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Butomus umbellatus-community in the Czech and Slovak Republics

Společenstvo s *Butomus umbellatus* v České a Slovenské republice

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Stands of *Butomus umbellatus* L. and their habitat characteristics were studied in the Czech and Slovak Republics in order to distinguish the *Butomus umbellatus*-community from other littoral vegetation and clarify the ecological causes of its formation and development. Ward's method of cluster analysis was used as a basis for phytosociological classification of the stands with dominant *B. umbellatus*; the chemical soil characteristics of habitats of *Butomus umbellatus*-community were treated by PCA. Cyclic changes of water level are the main factor encouraging the development of the community. Stands of *B. umbellatus* are usually species-poor and may be classified as *Butomus umbellatus*-community in a broad sense. A great proportion of the phytosociological relevés obtained represent heterogeneous stands formed by a mixture of species; they are transitional types of open water communities and littoral vegetation. This reflects the situation in natural habitats of *B. umbellatus*: the changes in vegetation follow those in water level and numerous stands occur in man-influenced or disturbed habitats.

Introduction

Fluctuations of water level are the main habitat characteristics of plant communities classified within the *Oenanthion aquaticae* alliance. This type of vegetation is variable in space and time; the communities can disappear for a long time, persist in the form of dormant underground organs or seeds of characteristic species (Hejný et Husák 1978), and reappear again after changes in water level. This dynamics are typical of all dominant species of these communities (*Sagittaria sagittifolia, Oenanthe aquatica, Rorippa amphibia, Butomus umbellatus, Alisma plantago-aquatica* etc.).

As regards *Butomus umbellatus*, the communities dominated by this species are relatively rare (they may occur temporarily), and the conditions leading to their formation and development are thus not clear. Substrate properties are among the most important factors influencing water environment, and in standing waters, they usually reflect bedrock

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properties (Sculthorpe 1967). Soils in habitats of *B. umbellatus* are mostly nutrient-rich, but variations in soil chemistry may be considerable (Samecka-Cymerman 1989). This corresponds to the habitat characteristics of the *B. umbellatus*-community (Konczak 1968, Philippi 1973). Hejný et Husák (1978) characterized habitats of *B. umbellatus*-community in Czechoslovakia by soils rich in mineral nutrients. However, as to the distribution of *B. umbellatus* stands in Czech and Slovak Republics, migration barriers can be as important as differences in substrate chemistry which differs with respect to region (Hroudová et Zákravský 1993). Hence the relationship of the community to the nutrient richness of the substrate appears to be an important problem to study.

Stands with *B. umbellatus* are mostly species-poor, characterized mainly by dominant *B. umbellatus*, without stable characteristic species combination (Konczak 1968). Transitional types to contact communities of the classes *Potametea* or *Phragmiti-Magnocaricetea* occur frequently, in dependence on the dynamics of water level. In this vegetational continuum, the *Butomus umbellatus*-community is sometimes difficult to define as well as to classify within the phytosociological system by using standard classification methods.

By studying the ecology of *B. umbellatus*, we collected numerous data on floristic composition and cover of stands with this species, as well as data on water depth dynamics and substrate properties of the habitats. On the basis of this material and the results of the previous work (Hroudová 1980, Hroudová 1989), we address the following questions: (1) What is the ecological causality of the origin and development of *Butomus umbellatus*-dominated stands? (2) How may these stands be classified within the Zürich-Montpellier phytosociological system?

Methods

Plant communities were recorded by phytosociological relevés using the seven-grade Braun-Blanquet scale (Klika et al. 1954). All sites in which *B. umbellatus* was recorded were sampled. When plant cover was fragmentary or nonhomogeneous, the list of plant species accompanying *B. umbellatus* in the given locality was made instead of a phytosociological relevé.

When two or more different types of stands containing *B. umbellatus* occurred within one locality (shore zonation in fishponds, variable vegetation of streams and ditches dependent on water depth, closely neighbouring field depressions), they were recorded separately. In this case, the distance between the location of relevés was 10-50 m; the distance between the closest geographical localities considered as separate was 100-500 m (small fishponds and pools in South Bohemia and South Moravia). Most of the localities sampled are identical with localities of diploid and triploid *B. umbellatus* plants, whose distribution is given in Hroudová et Zákravský (1993).

Sampling sites in the localities of *B. umbellatus* were chosen to characterize the plant community in which the species occurred; this means that stands as homogeneous as possible were selected for sampling and relevé size was proportional to the total size of stand (varied from 1 × 5 m to 5 × 10 m, mostly within the range of 15 to 25 m^2).

Soil samples were taken from rhizosphere (mostly from the soil layer up to 0.2 m under the soil surface); the samples were dried at room temperature. Chemical soil analyses were performed by the following methods: pH in H_2O and 1 mol KCl - electrometrically, N-NH_4 - colorimetrically using Nessler's reagent (Hraško et al. 1962), exchangeable Ca, Mg, K and Na by both flame and absorption spectrophotometry, N-NO_3 - colorimetrically using phenol 2,4 disulphic acid (Jackson 1958), P-PO_4 - colorimetrically using extraction with sodium bicarbonate (Olsen et al. 1954), total N and C - using CHN analyzer Heraeus, SO_4 and Cl - using isotachophoresis by ITP analyzer (Everaerts et al. 1976).

To determine variation in chemical soil properties within the set of habitats of the *Butomus umbellatus*-community, principal component analysis (PCA) was used (Orlóci 1978).

Classification of vegetation was based on preliminary numerical classification by PCORD (Ward method, data transformed to ordinary scale according to van der Maarel 1979), with Euclidean distance used as a similarity measure. Because most relevés did not form distinct clusters and their classification based on the similarity measure was difficult, some relevés of the group A were replaced by others owing to their preceding vegetation dynamics. To evaluate relationships between the communities summarized in synthetical table, PCA method was used (Orlóci 1978); species composition and their constancy values were compared (except of species present with low constancy).

The nomenclature follows Rothmaler (1982), with an exception of *Bolboschoenus maritimus* subspecies (Casper et Krausch 1980).

Phytosociological nomenclature follows Hejný in Moravec et al. (1983); authors names are given in the text for syntaxa not covered by that paper.

Results

In total, 112 phytocoenological relevés together with 12 species lists from fragmentary or nonhomogeneous stands were collected from 100 localities. These represent all main types of wetlands in the area studied (fishponds and other reservoirs, streams, river banks,. channels and wet ditches, pools, temporarily flooded field depressions).

