudová et al. 2006). *B. yagara* was thus undoubtedly a dominant species of the vegetation described in the original diagnosis of the association Bolboschoenetum maritimi Eggler 1933. Therefore we correct the name Bolboschoenetum maritimi Eggler 1933 to Bolboschoenetum yagarae Eggler 1933 corr. Hroudová, Hrivnák & Chytrý 2009 nom. corr. hoc loco. The nomenclatural type is the relevé given under the header Bolboschoenetum maritimi at the bottom of page 154 in Eggler (1933) – holotypus. This correction is possible although the taxon corresponding to *B. yagara* was first described only in 1944 as *Scirpus yagara* (Ohwi 1944), which is consistent with the above-mentioned interpretation of Example 3 for Art. 43 of the ICPN, and because no other association name for this vegetation was described before 1944. The association Bolboschoenetum yagarae Eggler 1933 corr. Hroudová, Hrivnák & Chytrý 2009 belongs to the alliance Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964.

Bolboschoenus laticarpus-B. planiculmis vegetation on wet arable land (cluster 4)

Cluster 4 differs substantially from the preceding ones: diagnostic species include weeds, species of wet disturbed habitats and wetland species, some of them occurring in base-rich to saline habitats. This vegetation is mostly dominated by *Bolboschoenus laticarpus* and *B. planiculmis*, rarely *B. maritimus* and occasionally *B. yagara* (the latter was found only on emerged bottoms of small abandoned fishponds). This floristic composition corresponds to man-made habitats (mainly arable land) which are only temporarily flooded. *B. laticarpus* and *B. planiculmis* have recently spread as weeds in wet crop fields due to changes in management (minimalisation technique instead of deep ploughing, which results in an increased ground water table – Mikulka & Zákravský 2007). These

weedy *Bolboschoenus* stands are found particularly in the Czech Republic, but have also been mentioned from Slovakia (Hejný 1960), Hungary (Ubrizsy 1961), Austria (Ries 1992) and Germany (Hilbig 1994, Kläge 1999). They have been classified in different ways, depending on the water regime of the fields and cover of dominant species: In Hungarian rice fields Ubrizsy (1961) assigned them to wetland vegetation – Scirpo-Phragmitetum Koch 1926 consociation bolboschoenetosum maritimi, Bolboschoenetum maritimi continentale Soó 1927 consociation Bolboschoenus maritimus-Schoenoplectus tabernaemontani Soó 1933, and Echinochloo-Oryzetum sativae Soó & Ubrizsy 1948 bolboschoenetosum maritimi Ubrizsy 1948. Hilbig (1994) included *Bolboschoenus* vegetation from crop fields in Bavaria in the association Rorippo-Chenopodietum polyspermi Köhler 1962, and the stands from drier habitats in a species-poor variant of the association Thlaspio-Fumarietum (Polygono-Chenopodion). In Lower Lusatia, Kläge (1999) recorded weed vegetation that differed from that in Bavaria (Hilbig 1994) by higher cover of *Bolboschoenus*, but did not classify it as a formal syntaxon.

The occurrence of *B. laticarpus* on arable land reflects the high adaptability and dispersal capacity of this species. Although it dominates mainly littoral communities in river floodplains and fishponds, it is also able to form dense stands in irrigated fields with cultivated vegetables, as well as in wet fields with maize, potatoes, beans or cereals. In contrast, *B. planiculmis* is confined to wet arable land. For *B. planiculmis* the habitat of intermittently flooded crop fields is probably similar to natural habitats in the eastern part of its distribution range, which include temporarily flooded depressions in the steppe zone (described by Litvinov in Kots 1882 for *B. koshewnikowii*, which is a synonym of *B. planiculmis*). So far the only association with dominant *B. planiculmis* was described by Kiprianova (2005) from shores of a shallow saline lake in the forest-steppe zone of Western Siberia. This community comprises a group of wetland plants shared with littoral zones of shallow freshwater reservoirs in Central Europe, and probably represents the natural vegetation containing *B. planiculmis,* which may have occurred in Central Europe before inland saline habitats were converted into arable land. Nevertheless, the present *Bolboschoenus*-dominated weedy vegetation in secondary habitats in Central Europe differs from the Bolboschoenetum planiculmis Kiprianova 2005 by its floristic composition (presence of weeds), habitat (arable land), ecology (not in saline habitats), and by its distribution range in Europe.

Therefore we suggest including it in a new association Tripleurospermo inodori-Bolboschoenetum planiculmis Hroudová, Hrivnák & Chytrý 2009 ass. nov. hoc loco. The nomenclatural type (holotypus hoc loco designatus) is relevé no. 366001 from the Czech National Phytosociological Database: Wet depression in the field 1 km SSW of the village of Šakvice, SE Czech Republic, altitude 170 m, flat land, herb layer cover = 60 %, recorded by Z. Hroudová on 6 June 2006, *Bolboschoenus planiculmis* 3, *Matricaria chamomilla* 2, *Capsella bursa-pastoris* 1, *Plantago major* subsp. *intermedia* 1, *Polygonum aviculare* agg. 1, *Echinochloa crus-galli* +, *Juncus bufonius* agg. +, *Persicaria lapathifolia* +, *Plantago major* +, *Thlaspi arvense* +, *Tripleurospermum inodorum* +, *Chenopodium ficifolium* r, *Cirsium arvense* r, *Conyza canadensis* r, *Epilobium* sp. r, *Lactuca serriola* r.

