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DISTRIBUTION PATTERNS OF THREE *POTAMOGETON* SPECIES (*P. CRISPUS*, *P. NODOSUS* AND *P. PECTINATUS*) ALONG VELOCITY AND BASE RICHNESS GRADIENTS FROM A LOWLAND RIVER

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ABSTRACT. This study presents distribution and abundance of three *Potamogeton* species, namely *Potamogeton crispus*, *P. nodosus* and *P. pectinatus* along environmental gradients in the lowland river Wełna (NW Poland). The relationships between 13 environmental factors and the pattern aquatic vegetation distribution along river were investigated. Among ecological factors rarely undertaken in aquatic ecology the light climate was concerned. It is postulated that the *Potamogeton* communities in the investigated river are strongly connected with water velocity, substrate of bottom and light conditions, in particular dissolved organic matter (DOM). *Elodeo-Potametum crispi* and algae communities with dominant species *Hildenbrandia rivularis* were well developed in the places shading by trees, with high velocity and fairly clean water, mostly with stony bottom. *Potametum nodosi* was noted in mean values of velocity and medium water quality with high content of organic matter in the bottom substrate. The last investigated community *Sparganio-Potametum interrupti* was found in poor water quality with the highest values of electric conductivity. The obtained results give a new approach of the ecology and abiotic typology of rivers with macrophytes including abundance of *Potamogeton* species (Nature 2000 habitat, code 3260 – "Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation").

KEY WORDS: ecology, distribution pattern, *Potamogeton*, gradients, river, environment, Natura 2000

INTRODUCTION

Potamogeton genus is represented by hydrophytes occurring in a wide range of diverse habitats from standing to fast flowing waters. They could be found in natural oligo-mesotrophic conditions as well as on hydromorphologically disturbed places with high water eutrophy level (e.g. Kłosowski and Tomaszewicz 1986, 1996, Kłosowski 1992, Szańkowski and Kłosowski 1999, Kaplan 2002, Jian et al. 2003, Kłosowski 2006, Chmara and Bociąg 2007, Ceschin and Salerno 2008, Zalewska-Gałosz 2008, Zalewska-Gałosz et al. 2011). They show a high variability in the phenotype relative to the environmental conditions (Passarge 1992 a, b, Kaplan 2002, Zalewska-Gałosz et al. 2009). The majority of these macrophytes are aquatic perennial and they produce turions and numerous seeds (Jian et al. 2003, Zalewska-Gałosz 2008). In Poland 20 *Potamogeton* species and six hybrids occur among 80-90 species in total noted worldwide (Zalewska-Gałosz 2008, Zalewska-Gałosz et al. 2011). Most of *Potamogeton* species is freshwater, only a few of them can occur in marine waters e.g. *P. filiformis*, *P. pectinatus*, *P. perfoliatus* and *P. pusillus* (Zalewska-Gałosz 2008).

Aquatic vegetation communities with *Potamogeton* genus are concerned as significant component of biological structure of riverine habitats. In Polish lowland rivers distinguished by fast flow of water different species could be found of *Potamogeton* genus. However, the most frequent are *P. nodosus*, *P. berchtoldii*, *P. crispus*, *P. pectinatus* and *P. ×fluitans*, in less range *P. polygonyfolius*, *P. alpinus* and *P. pusillus* could be found (e.g. Tomaszewicz and Kłosowski 1985, Kłosowski 1992, Zalewska-Gałosz 2008, Szoszkiewicz et al. 2010, Kowalski and Wróbel 2011, Zalewska-Gałosz et al. 2011). In fluvial ecosystem, the investigated *P. crispus*, *P. nodosus* and *P. pectinatus* are concerned as characteristic for impoverished type of *Ranunculion fluitantis* rivers and represent the habitat Nature 2000 – "Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation" (code 3260) (Council Directive 92/43/EEC, Annex I, II: Interpretation Mannual – EUR25). The mentioned above vascular plants are also used in quality assessments of rivers in many European countries, according to the Water Framework Directive (Directive 2000/60/EC).