Within this set of relevés (Table 1), the group of relevés with prevailing submerged macrophytes (C) represent the communities sampled at the time of higher water level (or immediately after it had subsided). The vegetation growing on emerged bottoms (E) relates to habitats after the water level had fallen, frequently found in *B. umbellatus* sites. The communities with dominant reeds (D) represent habitats in a period of shallow water (littoral ecophase sensu Hejný 1960). These three groups represent a smaller proportion of the total data set (38 relevés in total).

When treated by means of cluster analysis (Fig. 1), most relevés did not form distinct clusters, and almost entire vegetational continuum was found. In many cases the final classification into different types of communities (A-F in Table 1) did not correspond to

Table 1. - Synthetical table of phytocoenological relevés: A - community with *Butomus umbellatus*; B - stands with prevailing and mixed species of the all. *Oenanthion* and *Scirpion maritimi*; C - communities of submerged and floating plant species (class *Lemnetea, Potametea*); D - reed-bed communities (class *Phragmiti-Magnocaricetea*); E - communities on emerged bottoms (class *Bidentetea, Isoeto-Nanojuncetea*) and those of tenagophytes (class *Littorelletea*); F - mixed stands without determination of higher phytosociological units; CH - characteristic species of higher phytosociological units

community	A	B	C	D	E	F
number of relevés	22	26	14	10	14	26
CH - *Butomus umbellatus*-community						
Butomus umbellatus	V^{2-5}	V^{r-3}	V^{+-3}	V^{+-3}	V^{+-3}	V^{+-3}
CH - *Oenanthion, Scirpion maritimi*						
Alisma plantago-aquatica	I^{r-+}	IV^{r-4}	III^{+}	II^{r-1}	III^{+-3}	IV^{+-2}
Oenanthe aquatica	II^{r-1}	III^{r-5}	II^{+-2}	II^{+}	III^{r-1}	III^{r-3}
Alisma lanceolatum	I1	II^{+-4}			II^{r-1}	II^{+-1}
Bolboschoenus maritimus subsp. *maritimus*	I^{+}	II^{+-4}			I^{-}	
Sparganium emersum	I^{+-2}	II^{+-3}	I^{r}		II^{+-1}	I^{2}
Sagittaria sagittifolia	I^{+-1}	II^{+-3}	III^{+-3}		I^{+-1}	II^{+-2}
Eleocharis palustris	I^{+-1}	II^{+-3}	I^{+}		I^{1-2}	II^{+-2}
Bolboschoenus maritimus subsp. *compactus*		I^{+-3}			I^{+}	
Rorippa amphibia	I^{+}	I^{+-2}	I^{1}		I^{+}	III^{+-1}
CH - *Lemnetea, Potametea*						
Lemna minor	II^{+-3}	III^{+-5}	IV^{+-4}	III^{1-5}	III^{+-2}	II^{+-4}
Lemna trisulca	I^{+}	I^{+}	III^{+-2}			II^{+-2}
Spirodela polyrhiza	II^{+-1}	I^{+-2}	II^{+-4}	I^{+}	I^{+-3}	II^{+-3}
Fontinalis antipyretica			II^{2-4}			
Potamogeton acutifolius	I^{1}		II^{+-3}			I^{+}
Ceratophyllum demersum	I^{1-2}	I^{+-1}	II^{1-2}			I^{+-2}
Potamogeton natans	I^{1}	I^{+-2}	II^{r-2}		II^{1-2}	I^{+}
Riccia fluitans			II^{+}			I^{+}
Elodea canadensis	I^{1-2}		I^{2-4}			
Potamogeton pectinatus			I^{+-4}	I^{2}		I^{1}
Lemna gibba	I^{1-2}	I^{2-3}	I^{2}		I^{+}	I^{2-5}
Hydrocharis morsus-ranae	I+		I2			IIr-3
Nuphar lutea	I^{2}		I^{1-2}			
CH - *Phragmiti-Magnocaricetea*						
Sparganium erectum	I^{1-1}	II^{+-1}	I^{+-1}	V^{1-4}	II^{r-+}	III^{+-2}
Glycerie maxima	II^{+-1}	I^{+-1}	II^{+-1}	III^{+-3}	II^{+-2}	III^{+-2}
Lycopus europaeus	I^{+}			II^{r-+}	II^{+-1}	II^{+-1}
Typha latifolia	II^{+-2}	II^{r-1}		I^{2-3}	II^{+-2}	II^{r-2}
Myosotis palustris			I^{r}	I^{+-1}		II^{+-2}
Berula erecta			I^{2}	I^{+-1}		I^{2-3}
CH - *Bidentetea, Isoeto-Nanojuncetea, Littorelletea*						
Alopecurus aequalis	I^{+}	II^{+-2}	I^{+}	I^{+}	IV^{r-2}	I^{+-3}
Polygonum lapathifolium		I^{r-+}			III^{+-3}	I^{+}
Eleocharis acicularis		I^{1}	I^{+-1}		II^{+-4}	
Bidens frondosa	I^{+}	I^{2}		II^{r-+}	II^{+-3}	I^{+}
Rorippa palustris		I^{+}			II^{+-3}	I^{1}
Polygonum hydropiper	II^{+-2}	I^{+}		I^{+-1}	II^{+-3}	I^{r-+}
Agrostis stolonifera		I^{+-3}		II^{1}	II^{+-3}	II^{+-3}
Juncus bufonius					II^{1-2}	
Rumex maritimus	I^{1}		I^{+}		II^{+-2}	I^{r-1}
Matricaria maritima	I^{+}	I^{+}			II^{r-2}	I^{r}

community	A	B	C	D	E	F
Ranunculus sceleratus		I^+			II^{r-+}	I^1
Echinochloa crus-galli	I^+	I^1			II^{r-+}	
Cyperus fuscus					I^2	
Callitriche palustris	I^+	I^+			I^{1-2}	I^+
Ranunculus repens	I^+	I^+		I^+	I^{+-1}	I^+
Others:						
Juncus effusus		I^+			I^+	II^{+-1}
Urtica dioica			I^r			I^{+-2}
Equisetum palustre		I^+				I^{+-1}

