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ZOOPLANKTON COMMUNITIES OF A NEWLY CREATED SMALL WATER BODY

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Summary. The research was conducted on a newly created small water body. The presented results concern the first stage of the study (at weakly developed rush and water vegetation), where the samples were only collected from the open water zone. They are a part of a long-term examination planned in order to determine the impact of the creation of microhabitats in the process of plant succession on the structure of zooplankton community. Since 2004, when the examined water body was created, the number of hydromacrophyte species increased over 5 times from 4 to 25. Nymphaeids have never been recorded yet, while helophytes, elodeids and pleustophytes expanded their area. Within three years of the investigation the structure of zooplankton community has been totally rebuilt. In the first year the zooplankton community consisted of only 17 species and was in 100% dominated by Rotifera, which is characteristic for the first phase of zooplankton succession. In the following years the number of species increased. There was density fluctuations of plankton community observed. Additionally, the species diversity index was changeable depending on the year, having the lowest values in the initial stage of the pond.

Key words: crustaceans, rotifers, ecological succession, species diversity

INTRODUCTION

Ecological succession refers to the process of changes in the species structure of an ecological community over a period of time. Within any natural community some species may become more abundant or even new species may become a part of an existing community, invading it from adjacent ecosystems. At the same time other species within the community may become less abundant or they may even disappear from the ecosystem over some time interval. The trajectory of ecological succession greatly depends on site conditions, interactions between the species, and moreover on other factors such as availability of colonists or weather conditions at the time of disturbance [Luken 1990, Falińska 2004]. Even though there is a multiplicity of information concerning ecological succession, there is still a lack of knowledge considering mechanisms, reasons for initiation and for dying down of the succession process, as well as considering the role of environment, habitat and biological features of plants and animals taking part in this process [Faliński 2001].

There are some trends in ecosystem and community properties in the process of ecological succession that appear to be general. Species diversity is to one of them. It almost necessarily increases during early stage of succession as new species arrive to the

community, however, it may decline in later succession as competition eliminates opportunistic species and leads to dominance by locally superior competitors. Density as well as biomass and trophic properties show changeable patterns over succession, depending on the particular ecosystem or habitat.

The increasing complexity of macrophyte cover in the process of succession will cause an increased diversity of water plant microhabitats, which in turn will offer the inhabiting micro-organisms numerous ecological niches [Pianka 1988, Currie 1991, Krebs 1996]. The structural diversity of macrophytes is likely to provide a wide variety of concealment places for zooplankton from predators and this is why greater densities of zooplankton may be found in more heterogeneous habitats [Hanson 1990, Walsh 1995]. Moreover, competition between particular groups of organisms may structure freshwater communities, e.g. rotifers may be suppressed by crustaceans through exploitative and interference competition [Gilbert 1988, Hurtado-Bocanegra *et al*. 2002].

The focus of our study was to determine the changes in the biocoenotic community, including macrophyte cover and zooplankton assemblages, as well as in the physical-chemical parameters of a pond that was originated three years earlier in order to improve the water conditions within a forest area.

STUDY AREA, MATERIALS AND METHODS

The examined water body is one out of three mid-forest reservoirs being a part of Annogóra small retention project that planned to create in 2003 small water bodies on the Wilczak waterway in order to regulate the water relationships in the forested areas. It is located at the area of Krucz forestry district, Wielkopolska region, north-west part of Poland. The pond is of an area of 1.06 ha, water volume of 16 195 m^3 and during the examination period it had a depth of 1.5 m.

Each year the floristic examination was made in order to define the changes in the species diversity. Physical-chemical analyses were conducted in the consecutive years.

The plankton samples were taken in triplicate at each site using a plexiglass core sampler (method for sampling in the littoral zone recommended by e.g. Schriver *et al*. 1995).

To estimate the species diversity of zooplankton communities in the successive years the Shannon and Weaver coefficient was applied [Margalef 1957].

RESULTS AND DISCUSSION

Ecological succession belongs to those gradual processes by which a certain ecosystem changes and develops over a period of time. To observe such changes a multi-year study was conducted on a new-created water body and the discussed results represent the first three years of investigation.