This association is confined to temporarily flooded depressions, arable land and wet disturbed habitats in the lowlands. It occurs frequently on base-rich bedrocks in the Czech Republic and Slovakia, and also rarely in Poland, Germany, Austria and Hungary; it probably also occurs in other countries, such as the Ukraine. As its development depends on the fluctuating water level (relevés in cluster 4 represent the terrestrial stage), we have included this association in the alliance Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964. It is characterised by a prolonged period of terrestrial conditions and by a group of arable weeds established after the water level decreases, in contrast to the association Bolboschoenetum yagarae, which is characterised by a prolonged period of littoral conditions and by a group of ephemeral wetland species established on the emerged bottom.

Bolboschoenus maritimus vegetation of saline habitats (cluster 5)

Bolboschoenus vegetation in saline habitats is not considered in the current paper, because it is rather different in its species composition from freshwater *Bolboschoenus* vegetation, and includes different types from coastal habitats of NW Europe (e.g. van Langendonck 1931, Zonneveld 1960) and inland saline habitats of the Pannonian Basin (e.g. Soó 1957, Borhidi 1970, Vicherek 1973). In the ordination diagram (Fig. 1), saline vegetation clearly formed a separate cluster. It is usually dominated by *B. maritimus* and contains several halophytic species. Most of the relevés included in cluster 5 are from Vicherek (1973) and belong to the association Astero pannonici-Bolboschoenetum compacti Hejný & Vicherek ex Oťaheľová & Valachovič in Valachovič 2001.

Saline *Bolboschoenus* associations on the coast are assigned to the alliance Scirpion maritimi Dahl et Hadač 1941. In contrast, inland saline vegetation of continental areas, notably of the Pannonian Basin, differs in its species composition, and it has been traditionally placed in another alliance. This alliance has been given several names, which are all invalid or illegitimate: "Bolboschoenion (hal.)" of Soó (1945) is a nomen nudum, i.e. an invalid name according to ICPN Art. 2b; "Bolboschoenion maritimi" of Soó (1947) is a younger homonym of Scirpion

maritimi Dahl & Hadač 1941, i.e. an illegitimate name according to ICPN Art. 31; Bolboschoenion maritimi continentale (Soó 1945) Borhidi 1970 is an illegitimate name according to ICPN Art. 34a, because it contains an epithet indicating a geographical or ecological property. Passarge (1978) described the suballiance Cirsio-Bolboschoenenion (Soó 1947) Passarge 1978, which is also a nomen nudum, i.e. an invalid name according to ICPN Art. 2b. Mucina (in Balátová-Tuláčková et al. 1993) used this suballiance name and established the alliance "Cirsio brachycephali-Bolboschoenion (Passarge 1978) Mucina", which included halophilous *Bolboschoenus* associations described earlier from Hungary and replaced earlier alliance names described invalidly or illegitimately by Soó or Borhidi. Due to the invalid description of the suballiance by Passarge (1978), the correct author citation of this alliance should be "Passarge ex Mucina in Balátová-Tuláčková et al. 1993" or, alternatively "Passarge ex Mucina in Grabherr et Mucina 1993". Description of this alliance was valid, because Mucina (l. c.) indicated the nomenclatural type. Unfortunately, he selected the association name of Bolboschoenetum maritimi Eggler 1933 (freshwater association) as the type of this alliance name. Therefore the Cirsio brachycephali-Bolboschoenion Passarge ex Mucina in Balátová-Tuláčková et al. 1993 must be used for freshwater *Bolboschoenus* vegetation, and this alliance name becomes a younger syntaxonomic synonym of the alliance Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964. As a consequence, no legitimate alliance name is available for the inland saline *Bolboschoenus* vegetation of continental areas, and we therefore propose a new alliance name Meliloto dentati-Bolboschoenion maritimi Hroudová, Hrivnák & Chytrý 2009 all. nov. hoc loco, which includes saline reed vegetation of continental areas with diagnostic species *Aster tripolium* subsp. *pannonicus, Bolboschoenus maritimus, Cirsium brachycephalum, Eleocharis uniglumis, Juncus gerardii, Lotus tenuis, Melilotus dentatus, Mentha pulegium, Puccinellia distans, P. limosa, P. peisonis, Schoenoplectus tabernaemontani* and *Scorzonera parviflora*. The nomenclatural type of this alliance is the association Astero pannonici-Bolboschoenetum compacti Hejný & Vicherek ex Oťaheľová & Valachovič in Valachovič 2001 (Valachovič 2001: 162–164, holotypus hoc loco designatus).

Synopsis

Based on this study, we suggest the following classification of the inland Central European *Bolboschoenus*-dominated vegetation:

Phragmition australis Koch 1926 nom. mut. propos.
  Phalarido arundinaceae-Bolboschoenetum laticarpi Passarge 1999 corr. Krumbiegel 2006
Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964
(synonyms: Oenanthion aquaticae Hejný 1948 ms., Oenanthion aquaticae sensu auct. non Hejný ex Neuhäusl 1959, Cirsio brachycephali-Bolboschoenion Passarge ex Mucina in Balátová-Tuláčková et al. 1993)
  Bolboschoenetum yagarae Eggler 1933 corr. Hroudová et al. 2009
  Tripleurospermo inodori-Bolboschoenetum planiculmis Hroudová et al. 2009
Meliloto dentati-Bolboschoenion maritimi Hroudová et al. 2009
(pseudonym: Cirsio brachycephali-Bolboschoenion auct. non Passarge ex Mucina in Balátová-Tuláčková et al. 1993)
  Astero pannonici-Bolboschoenetum compacti Hejný & Vicherek ex Oťaheľová & Valachovič in Valachovič 2001
  other associations of inland saline habitats, e.g., Bolboschoeno-Phragmitetum communis Borhidi & Balogh 1970

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