Acta Rer. Natur. Mus. Nat. Slov.	Vol. LVI	Bratislava, 2010

AQUATIC MACROPHYTES AND THE LONGITUDINAL FLORISTIC-ECOLOGICAL ZONATION OF THE PATINSKÝ CANAL

Csilla Dorotovičová

Súhrn: *Vodné makrofyty a pozdĺžna floristicko-ekologická zonácia Patinského kanála.* Práca prináša výsledky výskumu distribúcie vodných makrofytov v Patinskom kanáli. Celkovo bolo zistených 26 druhov vodných rastlín (hydrofytov a amfifytov), 34 helofytov a vláknitých rias. V kanáli bol zistený jeden neofyt (*Elodea nuttallii*) a deväť druhov patriacich na území Slovenska medzi ohrozené (*Berula erecta, Butomus umbellatus, Najas marina, Nuphar lutea, Nymphaea alba, Potamogeton perfoliatus, Salvinia natans, Utricularia vulgaris* a *Sagittaria sagittifolia*). V práci sú spracované dáta o distribúcii druhov vo forme relatívneho množstva rastlín (*RPM%)*, priemerného množstva rastlín jednotlivých druhov (*MMT, MMO)* a ich index distribúcie.(*"d")*. Najvýznamnejšie ekologické faktory, ktoré ovplyvňujú zonáciu vodnej flóry v kanáli sú: veľkosť kanála, hĺbka vody a prítoky priľahlých kanálov.

Key words: aquatic vegetation, Kohler´s method, endangered species, relative plant mass, average distribution of species, distribution index, macrophytes – environmental relationship, zonation.

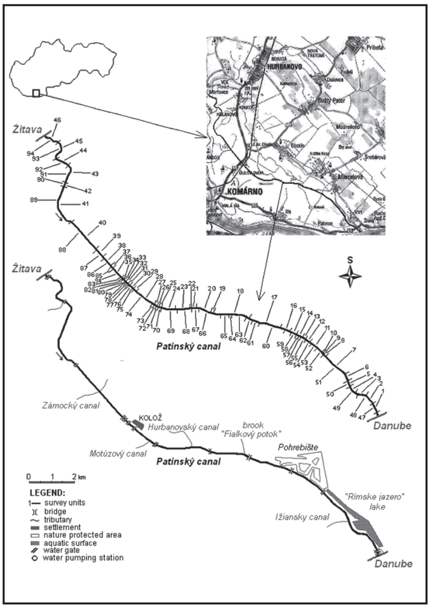

Fig. 1. Location of the survey units of the macrophytes along the Patinský canal and position of ecologically important objects

Introduction

In the last years, distribution and ecological conditions of growth of macrophytes in freshwater environment are intensively investigated all over the Europe. Attention is paid to the flora of the main channels of the European largest river, the Danube (eg, Pall et al. 1996; Janauer et al. 2003; Ráth et al. 2003; Sarbu 2003; Janauer & Exler 2004; Oťaheľová & Valachovič 2006) and its tributaries. In addition to natural tributaries of Danube (eg, Kohler et al. 2003, Germ et al. 2003; Hrivnák et al. 2003, 2007; Oťaheľová & Banásová 2005; Kuhar et al. 2006) also the water vegetation of flows created or changed by human activity is examined (eg Janauer & Wychera 2000; Sipos et al. 2003; Oťaheľová & Valachovič 2003; Jursa & Oťaheľová 2005; Dorotovičová & Oťaheľová, 2008; Dorotovičová 2009). These semi-natural flows have, in addition to their economic importance, an important role as elements of the environment replacing natural habitats.

They compensate partly the loss of aquatic habitats of wetlands that occurred due to extensive changes in water regime of the country.

This paper deals with man-modified water flow channel in southern Slovakia, the Patinský canal. The aim of the work was to study the diversity and distribution of aquatic macrophytes in the stream and see how certain environmental factors influence the longitudinal zonation of vegetation.

Site description

Patinský canal belongs to a system of drainage and irrigation canals in the south-western Slovakia (Fig. 1.). Its geographical location is 47 ° 51.063' N, 18 ° 08.170' E - 47 ° 44.562' N, 18 ° 19.469' E. It connects the river Žitava with the Danube. It begins as a small stream 3 m wide and 50 cm deep, and it gradually increases in size. It collects water from two major canals, Ižiansky and Hurbanovský, and from several small canals. Patinský canal is in the lower flow 20 m wide, and its maximum depth measured during the survey, was 210 cm. The canal is 21 km long. It flows into the Danube in place of 1751.5 rkm.

Most of the territory through which the Patinský canal flows, is formed by agricultural fields. It passes through a small settlement Kolož near Komárno. Its lower part continues through the Nature Reserve Pohrebište and Rímske jazero lake near the village of Virt. The average annual temperature in the region is 10 ° C. The average temperature in July: 20.2 ° C, in January: -1.5 ° C. Annual average rainfall: 550 mm (Miklós & Hrnčiarová 2002).

Material and methods

The semi-quantitative method of macrophytes mapping applying a 5-grade scale to describe the Plant Mass Estimate (PME) index (Kohler 1978, Kohler & Janauer 1995, Janauer 2003) has been used in the field work in 2004 (review in 2006). Mapping of macrophytes in deeper waters was carried out from a boat. The left and right side was examined separately. Canal was divided into 94 sections (left side: 46 survey units, right side: 48 survey units) (Fig. 1.) based on the homogeneity of vegetation. The length of survey units ranged mostly between 50 to 600 m, 440 m in average. Very short survey units (5-6 m) were recorded near the bridges. The boundaries of homogeneous survey units were measured using a GPS device GARMIN (WGS 84 system).

Based on the field data the distribution diagram and numerical derivates, as Relative Plant Mass (RPM), Mean Mass Indices (MMT, MMO) and distribution index (d) (Janauer et al. 1993, Pall & Janauer 1995) was calculated on-line on the web-site (*www.midcc.at*).

List of plant species (Marhold & Hindák 1998), abbreviations used in the distribution diagram and graphs, growth forms in which the species actually occurred in the canal, and categories of endangerment of species (Feráková et al. 2001) are shown in Tab. 1.

