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Physical-chemical parameters and zooplankton community structure of the Odra oxbow in the spring season

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Abstract

The examination of the distribution of rotifers and crustaceans between particular stations located within vegetated (zones of helophytes and nymphaeids) and unvegetated (open water area) zones of an oxbow lake situated within the River Odra valley was carried out during the period of high water level in April of 2007. The obtained results revealed a considerable species diversity along with low densities of particular zooplankton species, which are characteristic features for slightly humic waters. The most diverse species composition of rotifers was found in the littoral zone of the studied water body. This was probably due to the heterogeneity of the macrophyte-dominated area. Additionally, the presence of fish in the investigated oxbow lake may have been responsible for finding the greatest abundance of Crustacea in the zones dominated by aquatic vegetation.

Key words: rotifers, crustaceans, ponds, species diversity, macrophytes

Introduction

Oxbows as rather small and shallow water bodies, characterised by permanent diurnal and annual mixing (Kajak 2001), are an interesting object of hydrobiological examination due to specific physical-chemical conditions which rely directly on the atmospheric conditions, which in turn may contribute to the creation of specific communities of freshwater organisms. Such water bodies are created by river activity and when it reaches a low-lying plain in its final course to the sea or a lake, it meanders widely. Oxbows are periodically supplied by river waters, especially during the strong currents of a flood, which usually happen during the spring and autumn seasons in temperate climates and therefore they may support greater species diversity and create concealment conditions for numerous lacustrine organisms. Moreover, during the fluctuating water periods oxbows may also enrich the main river channel in nutrients (Kajak 2001). Oxbows represent young types of reservoirs and are characterised by very fast evolution. They are usually restricted into a littoral zone due to favourable light conditions (Mikulski 1974).

The rotifer species that inhabit oxbows are often ubiquistic species that usually occur in lakes, however, they are characterised by greater differentiation of morphological forms in the course of a year compared to lakes. An accelerated exchange of generations as well as parthenogenesis along with bisexual reproduction are adaptations to the extremely unstable conditions of this environment (Mikulski 1974).

In oxbow lakes an annual cycle begins in the spring and the density peak occurs between April and May in lakes of temperate climate. Later the densities decrease to reach a second peak during the autumn season, but lower than that of the spring (Mikulski 1974).

The functioning of small water bodies differs from that of lakes in many respects, including the spatial and vertical distribution of physical-chemical parameters and also their biological features, although, in both types of reservoirs aquatic plants may play an important role in the structuring of freshwater communities (Kuczyńska-Kippen & Nagengast 2006, Meerhoff et al. 2003).

The main objective of the present study was to compare the structure of both the rotifer and crustacean community of three stations located within the macrophyte-dominated zones (helophytes and nymphaeids) and an open water area of a small and shallow oxbow water body, situated within the River Odra valley.

Study area

The studied oxbow lakes occur on the right side of the River Odra valley, between Brzeg and Oława, near the eastern border of the forest Las Ryczyński, and close to a small village, Lednica (Fig. 1). They form an approximately 2 km long route of arc-shaped, shallow (up to 2 m depth) and narrow (10–12 m) lakes with steep slopes rising up to 3 m above the water level. Detailed studies were carried out for lake S-2.

