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REGENERATION OF „ECHO" PONDS' VEGETATION AFTER THEIR HYDROTECHNICAL RECONSTRUCTION

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Summary. The vegetation of the „Echo" ponds was analysed three years after their hydrological reconstruction. Aquatic as well as rush vegetation regenerated very fast. The majority of plant associations present before appeared again; there also developed new associations. The overall plant coverage in patches decreased and in some plant communities an average number of their species fell. The share of taxa characteristic of class *Molino-Arrhenatheretea* decreased markedly. There was also a change in the proportion of area share of single plant communities, especially rush vegetation, due to the curbing of *Typhetum angustifoliae* area and an increase of *Scripetum lacustris*.

Key words: aquatic and rush vegetation, ponds, regeneration

INTRODUCTION

Natural ponds are shallow water bodies with depths not exceeding a few meters. Unlike lakes, which are usually wide and deep bodies of standing water with vertical thermal and chemical variation of water layers, ponds are characterised by a rather slight variety of water and bottom diversification. In ponds, where the depth is not greater than a few meters, in summer there are no significant differences in temperature between bottom and surface layers. Sun rays reach deeply (with no obstructions) and make it possible for aquatic vegetation to develop on the whole area. These specific habitat conditions affect markedly floristic composition, structure and dynamics of vegetation.

The vegetation of ponds is diverse despite a limited number of composing species. There are a few reasons for that. One of the causes is a dynamic change of these plant communities. At times, in one or two vegetation seasons, substantial quantitative and qualitative changes can be observed. Since these communities do not abound in species, changes in quantity of components are important as they have a decisive influence not only on the structure of community but also on succession. A very common phenomenon is the appearance of single-species assemblies of plants consisting of highly expansive species able to develop relatively fast on new areas. Such phytocenoses, being close to each other, mix and penetrate each other, which results in a mosaic structure of communities.

Aquatic and rush vegetation play an important role in the overgrowing of ponds. Producing a lot of slowly decomposing organic matter it makes a water body shallow. In addition, rush vegetation is extremely expansive which, in such favourable pond conditions, gives it a chance to quickly settle on a given area [Podbielkowski and Tomaszewicz 1979].

Degradation of natural habitat triggers changes in communities defined as degeneration. Such a process leads to deformation of community structure. The term 'degeneration of communities' may be defined as distortion of natural and semi natural plant communities exemplified by distortion of structure and organisation, changes in species composition and, finally, loss of characteristic features [Faliński 1991]. Degeneration may be initiated either by an impact of external biocenotic factors, or as a result of serious human interference, for example draining of water body and hydro-technical reconstruction, as it was in the case of the „Echo" Ponds [Faliński 1991].

Regeneration is a process of restoring the structure and functions of degenerated parts of community. It is driven by internal forces – seeds and vegetative organs of a given community. Characteristic, in early stages of the regeneration process, is mosaic or belt occurrence of pioneer species which are later replaced by transitional and, ultimately, final (permanent) components of communities [Faliński 1991].

STUDY AREA, MATERIALS AND METHODS

The „Echo" Ponds are situated in the western part of the Roztocze National Park (ca. 1 km south from Zwierzyniec) and their total area approximates 40 ha. The ponds were created in 1934 by a little stream Świerszcz which flooded a wide valley. In the late 1980s careful studies of „Echo" Ponds vegetation showed the presence of many interesting species and plant communities [Izdebski *et al*. 1992]. However, with time some unfavourable changes took place – formerly floristically rich ponds began to lose their diversity. There disappeared not only some rare species, such as *Beckmannia ercuciformis*, but also many common species (*Batrachium circinatum, Carex diandra* and many other taxons). Complete plant communities, for instance *Equisetetum fluviatile, Oenantho-Rorippetum, Eleocharidetum palustris, Phalaridetum arundinaceae, Caricetum rostratae* and *Caricetum diandrae,* ceased to exist on this area [Grądziel *et al*. 2003], whereas the range of other communities became smaller (*Phragmitetum australis, Glycerietum maximae, Caricetum gracilis, Scirpetum sylvatici*). Only one of the rush communities (*Typhetum angustifoilae*) markedly increased its range, pushing out of the area phytocenoses of other associations. By producing a lot of organic matter, phytocenoses of this association increase the pace of overgrowing of water bodies and contribute to excessive eutrophication of habitats. As a result of expansion of the *Typhetum angustifoilae* association, there occurred monotypisation of the whole ecosystem, which resulted in a decrease of biodiversity of all components of the biocenosis. Therefore, in autumn 2002, protection actions were undertaken. In spring 2003 the rebuilding of almost the whole system of ponds, removal of bottom sediments and deepening were completed.