The environmental requirements of *Potamogeton* communities occurring in water course have been still poorly investigated compared to standing waters. Previous studies of parameters determining the distribution of *Potamogeton* were just related to one species of this genus e.g. *P. crispus* (Sabbatini and Murphy 1994, Foley 1997, Jian et al. 2003), *P. nodosus* (Pujol et al. 2010, Kowalski and Wróbel 2011) and *P. pectinatus*

(Spencer 1987, van Dijk and Janse 1993, LaMontagne et al. 2003) or were concerned general studies of aquatic vegetation (Oberdorfer 1957, Pott 1992, Baatrup-Pedersen et al. 2002). This is the first study to attempt to determine the effect of environmental factors on the distribution pattern of three *Potamogeton* species and co-occurring plants (mosses, macroscopic algae, vascular plants) in one lowland river. The present publication answers the following questions:

– What is the main ecological factor responsible for the distribution and abundance of *Potamogeton* species?
– What is the species composition of vegetation patches?

METHODS

Study area

The study area was the Wełna river, being right tributary of the Warta river (NW Poland). The field study was performed along 30 km distance of the Wełna river. This lowland, naturally meandering river flows through the feeding system of eight eutrophic lakes. The total length of the river is 117.8 km. The study was conducted during one vegetation period (June-September 2012) (Fig. 1).

Field sampling and laboratory analyses

In all 52 research vegetation plots (each 16 m^2) containing particular of *P. crispus*, *P. nodosus* and *P. pectinatus* or each altogether species at the same vegetation plot the physical and chemical parameters of the water as well as hydrological factors were analysed (Phot. 1-6). The following parameters were measured in situ: temperature (Temp), pH, electric conductivity (EC), dissolved oxygen (DO). In each plot, water velocity was measured at the surface layer (0.1 m) among the plants using a hydrometric universal current meter. The depth at the sites of *Potamogeton* species was measured in centimetres. The width of the channel (Width) in each of the study plots was measured using a laser rangefinder (type Hilti PD40). The percentage shading by trees (Tree) and the stones percentage coverage by mosses and algae (Stones) was also noted.

