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Hydrobotanic characteristics of some peat-pits of the Polesie National Park with special emphasis on charophytes

Hydrobotaniczna charakterystyka wybranych torfianek Poleskiego Parku Narodowego ze szczególnym uwzględnieniem ramienic

SUMMARY

The investigations were carried out in four peat-pits located in the northwestern part of Bubnów Swamp, situated within the Polesie National Park. It is a fen created on chalk ground. The analysis of physicochemical factors of water and qualitative and quantitative analysis of macrophytes of the peat-pits were carried out in the vegetation season in 2008 and 2009. The aim of investigations was to determine the water habitat conditions and composition of plant associations especially charophytes in peat-pits of protected areas. In the investigated peat-pits there was a slight defferentiation of physical and chemical properties of water. The investigated peat-pits are naturally and floristically valuable hydrogenic ecosystems in various stages of succession. The peat-pits are characterized by occurrence of endangered species of charophytes: *Chara hispida* and *Chara intermedia*, as well as a protected species such as *Nymphaea candida* and *Chara globularus* as vulnerable species.

STRESZCZENIE

Badania prowadzono w czterech torfiankach, zlokalizowanych w północno-zachodniej części Bagna Bubnów, które znajduje się w granicach Poleskiego Parku Narodowego Jest to torfowisko niskie, wykształcone na podłożu kredowym. Badania właściwości fizyczno-chemicznych wody oraz struktury jakościowej i ilościowej makrofitów wybranych torfianek prowadzono w sezonie wegetacyjnym 2008 i 2009 roku. Celem badań była analiza warunków siedliskowych oraz struktury jakościowej makrofitów, szczególnie ramienic, torfianek położonych na terenie parku narodowego. Badane torfianki to cenne przyrodniczo i florystycznie ekosystemy hydrogeniczne, będące w różnym stadium sukcesyjnym. Były one nieznacznie zróżnicowane pod względem właściwości fizycznych

i chemicznych wody. Są one miejscem występowania wymierających gatunków ramienic: *Chara hispida* i *Chara intermediae* oraz chronionych gatunków takich jak *Nymphea candida* oraz *Chara globularis* jako gatunek narażony.

Key words: peat-pit, charophytes, macrophytes, Polesie National Park

INTRODUCTION

Charophytes (*Characeae*) are aquatic plants included among algae (chlorophytes). In Poland, there have already been found 34 of all 400 known species in the world. In Łęczna-Włodawa Lakeland 16 species of stoneworts were found (Karczmarz, Malicki 1971). In our environmental conditions *Characeae* occurred in various types of freshwater ecosystems, especially lakes, ponds, peat-pits, as well as dry lakes. The presence of charophytes is also noticed in salt water (the shore of the Baltic Sea) (Pełechaty, Pukacz 2008). Charophytes are considered as a pioneer stage in ecological succession of lakes (Gąbka 2006 a).

Water inhabited by charophytes has high calcium content with pH above 7. Such ecosystems are characterized by high mineralization of waters and oxygen concentration, as well as the low nitrogen and phosphorus content. In the eutrophic lakes charophytes occur in small areas. Their growth is limited by shortage of light and competition from the other species of aquatic macrophytes. In oligotrophic and mesotrophic lakes with high water transparency and calcium content, communities of *Characeae* form so-called "underwater meadows" (Piotrowicz 2004).

Charophytes play a very important role in the functioning of aquatic ecosystems. Their significance is greater in shallow lakes, unlike the deep ones, which are influenced by submerged macrophytes. As the autotrophs, they are able to compete with other producers (like e.g. other algae and cyanobacteria) for the light, nutrients, and carbon dioxide. They have ability to bind nutrients effectively, excluding them from circulation of matter for a long time. Charophytes may also restrict the availability of nutrients in the process of incrustation. At the same time phosphorus precipitation takes place. Charophytes also oxidize bottom water levels, take part in stabilization of bottom sediments and increase sedimentation. These processes improve the light conditions in the water as a result. *Characeae* may also serve as refuge for zooplankton. Refuges among plants may increase the density of their population and reduce phytoplankton abundance. Some species of charophytes demonstrate allelophatic ability. They secrete substances which inhibit the development of algae and planktonic cyanobacteria (Pełechaty, Gąbka 2006 a).

Despite widespread occurrence of some species, they usually have a narrow range of tolerance, especially to anthropogenic factors. Charophytes can be used as bioindicators. *Characeae* and some other submerged macrophytes may indicate increase in the concentration of nutrients by disappearance from the lake (especially in large lakes) (Pełechaty 2006).