Species present with low constancy: CH - *Oenanthion*, *Scirpion maritimi*: *Glyceria fluitans* B,C,D,E,F, *Scirpus radicans* B,F, *Eleocharis mamillata* A; CH - *Lemnetea*, *Potametea*: *Stratiotes aloides* C,F, *Salvinia natans* C,F, *Zannichellia palustris* C, *Potamogeton pusillus* C, *Potamogeton trichoides* A,C,F, *Potamogeton lucens* C,F, *Potamogeton crispus* A,C,F, *Batrachium aquatile* A,C,D,E,F, *Alisma gramineum* E, *Batrachium rionii* E, *Batrachium trichophyllum* B,E,F, *Batrachium circinatum* F, *Chara* sp. B, *Hottonia palustris* F, *Myriophyllum verticillatum* B,F, *Nymphaea alba* F, *Polygonum amphibium* A,B,D,E,F, *Utricularia vulgaris* F; CH - *Phragmiti-Magnocaricetea*: *Lythrum salicaria* A,B,C,D,E,F, *Lysimachia vulgaris* B,D,F, *Epilobium hirsutum* D,E,F, *Carex vulpina* A,D,F, *Iris pseudacorus* A,B,C,D,E,F, *Phragmites australis* A,B,C,D,F, *Lythrum virgatum* B,D, *Symphytum officinale* A,B,D, *Phalaris arundinacea* A,B,C,D,E,F, *Sium latifolium* B,C,D,E,F, *Carex gracilis* C,D,E,F, *Solanum dulcamara* A,D,E,F, *Acorus calamus* A,E,F, *Calystegia sepium* B,E,F, *Carex acutiformis* A,F, *Carex pseudocyperus* juv. E, *Carex riparia* B, *Carex vesicaria* A,F, *Equisetum fluviatile* A,B, *Galium palustre* B,F, *Leersia oryzoides* B,E,F, *Mentha aquatica* A,E,F, *Poa palustris* E,F, *Rumex aquaticus* B,F, *Rumex hydrolapathum* A,B,C,E,F, *Schoenoplectus lacustris* B, *Scutellaria galericulata* E, *Teucrium scordium* E, *Typha angustifolia* A,B,C,E,F, *Veronica anagallis-aquatica* A,E,F, *Veronica beccabunga* F; CH - *Bidentetea*, *Isoeto-Nanojuncetea*, *Littorelletea*: *Trifolium hybridum* E, *Chenopodium glaucum* E, *Myosotis caespitosa* B,E, *Bidens tripartita* A,D,E, *Chenopodium album* E, *Polygonum persicaria* E, *Rumex crispus* E,F, *Myosoton aquaticum* B,E,F, *Vicia hirsuta* E, *Lythrum hyssopifolia* E, *Potentilla supina* E, *Limosella aquatica* A,E, *Bidens cernua* A,B,F, *Bidens radiata* B,F, *Carex bohemica* A,F, *Chenopodium rubrum* A, *Elatine alsinastrum* B, *Eleocharis ovata* B, *Epilobium palustre* D, *Mentha arvensis* D,F, *Myosurus minimus* B, *Peplis portula* B, *Plantago major* subsp. *intermedia* B, *Polygonum minus* D, *Ranunculus flammula* F, *Ranunculus lateriflorus* B, *Schoenoplectus tabernaemontani* F, *Stachys palustris* B,D; others: *Alopecurus geniculatus* F, *Potentilla anserina* F, *Caltha palustris* C,F, *Galium mollugo* B,F, *Juncus articulatus* B,F, *Plantago major* subsp. *major* B,E,F, *Cirsium oleraceum* F, *Epilobium ciliatum* E,F, *Impatiens parviflora* F, *Artemisia vulgaris* E,F, *Galium aparine* F, *Impatiens noli-tangere* F, *Armoracia rusticana* A, *Atriplex* sp. D, *Cardamine amara* B,E, *Carex hirta* B, *Agropyron repens* B, *Gratiola officinalis* B,E, *Lolium perenne* E, *Myriophyllum spicatum* ter. E, *Nasturtium officinale* E, *Polygonum aviculare* B,D, *Salix* sp. juv. E, *Thalictrum lucidum* B.