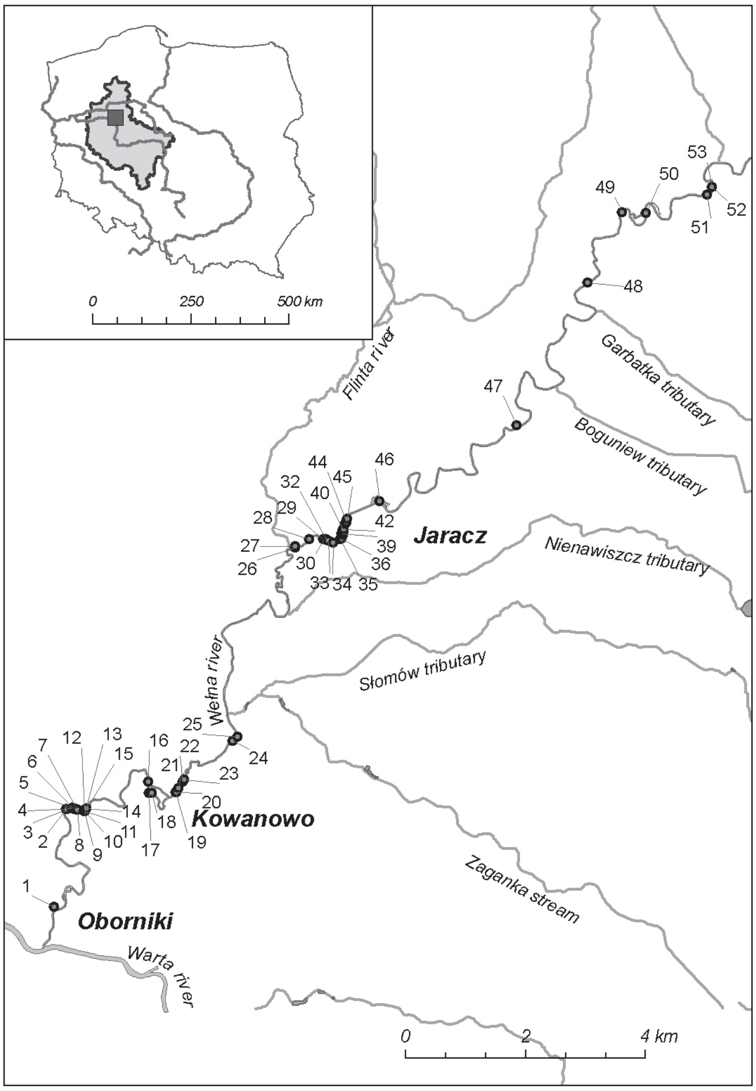
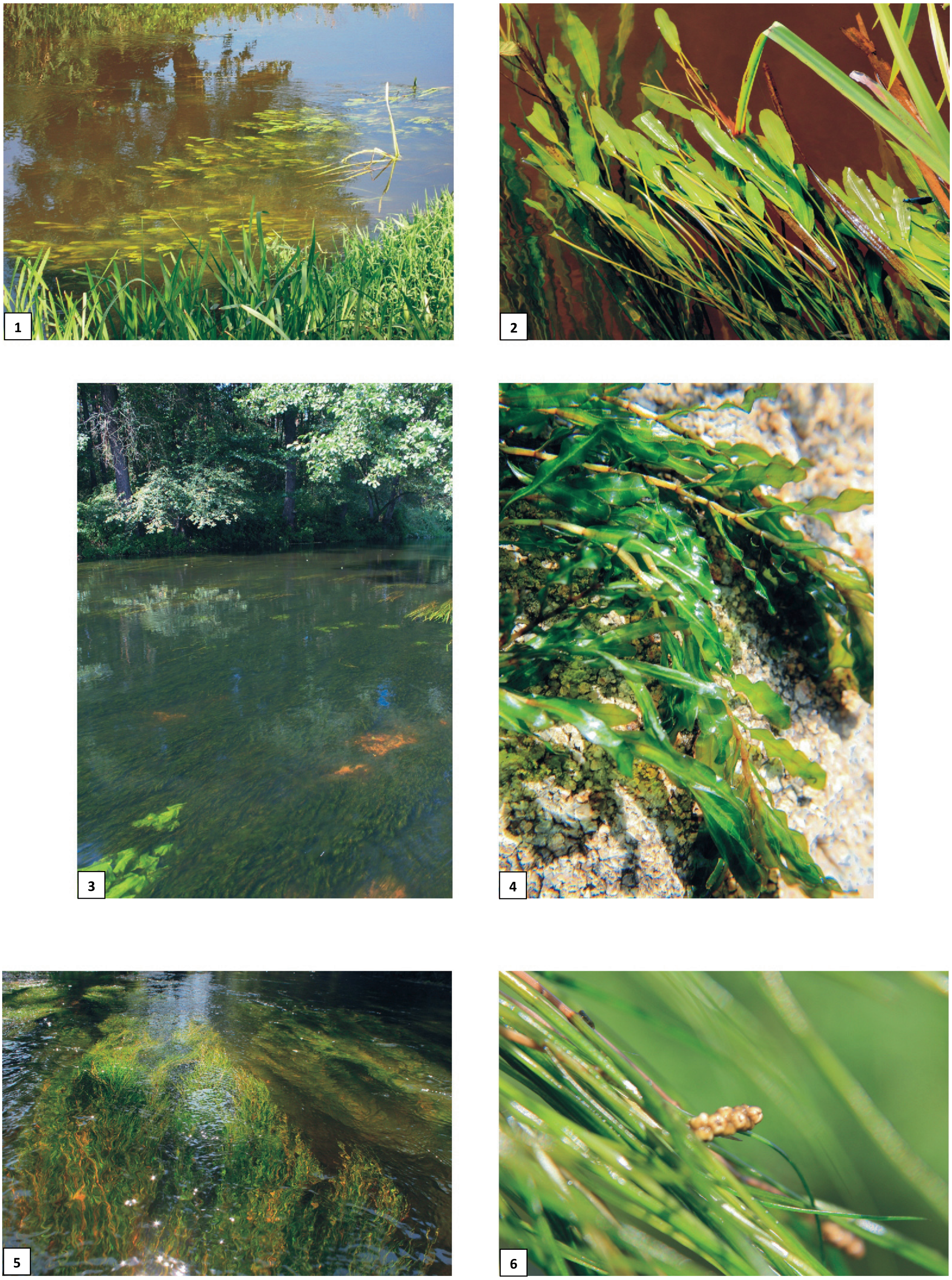


Fig. 1. Location of the Wełna river with the distribution of the *Potamogeton* species stands



PHOT. 1-6. *Potamogeton* species and their communities in the Wełna river: 1-2 – *Potamogeton nodosus*, 3-4 – *Potamogeton crispus*, 5-6 – *Potamogeton pectinatus* (Phot. 1 – M. Gąbka, Phot. 2-6 – E. Jakubas)

Standard measurements for the following characteristics were made at each site: forms of dissolved organic matter (DOM 254 nm) were measured spectrophotometrically using a Cadas 200 UV-VIS (Dr Lange) spectrophotomether, with 5 cm quartz cell on filtrate (after filtration through 0.45 µm membrane filter, converted into the m^{-1}).