Eutrophication is considered to be the greatest threat to communities of *Characeae* in Poland. The direct threats are fertilization of water for fish farming, nutrient supply, and inflow of humic substances from the catchment area. As the pioneer species, charophytes may disappear because of natural changes in tanks. Examples of these changes are: competition from other aquatic plants, overgrowing and shallowing of water ecosystems, limiting of the access of light (Piotrowicz 2004). As a result of their disappearance, *Characeae* communities are being entered to *The Red List of Endangered Algal Species in Poland* (Siemińska et al. 2006). Therefore, every locality of charophytes should be specially protected.

The aim of investigations was to determine the water habitat conditions and composition of plant associations, especially charophyte species in peat-pits of protected areas.

MATERIAL AND METHODS

The researches were carried out in Łęczna-Włodawa Lakeland. This is a flat terrain situated in central-eastern Poland, between the rivers Wieprz and Bug. The area is characterized by the presence of many lakes, mires and other types of wetlands (Harasimuk et al. 1998). The study area includes Bunbów Swamp and Staw Swamp reserves connected by a narrow passage of water. The investigations were carried out in 4 peat-pits located in the northwestern part of Bubnów Swamp. It is a fen created on chalk ground. The area of swamp (1 500 ha) is dominated by sedges, the east part is covered by reed (Piotrowska ed. 1988).

The Bubnów Swamp was included in the Polesie National Park in 1994 (Fig.1), in 2002 the whole Lakeland formed the UNESCO West Polesie Biosphere Reserve (Radwan 2002, Chmielewski ed. 2005).

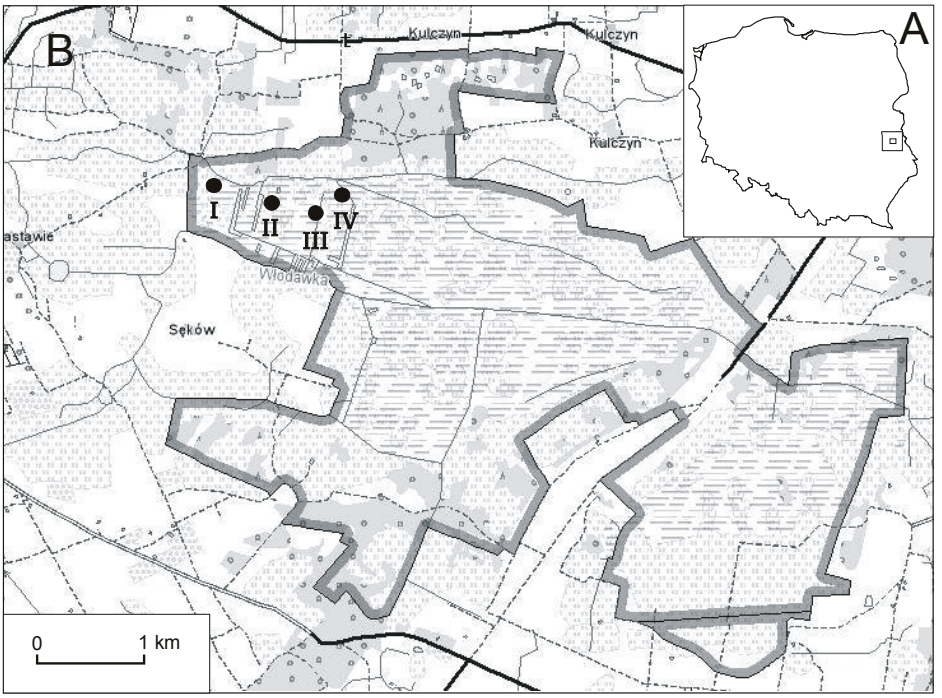

Fig. 1. The location of the Polesie National Park (A). Distribution of the investigated peat-pits on the area of Bubnów Swamp in the southeastern part of the Polesie National Park (B)

The analysis of physicochemical factors of water and qualitative and quantitative analysis of macrophytes of the peat-pits were carried out in the vegetation season in 2008 and 2009. Simultaneously with the floristic research, water physical and chemical factors were analyzed: pH, temperature, electrolytic conductivity, oxygen content, total P, total N.

For all the peat-pits Carlson's (1977) Trophic State Index (TSI) was calculated, based on visibility of Secchi disk (SD), nitrogen (TN) and phosphorus (TP) content.