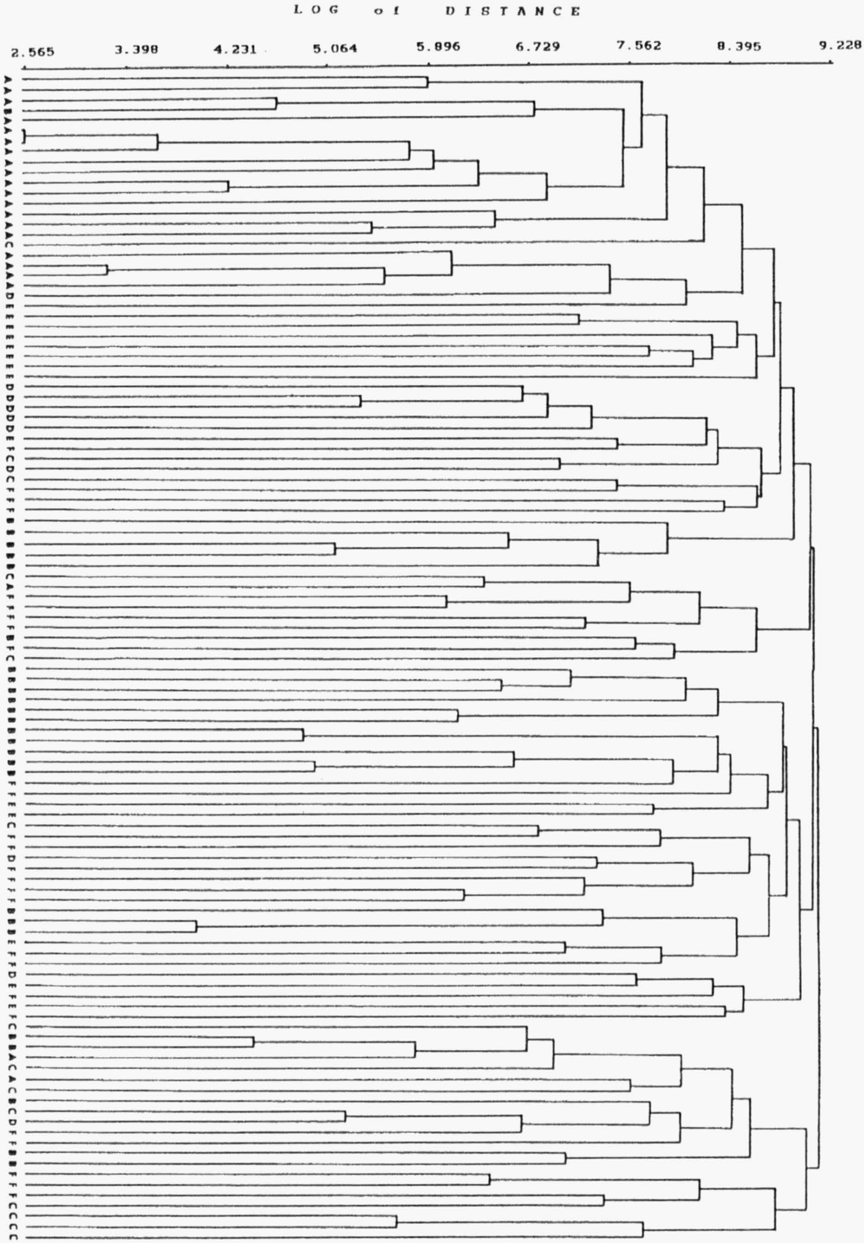

Fig. 1. - Cluster diagram of phytosociological relevés sampled in stands with *Butomus umbellatus* over the Czech and Slovak Republics. Letters correspond to the columns in Table 1: A - *Butomus umbellatus*-community, B - stands of the all. *Oenanthion*, C - communities of submerged and floating plants (*Lemnetea, Potametea*), D - reed-bed communities (*Phragmiti-Magnocaricetea*), E - communities of emerged bottoms (*Bidentetea, Isoeto-Nanojuncetea, Littorelletea*), F - other mixed stands.

clusters in Fig. 1. It was caused by (1) great proportion of heterogeneous stands; (2) regional differences in the floristic composition of stands (the communities from South Bohemia, South Moravia and East Slovakia differed although belonging to the same higher phytosociological unit); (3) broad range of groups B-F.

Only one group of relevés (A - 22 rel.), containing mainly species-poor stands with dominant *B. umbellatus* differed from the others in being relatively homogeneous, with relevés grouped at lower levels. From the cluster, some relevés were removed and replaced by others on the basis of knowledge of previous stand dynamics - this concerns relevés (one in each) from submerged plant community under decreased water level (C), terrestrial stand with prevailing reed-bed species (D), terrestrial stand with prevailing species of emerged bottoms (E), stands with high proportion of other species of the alliance *Oenanthion* (B). Three relevés were incorporated into this group; these represented stable communities with well developed population of *B. umbellatus* and greater proportion of accompanying species. The relevés in group A may be considered as those belonging to the *Butomus umbellatus*-community in the area studied (Table 2).

The greater number of relevés (52) represent mixed stands, without distinct dominant species or characteristic species combination. They include mixed stands in habitats with frequent fluctuations of water level, i.e. the vegetation belonging to the alliance *Oenanthion* (Hejný in Moravec et al. 1983) - see Table 1, col. B. The other types of mixed stands are those of the following habitats: (a) nonhomogeneous or fragmentary shore stands in canalized rivers or reservoirs; (b) vegetation of channels and ditches; (c) relatively species--rich stands in disturbed habitats, including stages when shallow reservoirs or field depressions are overgrown (Table 1, col. F).

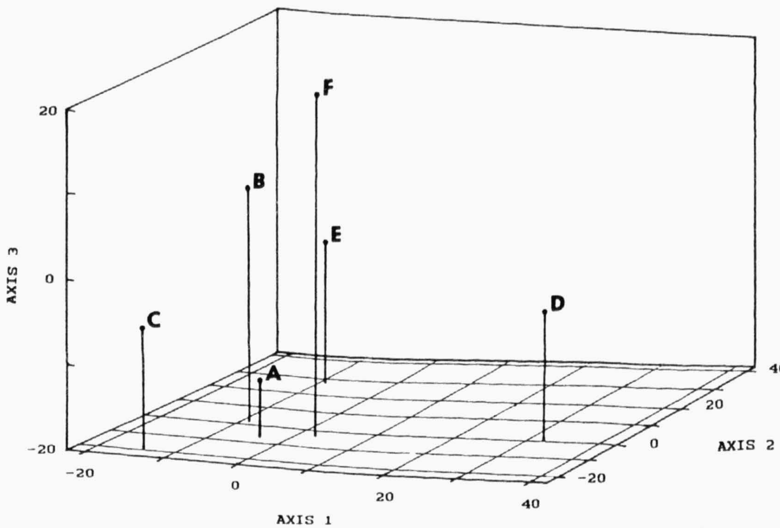

Fig. 2. - Ordination of communities containing *Butomus umbellatus* according to species composition and their constancy values. Data from synthetical table (Table 1) were used excluding species present with low constancy. Axis 1 takes 33.45 % of total variation, axis 2 - 29.36 % and axis 3 - 18.08 %. Letters correspond to columns in Table 1 (the same as in Fig. 1).

Table 2. - Community with *Butomus umbellatus*. CH - characteristic species of higher units. Numbers of relevés correspond to those of localities given in Appendix 1.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Const. class
Locality number	9	10	6	21	16	1	20	19	11	13	2	8	4	17	18	22	12	7	14	5	3	15	
Date	27.6. 1982	26.7 1991	23.7. 1988	27.6. 1985	7.7. 1986	17.8. 1986	10.7. 1986	9.7. 1982	19.7. 1988	16.8. 1986	20.8. 1986	4.7. 1991	28.8. 1991	14.7. 1982	6.7. 1986	5.7. 1985	20.7. 1988	23.7. 1988	8.7. 1986	6.7. 1987	20.8. 1986	8.7. 1986	
Relevé size (m^2)	20	18	18	16	6	20	10	5	30	6	10	36	12	20	24	12	50	12	20	15	12	10	
Height of the stand above water level (m)	0.4	0.5	0.9	1.0	1.5	1.0	1.0	1.0	1.0	0.8	0.5	1.0	0.8	0.7	1.5	1.0	1.5	1.0	1.0	0.6	0.8	1.5	
Water depth (m)	0.15	0.4	0	0.3	0	0.1	0.1	0.1	0.15	0.6	0.6	0.4	0.5	0	0.3	0.05	0.05	0.4	0.4	0.6	0.15	0.3	
Cover E1 (%)	40	50	60	60	60	60	80	50	100	50	75	70	40	75	80	50	90	25	60	95	50	30	
CH - *Butomus umbellatus*-community																							
Butomus umbellatus	2	3	3	3	3	3	4	3	4	2	3	4	2	4	4	3	5	2	3	5	2	2	V
CH - *Oenanthion*																							
Oenanthe aquatica	.	+	1	r	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	II
Eleocharis palustris	+	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Alisma plantago-aquatica	.	.	.	.	.	+	r	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sparganium emersum	.	.	.	.	.	.	.	.	+	2	2	.	.	.	.	.	.	.	.	.	.	.	I
Sagittaria sagittifolia	.	.	.	.	.	.	.	.	.	.	.	1	1	+	.	.	.	.	.	.	.	.	I
CH - *Lemnetea*																							
Lemna minor	.	.	.	.	1	.	.	.	3	+	1	+	.	+	.	+	+	.	.	.	+	.	II
Spirodela polyrhiza	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	1	+	.	.	.	.	II