Abiotic parameters as water depth (maximum water depth in survey units) and water width (width of the channel by water-level) were evaluated in each survey unit.

In search of similarity between samples (survey units), we used the Sørensen floristic similarity index (ISs) and indirect and direct gradient analysis (DCA, CCA) (Ter Braak & Šmilauer 2002). Since we were searching a zonation trend in the canal, in analysis we released very short survey units (5-6 m) (samples with low weight). These are survey units near the bridges with a very different species composition of vegetation due to the hardening of banks (concrete reinforcement), and local shielding. By gradient analysis

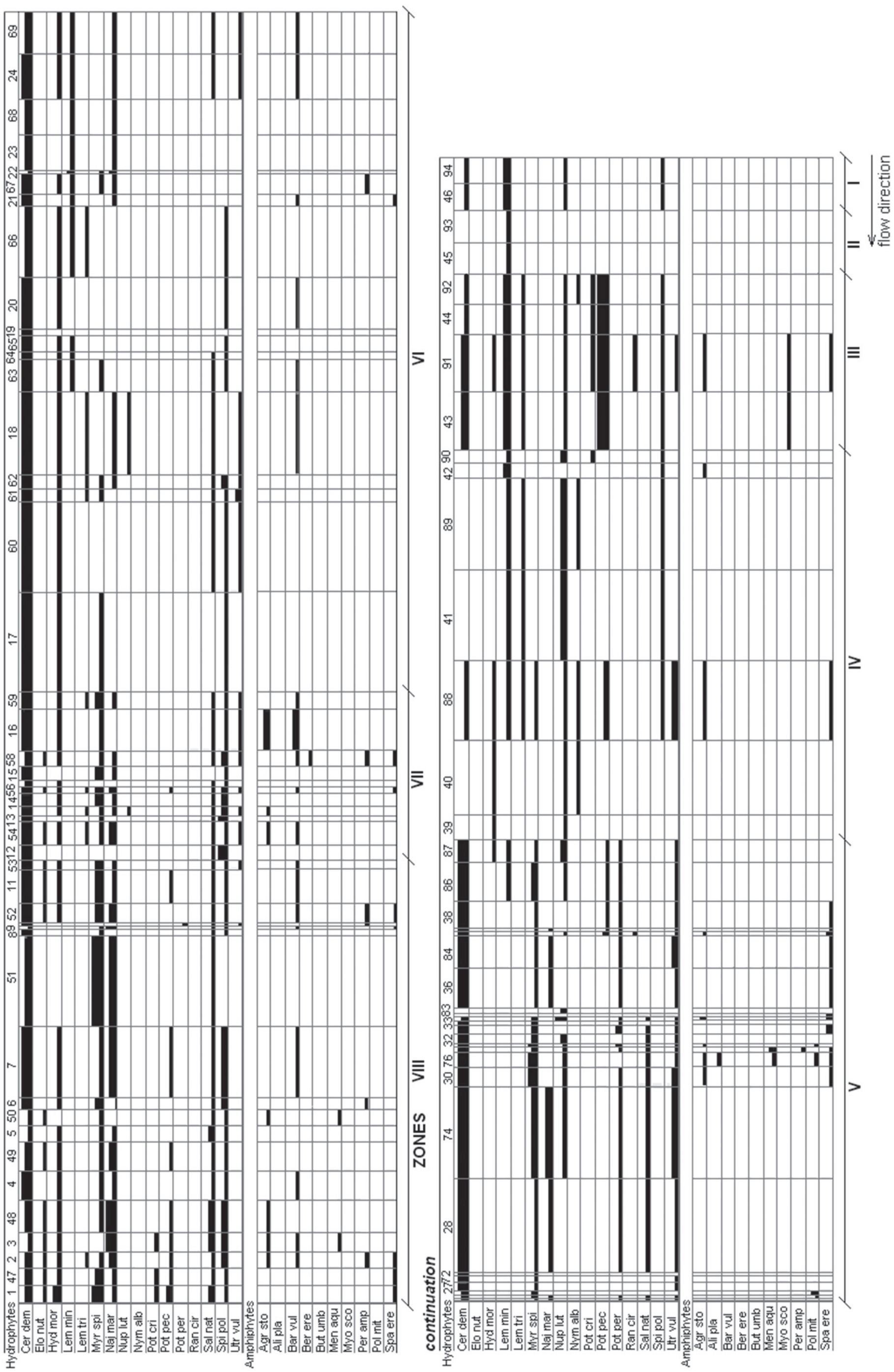

Fig. 2. Distribution diagram of aquatic macrophytes (hydrophytes and amphiphytes) of the Patinský canal (location of the survey units 1 - 94 show Fig. 1.)

Tab. 1. List of macrophyte species found in the Patinský canal their growth forms and categories of threat.

Species	Abbr.	Growth form	Categories of threat
Hydrophytes			
Batrachium circinatum (Sibth.) Spach	Ran cir	sa	
Ceratophyllum demersum L.	Cer dem	sa	
Elodea nuttallii (Planch.) H. St. John	Elo nut	sa	
Hydrocharis morsus-ranae L.	Hyd mor	fl	
Lemna minor L.	Lem min	ap	
Lemna trisulca L.	Lem tris	sp	
Myriophyllum spicatum L.	Myr spi	sa	
Najas marina L.	Naj mar	sa	LR:nt
Nuphar lutea (L.) Sm.	Nup lut	fl	VU, §
Nymphaea alba L.	Nym alb	fl	VU, §
Potamogeton crispus L.	Pot cri	sa	
Potamogeton pectinatus L.	Pot pec	sa	
Potamogeton perfoliatus L.	Pot per	sa	LR:nt
Salvinia natans (L.) All.	Sal nat	ap	LR:nt, §
Spirodela polyrhiza (L.) Schleid.	Spi pol	ap	
Utricularia vulgaris L.	Utr vul	sa	VU
Amphiphytes			
Agrostis stolonifera L.	Agr sto	he, am	
Alisma plantago-aquatica L.	Ali pla	he	
Barbarea vulgaris R. Br.	Bar vul	he	
Berula erecta (Huds.) Coville	Ber ere	he	VU
Butomus umbellatus L.	But umb	am	VU
Mentha aquatica L.	Men aqu	he	
Myosotis scorpioides L.	Myo sco	he	
Persicaria amphibia (L.) Delarbre	Per amp	am	
Persicaria dubia (Stein) Fourr.	Pol mit	he	
Sparganium erectum L.	Spa ere	he	
Helophytes			
Alisma lanceolatum With.	Ali lan	he	
Calamagrostis epigejos (L.) Roth	Cal epi	he	
Calystegia sepium (L.) R. Br.	Cal sep	he	
Carex acuta L.	Car acu	he	
Carex riparia Curtis	Car rip	he	
Carex vulpina L.	Car vul	he	