In each of the vegetation plots, the bottom samples were collected using a core cutting sampler, which was divided into layers (5 cm). The content of organic matter (OM) was measured with weight method after sample combustion at 550°C and hydration (H) was analysed after drying of sample in 150°C to a content weight.

Physical and chemical analyses were performed according to the standard methods for hydrochemical analyses (APHA 1998). Water samples for spectrophotometrical analysis (inherent colour and organic matter forms) and dissolved organic carbon were filtered through 0.45 µm membrane filters.

Numerical analyses

Statistical analyses were performed by using CANOCO software (ter Braak and Šmilauer 2002). The CCA (canonical correspondence analysis) to explore the relations between the species distribution and environmental variables was used (ter Braak and Šmilauer 2002).

Furthermore in Monte Carlo permutation test (with 999 permutations made to reduce the number of variables) velocity of water, substrate and light conditions reflected by dissolved organic matter were statistically significant ($P < 0.05$).

The assessment of environmental data in bioindication was made by using software C2 (Juggins 2003) including model weighted averaging (WA). This enabled to determine optima (weighted-average) and tolerance range (SD) of species in relation to environmental parameters.

Nomenclature

Names of syntax are according to treatise of Mirek et al. (2002), mosses of Ochyra et al. (2003) and algae of Algaebase.org. Names of vegetation compositions are according to Ratyńska et al. (2010) including study of Passarge (1992 a, b, 1996).

RESULTS

Species richness

Aquatic vegetation surveys including performance of species composition and their cover in the channel showed floristic communities among the study sites (52 vegetation plots). The macrophyte composition of 52 vegetation plots contains: three species of algae, two mosses and 23 vascular plants including *P. crispus*, *P. nodosus* and *P. pectinatus*. Abundance according to Van der Maarel scale (1979) and frequency of occurrence under study are presented in Table 1. The analysed plots were quite rich in species. Among algae, the most often *Hildenbrandia rivularis* occurred, among mosses *Fontinalis antypyretica* and vascular plants were mainly represented by *Sagittaria sagittifolia* (submerged form) and *Nuphar lutea* (submerged form). In *Potamogeton* genus *P. nodosus* (28 stands), *P. crispus* (22 stands) and *P. pectinatus* (20 stands) dominated respectively.

The *Potamogeton nodosus* association (*Potametum nodosi* Segal (1964) 1965) composition was distinguished by vascular plants mostly by *S. sagittifolia* (submerged and emergent form) and *N. lutea* (submerged form). In this case pleustophytes occurred in smaller range and no species of grasses were found. The vegetation compositions of *Potamogeton crispus* (*Elodeo-Potametum crispi* (Pignatti 1953) Pass. 1994) was dominated by macrophytes preferring fast flow of water and stones as substrate of bottom e.g. algae such as *Hildenbrandia*

Table 1. Frequency and mean and max value of cover van der Maarel scale of *Potamogeton* species and other species in vegetation samples (n = 52)

	Species	Symbol	I	II	III
1	2	3	4	5	6
Algae	*Hildenbrandia rivularis*	*Hilriv*	21.43 (1-6)	59.09 (3.36-7)	35.00 (1.95-7)
	Heribaudiella fluviatilis	*Herflu*	7.14 (0.46-7)	22.73 (1.50-7)	15.00 (0.80-7)
	Rhizoclonium sp.	*Rhizsp*	3.57 (0.21-6)	4.55 (0.18-4)	–
Mosess	*Fontinalis antypyretica*	*Fonant*	21.43 (1.07-7)	86.36 (3.96-8)	40.00 (1.75-7)
	Leptodictum riparium	*Leprip*	21.43 (1.00-6)	59.09 (3.14-8)	35.00 (1.55-6)
Vascular plants	***Potamogeton nodosus***	***Potnod***	**100 (6.14-9)**	**13.64 (0,82-8)**	**45.00 (3.30-9)**
	Potamogeton crispus	***Potcri***	**10.71 (0.57-7)**	**100 (4.82-9)**	**35.00 (2.00-7)**
	Potamogeton pectinatus	***Potpec***	**32.14 (2.07-9)**	**31.82 (1.82-7)**	**100 (6.15-9)**
	Sagittaria sagittifolia	*Sagsag*	39.29 (1.93-6)	77.27 (4.77-6)	45.00 (2.95-8)
	Nuphar lutea	*Nuplut*	21.43 (1.07-8)	68.18 (4.45-9)	50.00 (3.40-9)
	Sparganium emersum	*Spaeme*	10.71 (0.71-7)	22.73 (1.27-7)	10.00 (0.65-7)

TABLE 1 – cont.