The investigations included: qualitative analysis of macrophytes (determination of the area inhabited by the plants and the range of individual formations occurrence, making the plant

distribution maps), quantitative analysis (determination of total biomass of macrophytes and individual vegetation groups, assessment of plant diversity).

In phytosociological investigations the Braun-Blanquet's method (1951) was used. Phytosociological units were distinguished on the basis of the systematic system and they follow Matuszkiewicz nomenclature (2008). Emergent macrophytes were analyzed using the floristic fork, while the submerged macrophytes using the floristic rake (Bernatowicz 1960).

The following instruments were used for determination of physical and chemical properties of water: OXI 330 oxymeter made by WTW (oxygen content, temperature), electronic conductivity meter made by Hanna (electrolytic conductivity), microchip Slandi SP300 pH-meter (water reaction). The content of biogenic nitrogen and phosphorus compounds was determined using the microchip Slandi photometer LF 205.

RESULTS AND DISCUSSION

In the investigated peat-pits there was a slight differentiation of physical and chemical properties of water. The highest oxygen concentration was in peat--pit I, the lowest in peat-pit IV (Tab. 1). The values of electrolytic conductivity were similiar and high in all peat-pits. That demonstrates highly mineralized water in these objects. Because of shallowness of the investigated peat-pits and high insolation, the water temperatures were in the range 26–27.4^{0}C. The pH values indicate slightly alkaline water. The content of biogenic compounds did not differentiate the investigated peat-pits, although the concentrations of these substances were high. This can be explained by the local floods associated with increase in the water level and total flooding of the investigated area.

Table 1. Some physical and chemical parameters of the investigated peat-pits (2008 according to Wojciechowska et al., 2008)

Parameter		I		II		III		IV	
		2008	2009	2008	2009	2008	2009	2008	2009
1	2	3	4	5	6	7	8	9	10
Conductivity [µS · dm^{-3}]	$\overline{X}$	306	425.5	520	463	488	455	390	463
	SD		16.26		15.56		19.8		
pH	$\overline{X}$	8.3–8.4	7.9	7.3–8.0	7.89	7.3–8.0	7.65	7.2–8,3	7.56
	SD		0.31		0.4		0.21		
O_2 dissolved [mg ·dm^{-3}]	$\overline{X}$	11.2–6.8	4.88	8.2–6.5	3.45	8.2–3.5	2.27	4.9–6,8	1.64
	SD		1.8		2.62		1.62		
Oxygen content [%]	$\overline{X}$		61.3		43.4		28.28		22.8
	SD		20.08		31.11		20.11		

1	2	3	4	5	6	7	8	9	10
Temperature [°C]	$\overline{X}$	24.2	27.4	23.8	27	24,1	26.1	26.2	26
	SD		0.57		0		0.14		
Visibility [m]			1.2 (to the bottom)		0.8 (to the bottom)		0.7 (to the bottom)		1.0 (to the bottom)
Water hardness [mg ·dm^{-3}]			13.55		11.2		10.53		11.64
PO_4^{3-} [mg ·dm^{-3}]		0.08–0.032	< 0.010	0.002–0.020	0.07	0.010–0.017	0.020	0.003–0.022	0.018
Total P [mg ·dm^{-3}]		0.022–0.054	0.9	0.041–0.026	1.14	0.010–0.020	0.74	0.008–0.101	1.04
Total N [mg · dm^{-3}]		0.98–2.98	< 0.50	0.97–2.71	< 0.50	0.94–1.81	< 0.50	0.96–1.70	< 0.50

The values of Carlson's Trophic State Index (TSI) between 56.9–60.0 indicate eutrophy (Tab. 2).

Table 2. Trophic State Index of the investigated peat-pits

Parameter	I	II	III	IV
TSI_{SD}	57.4	63.2	65.2	60.0
TSI_{TP}	69.0	72.4	66.2	71.1
TSI_{TN}	44.5	44.5	44.5	44.5
Carlson's TSI	56.9	60.0	58.6	58.5

Peat-pits are as a rule the shallow water bodies. Peat-pits habitat is one of the many ecological niches for charophytes. Due to small depth and polymictic character, it is usually characterized by higher trophy, increased turbidity and resuspension of bottom sediments. Charophytes create dense turf near the bottom, while the flowering plants create the concentration of shoots and leafs near the surface, avoiding the shortage of light. They additionaly cause the shade on lower water levels, which may affect the gradual disappearance of charophytes. In the investigated peat-pits charophytes created splendid underwater meadows of *Charetea* communities. Throughout the direct interaction on physicochemical properties of water and indirect interrelationships with other biotic components of shallow water bodies (i.a. phytoplankton), the macrophytes (especially charophytes) improve significantly the water clarity by causing so-called alternate clear water state (Pełechaty 2006, Pukacz, Pełechaty 2006).