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Const. class
Locality number	9	10	6	21	16	1	20	19	11	13	2	8	4	17	18	22	12	7	14	5	3	15	
CH - *Potametea*																							
Polygonum amphibium	2	+	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	II
Batrachium aquatile	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Ceratophyllum demersum	.	.	.	.	.	1	.	.	2	.	.	.	.	.	1	.	.	.	.	.	.	.	I
Potamogeton crispus	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	I
CH - *Phragmiti-* *-Magnocaricetea*																							
Typha latifolia	.	.	.	.	2	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	2	II
Glyceria maxima	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	+	1	+	1	.	II
Phalaris arundinacea	.	r	.	.	.	.	2	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Rumex hydrolapathum	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	I
Others:																							
Polygonum hydropiper	.	.	.	.	+	2	+	.	+	.	.	.	+	.	1	.	.	.	.	.	.	+	II
Alopecurus aequalis	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I

Species present in one or two relevés only: Rel.1: *Elodea canadensis* 1, *Potamogeton crispus* +, *Potamogeton acutifolius* 1; rel.2: *Potamogeton trichoides* 1; rel.3: *Bidens tripartita* +, *Matricaria maritima* +, *Carex bohemica* +, *Chenopodium rubrum* +, *Rumex maritimus* 1, *Limosella aquatica* +, *Callitriche palustris* +; rel.4: *Alisma lanceolatum* 1, *Carex vulpina* +, *Lycopus europaeus* +, *Lythrum salicaria* +, *Ranunculus repens* +; rel.5: *Lycopus europaeus* +, *Carex acutiformis* 1; rel.6: *Acorus calamus* 2; rel.7: *Armoracia rusticana* +, *Bidens frondosa* +; rel 8: *Rorippa amphibia* +; rel.9: *Eleocharis mamillata* 1, *Elodea canadensis* 2, *Bidens cernua* r; rel.10: *Solanum dulcamara* +; rel. 11: *Sparganium erectum* 1; rel 12: *Lemna trisulca* +, *Potamogeton natans* 1, *Phragmites australis* +, *Carex vesicarica* +; rel.13: *Nuphar lutea* 2, *Sparganium erectum* 1, *Veronica anagallis-aquatica* + ; rel.14: *Lemna gibba* 1, *Bolboschoenus maritimus* subsp. *maritimus* +, *Iris pseudacorus* +; rel.15: *Lemna gibba* 2, *Mentha aquatica* 1; rel.16: *Alisma lanceolatum* 1, *Bidens tripartita* r, *Echinochloa crus-galli* +; rel.17: *Solanum dulcamara* +, *Equisetum fluviatile* 1, *Typha angustifolia* +; rel.19: *Symphytum officinale* +,; rel.20: *Lythrum salicaria* +; rel.21: *Hydrocharis morsus-ranae* +, *Acorus calamus* 2.

Three groups of communities (col. C, D, E) represent marginal points in the vegetational continuum (Fig. 2), well differentiated from the mixed stands; the community with *B. umbellatus* is similar to the mixed stands in the composition of species accompanying *B. umbellatus*, but it is usually species-poorer. The *Butomus umbellatus*-community is distributed from warm lowland regions up to the colline belt, especially in river floodplains and fishpond basins (see Appendix 1).

As regards chemical soil properties (Fig. 3), the high upper limits of the C_{ox} and N_{tot} content correspond to the occurrence of the community on sapropel soils with organic deposits. The upper range of SO_4^{2-} and Cl^- contents reached the values typical for saline soils (cf. Vicherek 1973); the cation content was, however, considerably lower. In general, compared to limestone or base-rich soils, the soils do not appear to be rich in cation content (Dykyjová et al. 1989).

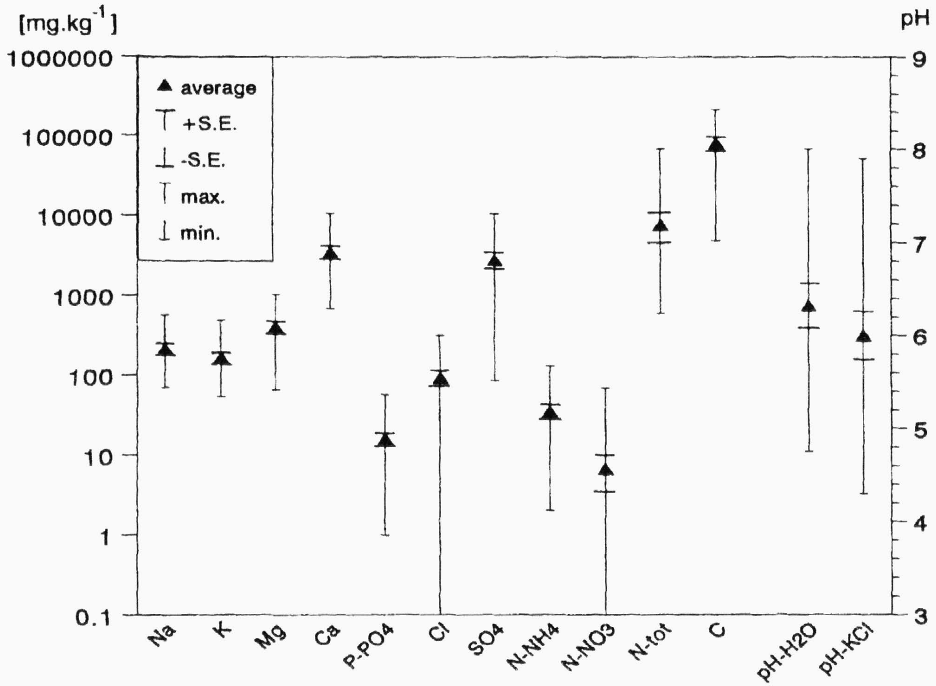

Fig. 3. - Soil chemical properties of habitats of *Butomus umbellatus*-community. Soil samples from 21 localities (except of loc. 13) of the community were analyzed (see Appendix 1 and Table 2). At locality 13 (the bank of the Labe river in Pardubice town), no soil could be sampled in crevices of the embankment. In each variable, the following values are marked: average, standard error and the total range of variation.