The research of the „Echo" Ponds in the Roztocze National Park took place in 2002 and 2005. During the first one, the state of vegetation before the reconstruction was analysed, whereas in the second – that after the restoration. There were prepared maps of aquatic and rush vegetation in the scale 1:2500, and in typical patches of phytocenoses phytosociological relevés (total of 110) were made using 11-degree scale of species coverage.

The aim was determining the changes in aquatic and rush vegetation of the „Echo" Ponds, and the pace and directions of regeneration after their restoration.

RESULTS

In 2002, 12 plant associations (4 aquatic and 8 rush vegetation) were recorded in the „Echo" Ponds. Among the aquatic vegetation the highest surface share was that of *Charetum contrariae* patches, while the rush vegetation was dominated by phytocenoses of *Typhetum angustifoilae* (Tab. 1). Patches of the associations mentioned above occupied almost 70% of the ponds. Research after the restoration proved the presence of 9 aquatic plant associations and 8 rush ones. As new, not noted before, there appeared patches of *Lemnetum minoris, Ranunculetum circinati, Myriophylletum spicati, Potametum pectinati, Polygonetum natantis, Glycerietum fluitantis* and *Eleocharitetum palustris.* It proves that regeneration of vegetation is of creative secondary succession type, despite the fact that the phytocenoses of two associations – *Caricetum gracilis* and *Scirpetum sylvatici* – have not regenerated so far.

Table 1. Changes in the share of plant communities in the vegetation of the „Echo" ponds in 2002 and 2005 (in %)
Tabela 1. Zmiany procentowego udziału powierzchni zbiorowisk roślinnych stawów „Echo" w latach 2002 i 2005

No. – Nr	Plant community – Zbiorowisko roślinne	2002	2005
1.	*Typhetum angustifoliae*	42.10	11.02
2.	***Charetum contrariae***	26.93	41.56
3.	*Scirpetum lacustris*	5.75	12.78
4.	*Potametum lucentis*	2.78	7.89
5.	*Sagittario – Sparganietum emersi*	2.26	0.74
6.	*Glycerietum maximae*	2.12	0.40
7.	*Phragmitetum australis*	1.34	2.28
8.	*Potametum natantis*	0.91	0.32
9.	*Caricetum gracilis*	0.87	-
10.	*Potametum graminei*	0.33	1.34
11.	*Typhetum latifoliae*	0.08	0.26
12.	*Scirpetum sylvatici*	0.08	-
13.	*Ranunculetum circinati*	-	0.52
14.	*Eleocharitetum palustris*	-	0.46
15.	*Potametum pectinati*	-	0.32
16.	*Polygonetum natantis*	-	0.22
17.	*Glycerietum fluitantis*	-	0.18
18.	*Myriophylletum spicati*	-	0.10
19.	*Lemnetum minoris*	-	0.02
20.	Other plant communities – Inne zbiorowiska roślinne	5.78	3.84
21.	Areas without vegetation – Obszar bez roślinności	5.32	15.74

Hydro-technical procedures caused also changes in the area of single plant communities in the „Echo" Ponds (Tab. 1). The highest growth of percentage share of area was noted for *Charetum contrariae* (from 27 to 42%). Conditions after the reconstruction had a very positive impact on the development of this pioneer association. A marked decrease in the area occupied by *Typhetum angustifoilae* (from 42 to 11%) allowed for expansion of communities: *Potametum pectinati, Potametum lucentis, Scirpetum lacustris, Phragmitetum australis* and *Typhetum latifoliae,* and at the same time made it possible for the seven above mentioned associations to appear.

Regeneration of the ponds vegetation was very fast after scraping. It is explicit by the changes in general coverage of vegetation patches and in the amount of species they are composed of. An increase in the first of the mentioned parameters was noted in *Charetum contrariae, Potametum lucentis, Glycerietum maximae* and *Sagittario-Sparganietum emersi* associations, whereas a drop occurred in *Potametum graminei, Potametum natantis, Typhetum* *angustifoilae, Typhetum latifoliae* and *Phragmitetum australis* phytocenoses. Almost in the same associations similar tendencies for changes in average number of plant species in the studied patches were observed (Tab. 2). Mean coverage of characteristic species may serve as an indicator of regeneration pace, because in aquatic and rush associations they usually constitute a basic quantity composition. There was also noted a growth in the coverage of *Potamogeton gramineus, Potamogeton lucens, Glyceria maxima, Saggitaria sagittifolia* and a fall in mean coverage of *Chara contraria, Scirpus lacustris, Typha angustifolia, T. latifolia* and *Phragmites australis* (Tab. 2).