Analysing the physical-chemical parameters of water in the Miłkowo pond similar values of conductivity were observed throughout the three-year study. The pH rose from 7.02 in 2004 to 8.23 and 8.28 in the consecutive years. The concentrations of oxygen were very fluctuate, probably due to high variation in the water temperature between particular years. In the process of succession physical-chemical features as well as the

structure of organism communities will undergo changes until the waters reach a certain level of trophic conditions (what will also be the aim of future observations).

In the first year of the study – 2004 – after filling the pond with water there was hardly any typical water vegetation. Banks were overgrown by species characteristic for the pond surroundings – meadow and forest plants. The pond bottom was bare, with single patches of flooded grasses. A single specimen of *Alisma plantago-aquatica* L. and small clusters of *Callitriche* sp., *Lemna minor* L. and *Spirodela polyrrhiza* (L.) Schleid were found. These species may colonise new sites as whole plants (*Lemna minor*, *Spirodela polyrrhiza*), or their diasporas (*Alisma plantago-aquatica*) may be transported by water or waterfowl [Podbielkowski and Tomaszewicz 1979]. In the second year – 2005 – an increase in the infested area as well as in the number of hydromacrophyte species was observed. There were 17 species in total identified – 4 that were already present in the previous year and 13 new species: 2 representatives of elodeids: *Batrachium aquatile* (L.) Dumort., *Hottonia palustris* (L.) and 7 species of helophytes which will possibly build communities in the future: *Glyceria aquatica* (L.) Wahlenb., *Phragmites australis* (Cav.) Trin. ex Steud., *Typha angustifolia* L., *Heleocharis palustris* (L.) Roem. & Schult., *Sparganium ramosum* Huds., *Irys pseudacorus* L., *Carex riparia* Curtis and *Juncus macer* Gray, *Juncus articularis* L., *Myosotis palustris* (L.) Nath., *Bidens tripartitus* (L.). In the last year *Alisma plantago-aquatica* created extensive clusters and duckweed built its community *Lemno-Spirodeletum*. In 2006 a great differentiation in the macrophyte cover was noticed, compared to the previous years. 25 species of hydromacrophytes were found, including 3 that were recorded in the examined water body since its creation, 11 recorded in 2005, and 11 species recorded in 2006 for the first time: *Phalaridetum arundinaceae* (L.), *Scirpus silvaticus* (L.), *Glyceria fluitans* (L.) R. Br., *Lemna trisulca* (L.), *Equisetum palustre* (L.), *Typha latifolia* L., *Carex acutiformis* Ehrh., *Epilobium parviflorum* Schreb., *Carex pseudocyperus* L., *Mentha aquatica* L., *Rumex hydrolapathum* Huds. Moreover, in 2006 an expansion of the area of rush vegetation was observed, especially along the eastern banks and some of the middle parts of the pond. There were small stands of *Typha angustifolia* and *T. latifolia* or *Sparganium ramosum* observed. The banks were overgrown by *Phalaridetum arundinaceae* Libbert 1931, *Scirpetum silvatici* Ralski 1931 and *Caricetum riparie* Soó 1928. In 2006 no new species among elodeids appeared, however, *Batrachium aquatile* increased its area in the pond. Also pleustophytes increased their area – in the northern part of the pond *Lemno-Spirodeletum* W. Koch 1954 and *Lemnetum trisulce* Kelhofer 1915 were noted. Nymphaeids belong to the only ecological type that has not appeared in the examined water body yet. The occurrence of *Juncus macer*, *Hottonia palustris*, *Callitriche* sp. has not been confirmed in 2006, either.

It can be presumed that in 2007 the helophytes communities should be well developed, however, it is difficult to predict how will elodeids and pleustophytes behave, as their development often relies on the water level in a reservoir. It should also be remembered that in the case of newly created water bodies the conditions of vegetation greatly depend on the accident-orders of bringing diaspores [Tomaszewicz 1979]. In the following years the resultant of environmental attitudes will be more decisive. A part of the observed changes may be of a fluctuating character as the water level may often change in such a kind of water body. An essential part of the observed changes in the vegetation communities belongs to the succession process that will lead to colonisation by plants of all available sites. Creation of new microhabitats will in turn provide numerous microorganisms with favourable life conditions. Organisms, including macrophytes and zoo-

plankton, as a result of their own activity will transform their environment. In this way they also change the conditions of the selection that they undergo [Lamper and Sommer 2001]. In the next years a strong relationship between macrophytes and zooplankton may be created, which is characteristic for shallow water bodies.