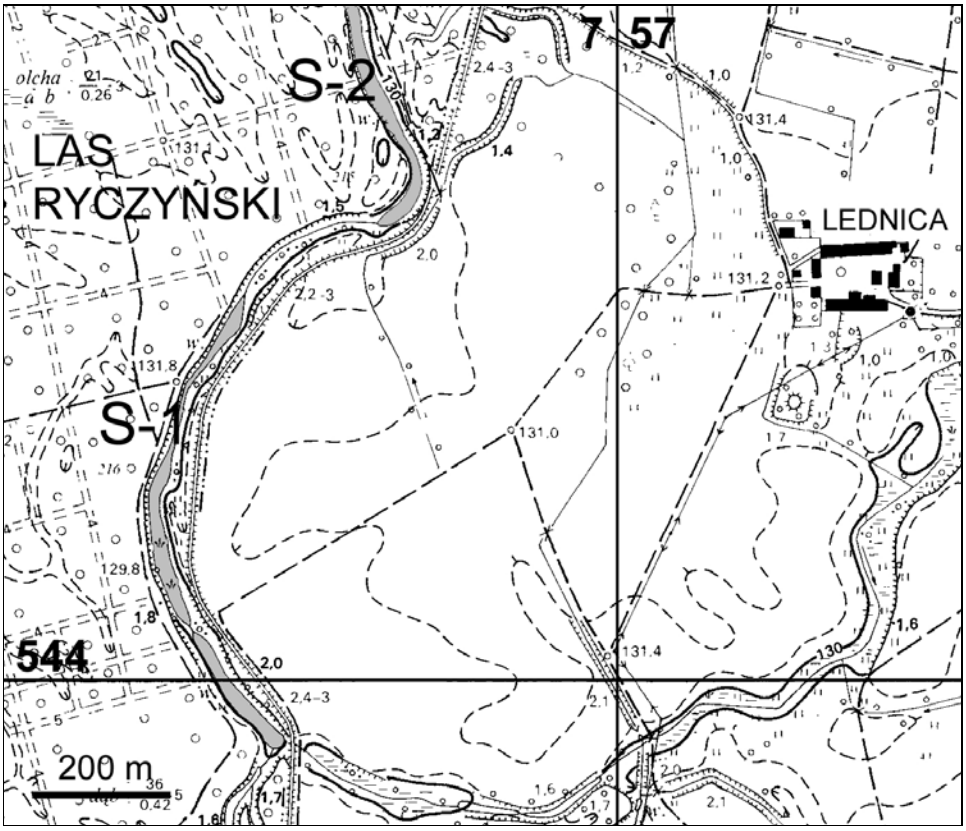


Fig. 1. Geographical position of the studied oxbow lakes

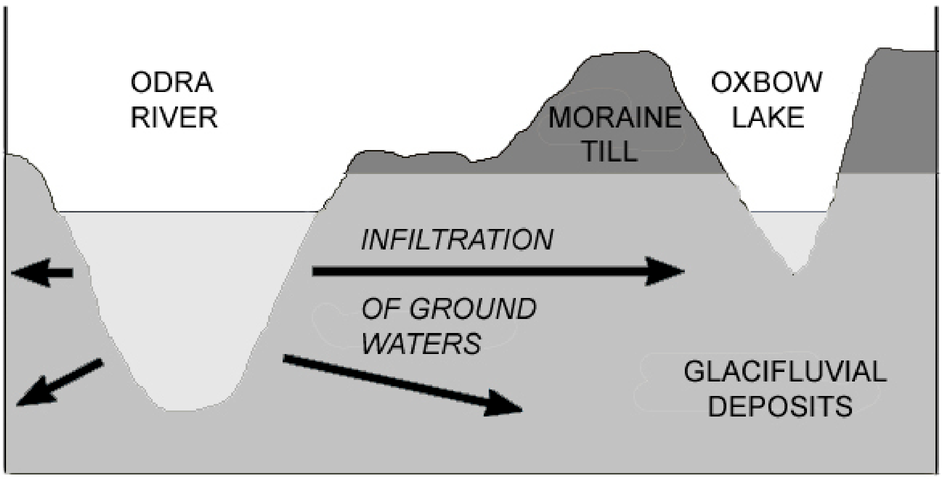


Fig. 2. Schematic geological cross section between the Odra river and the oxbow lakes (not to scale)

Peat deposits cover the coast of oxbow lakes, while leaves form a surficial deposit in their inner parts. These oxbow lakes occur at the surface of a complex, Pleistocene terrace. This is composed of glacifluvial sand with gravel, deposited during the South-Polish glaciation, covered by younger (Middle-Polish glaciation) till. The slopes of the lakes cut the moraine deposit across, penetrating the underlying sediment to some extent, therefore, ground water infiltrating from the Odra River contributes to the lakes (Fig. 2). From time to time, during heavy flooding of the Odra River, flood waters also fill lake basins. The exact age of the oxbow lakes is unknown. Most probably, primary meanders developed during the Baltic glaciation, when the river level was higher due to the blocking of the drain by glacier lobes, which were then cut off during the last deglaciation (8–10 thousand years ago), when the drainage system was cleared, after which intensive erosion began the lowering of the rivers to their present level.