Table 2. Changes of selected properties of the plant communities structure in 2002 and 2005
Tabela 2. Zmiany wybranych właściwości struktury zbiorowisk roślinnych w latach 2002 i 2005

Plant community Zbiorowisko roślinne	Mean number of species in relèves Średnia liczba gatuków w płatach		Mean cover of vegetation (in %) Średnia pokrywa roślinna (%)		Mean quantity of characteristics species (in degrees of coverage) Średnia liczba charakterystycznych gatunków (w stopniach pokrycia)	
	2002	2005	2002	2005	2002	2005
Charetum contrariae	1.0	4.3	85	87	8.0	7.4
Potametum graminei	8.5	7.3	95	30	4.5	5.7
Potametum lucentis	5.0	5.0	90	93	4.0	6.0
Potametum natantis	6.3	5.0	83	65	4.0	4.0
Potametum pectinati	–	8.0	–	80	–	4.0
Polygonetum natantis	–	7.0	–	100	–	4.0
Ranunculetum circinati	–	5.0	–	100	–	9.0
Lemnetum minoris	–	5.0	–	80	–	5.0
Myriophylletum spicati	–	3.0	–	100	–	6.0
Typhetum latifoliae	18.0	16.0	80	75	5.0	3.5
Typhetum angustifoliae	7.1	6.1	72	63	4.0	3.8
Sagittario-Sparganietum emersi	6.3	5.0	56	90	3.0	7.0
Glycerietum maximae	6.0	19.7	70	90	4.0	5.5
Phragmitetum australis	4.0	4.5	85	65	4.3	3.6
Scirpetum lacustris	3.5	5.6	72	73	3.5	3.0
Glycerietum fluitantis	–	11.0	–	70	–	5.0
Eleocharitetum palustris	–	13.0	–	47	–	3.3

Important alternations also affected the percentage share of species characteristic for given classes in the "Echo" Ponds vegetation (Fig. 1).

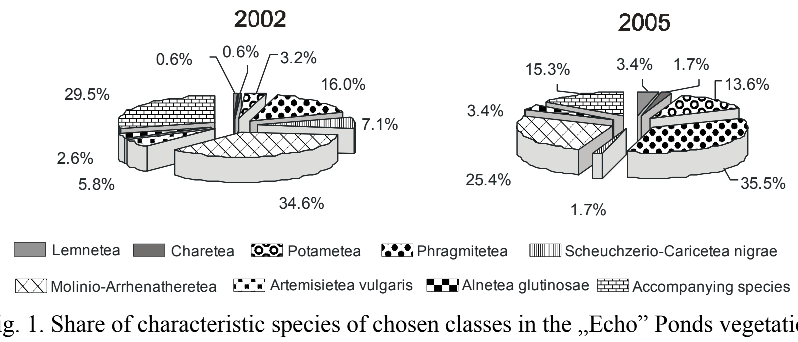

Fig. 1. Share of characteristic species of chosen classes in the „Echo" Ponds vegetation in the years 2002 and 2005
Rys. 1. Procentowy udział gatunków charkterystycznych wybranych klas roślinności stawów „Echo" w roku 2002 i 2005

Before the reconstruction, the most numerous group were taxa typical for the class *Molinio-Arrhenatheretea*. Apart from accompanying species, there was also a considerable share of rush species (16%) and the remaining classes were represented by 1-9 taxa. After restoration the largest increase in share was noted for the vegetation of the classes *Potametea* and *Phragmitetea*, while the share of meadow species decreased (*Molinio-Arrhenatheretea* class).

DISCUSSION

Scraping had both positive and negative effects on vegetation. Positive effects were the removal of muddy deposits preventing anaerobic processes on the bottom, and the formation of open sites on the shores free from competition by reeds, on which species-rich littoral stands could develop during succession. Favourable conditions for the development of some rare or endangered species were also provided there. Negative effects occurred on sites with a greater angle of slope – the regeneration of shore vegetation was difficult or impossible due to the high water level and the action of wind and waves. Sites created by the deposition of bottom material became centres of ruderal vegetation [Hroudova and Zakravsky 1999].

The initial phases of the settlement of ponds are various and depend on whether a pond has been thoroughly cleared or not before it is filled with water. In the first case, if flooding took place after scraping the bottom, there is no vegetation in a pond. However, incoming water carries different diasporas which germinate soon after flooding. Algae appear at the beginning. Almost simultaneously *Lemna minor, Spirodela polyrrhiza* and *Lemna triscula* begin their settlement. They are found usually in the littoral zone. Then, there emerge other water plants such as charophytes, *Myriophylum spicatum* or *Hydrocharis morsus-ranae*. They are accompanied by heralds of rush vegetation – usually individuals of *Typha angustifolia, Phragmites australis, Glyceria aquatica, Sparganium erectum* and other species. They originate either from vegetative diasporas brought by water during flooding or from rhizomes left on the bottom. Invasion of rush vegetation usually begins at the banks. Yet, it is not a rule and often it is possible to see it developing in middle parts of a pond, as it was the case in the analysed water bodies. At this stage communities are composed mainly of aquatic plants, occasionally with rush plants admixture. Ponds that were not scraped and flooded again have at least partially established vegetation. Those rush plants that remain on the bottom (and some other aquatic species that survived the unfavourable period) begin, after flooding, intensive growth and expansion. The renewal of vegetation and the development of initial stages of overgrowing take place here much faster than in thoroughly cleaned ponds, where communities have to emerge anew [Hroudova *et al*. 1988].