Tab. 1. (continuation)

Species	Abbr.	Growth form	Categories of threat
Eleocharis palustris (L.) Roem. et Schult.	Ele pal	he	
Epilobium hirsutum L.	Epi hir	he	
Equisetum arvense L.	Equ arv	he	
Equisetum palustre L.	Equ pal	he	
Galium palustre L.	Gal pal	he, am	
Glyceria maxima (Hartm.) Holmb.	Gly max	he	
Iris pseudacorus L.	Iri pse	he	
Lycopus europaeus L.	Lyc eur	he	
Lysimachia nummularia L.	Lys num	he	
Lysimachia vulgaris L.	Lys vul	he	
Lythrum salicaria L.	Lyt sal	he	
Myosoton aquaticum (L.) Moench	Myo aqu	he	
Phragmites australis (Cav.) Trin.	Phr aus	he	
Polygonum persicaria L.	Pol per	he	
Ranunculus repens L.	Ran rep	he	
Rumex hydrolapathum Huds.	Rum hyd	he	
Sagittaria sagittifolia L.	Sag sag	he	LR:nt
Salix alba L.	Sal alb	he	
Salix caprea L.	Sal cap	he	
Salix purpurea L.	Sal pur	he	
Schoenoplectus lacustris (L.) Palla	Sch lac	he	
Sium latifolium L.	Siu lat	he	
Stachys palustris L.	Sta pal	he	
Symphytum officinale L.	Sym off	he	
Typha angustifolia L.	Typ ang	he	
Typha latifolia L.	Typ lat	he	
Urtica dioica L.	Urt dio	he	
Veronica beccabunga L.	Ver bec	he	
Algae			
algae filamentosae	Alg fil	alg	

Abbreviations: ap – acro-pleustophytes, sp – submersed pleustophytes, sa – submersed anchored plants, fl – floating leaf rooted plants, am – amphiphytes, he –helophytes, alg – algae filamentosae; VU – vulnerable, LR:nt – lower risk, § – species protected in Slovakia

Note: Growth form presented as the first in the corresponding cell of the table means that this growth form of the species is more frequent in the canal.

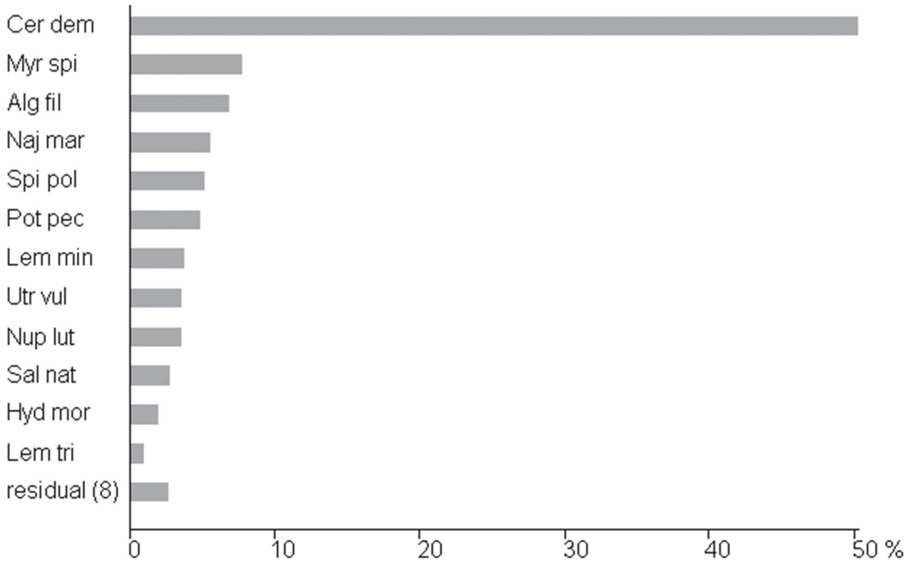

Fig. 3. Relative plant mass (RPM%) of aquatic plants (hydrophytes and amphiphytes) of the Patinský canal (amphiphytes in helophytic grow form are not included)

the primary data were semi-quantitative values of the abundance of plant species according to the Kohler's five-point scale. Since in DCA the longest gradient reached the value of 4,772, it indicates application of unimodal technique. In the CCA analysis we tested the effects of two characteristics of the environment, the width of the river bed and depth of the water (Fig. 7., 8.).

Results

<u>The physical habitat</u>

Morphometric characteristics of the river bed and water depths do not change continuously (Fig. 6.). A significant discontinuity occurs in places of inflow of side streams, Zámocký and Hurbanovský canals, respectively, and location of objects: a functional lock and a double road bridge (Fig. 1., 6.).

<u>*Species composition and distribution*</u>

During the fieldwork, we found 16 true aquatic plant taxa, 10 amfiphytes, 33 helophytes and few non-specified fibrous algae (Tab. 1.). Neophyte *Elodea nuttallii* is growing there, too. Nine species, *Berula erecta, Butomus umbellatus, Najas marina, Nuphar lutea, Nymphaea alba, Potamogeton perfoliatus, Salvinia natans, Utricularia vulgaris* and *Sagittaria sagittifolia* are endangered in Slovakia (Tab. 1.).

The most widespread hydrophyte was *Ceratophyllum demersum*, which reached high levels almost in the whole lenght of the flow (Fig. 2.). However, in most homogeneous survey units small amounts of the species *Myriophyllum spicatum* and *Najas marina* were present. They were missing only in the first survey units of the upper stream. *Batrachium circinatum* was the hydrophyte with the narrowest occurrence, it grew only in two survey units.