1	2	3	4	5	6
	Lemna trisulca	*Lemtri*	3.57 (0.11-3)	18.18 (0.55-3)	–
	Schoenoplectus lacustris	*Scilac*	10.71 (0.57-7)	13.64 (0.41-3)	10.00 (0.30-3)
	Sparganium erectum	*Spaere*	3.67 (0.21-6)	13.64 (0.55-4)	20.00 (1.05-6)
	Myriophyllum spicatum	*Myrspi*	14.29 (0.96-9)	9.09 (0.64-7)	10.00 (0.70-7)
	Spirodella polyrhiza	*Spipol*	3.57 (0.11-3)	9.09 (0.32-4)	15.00 (0.50-4)
	Rorippa amphibia	*Roramp*	–	9.09 (0.27-3)	5.00 (0.20-4)
	Butumus umbellatus	*Butumb*	10.71 (0.50-5)	4.55 (0.18-4)	5.00 (0.2-4)
	Veronica anagalis-aquatica	*Verana*	3.57 (0.14-4)	4.55 (0.18-4)	–
	Lemna gibba	*Lemgib*	3.57 (0.18-5)	4.55 (0.18-4)	10.00 (0.45-6)
	Berula erecta	*Berer*	3.57 (0.18-5)	4.55 (0.14-3)	5.00 (0.25-5)
	Hydrocharis morsus-ranae	*Hydmor*	–	4.55 (0.18-4)	5.00 (0.30-6)
	Elodea canadensis	*Elocan*	–	4.55 (0.18-4)	–
	Ceratophyllum demersum	*Cerdem*	–	4.55 (0.32-7)	–
	Lemna minor	*Lemmin*	3.57 (0.18-5)	–	10.00 (0.40-5)
	Alisma plantago-aquatica	*Alipla*	3.57 (0.11-3)	–	–
	Phalaris arundinacea	*Phaaru*	–	–	5.00 (0.20-4)
	Phragmites australis	*Phraus*	–	–	5.00 (0.20-4)

Abbreviation: I – *P. nodosus* (28 stands), II – *P. crispus* (22 stands) and III – *P. pectinatus* (20 stands).

TABLE 2. Summary of water chemistry collected within 52 stands of *Potamogeton* species

Property	Abbreviation	Mean	Min	Max
Physicochemical indicators of water and substrate				
Temperature (°C)	Temp	17.70	23.00	20.90
pH	pH	7.18	8.03	7.71
Conductivity ($\mu S \cdot cm^{-1}$)	EC	601.00	848.00	665.33
O_2 dissolved ($mg \cdot O_2\ l^{-1}$)	DO	3.84	28.50	7.62
Dissolved organic matter (m^{-1})	DOM	27.96	38.14	32.45
Organic matter (%)	OM	1.72	0.17	21.59
Hydration (%)	H	16.98	8.24	65.21
Stones as bottom substrate covered by mosses and algae (%)	Stones	0.00	100.00	23.77
Shaded by tree (%)	Tree	0.00	100.00	27.50
Hydrological indicators of water				
Surface velocity of water ($m \cdot s^{-1}$)	H_surf	0.00	1.51	0.51
Velocity of water in plants ($m \cdot s^{-1}$)	H_veg	0.00	1.24	0.39
Hydrological indicators of river				
Depth of water (m)	Deep	0.13	1.25	0.57
Width (m)	Width	4.12	29.99	15.47

rivularis and mosses like *Fontinalis antypyretica*. For this association any species of grasses were not also noted. The floristic community of *Potamogeton pectinatus* (*Sparganio-Potametum interrupti* (Hilbig 1971) Weber 1976) consisted mostly of *N. lutea* (submerged form) and *Fontinalis antypyretica*.

Only in three of 52 investigated vegetation plots above-mentioned *Potamogeton* species occurred altogether in following system *Potamogeton crispus-nodosus-pectinatus*, whereas in seven stands occurred two among three species. They created two different systems: 1) *Potamogeton nodosus-pectinatus* and 2) *Potamogeton crispus-pectinatus*. Nevertheless *P. nodosus* and *P. crispus* have never been presented in one individual composition. *Potamogeton nodosus* occurred alone or in the whole group of *Potamogeton* species.