In the process of plant regeneration in the „Echo" Ponds, *Chara contraria* was especially expansive. *Characeae* may play a significant role as a part of macrophyte vegetation of lakes and ponds, hence, they may have a strong impact on the functioning of water bodies [Jeppesen *et al*. 1998]. The role of macrophytes in the trophic web of lakes has been recognized as being crucial in determining the state of the system as a whole, including the unvegetated areas. Charophytes are probably superior competitors for both space and nutrients, and thus have a competitive advantage over angiosperms in shallow water bodies. Additionally, charophytes may be highly resistant to hydraulic forces caused by wind inducted waves, because of their low individual weight and their massive bottom covering growth form [Schutten and Davy 2000].

The propagule bank plays an important role in regeneration of the vegetation and in the year to year dynamics of aquatic macrophytes [Van der Berg *et al*. 1999; Van Nes *et al*. 2002a]. Various studies show the ability of *Chara* oospores to lay dormant in the sediment for years and to germinate when conditions become favourable [Bonis and Grillas 2001]. Charophytes depend on disturbance of the existing vegetation for their establishment, which may be scraping the ponds. In fact, the rapid development of charophytes may be the first successional stage leading to a stable macrophyte-dominant ecosystem [Van Nes *et al*. 2002b].

CONCLUSIONS

1. Before reconstruction, vegetation of the „Echo" Ponds was represented by 12 plant associations (4 aquatic and 8 rush ones), whereas in 2005 there were 17 of them (9 aquatic and 8 rush ones).

2. After the renovation, associations of *Caricetum gracilis* and *Scripetum sylvatici* withdrew from the ponds, while *Lemnetum minoris*, *Potametum pectinati*, *Ranunculetum circinati*, *Myriophylletum spicati*, *Polygonetum natantis*, *Eleocharitetum palustris* and *Glycerietum fluitantis* appeared as new ones.

3. From among the plant communities noted in 2002 and 2005, 3 aquatic vegetation communities (*Charetum contrariae*, *Potametum graminei*, *Potametum lucentis*) and 3 rush vegetation communities (*Scripetum lacustris*, *Phragmites australis*, *Typhetum latifoliae*) increased their percentage share in the ponds area.

4. The highest increase in the share of occupied surface was that of *Charetum contrariae*. Percentage share in the total area of the ponds became smaller in the case of 1 aquatic plant community (Potametum natantis) and 3 rush communities (*Typhetum angustifoliae*, *Sagittario-Sparganietum emersi*, *Glycerietum maximae*).

5. Taking into account mean coverage of the characteristic species of the associations and mean amount of species in patches, it can be observed that associations: *Glycerietum maximae*, *Typhetum latifoliae*, *Sagittario-Sparganietum emersi*, *Charetum contrariae*, *Potametum lucentis* and *Typhetum angustifoliae* are characterised by the highest pace of regeneration.

6. The appearance of new communities is an example of regeneration of vegetation characteristic for creative secondary succession.

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REGENERACJA ROŚLINNOŚCI STAWÓW „ECHO” PO ICH PRZEBUDOWIE HYDROTECHNICZNEJ

Streszczenie. Badano regenerację roślinności stawów po upływie 3 lat od ich przebudowy hydrotechnicznej. Zarówno roślinność wodna, jak i szuwarowa odbudowały się w bardzo szybkim tempie. Większość zespołów obecnych wcześniej zregenerowała się, pojawiły się także asocjacje niewystępujące wcześniej. Zmalało ogólne pokrycie roślinności w płatach, w niektórych zespołach nastąpił spadek średniej liczby tworzących je gatunków. Szczególnie wydatnie spadł udział taksonów charakterystycznych klasy *Molinio-Arrhenatheretea*. Zmieniły się także proporcje powierzchniowego udziału poszczególnych zbiorowisk roślinnych, zwłaszcza szuwarowych, dzięki ograniczeniu areału *Typhetum angustifoliae* i wzrostowi powierzchni szuwaru oczeretowego *Scirpetum lacustris*.

Słowa kluczowe: roślinność wodna i szuwarowa, stawy, regeneracja