In the newly created environment the bare ground conditions will favour specific plants – pioneer species. These are often organisms which grow best in the conditions of little competition for resources and space. At the first stage of the succession process, freshwater will not support rooted elodeids as the light and bottom conditions may be unfavourable and therefore microorganisms will predominate in the water. Over time, sediments are transported into the water body and thus the water depth gradually decreases, allowing submerged plants to grow.

With the expanding and increasing variation of the macrophyte cover a greater variety of invertebrates occurs. The large numbers of different species account for complex food-webs.

In the process of succession, the species present within the area will gradually change. Each species in a community is well adapted to compete against other species under a specific set of environmental conditions. And when these conditions undergo changes, the existing species may be easily replaced by a new set of species which are then better adapted to these new conditions. In the case of the Miłkowo pond, over three years of investigations a shift in the species composition was observed. Analysis of zooplankton communities over three years from the pond's origination revealed that there were 61 species identified in total (52 of Rotifera, 7 of Cladocera and 2 of Copepoda). The total number of zooplankton species obtained in the successive years differed, reaching the minimum in the first year (only 17 species) and rising up to 49 in the second year and 41 in the third year. However, observing the taxonomical structure distribution, among each group an increasing trend was found (Fig. 1). It was found that only 20% of the taxonomical structure was common for the three years of study, which emphasizes the unstable state of the zooplankton communities in the water body being in the process of ecological succession.

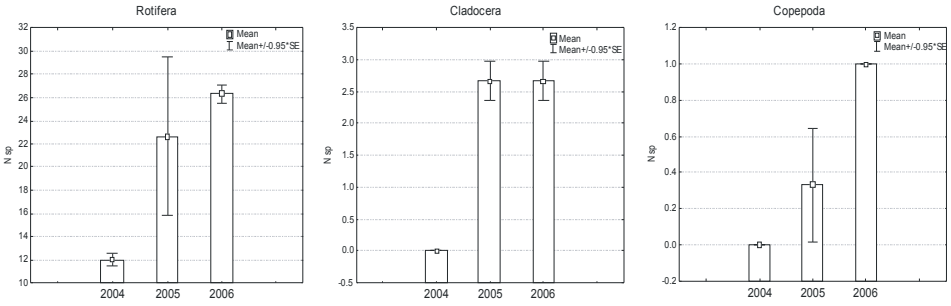

Fig. 1. Number of zooplankton species in the Miłkowo water body
Rys. 1. Liczba gatunków zooplanktonu zbiornika Miłkowo

The mean zooplankton community densities throughout the examination period revealed a fluctuating pattern, with the lowest abundance in 2005 and much higher in the remaining years (Fig. 2). Detailed analysis of the densities within particular zooplankton groups exhibited an exchange pattern between rotifers and cladocerans.

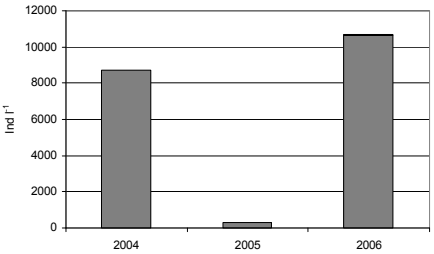

Fig. 2. Total zooplankton community densities of the Miłkowo water body
Rys. 2. Liczebność ogólna ugrupowań zooplanktonu zbiornika Miłkowo

In the first and third years of the investigation rotifers prevailed, while in the second year cladocerans dominated (Fig. 3). This zooplankton distribution resembles the competition between particular groups of organisms that is typical of the first stages of ecological succession. Rotifers are often suppressed by crustaceans through exploitative or interference competition [Gilbert 1989, Wickham and Gilbert 1990]. Copepods systematically increased their numbers in the consecutive years (Fig. 3).