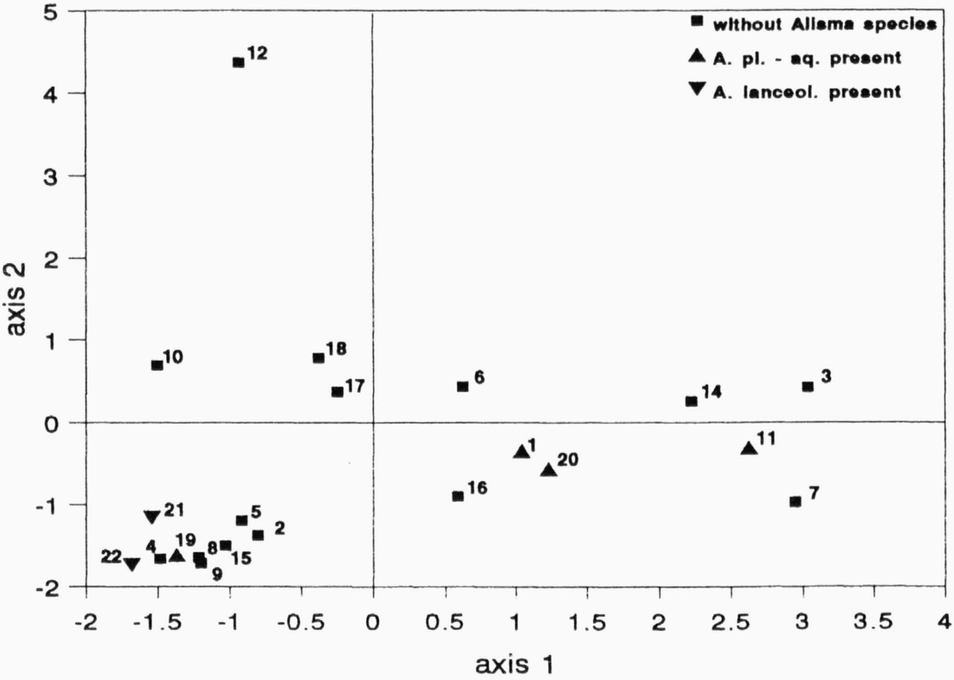

Fig. 4. - Ordination of habitats of *B. umbellatus*-community according to soil chemistry. Results of soil analyses from the same 21 localities as in Fig. 1 were evaluated. The occurrence of *Alisma* species in the relevés is marked; for numbers see List of localities.

Ordination based on soil chemistry arranged the localities according to their trophic level expressed by C and N contents (Fig. 4). Axis 1 accounted for 95.8 % of variation and corresponds to the gradient of oxidizable carbon content (r = 0.99); axis 2 accounted for 4.0 % of variation and corresponds to the gradient of total nitrogen content (r = 0.98).

Numerous localities characterized by the low content of carbon and nitrogen were grouped together (nos. 5, 2, 8, 15, 9, 19, 4, 21, 22). Localities with low nitrogen content were found on banks of reservoirs and streams or in field depressions with clay or loam soils; increased carbon content indicates an increased amount of humous sediments (nos. 3, 7, 11, 14). The most outlying locality (no. 12) represents a small isolated fishpond surrounded by fields (NW Bohemia), with a high content of total nitrogen and phosphorus. The geographical position of localities was not reflected by their position in the ordination space. Stands with different *Alisma* species did not form distinct groups; the species were present in a small proportion of relevés of the *Butomus umbellatus*-community.

Discussion

Ecology and development of Butomus umbellatus-stands

The origin of stands with dominant *B. umbellatus* in natural habitats is conditioned by fluctuations of water level, which phenomenon is common in all plant communities of the *Oenanthion* alliance. As observed by some authors, stands of *B. umbellatus* arise and expand in dam reservoirs mainly in the first year after filling (Zerov 1976, Koreljakova 1977, Husák 1984) and in fishponds in the year after summer draining (Hroudová 1980). Communities with dominant *B. umbellatus* become well developed within 3 to 4 years after the reservoir is filled, and are suppressed later by stronger competitors, particularly by *Typha* species (Koreljakova 1977).

Cyclic changes of water level appear to be necessary for the full development of the *B. umbellatus*-community particularly in standing waters (small fishponds), where, provided these changes do not occur, *B. umbellatus* can be competitively suppressed by reeds (Fig. 5).

Draining of the bottom initiates the growth of shoots of *B. umbellatus* from rhizomes and fragments lying in the surface bottom layer, and leads to increased population density

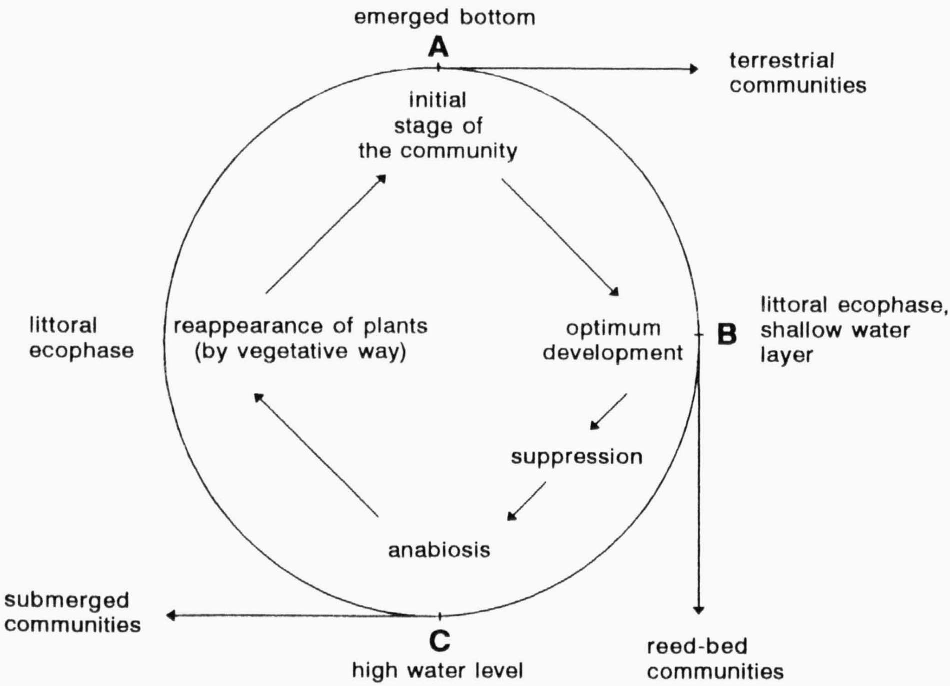

Fig. 5. - Diagram of developmental changes of a stand of *Butomus umbellatus* depending on cyclic changes of water level. Points A, B, C denote interruption of the cycle at different water levels.