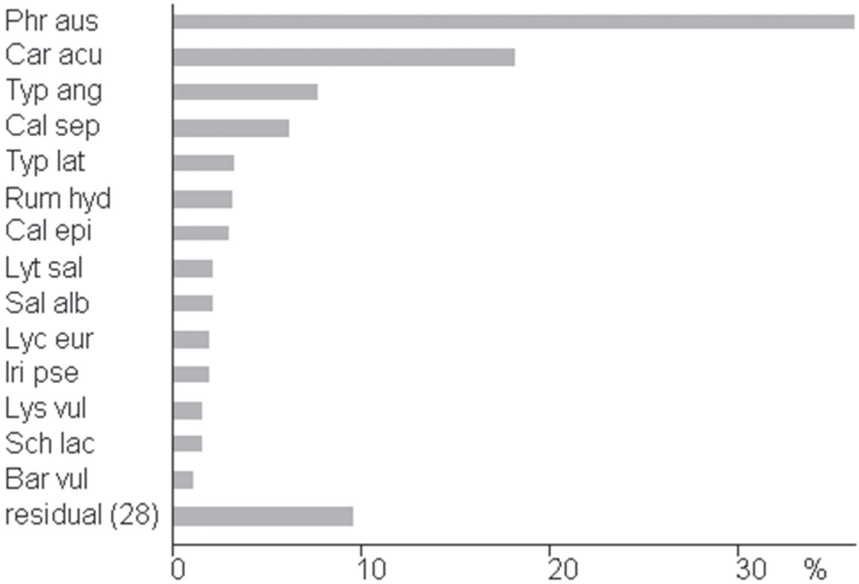

Fig. 4. Relative plant mass (RPM%) of aquatic helophytes of the Patinský canal (amphiphytes in helophytic grow form are included also)

The most spreading helophytes were *Phragmites australis* and *Carex acuta*. On the contrary, species *Lysimachia nummularia, Sagittaria sagittifolia* and *Veronica beccabunga* grew only in a single survey unit.

<u>Relative Plant Mass - RPM%</u>

The largest relative amount in the Patinský canal reached *Ceratophyllum demersum* with a ratio of 50.3% of the total quantity of hydrophytes and amfiphytes (Fig. 3.). It was highly dominant species. Higher values achieved also *Myriophyllum spicatum* (7.8%), *Najas marina* (5.6%), *Spirodela polyrhiza* (5.2%) and fibrous algae (6.9%).

Dominant helophyte *Phragmites australis* contributed to the total amount of helophytes by 36.2%. Species *Carex acuta* (18.2%), *Typha angustifolia* (7.7%), *Calystegia sepium* (6.2%) could be considered as subdominant (Fig. 4.).

<u>*Mean Mass Indices - MMT, MMO, and "d"*</u>

Fig. 5. shows that the high value of the average amount of hydrophytes was reached only by *Ceratophyllum demersum*. The small difference between the values of MMT and MMO means that the species is widespread throughout the canal relatively homogeneously. This confirms also the value of the distribution ratio (d = 0.84). Other types of hydrophytes reached lower values. Among these *Hydrocharis morsus-ranae, Myriophyllum spicatum* and *Spirodella polyrhiza* were present in more than half of the canal survey units. *Potamogeton pectinatus* showed clearly clumped distribution.

Helophyte *Phragmites australis* showed a balanced distribution over the whole Patinský canal; the d-value was d = 0.91. Another species, *Carex acuta* had also both of the mean mass values (MMO, MMT) higher than the 3. Value of d > 0.5 has been reached