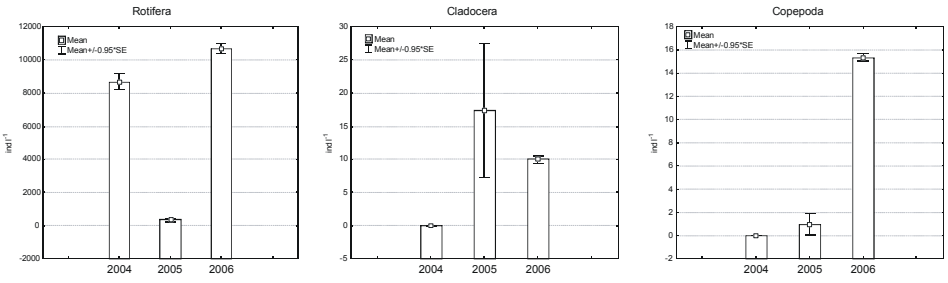

Fig. 3. Differentiation of densities of particular groups of zooplankton communities in the Miłkowo water body
Rys. 3. Zróżnicowanie zagęszczenia poszczególnych ugrupowań zooplanktonu zbiornika Miłkowo

The community of dominants of the Miłkowo pond was created by 4 rotifer and 3 crustacean species (Tab. 1).

Table 1. Dominating species of zooplankton communities in the consecutive years in the Miłkowo water body
Tabela 1. Gatunki dominujące ugrupowań zooplanktonu w kolejnych latach w zbiorniku Miłkowo

Species – Gatunki	Year – Rok 2004	2005	2006
Rotifera			
Bdelloidae		x	
Keratella cochlearis			x
Keratella cochlearis f. *tecta*			x
Polyarthra remata	x	x	
Crustacea			
Bosmina longirostris			x
Chydorus sphaericus		x	
Mesocyclops oithonoides			x

None of the species dominated in each year of the examination. Only a typical pelagic form [Koste 1978, Radwan *et al*. 2004] – *Polyarthra remata* (Skorikov) prevailed during the first two years. It was also noticed that the structure of dominance expanded from year to year (from 1 species dominating in 2004 to 4 species in 2006), which might suggest a slow process of stabilisation of the water conditions after three years since the pond origination. Moreover, the index of species diversity also changed from year to year, however, at the beginning when the pond was only originated and was characterised by the lowest floristic diversity, it was of a minimum value – 0.07, reaching 2.53 in the second year of the study (Fig. 4).

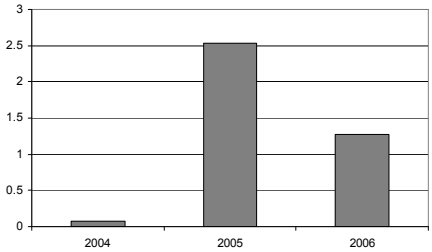

Fig. 4. Biodiversity index of zooplankton communities in the Miłkowo water body
Rys. 4. Wskaźnik różnorodności gatunkowej ugrupowań zooplanktonu w zbiorniku Miłkowo

CONCLUSION

All the observed changes within the community of macrophytes as well as zooplankton are characteristic for the first stage of the process of ecological succession that takes place in newly created environments. There were first of all slow changes in the species enrichment observed. At the same time, some of the physical-chemical parameters of water of the Miłkowo water body as well as some of the organisms' community indices revealed a fluctuating pattern from year to year.

REFERENCES

Currie D.J., 1991: Energy and large-scale patterns of animal- and plant-species richness. American Naturalist, 137, 27-49.

Falińska K., 2004: The Plant Ecology. PWN, Warszawa, pp. 512.

Faliński J. B., 2001: Guide for Long-Term Ecological Examinations. PWN, Warszawa, pp. 672.

Gilbert J.J., 1988: Suppression of rotifer populations by Daphnia: A review of the evidence, the mechanisms, and the effects on zooplankton community structure. Limnol. Oceanogr., 33, 1286-1303.

Gilbert J.J., 1989: Competitive interactions between the rotifer *Synchaeta oblonga* and the cladoceran *Scapholeberis kingi* Sars. Hydrobiologia, 186/187, 75-80.