Environmental factors

The *Potamogeton* species were found in the river section where the width of the river channel was 4.12--29.99 m, at 0.13-1.25 m depth. The surface velocity values of water ranged 0-1.51 m·s^{-1} and water velocity among plants was always smaller 0-1.24 m·s^{-1}. *Potamogeton* species preferred warm 17.70-23.00°C and alkaline water in the range 7.18-8.03 pH. These vascular plants occurred in quite high values of light conditions e.g. dissolved organic matter was 27.97-38.14 m. In the vegetation plots substrate of bottom was mostly with low content of organic matter. These data are presented in Table 2.

Potamogeton species along environmental gradients

The used biplots of canonical analysis (CCA; Fig. 2) showed distribution pattern of aquatic vegetation in relation to environmental gradients. The occurrence of *Potamogeton nodosus* which was the most common species among all *Potamogeton* genus in the Wełna river was strongly connected with light parameters such as dissolved organic matter (DOM), *Potamogeton crispus* with strong water velocity in shallow, stony places and the abundance of *Potamogeton pectinatus* was associated with higher electric conductivity.

The optimum and tolerance of particular *Potamogeton* species compared to selected environmental factors are presented in Table 3. In particular, *Elodeo-Potametum crispi* and algae communities with *Hildenbrandia rivularis* were developed in high velocity and clean water, in shady places and stones as substrate of bottom. *Potametum nodosi* was noted in mean values of water velocity with high content of organic matter in substrate. The last investigated community *Potametum pectinati* was found in water of poor quality with the highest values of electric conductivity.

It seems that *Potamogeton nodosus* showed the most flexible compared to shading by trees while *P. pectinatus*

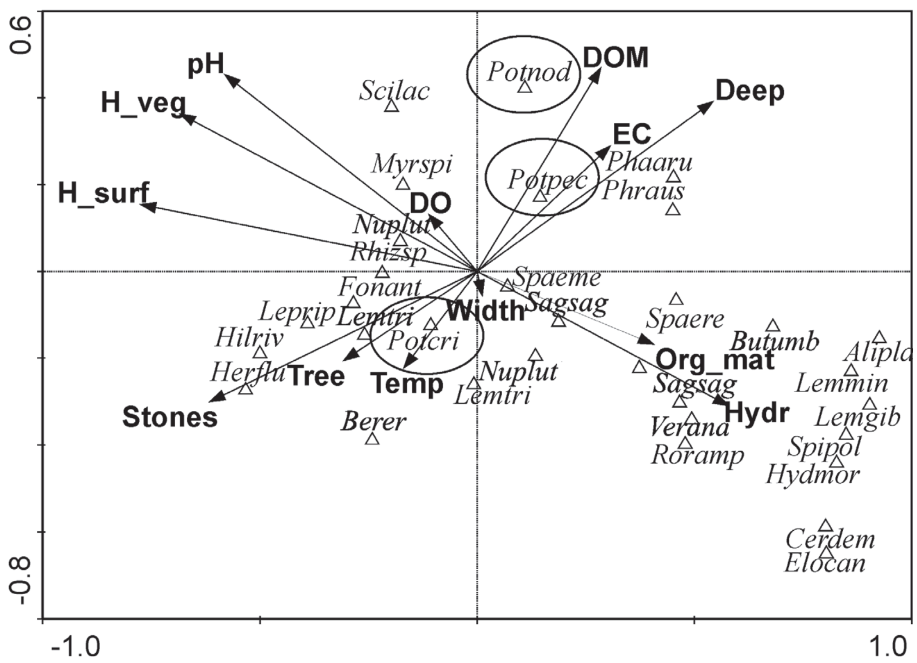


FIG. 2. Biplots of canonical analysis (CCA) for species. *Hildenbrandiarivularis – Hilriv, Heribaudiellafluviatilis – Herflu, Rhizoclonium* sp. *– Rhizsp, Fontinalisantypyretica – Fonant, Leptodictumriparium – Leprip, Sagittariasagittifolia – Sagsag, Nupharlutea – Nuplut, Potamogetonnodosus – Potnod, Potamogetoncrispus – Potcri, Potamogetonpectinatus – Potpec, Sparganiumemersum – Spaeme, Sparganiumerectum – Spaere, Scirpuslacustris – Scilac, Spirodellapolyrhiza – Spipol, Veronica anagalis – aquatica – Verana, Lemnatrisulca – Lemtri, Lemnagibba – Lemgib, Myriophyllumspicatum – Myrspi, Berulaerecta – Berer, Butumusumbellatus – Butumb, Rorippaamphibia – Roramp, Lemna minor – Lemmin, Hydrocharismorsus – ranae – Hydmor, Lemnatrisulca – Lemtri, Alismaplantago – aquatica – Alipla, Elodea canadensis – Elocan, Ceratophyllumdemersum – Cerdem, Phalarisarundinacea – Phaaru, Phragmites australis – Phraus.*