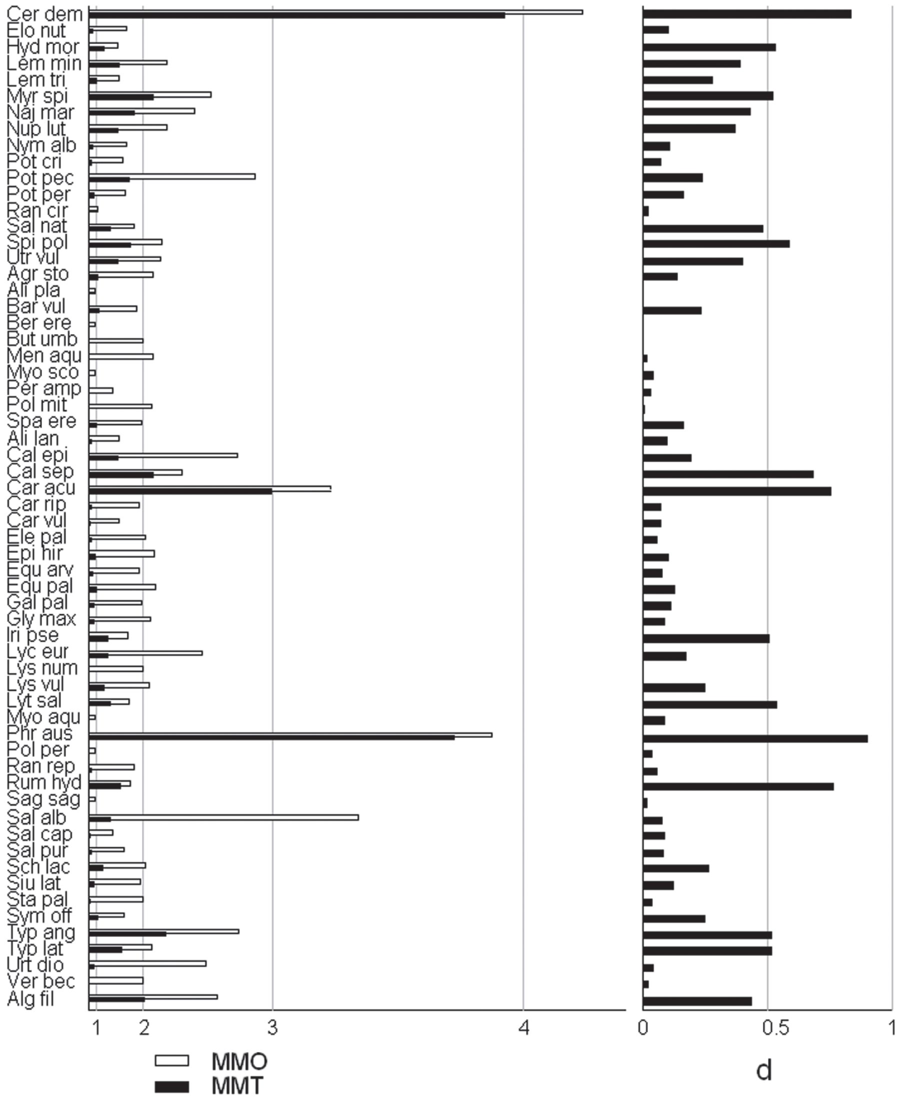

Fig. 5. Mean mass index (MMT, MMO) and distribution index (d) of all aquatic macrophytes of the Patinský canal

by eight species of helophytes, they were growing in more than half of the survey units of the canal.

<u>Floristic-ecological zonation</u>

Canal shows signs of longitudinal zonation of water plants (Fig. 2.):

Zones I and II – First zones represent the upper flow of the canal. They are surrounded by the willow-poplar stands. Stream bed is narrow, shallow and diversity of hydro-

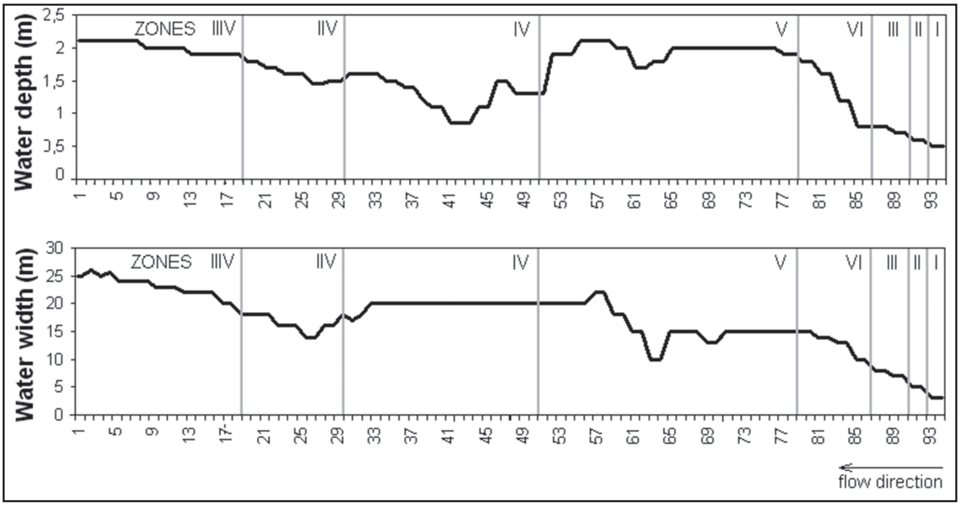

Fig. 6. Waterdepth and width of the channel-bed in survey units of the Patinský canal

phytes and helophytes is low. In zone II dominate helophytes, from hydrophytes only *Lemna minor* grow there.

Zone III – *Potamogeton pectinatus* has high values of RPM there. *Lemna minor* and *Ceratophyllum demersum* occur here in increased ratio.

Zone IV – In this zone increases occurrence of the species *Nuphar lutea* and *Nymphaea alba*. Almost completely missing is *Ceratophyllum demersum*, which is in other survey units dominant species. Changes on the border of zones IV and V can may be caused by Zámocký canal which crosses Patinský canal in the direction north-south at survey units 39 (left side) and 87 (right side). Circulation of flowing water is a possible cause of differences in vegetation of adjacent survey units 39 - 40 (left side) and 87 - 88 (right side).

Zones V and VI – They represent a central flow of the canal. *Ceratophyllum demersum* is dominant species. In the zone V the higher values of RPM has also *Myriophyllum spicatum* and *Najas marina* appears here as well. *Potamogeton perfoliatus* grows only in this zone. Zone VI is characterized by a clear dominance of species *C. demersum* and *Phragmites australis*. Changes in the flora is caused by the inflow of Hurbanovský canal. Its water flows into the Patinský canal at the beginning of this zone.

Zones VII and VIII – It is the lower flow of the canal. There is a great diversity of hydrophytes, helophytes, and comparing to other areas, also of amfiphytes. Zone VII is a sort of transitory part. In zone VIII *Ceratophyllum demersum* shares its dominance with hydrophytes *Myriophyllum spicatum* and *Najas marina*. Most abundant helophyte here is *Carex acuta* that creates, except of smaller sections, a continuous loop on the shore. *Phragmites australis* has less favorable conditions for its growth due to the steep shore and deep water.

Correspondence analysis, DCA CCA

The graph of the indirect gradient analysis, DCA (Fig. 7.) shows the similarity of species composition of the samples (homogeneous survey units) regardless of the cha-

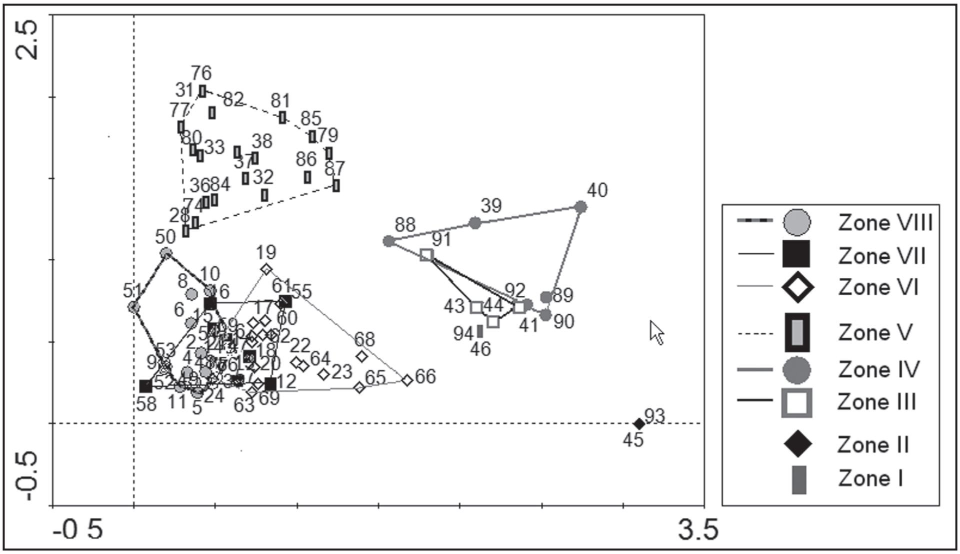

Fig. 7. Detrended correspondence analysis (DCA). Diagram of the samples - homogeneous sections of the Patinský canal with indication of zones

racteristics of the environment. Total inertia of the data was 2.839. From that 11,8 % of variance of species data fall on the first axis and 19 % on the second one.