(Hroudová 1980). This stage of cyclic vegetation changes (point A in Fig. 5) is demonstrated by the relevés of the communities of emerged bottoms in Table 1, column E.

In the following year, when the water layer remains shallow, communities with dominant *B. umbellatus* can develop at best (point B in Fig. 5). Once the shallow water layer is stabilized, the *B. umbellatus* stand would be probably replaced by stronger competitors (reeds). Without competitive suppression, *B. umbellatus* is able to grow very well under the stable water level of about 0.8 m in depth (Hroudová 1989). The group of relevés with prevailing reed-bed species in Table 1 (column D) demonstrate the stage of reed expansion into shallow water; the presence of *B. umbellatus* in such a stand indicates previously lower water level.

Under a deep water layer, *B. umbellatus* can survive in submerged form, or disappear temporarily and survive by dormant rhizomes. Submerged plant communities develop at this stage of the water fluctuation cycle (see water plant communities in Table 1, column C and point C in Fig. 5), and this situation may persist due to the stabilization of high water level. A gradual decrease in water level leading to the draining of soil surface initiates sprouting of *B. umbellatus* shoots and makes the renewal of the stand possible.

Interruption of this fluctuation cycle leads to successional processes towards reed communities (in shallow water), terrestrial communities (in the case of permanent drying of the bottom), or to the stabilization of submerged plant communities (in deep water). The presence of *B. umbellatus* in different littoral communities may indicate fluctuations in the water level of the habitat.

The stages A, B, C in Fig. 5 represent well defined vegetational types corresponding to various heights of the water level (Fig. 2). The *B. umbellatus*-community is similar to mixed stands as regards the composition of species accompanying *B. umbellatus* (Table 1, Fig. 2); *B. umbellatus* is the only species distinguishing this community from the others. The groups B and F in Fig. 2 are similar in species composition; both represent mixed stands, but the source of variation in the species composition differs. The communities of the *Oenanthion* alliance (B) vary in dependence on the cyclic changes of water level, whereas other mixed stands (F) vary with respect to the habitat type and human impact. In general, *B. umbellatus* does not dominate plant communities frequently; Hejný (1960) pointed out the low phytosociological value of this species in fishponds of South- and East-Slovakian lowlands. The frequent presence of *B. umbellatus* in nonhomogeneous mixed stands is conspicuous (Table 1). This is frequently the result of vegetative spreading of this species by rhizome fragments to new (secondary) habitats.

Even if *B. umbellatus* is a dominant species in the community, its cover may be still low for two reasons: (1) its leaves are erect and triangular in cross section; thus, in vertical projection, their cover percentage is low; (2) the species produces several times more underground rhizome biomass compared to aboveground shoot biomass (Hroudová 1980, 1989). The dense rhizome system therefore does not correspond to equally dense aboveground shoots. This may be the cause of low total cover values in species-poor communities with *B. umbellatus*.

Phytosociological classification of communities with Butomus umbellatus

As follows from the above, fluctuations of water level cause continuous changes of the vegetation (see Fig. 1), making it difficult to determine clear boundaries between individual communities. This means that floristic criteria of classification could be hardly used for determination of this community. The descriptions of the community in the literature do not bring clear characteristics either:

The community described as ass. *Butometum umbellati* (Konczak 1968) Philippi 1973 represents a species-poor plant community, distinguishable mainly by the dominance of *Butomus umbellatus* (Konczak 1968). It inhabits sites with strongly fluctuating water level, temporarily drying, often in connection with stands of *Sagittario-Sparganietum emersi* Tx. 1953 (Philippi 1973). This community was found in oxbows of the Hase river (Starmann 1987), and in the Danube river alluvium (Ahlmer 1989); Lindner et Schrautzer (1983) described *Butomus umbellatus*-community from wetlands in Nordfriesland. In the Czech Republic, this community was reported by Hroudová (1980) in South Moravia and by Rydlo (1991, 1992) from the Mdlina and Berounka rivers.

Ass. *Butomo-Alismatetum lanceolatae* (Timár 1957) Hejný 1969, Westhoff et Segal in Westhoff et den Held 1969 has been given for the Czech and Slovak Republics by Hejný et Husák (1978), Hejný (1981), Hejný in Moravec et al. (1983), Mucina et Maglocký (1985). No phytosociological relevés or tables of this community were published in these papers. In Timár's original work (Timár 1957), the phytosociological table of consoc. *Alisma lanceolatum* was published, belonging to ass. *Bolboschoenetum maritimi* Soó 1927; this community occurred mainly in summer drained fishponds and did not include *Butomus umbellatus*. Thus, *Butomo-Alismatetum lanceolatae* is not a valid name for the unit.

Ass. *Butomo-Alismatetum plantaginis-aquaticae* (Slavnić 1948) Hejný in Dykyjová et Květ 1978 represents the community found by Hejný et Husák (1984) in East Slovakia, and reported also by Mucina et Maglocký (1985). Rydlo (1986) published two relevés of the community with *B. umbellatus* from the banks of the Berounka river (Central Bohemia), and related them to the ass. *Butomo-Alismatetum plantaginis-aquaticae*. With an exception of the two releves in the unpublished paper mentioned above (Hejný et Husák 1984), no phytocoenological relevés or tables of this community have been published. In the original work by Slavnić (1948), the subassociation with *Alisma plantago-aquatica* was described, belonging to the ass. *Scirpetum maritimi* Tx. 1937 on slightly saline habitats (with no published relevés); *B. umbellatus* distinguished this subassociation from the others. Soó (1957) considered all the subassociations given by Slavnić (1948) as successional stages or transitional types to the *Beckmannion eruciformis* alliance or nitrophilous *Phragmition*. The name of the unit *Butomo-Alismatetum plantaginis-aquaticae* is not based on published relevés and, thus, in that form, invalid.

Transitional types between the *B. umbellatus*-community and contact communities are frequently found. Close contact with *Sagittario-Sparganietum emersi*, in particular, may result in a continuous transition between these two communities. Some authors include relevés with dominant *B. umbellatus* in *Sagittario-Sparganietum emersi* Tx. 1953, var. with *Butomus umbellatus* (Tomaszewicz 1979, Wojtaszek 1989, Brzeg et Ratyńska 1991).

The role of *Alisma* species in the community studied is questionable. In the Czech and Slovak Republics, *A. lanceolatum* and *A. plantago-aquatica* do not exhibit specific association with *Butomus umbellatus* neither in habitat types, nor in the frequency of occurrence or distribution (Hroudová, unpublished data). The areas of distribution of the two *Alisma* species in the Czech and Slovak Republics overlap to a great extent; *A. lanceolatum* is absent from South Bohemian basin (Hrouda et Hroudová 1989). Within the set of relevés of the *Butomus umbellatus*-community, the presence of both *Alisma* species was rare; they differentiated the data set neither with respect to floristic composition (Table 2) nor to the substrate properties (Fig. 4).