In the investigated peat-pits, with typical of eutrophy concentration of nutrients, the presence of charophytes was found, as well as visibility to the bottom. In all of the peat-pits phytolittoral covered the whole bottom and charophytes usually dominated (Fig. 2).

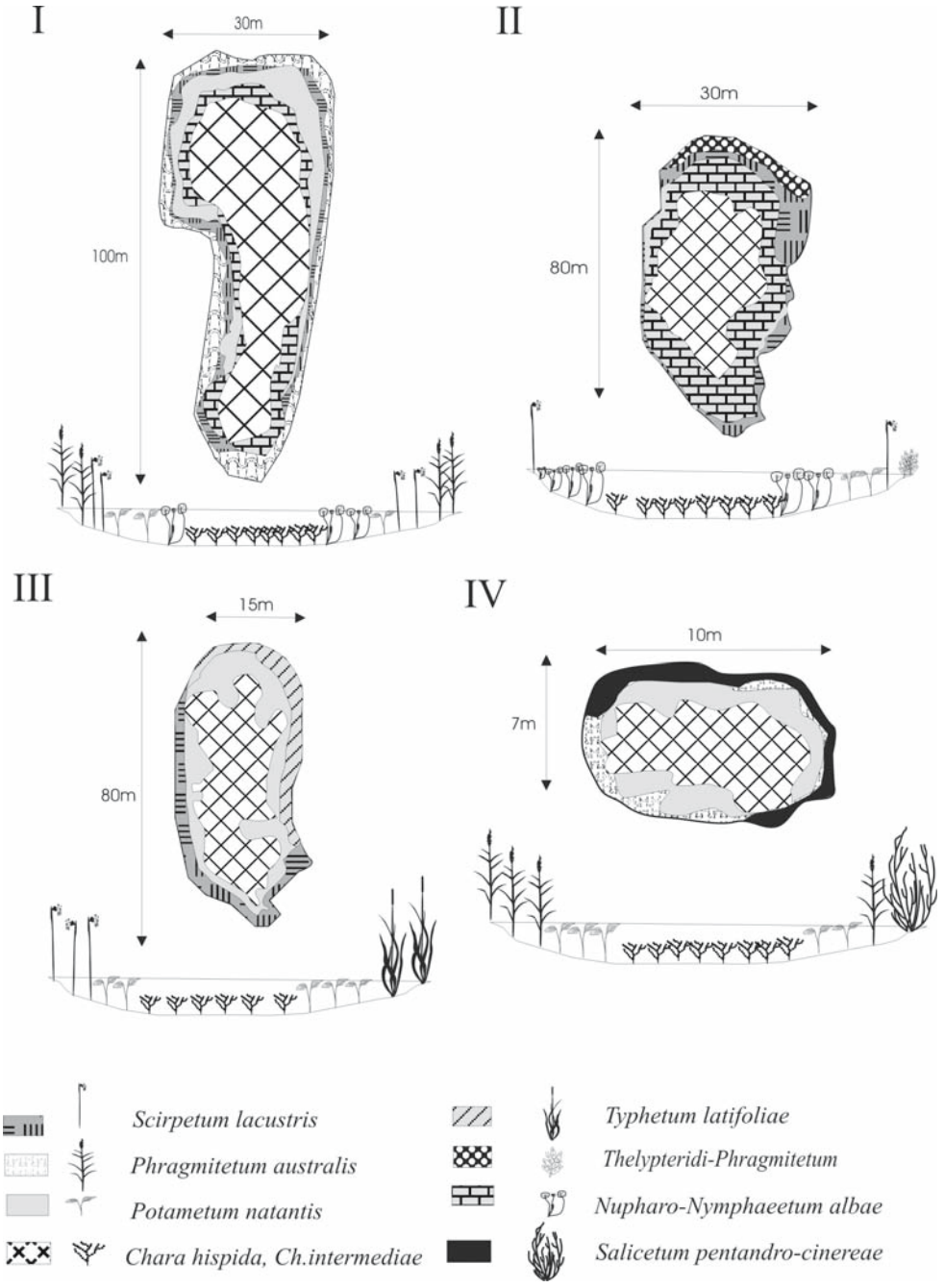

Fig. 2. Distribution of plant communities in the investigated peat-pits

The occurrence of *Charetum hispidae* and *Charetum intermediae* was found in all of the investigated objects, with a small domination of the second species. *Chara globularis* occurred as a casual species in both communities. Both of the communities occur in different types of freshwater and brackish water bodies throughout the country, but rarely (Pełechaty, Pukacz 2008). The species are not protected, although both are endangered species by categories of threat (Siemińska et al. 2006). In the 70's those associations have occurred especially in big peat-pits of the Łęczna-Włodawa Lakeland and *Charetum contrariae* associations were also typical of such habitats (Karczmarz, Malicki 1971)