After omitting the very short survey units (5-6 m) (samples with low weight) the total inertia of the set was 2.194. Using canonical correspondence analysis (CCA), we found that two observed environmental parameters (water depth and width) explain 18.9% of the total variability of the floristic composition of vegetation, where water depth explained 10.5% and water width 8.3% the total variability (Fig. 8.).

Discussion

In comparison with other anthropogenic waterflows of the Danube River Basin (Janauer & Wychera 2000, Oťaheľová & Valachovič 2003, Jursa & Oťaheľová 2005, Dorotovičová 2005, Dorotovičová & Oťaheľová 2008, Dorotovičová 2009), diversity of species in the Patinský canal is relatively high. We found there total of 59 taxa of aquatic macrophytes. Similarly high diversity has been reported by Sipos et al. (2003) in two semi-natural canals of Kiskunság (Hungary).

Distribution of macrophytes of the Patinský canal is continuous without empty units. This type of distribution is prevailing in the older sections of canalized streams or flows (Jursa & Oťaheľová 2005). Low speed of flow, a high diversity of plants and species composition of aquatic flora and continuity of the distribution shows that the Patinský canal inclines more to lentic environment rather than to lotic one.

The highest index of distribution (d) achieved dominant species, *Ceratophyllum demersum*. It is a frequented species of stagnant and slowly flowing lowland waterflows, including also the streams created or modified by human activity (Janauer & Wychera 2000, Sipos et al. 2003, Oťaheľová & Valachovič 2003, Jursa & Oťaheľová 2005, Dorotovičová 2009). In these slow water flows often appears accumulation of muddy sediment. A positive correlation between the amount of this species and the presence of muddy

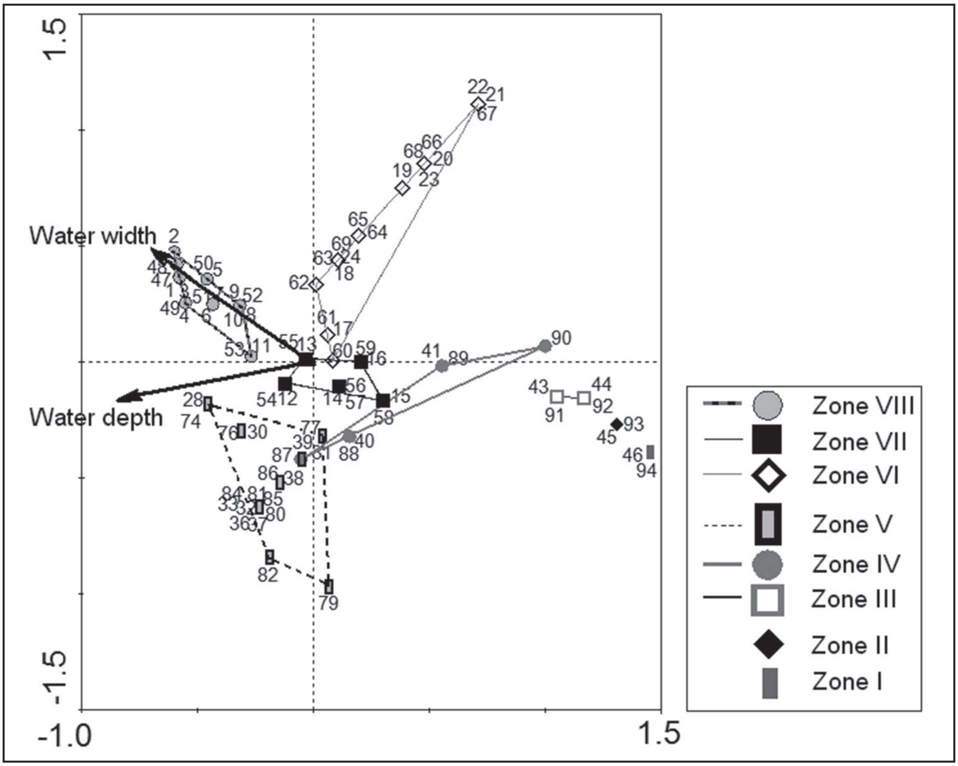

Fig. 8. Canonical correspondence analysis (CCA). Samples-environment biplot of the Patinský canal with indication of zones

sediment is referred by Oťaheľová & Oťaheľ (2006).

Canals and other anthropic flows can serve as refugia for endangered species. In the Patinský canal nine taxa belonging to endangered species occur (Feráková et al. 2001). Some species had relatively high distribution of continuity in its whole flow (*Utricularia vulgaris*) or part of the flow (*Nuphar lutea, Najas marina, Salvinia natans*). Most of them were present only in small amounts, but *N. marina* reached high abundance in the lower stream. This species appeared in the canalized flows in a higher degree of succession (Janauer & Wychera 2000, Sipos et al. 2003, Dorotovičová 2005, Jursa & Oťaheľová 2005) and in anthropic reservoirs (Oťaheľová 1995).

In the Patinský canal grows neophyt *Elodea nuttallii*. It occurs there only in small numbers in the lower flow (sections 1-11 on the left side and 47-58 on the right side). This species was also found in the adjacent section of the Danube (Oťaheľová et al. 2007). Since the inflow of the Patinský canal into the Danube (rkm 751.5) is in direction of the flow of the Danube downstream the detected site of the presence of *E. nuttallii*, one can assume that it spread into the Patinský canal from the Danube.