TABLE 3. Optimum tolerance of particular *Potamogeton* species compared to 13 studied environmental parameters

Parameter	I	II	III
Shaded by tree (%)	5.03 (10.94)	2.40 (7.68)	3.58 (6.25)
Stones as bottom substrate covered by mosses and algae (%)	2.63 (6.50)	26.15 (9.68)	4.83 (10.32)
Conductivity ($\mu S \cdot cm^{-1}$)	660 (46.96)	609 (0.66)	660 (34.50)
Dissolved organic matter (m^{-1})	34.06 (3.39)	30.46 (0.58)	34.30 (2.79)
Surface water velocity ($m \cdot s^{-1}$)	0.47 (0.22)	0.62 (0.34)	0.59 (0.26)
Velocity of water in plants ($m \cdot s^{-1}$)	0.41 (0.18)	0.54 (0.29)	0.47 (0.19)
Depth of water (m)	0.72 (0.24)	0.32 (0.20)	0.58 (0.16)
Width (m)	15.87 (5.60)	23.91 (0.30)	18.98 (4.83)
pH	7.84 (0.14)	8.01 (0.02)	7.78 (0.21)
Temperature (°C)	20.22 (1.83)	22.48 (0.12)	20.15 (2.04)
O_2 dissolved ($mg \cdot O_2\ l^{-1}$)	7.15 (3.46)	7.76 (0.26)	6.47 (1.43)
Hydration (%)	16.32 (5.86)	14.00 (1.56)	15.24 (5.14)
Organic matter (%)	1.89 (3.41)	1.06 (2.08)	1.04 (1.20)

Abbreviation: I – *P. nodosus* (28 stands), II – *P. crispus* (22 stands) and III – *P. pectinatus* (20 stands).

the lowest. As for factors such as width of channel and depth of water the highest tolerance had also *P. nodosus*. *Potamogeton crispus* preferred places the hardest overgrown by mosses and algae contraire to *P. nodosus*. However, *P. crispus* had the narrowest tolerance of conductivity and pH gradient and this species could be very sensitive to change of these parameters (Table 3).

DISCUSSION

Species composition

Our study in the lowland river ecosystem revealed that investigated *Potamogeton* species such as *P. nodosus*, *P. crispus*, and *P. pectinatus* belong to the species inhabiting the river current, where mean velocity of water was 0.51 $m \cdot s^{-1}$. These vascular plants, mainly *P. nodosus* are believed as characteristic for running waters (e.g. GOLUB et AL. 1991, PASSARGE 1996, ZALEWSKA-GAŁOSZ 2008, KOWALSKI and WRÓBEL 2011). Nevertheless, it should be noted that all of them commonly occur also in lakes and ponds (KŁOSOWSKI 1992, 2006, SZAŃKOWSKI and KŁOSOWSKI 1999, JIAN et AL. 2003, CHMARA and BOCIĄG 2007, ZALEWSKA-GAŁOSZ 2008). The vegetation analysis showed that *P. nodosus* and *P. pectinatus* were closer together and occurred among vascular plants such as *Schoenoplectus lacustris*, *Myriophylllum spicatum* and *Nuphar lutea*, while *P. crispus* was located further, among macrophytes preferring high water velocity such as *Hildenbrandia rivularis* and mosses such as *Fontinalis antypyretica* and *Leptodictyum riparium*. Previous literature on vegetation communities in watercourse indicated that same of *Potamogeton* species like *P. nodosus* is a characteristic of patches of *Potametum nodosi* or *Ranuculetum fluitantis* habitat with plant communities of pleustophytes e.g. *Lemnetum gibbae* Miy. et J. Tx. 1960 (KOWALSKI and WRÓBEL 2011). This association of *Potametum nodosi* has been categorised in Poland as very rare and endangered (RATYŃSKA et AL. 2010). However, in the Wełna river *Lemna trisulca* occurred in fast flow water as submerged form and it was strongly adhered to stones, which substrate of bottom was overgrown in this case by *P. crispus*. These species of *Potamogeton* are typical of *Lemnetum* communities and were noted previously (OBERDORFER 1957, GOLUB et AL. 1991).