Table 3. Participation (%) of individual macrophyte communities in creating the phytolittoral

Plant associations	I	II	III	IV
Nupharo-Nymphaeetum albae	8	41		
Potametum natantis	16	3	31	21
Scirpetum lacustris	9	15	14	
Charetum intermediae	55	36	42	
Charetum hispidae				56
Phragmitetum australis	12			10
Typhetum latifoliae			13	
Salicetum pentandro-cineareae				13
Thelypteridi-Phragmitetum		5		

Scirpetum lacustris (Allorge 1922) Chouard 1924 is a phytocoenosis with *Schoenoplectus lacustris* as a characteristic species. It is commonly encountered species in Poland, it inhabits shoals and coastal parts of eutrophic lakes. It occurs in waters with mineral soils, sometimes with muddy sediments, at the depths up to 2 m (Matuszkiewicz 2008, Podbielkowski, Tomaszewicz 1982). The community was represented in 2 of the investigated peat-pits, occupying from 9% to 15% of the area of phytolittoral (Tab. 2).

Nupharo-Nymphaeetum albae Tomasz. 1977 is built mainly by 2 species: *Nuphar lutea* and *Nymphaea alba*. The community may occur in shallow lakes, old river beds and also less fertile waters with both organic and mineral soils (Podbielkowski, Tomaszewicz 1982). It occurred in 2 peat-pits, with the biggest percentage of phytolittoral in peat-pit II (Tab. 2).

Potametum natantis Soo 1927 is a community of *Potamogeton natans*, the species characteristic especially of shallow mesotrophic and eutrophic water bodies with organic soils, as well as peat (Matuszkiewicz 2008). It was represented in all of the investigated peat-pits, occupying from 3% to 31% of phytolittoral (Tab. 2).

Phragmitetum australis (Gams, 1927) Schmale 1939 is a community dominated by the very expansive *Phragmites australis*. It significantly affects the process of terrestrialisation (Matuszkiewicz 2008). The presence of the community was found in 3 of investigated peat-pits (Tab. 2).

Typhetum latifoliae Soo 1927 exists in mesotrophic and eutrophic stillwater habitats at small depths, with organic or organo-mineral soil (Matuszkiewicz 2008). It grew in 3 peat-pits (Tab. 2).

Salicetum pentandro-cinereae (Almq. 1929) Pass. 1961 is a willow scrub dominated by the species: *Salix cinerea* and *Salix pentandra,* commonly occurring in Poland (Matuszkiewicz 2008). It grew in the shallow littoral zone of the peat-pit IV, occupying up to 13% of the phytolittoral zone.

Thelypteridi-Phragmitetum Kuiper 1957 is the community characteristic of the process of shallowing of the mesotrophic lakes. It creates a floating mat with the structure of diluted peat, growing to the middle of the waterbody, above the water surface. It is a stage of succession between reeds communities and mire vegetation (Matuszkiewicz 2008). The community was found in peat-pit II (Tab. 2). It developed on the shore in the southern part of the peat-pits.

Agricultural areas are surrounding the Bubnów Swamp. The watercourse which belongs to the catchment of Włodawka river, is draining the mire. The water level does not remain constant and fluctuates depending on the local conditions. Large sedges communities were in domination, the edges of the mire were overgrown by willow scrubs. The investigated peat-pits were characterized by different stages of plant development, which can demonstrate a different age of waterbodies. The occurrence of communities entering the water surface such as *Salicetum pentandro-cineareae* in peat-pit IV and *Thelypteridi-Phragmitetum* in peat-pit II suggests their final stages of growth (Podbielkowski, Tomaszewicz 1982).