Materials and methods

Zooplankton was sampled from three stations: st. I located within the nymphaeids (*Nymphaea alba* L.), st. II in the zone of open water, st. III within helophytes (*Carex* sp., *Phragmites australis* (Cav.) Trin. ex Steud., *Typha* sp.). The examination of the distribution of rotifers and crustaceans between particular stations of an oxbow lake situated within the River Odra valley was carried out during the period of high water level in April of 2007. The zooplankton samples were collected in triplicate using a calibrated vessel from the three stations. The collected material of a total volume of 5 L was concentrated using a 45-µm plankton net and was fixed immediately with 4% formalin.

The dominating species of the zooplankton community were calculated as those which exceeded 10% of the total zooplankton abundance at each station.

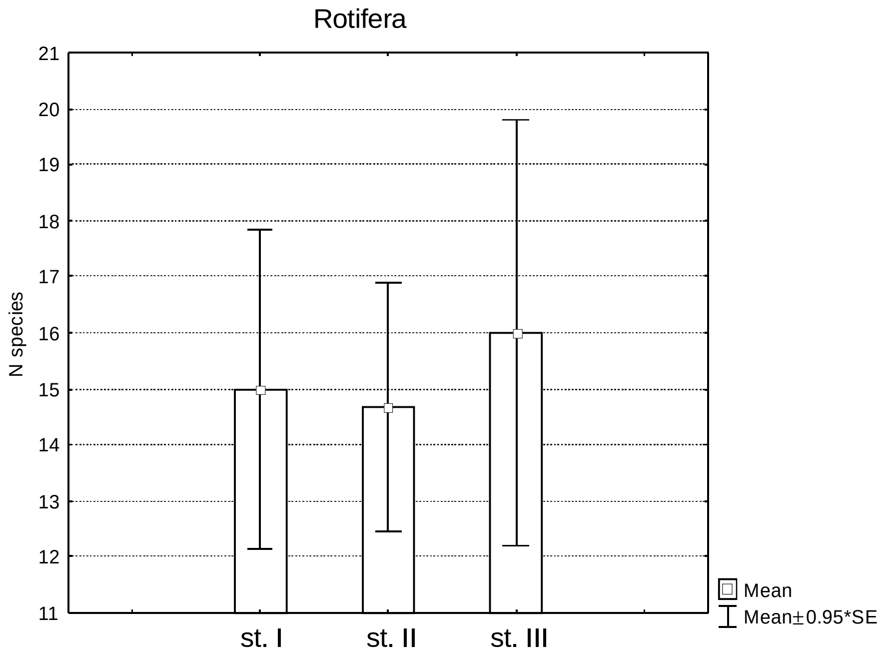
Species diversity of zooplankton inhabiting the different habitats was examined using the Shannon-Weaver index (Margalef 1957).

The Mann-Whitney U-test was used in order to determine the effect of site on the distribution of the zooplankton community ($n = 9$).

A water sample for physical-chemical analyses was collected from the surface level from one station (st. II) located in the central part of the examined water body (Table 1). The chemical analyses were carried out in a laboratory according to Standard Methods for the Examination of Water and Wastewater (1992) in order to evaluate the content of N and P.

Results and discussion

Analysing taxonomical composition it was noticed that there were 58 zooplankton species (42 of rotifers, 11 of cladocerans and 5 of copepods) identified in total from three investigated stations in the studied water body.