The main reasons for the longitudinal zonation of the aquatic flora in the Patinský canal seem to be:

– *Gradient of gradually increasing size the channel-bed and water depth along the channel*. The similarity of species composition of samples and the impact of these environment characteristics to vegetation in the canal illustrate the plots of the direct gradient analysis CCA (Fig. 8.).

– *Major tributaries* (Zámocký canal, Hurbanovský canal) (Fig. 1.). In their inflows occur an accumulation of sediments and reduced water depth. Such way both tributaries may by interrupting the gradient of one of the factors examined, the water depth, indirectly affect the zonation of vegetation. We did not investigate whether sediment thickness directly correlates to the composition of vegetation. Hurbanovský canal affects directly the aquatic flora of the Patinský canal, by its different species composition of macrophytic flora in the last sections, the lower flow (Dorotovičová & Oťaheľová 2008). Another tributary in the lower stream, Ižiansky canal (Fig. 1.) has minor impact on the Patinský canal, possibly due to similar composition of vegetation in the final parts (Dorotovičová, 2005).

– *Built objects* (lock in function, a large double-bridge; Fig. 1.). In the area of these larger objects due to surface modifications and reinforcements of channel-bed lowering of the water level and narrowing of the channel-bed occurred, which probably influenced composition and structure of aquatic vegetation.

Locally changed banks (concrete reinforcement) and shielding in places of smaller bridges and locks caused only local differences in the composition of vegetation, as demonstrated in the case of the other canal (Dorotovičová 2005), but the continuity of individual zones was probably not influenced.

Conclusion

During the mapping of diversity and distribution of aquatic macrophytes in the Patinský canal we found 16 hydrophytic taxa, 10 amfiphytes, 33 helophytes, and non-specified fibrous algae. The most widespread hydrophytes were *Ceratophyllum demersum* and helophytes *Phragmites australis* and *Carex acuta*. Neophyte *Elodea nuttallii* is also growing there. Nine species, *Berula erecta, Butomus umbellatus, Najas marina, Nuphar lutea, Nymphaea alba, Potamogeton perfoliatus, Salvinia natans, Utricularia vulgaris*, and *Sagittaria sagittifolia* belong to endangered species.

The main impact of the longitudinal zonation of vegetation in the canal had gradient of gradually increasing width of the channel-bed and depth of the water, and changes in this gradient caused by impact of tributaries (Zámocký canal and Hurbanovský canal) and by built structures on the channel (bridge, lock). Environmental variables, channel-bed width and water depth, explain 18.9% of the total variability of the floristic composition of vegetation.

Acknowledgements

The contribution has been prepared in international project MIDCC (No bwkGZ 45.512/1-VI/B/7a (VIII/B/8a) / 2001) under the auspices of the University of Vienna and supported by grants VEGA 5083. I am grateful to Dr. Helena Oťaheľová for valuable advices to my work and to my husband, Dr. Ivan Dorotovič that he had accompanied me and assisted me in field work.

References

DOROTOVIČOVÁ, CS., 2005: The aquatic macrophytes of the Ižiansky kanál canal near the town Komárno (South Slovakia). *Acta Rer. Natur. Mus. Nat.*, Bratislava. 51: 30-39.

DOROTOVIČOVÁ, CS., 2009: Výskyt vodných makrofytov v ľudskou činnosťou vytvorených alebo zmenených vodných tokoch južného Slovenska. *Bull. Slov. Bot. Spoločn.*, Bratislava. 31/1:11-20.
DOROTOVIČOVÁ, CS., OŤAHEĽOVÁ, H., 2008: The influence of anthropogenic factors on the structure of aquatic vegetation in the Hurbanovský canal (South Slovakia). *Arch. Hydr. Suppl.* 162(1-2).,*Large Rivers* 18(1-2): 81-90.
FERÁKOVÁ, V., MAGLOCKÝ, Š., MARHOLD, K., 2001: Červený zoznam papraďorastov a semenných rastlín Slovenska. In Baláž, D., Marhold, K. & Urban, P. (Eds). Červený zoznam rastlín a živočíchov Slovenska. *Ochr. Prír.*, 20 Suppl.: 48-81.
GERM, M., DOLINŠEK, M., GABERŠČIK, A., 2003: Macrophytes of the River Ižica - comparison of species composition and abundance in the year 1996 and 2000. In Janauer, G. A. Hale, P. & Sweeting, R. (Eds). Macrophyte inventory of the River Danube: A pilot study. *Arch. Hydrobiol. Suppl.* 147 (1-2), *Large Rivers* 14 (1-2): 181-193.
HRIVNÁK, R., VALACHOVIČ, M. & RIPKA, J., 2003: Relation between macrophyte vegetation and environmental conditions in the Ipeľ River (Slovakia) – case study. In: Janauer, G.A., Hale, P., Sweeting, R. (eds.), Macrophyte inventory of the river Danube: A pilot study. *Arch. Hydr. Suppl.*, 147(1-2), *Large Rivers* 14 (1-2): 117–127.
HRIVNÁK, R., OŤAHEĽOVÁ, H., VALACHOVIČ, M., 2007: The relationship between macrophyte vegetation and habitat factors along a middle-size European river. *Pol. J. Ecol.*, 55: 717–729.
JANAUER, G. A,. WYCHERA, U., 2000:. Biodiversity, succession and the functional role of macrophytes in the New Danube (Vienna, Austria). *Arch. Hydrobiol. Suppl.* 135 / 1, *Large Rivers* 12 (1): 61-74.
JANAUER, G. A., 2003: Methods. In Janauer, G. A. Hale, P., Sweeting, R. (Eds). Macrophyte inventory of the River Danube: A pilot study. *Arch. Hydrobiol. Suppl.* 147 (1-2), *Large Rivers* 14 (1-2): 9-17.
JANAUER, G. A. VUKOV, D., IGIC, R., 2003: Aquatic macrophytes of the Danube River near Novi Sad (Yugoslavia, river-km 1255-1260). In Janauer, G. A. Hale, P. & Sweeting, R. (Eds). Macrophyte inventory of the River Danube: A pilot study. *Arch. Hydrobiol. Suppl.* 147 (1-2), *Large Rivers* 14 (1-2): 195-203.
JANAUER, G. A., ZOUFAL, R., CHRISTOPF-DIRRY, P. & ENGLMAIER, P., 1993: Neue Aspekte der Charakterisierung und vergleichenden Beurteilung der Gewasservegetation. Ber. Inst. Landschafts- Pflanzenökologie Univ. Hohenheim. 2: 59–70.
JANAUER, G. A., EXLER, N., 2004: Distribution and habitat conditions of the six most frequent hydrophytes in the Danube River corridor: status 2002 *Limnological Reports* 35: 407-411.
JURSA M. OŤAHEĽOVÁ H., 2005: The distribution of aquatic macrophytes in man-modified waterbodies of the Danube river in Bratislava region (Slovakia). Ecology (Bratislava) 24 / 4: 368-384.
KOHLER, A., 1978: Kartierung methoden der von Flora und Vegetation von Süßwasserbiotopen. Landschaft + Stadt 10: .23-85.
KOHLER, A. JANAUER G. A., 1995: Zur Methodik der Untersuchung von aquatischen Makrophyten in Fließgewässern. In Steinberg, C., Berndhardt, H. & Klapper, H. (Hrsg.). Handbuch Angewandte Limnology. VIII-1.1.3. Ecomed-Verlag. p. 1 - 22
KOHLER, A., SONNTAG, E., ENCODER, M., PALL, K., VEIT, U., ZELTNER, G. H. JANAUER G. A., 2003: Macrophyte distribution in the River Vils (Oberpfalz, Bavaria). *Arch. Hydrobiol. Suppl.* 147 (1-2), *Large Rivers* 14 (1-2): 33-53.
KUHAR, U., ŠRAJ-KRŽIČ, N., GERM, M., URBANC-BERČIČ, O., GABERŠČIK, A., 2006: Quality of aquatic environment and macrophytes in Slovenian Watercourses Introduction Material and Methods. In Proceedings 36th International Conferen-