The vegetation zone of reeds was created by 5 plant communities (Tab. 2). Width of the zone has been varied, depending on the edge steepness. No elodeids occurred in the littoral zone, unlike the nympheids (Fig. 2). Since inception, peat-pits located on the area of mires are characterized by the occurrence of algae communities, which take part in initial stages of overgrowing, as well as the later stages (Podbielkowski, Tomaszewicz 1982). Because of persistent clear water state in the investigated peat-pits, the algal blooms have not been noticed. The occurrence of charophytes achieving generally large increase in biomass may indicate the early stages of overgrowing (Fig. 3, 4). Reduction of the quantity of *Characeae* suggests the transitional state.

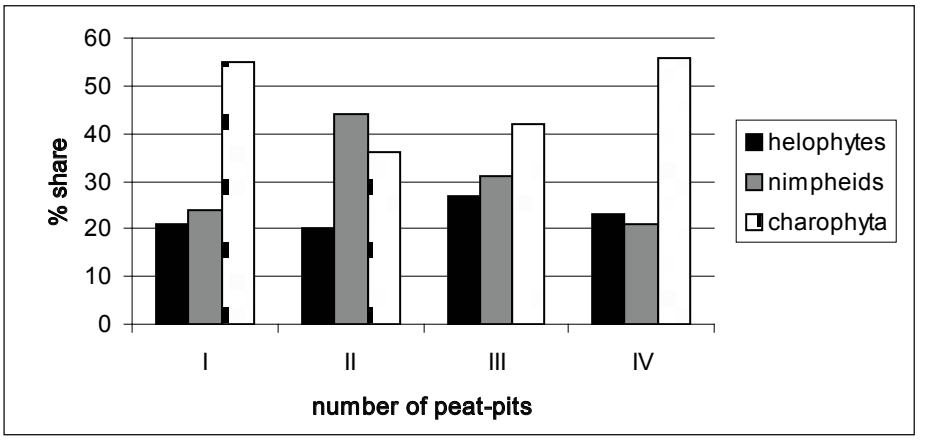

Fig. 3. Participation of individual groups of macrophytes in phytolittoral in the investigated peat-pits

Both the surface covered with charophyta and also high, in relation to the remaining groups of macrophytes, biomass, in all the studied peat-pits, were indicators of their good ecological state (Fig. 4). However, this type of reservoirs is most often subject to even small changes leading to their degradation. At present stoneworts have been retreating from lakes. So, the small water reservoirs are becoming the most important place of their occurrence, as well as peat-pits (Gąbka 2006 a).

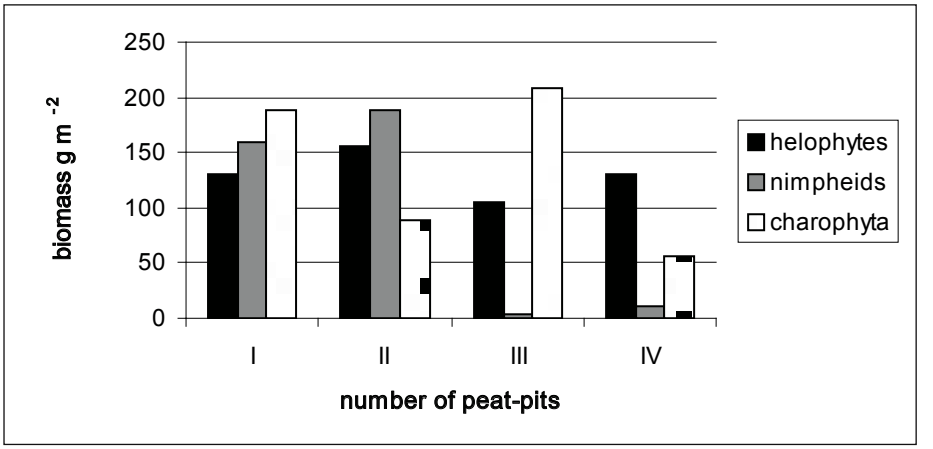

Fig. 4. Biomass of individual groups of macrophytes in the investigated peat-pits

Hydrobotanic investigations of chosen calcareous peat-pits of the Bubnów Swamp confirmed that they are rich habitat of stoneworts similarly as the same places from the Wielkopolska region which represented a larger variety of charophyta (Gąbka 2006 b).

The investigated peat-pits are naturally and floristically valuable hydrogenic ecosystems in various stages of succession.

The peat-pits are characterized by occurrence of endangered species of charophytes: *Chara hispida* and *Chara intermedia*, as well as protected species such as *Nymphaea candida.*

The National Park is the highest form of protection ef ecosystems, resulting in reduction of eutrophication and overgrowth processes in small water bodies (including peat-pits), as well as extension of their existence.

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