Because the classification of the *Butomus umbellatus*-community is based only on the dominance of the charaster species, it is similarly difficult as in other communities of the alliance *Oenanthion*, and also in reed-bed and tall-sedges communities (class *Phragmiti-Magnocaricetea*) and in submerged communities (class *Potametea*) - see Hejný et Husák (1978). This reflects the real situation in nature, especially the remarkable dynamics of water and littoral vegetation compared to terrestrial communities. Frequent occurrence of transitional types between contact communities is a result of this dynamics.

Besides, the high proportion of mixed nonhomogeneous stands (Table 1, col. F) represents very frequent vegetation types in secondary man-influenced habitats: (a) canalized river beds and streams; (b) narrow channels and ditches of V-profile, where depth zonation of plant communities cannot not be formed and water plants grow in mixture with shore plants; (c) initial stages of vegetation development or transitional successional stages in disturbed or newly formed habitats (small ponds after scraping, sand pits). *Butomus umbellatus* is capable of establishing in secondary habitats and it is thus frequently found in these mixed stands.

If we consider the community with *Butomus umbellatus* as a separate unit of the phytosociological system, it is closest to the ass. *Butometum umbellati* (Konczak 1968) Philippi 1973. Owing to its not too clear definition and difficult classification, we prefer to define it as a broadly considered *Butomus umbellatus*-community.

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Souhrn

Vznik a rozvoj společenstva s *Butomus umbellatus* je (stejně jako u ostatních společenstev sv. *Oenanthion*) podmíněn kolísáním vodní hladiny, které mu umožňuje využít dočasně volnou niku v pobřežní hydroserii.

Dynamika vodní hladiny způsobuje rovněž dynamiku vegetační: jednotlivé fáze tohoto cyklu změn na sebe plynule navazují, čímž vzniká řada přechodných typů mezi vegetací submersní, obnažených den i litorálu, tvořící dohromady cyklické vegetační kontinuum.

Vzhledem ke svému vegetativnímu šíření je *B. umbellatus* velmi často přítomen ve směsných nehomogenních porostech na těchto typech stanovišť: fragmentární porosty na březích řek a nádrží; kanály, potoky a příkopy s vodou; iniciální stadia zarůstání a regenerující porosty na narušených mokřadních stanovištích.

Z celkového souboru studovaných porostů představují proto podstatnou část právě směsné nehomogenní porosty, které není možno fytocenologicky klasifikovat; celý soubor představuje do značné míry vegetační kontinuum. Vymezení vegetačních jednotek je proto velmi obtížné a může být založeno prakticky jen na dominanci charakteristických druhů. To je ovšem typické pro většinu vodních a pobřežních společenstev a zobrazuje přírodní realitu.

Porosty s dominantním *B. umbellatus* představují druhově chudé společenstvo bez významné druhové kombinace, floristicky variabilní. Pokud jsou považovány za samostatnou vegetační jednotku, stojí nejblíže k ass. *Butometum umbellati* (Konczak 1968) Philippi 1973. Druhy r. *Alisma* se nejeví jako diferenciální druhy v rámci areálu tohoto společenstva v České a Slovenské republice. Vzhledem k nepříliš jasnému vymezení tohoto společentva klasifikujeme tyto porosty jako široce pojaté společenstvo s *Butomus umbellatus*.

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Appendix 1.

List of localities of the *Butomus umbellatus*-community in the Czech and Slovak Republics

C e n t r a l B o h e m i a

Kutná Hora district:
1. The small pond at the W end of Nové Dvory village, about 4 km NE of Kutná Hora town.
2. Doubrava brook, under the road bridge at the S end of Záboří village, about 2 km SW of Týnec nad Labem town.

Nymburk district:
3. An oxbow at the left bank of Labe river, near the road bridge in Nymburk town.
4. The Mdlina small river at the E end of Budiměřice village about 4 km NE from Nymburk town.

Benešov district:
5. The Podhájský fishpond near the road at the S end of Brodce village, about 1 km E of Týnec nad Sázavou town.

S o u t h B o h e m i a

Tábor district:
6. The small fishpond at the NW end of Karlov settlement, about 1.5 km NNE of Opařany village, 11 km W of Tábor town.
7. The small pool in Opařany village about 11 km W from Tábor town.
8. The Hluboký Sax fishpond near Hamr village about 5 km SE from Veselí nad Lužnicí town.

Jindřichův Hradec district:

9. The Zadní Pasecký fishpond about 2 km S from Kolence village, about 6 km E from Lomnice nad Lužnicí town.

W e s t B o h e m i a

Karlovy Vary district:

10. The fishpond near Horní Tašovice village, S of the road Karlovy Vary - Praha, about 2.5 km of Bochov village.

N o r t h B o h e m i a

Česká Lípa district:

11. The sand pit near Dubice village, at the W end of Česká Lípa town.

Louny district:

12. The small fishpond about 1 km SE of Chmelištná village, about 9 km W of Podbořany town.

E a s t B o h e m i a

Pardubice district:

13. The left bank of Labe river near the ice-hockey stadium in the Pardubice town.

S o u t h M o r a v i a

Hodonín district:

14. The Prušánka brook about 1.5 km W of Prušánky village, about 11 km WSW of Hodonín town.
15. A reservoir at the NE end of Lužice village about 3 km SW from Hodonín town.

Břeclav district:

16. The bay at the SE end of the dam of the upper Nové Mlýny reservoir, about 8 km NNW of Mikulov town.
17. The Pansee wetland between Šakvice village and that of Dolní Věstonice: this locality was destroyed by the construction of the Nové Mlýny reservoirs.
18. The Lednický náhon channel under the road bridge at the N end of Lednice town.
19. The small pool on the left bank of Dyje river about 1.5 km of Lednice town, near the road between Lednice and Podivín towns.
20. The Kyjovka brook under the motorway bridge at the NE end of Lanžhot village, about 6 km of Břeclav town.

S o u t h S l o v a k i a

Nové Zámky district:

21. The salt marsh between the railway line and the road at the S end of Kamenín village, near the branch road to Gbelce village, about 9 km NNW of Štúrovo town.

E a s t S l o v a k i a

Trebišov district:

22. The field depression near the road between Královský Chlmec town and Čierna nad Tisou village, about 3 km E of Královský Chlmec town.