Hanson J.M., 1990: Macroinvertebrate size-distributions of two contrasting freshwater macrophyte communities. Freshwat. Biol., 24, 481-491.

Hurtado-Bocanegra M.D., Nandini S., Sarma S.S.S., 2002: Combined effects of food level and inoculation density on competition between *Brachionus patulus* (Rotifera) and the cladocerans *Ceriodaphnia dubia* and *Moina macrocopa*. Hydrobiologia, 468, 13-22.

Koste W., 1978: Rotatoria. Die Rädertiere Mitteleuropas. Gebrüder Borntraeger, Berlin, Stuttgart, pp. 673.

Krebs Ch.J., 1996: Ecology. Ecology: the Experimental Analysis of Distribution and Abundance. PWN, Warszawa, pp. 654.

Lampert W., Sommer U., 2001: Ecology of Inland Waters. PWN, pp. 416 (in Polish).

Luken J.O., 1990: Directing Ecological Succession. Chapman & Hall, London, pp. 251.

Margalef R., 1957: Information theory in ecology. Gen. Syst., 3, 36-71.

Pianka E.R., 1988: Evolutionary Ecology, 4th ed. Harper & Row, New York, pp. 468.

Podbielkowski Z., Tomaszewicz H., 1979: Hydrobotany. PWN, Warszawa, pp. 550 (in Polish).

Radwan S., Bielańska-Grajner I., Ejsmont-Karabin J., 2004: Rotifers Rotifera. Freshwater fauna of Poland. Oficyna Wydawnicza Tercja, 447 pp. (in Polish).

Schriver P.J., Bøgestrand E., Jeppesen E., Søndergaard M., 1995: Impact of submerged macrophytes on fish-zooplankton-phytoplankton interactions: large scale enclosure experiments in a shallow eutrophic lake. Freshwat. Biol., 33, 255-270.

Tomaszewicz H., 1979: Water and Rush Vegetation of Poland. Wyd. Uniw. Warsz., Warszawa, pp. 325.

Walsh E.J., 1995: Habitat-specific predation susceptibilities of a littoral rotifer to two invertebrate predators. Hydrobiologia, 313-314, 205-211.

Wickham S.A., Gilbert J.J., 1990: Relative vulnerability of natural rotifer and ciliate communities to cladocerans: laboratory and field experiments. Freshwat. Biol., 26, 77-86.

UGRUPOWANIA ZOOPLANKTONU W NOWO POWSTAŁYM MAŁYM ZBIORNIKU WODNYM

Streszczenie. Badania prowadzono na nowo wykopanym małym zbiorniku. Prezentowane wyniki dotyczą pierwszego etapu badań (przy słabo rozwiniętej roślinności wodnej i szuwarowej), w którym próby wody pobierano wyłącznie z toni wodnej, i są częścią długofalowych badań, których celem jest ocena wpływu kształtowania się mikrosiedlisk powstałych w wyniku zachodzącej sukcesji roślinności na strukturę ugrupowań zooplanktonu. Od 2003 roku liczba gatunków hydromakrofitów wzrosła ponad pięciokrotnie, z 4 do 25. Nie stwierdzono przedstawicieli nymfeidów, natomiast helofity, elodeidy i pleustofity zwiększyły swój areał występowania. W ciągu trzech lat od powstania zbiornika struktura zbiorowisk zooplanktonu uległa całkowitej przebudowej. W pierwszym roku badań ugrupowanie zooplanktonu liczyło zaledwie 17 gatunków i było w 100% zdominowane przez Rotifera, co jest charakterystyczne dla pierwszej fazy sukcesji zooplanktonu. W kolejnych latach wzrastała liczba gatunków. Zaobserwowano ponadto fluktuacje liczebności całkowitej zespołu zwierząt planktonowych. Również wartość współczynnika różnorodności gatunkowej zmieniła się w zależności od roku badań i była najniższa w początkowej fazie po utworzeniu stawu.

Słowa kluczowe: skorupiaki, wrotki, sukcesja ekologiczna, różnorodność gatunkowa