Furthermore, the species structure analysis together with CCA explains that *P. nodosus* and *P. crispus* have never created common composition, therefore they are isolated from each other and prefer different environmental conditions. That *P. crispus* could be able to form communities corresponding to *Elodeo-Potametum crispi* has been well known from many lowland rivers in Europe (e.g. PASSARGE 1996, FOLEY 1997, JIAN et AL. 2003, CESCHIN and SALERNO 2008).

According to earlier studies of aquatic vegetation the floristic lists of *Potamogeton* communities including *P. gramineus*, *P. lucens*, *P. perfoliatus*, *P. natans*, *P. pusillus* and other vascular plants such as *Myriophyllum spicatum*, *M. verticillatum*, *Ceratophyllum demersum* and *Elodea canadensis* (OBERDORFER 1957, GOLUB et AL. 1991, POTT 1992). These mentioned, co-occuring vascular plants could be considered as a constant for *Potamogeton* communities. Some of them e.g. *Myriophyllum spicatum, Ceratophyllum demersum* and *Elodea canadensis* were also rarely noted in the Wełna river.

The communities of *P. pectinatus* created simple, underwater meadows while *P. crispus* and *P. nodosus* occurred in richer species compositions.

Ecological parameters

Our results from the Wełna river suggest that distribution pattern of three *Potamogeton* species, *P. nodosus*, *P. crispus*, and *P. pectinatus* is distinctly connected with water quality and velocity as well as type of bottom (stones) and light conditions. *Potamogeton nodosus* and *P. pectinatus* were found in conditions of higher values of dissolved organic matter (DOM). The significance of light availability e.g. on turion germination was concerned in previous literature compared to *P. crispus* (Jian et al. 2003). Moreover, the experiment of resource allocation for long term survival of *P. pectinatus* has been made. This allocation model emphasized the importance of light conditions in biomass development of *P. pectinatus* (Van Dijk and Janse 1993). Nevertheless, another study indicated that *P. nodosus* prefers moderate light conditions (Zarzycki et al. 2002).

The CCA analysis (Fig. 2) revealed that occurrence of *P. crispus* is dependent on surface water velocity and water temperature. A number of studies confirmed that the ecological amplitude of *Potamogeton* genus is wide and could be associated with above mentioned factors such as light climate, temperature of water and pH gradient (Tomaszewicz and Kłosowski 1985, Kłosowski 2006, Ceschin and Salerno 2008, Zalewska-Gałosz 2008, Zalewska-Gałosz et al. 2010, Kowalski and Wróbel 2011).

However, the occurrence of *Potamogeton* species can be dependent on completely different factors e.g. LaMontagne et al. (2003) has studied impact of foraging by migrating trumpeter swans on tuber and rhizome density and biomass of *P. pectinatus* and co-occurring species compositions. Another study has reported that also planting depth influences growth of *P. pectinatus* (Spencer 1987). A detailed comparison of all three *Potamogeton* species enables to say that *P. nodosus* prefers the deepest water (optimum 0.72, tolerance 0.24), *P. pectinatus* can be found both in streams and river in shallower places (0.10-0.90 m) as well as in intermediate deep habitats in standing waters (1-2 m; Golub et al. 1991).

Furthermore, plant communities could be also dependent on stream and rivers management. The land-use of catchment and hydromorphological changes influence the occurrence of slow-growing species including *Potamogeton* species (Baattrup-Pedersen et al. 2002). In response to environmental conditions they show significant variable of plastic (Kaplan 2002, Zalewska-Gałosz 2008). For instance *P. nodosus* by its flexibility could be able to reduce the turbulent kinetic energy of vertical mixing (Pujol et al. 2010). From aquatic ecology point of view the really interesting is significance of communities with three investigated *Potamogeton* species in relation to the quality of water. Previous studies e.g. Ceschin and Salerno (2008) clearly indicated that *Potamogeton* genus show different requirements of the trophic level from mesotrophy (*P. crispus*), through eutrophy (*P. nodosus*) to hypertrophy (*P. pectinatus*) in rivers and streams. Our results revealed similar pattern of macrophytes compared to light conditions and base richness in the Wełna river. Hence, environmental data mostly physico-chemical parameters of water, could be useful in defining separateness plant communities in the lowland rivers.

Our results emphasize the significance of some *Potamogeton* species in the aquatic vegetation compositions of lowland rivers. The obtained results of the species structure and their habitats provide a new information of ecology of rivers and macrophytes compositions with *Potamogeton* species communities (Nature 2000 habitat, code 3260).

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