ce of IAD. Austrian Committee DanubeResearch / IAD, Vienna. ISBN 13: 978-3-9500723-2-7. p. 96-100.
MIKLÓS L., HRNČIAROVÁ T., (Eds) 2002: Landscape Atlas of the Slovak Republic, Ministry of Environment, Bratislava & Slovak Environmental Agency, Banská Bystrica. 344 pp.
PALL, K. & JANAUER, G.-A., 1995: Die Makrophyten-Vegetation von Flusstauen am Beispiel der Donau zwischen Fluss-km 2552,0 und 2511,8 in der Bundesrepublik Deutschland. Arch. Hydrobiol. Suppl. 101, Large Rivers. 9/2: 91–109.
PALL, K., RATH, B. JANAUER G. A., 1996: Die dynamischen und Makrophyten in the small abgedämmten Gewässersystem Schüttinsel (Donau Fluss-km-1948 bis 1806) in Hungary. Limnologica 26: 105-115.
OŤAHEĽOVÁ, H., 1995: Potametea. In Valachovič, M. (ed.). Plant communities of Slovakia I. Break new ground vegetation. Science, Bratislava. p.153-179.
OŤAHEĽOVÁ, H., BANÁSOVÁ, V., 2005: The response of aquatic macrophytes to restoration management in the Morava river oxbows. *Biológia* (Bratislava). 60: 403-408.
OŤAHEĽOVÁ, H., VALACHOVIČ, M., 2003: Distribution of macrophytes in different water-bodies (habitats) influenced by the Gabčíkovo hydropower station (Slovakia) - present status. In Janauer, G. A. Hale, P. & Sweeting, R. (Eds). Macrophyte inventory of the River Danube: A pilot study. *Arch. Hydrobiol. Suppl*. 147 (1-2), *Large Rivers*. 14 (1-2): 97-115.
OŤAHEĽOVÁ, H., VALACHOVIČ, M., 2006: Diversity of macrophytes in aquatic habitats of the Danube River (Bratislava region, Slovakia). *Thaiszia - J. Bot*. 16: 27-40.
OŤAHEĽOVÁ H., OŤAHEĽ J., 2006: Distribution of aquatic macrophytes in pit lakes in relation to the environment (Borská nížina lowland, Slovakia. *Ecology* (Bratislava). 25 / 4: 398-411.
OŤAHEĽOVÁ H., VALACHOVIČ, M., HRIVNÁK, R., 2007: The impact of environmental factors on the distribution pattern of aquatic plants along the Danube River corridor (Slovakia). *Limnologica*. 37: 290-302.
RÁTH, B., JANAUER, G. A., PALL, K., BERCZIK, A., 2003: The aquatic macrophyte vegetation in the Old Danube / Hungarian bank, and other water bodies of the Szigetköz wetlands. *Arch. Hydrobiol. Suppl*. 147 (1-2), *Large Rivers*. 14 (1-2): 129-142.
SARBU, A., 2003: Inventory of aquatic plants in the Danube Delta: A pilot study in Romania. ¬ In Janauer, G. A. Hale, P., Sweeting, R. (Eds). Macrophyte inventory of the River Danube: A pilot study. *Arch. Hydrobiol. Suppl*. 147 (1-2), *Large Rivers*. 14 (1-2): 205-216.
SIPOS, V. K. KOHLER, A., KÖDER, M., JANAUER, G. A., 2003: Macrophyte vegetation of the Danube channels in Kiskunság (Hungary). Arch. Hydrobiol. Suppl. 147 (1-2), Large Rivers. 14 (1-2): 143-166.
TER BRAAK, C. J. F. ŠMILAUER P., 2002: CANOCO Reference Manual and Cano Draw for Windows-User's Guide Software for Canonical Community Ordination (Version 4.5) Microcomputer Power, Ithaca, NY.

Author’s address:
PaedDr. Csilla Dorotovičová, Danube Region Museum, Palatinova 13, 945 01 Komárno, Slovakia;
e-mail: dorotovicova@gmail.com, csilla.dorotovicova@muzeumkn.sk