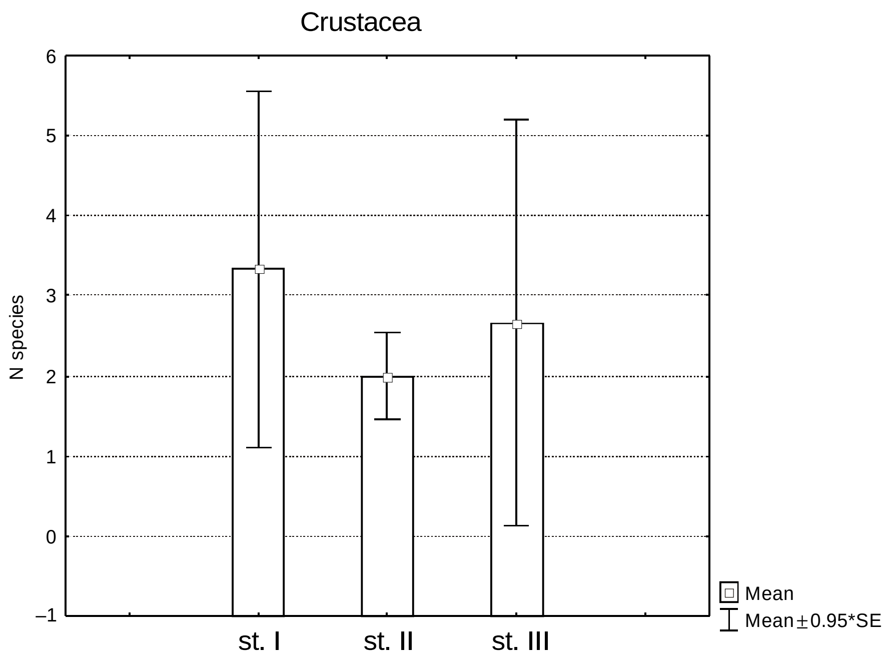


Fig. 3. The number of species between particular sampling stations of the examined oxbow

There were only 13 zooplankton species common for those three stations, which was probably a result of a great differentiation in the structure of the sampling stations. Two stations (st. I and III) were located within the macrophytes, however, the first one was within nymphaeids while the second one was within helophytes. The third investigated station (st. II) was a typical open water zone. The examined zones differed between each other in respect to the number of species. In the case of station I 33 zooplankton species were found in total, while at station II only 27 species and at station III 37 zooplankton species were identified (Fig. 3). The station located within the open water was characterised by the poorest taxonomical structure of both rotifer and crustacean communities, which is typical for most homogenic areas (Pennak 1966, Havens 1991). The littoral part of water bodies is often the most diverse region, especially due to the plant and animal organisms associated with the variety of water vegetation. Gliwicz and Rybak (1976) suggested that the more biologically and spatially complicated is the habitat, the more available niches there are, therefore the zooplankton communities within macrophyte-dominated areas, which were more heterogenic compared to the open water zone, were richer. In the examined material the presence of two rare species – *Cephalodella mus* Wulfert, *Colurella hindenburgi* Steinecke – was recorded (Radwan et al. 2004). Moreover, a participation of species characteristic for humic waters was also found (e.g. *Cephalodella gibboides* Wulfert, *C. hindenburgi*, *Gastropus minor* Rousselet, *Monommata caudata* Myers), making up between 2.27% (st. I) and 12.5% (st. III) of the total zooplankton densities (Radwan et al. 2004).

Rotifers dominated over crustaceans both in respect to the species composition and the abundance (Fig. 3 and 4), which is typical for reservoirs with fish predation (Pogozhev & Gerasimova 2005) and reflects the size-efficiency hypothesis. In water bodies with strong fish predation pressure and when the food resources are limited large-bodied cladocerans are worse competitors for food than small-bodied species and therefore rotifers would dominate (Lampert & Sommer 2001).

The number of zooplankton specimens per 1 litre ranged from 30 up to 55 ind l^{-1} at st. I, from 90 up to 158 ind l^{-1} at st. II and finally from 62 up to 93 ind l^{-1} at st. III. Densities of rotifers ($Z = -1.964$, $p < 0.05$) differed significantly in respect to particular stations with the greatest mean abundance at station II and the lowest at station I (Fig. 4). The highest densities of rotifers at the open water station was due to the mass dominance of *Synchaeta pectinata* Ehrenberg, which is a typical pelagic species, finding optimal conditions for development in the open water zone of various water bodies (Koste 1978, Radwan et al. 2004) being morphologically adapted to limnetic life conditions (Ruttner-Kolisko 1974). In the case of crustaceans, which did not reach high abundance in general, the highest densities were found at the station located within the floating leaved vegetation (Fig. 4). Vegetated zones are structurally

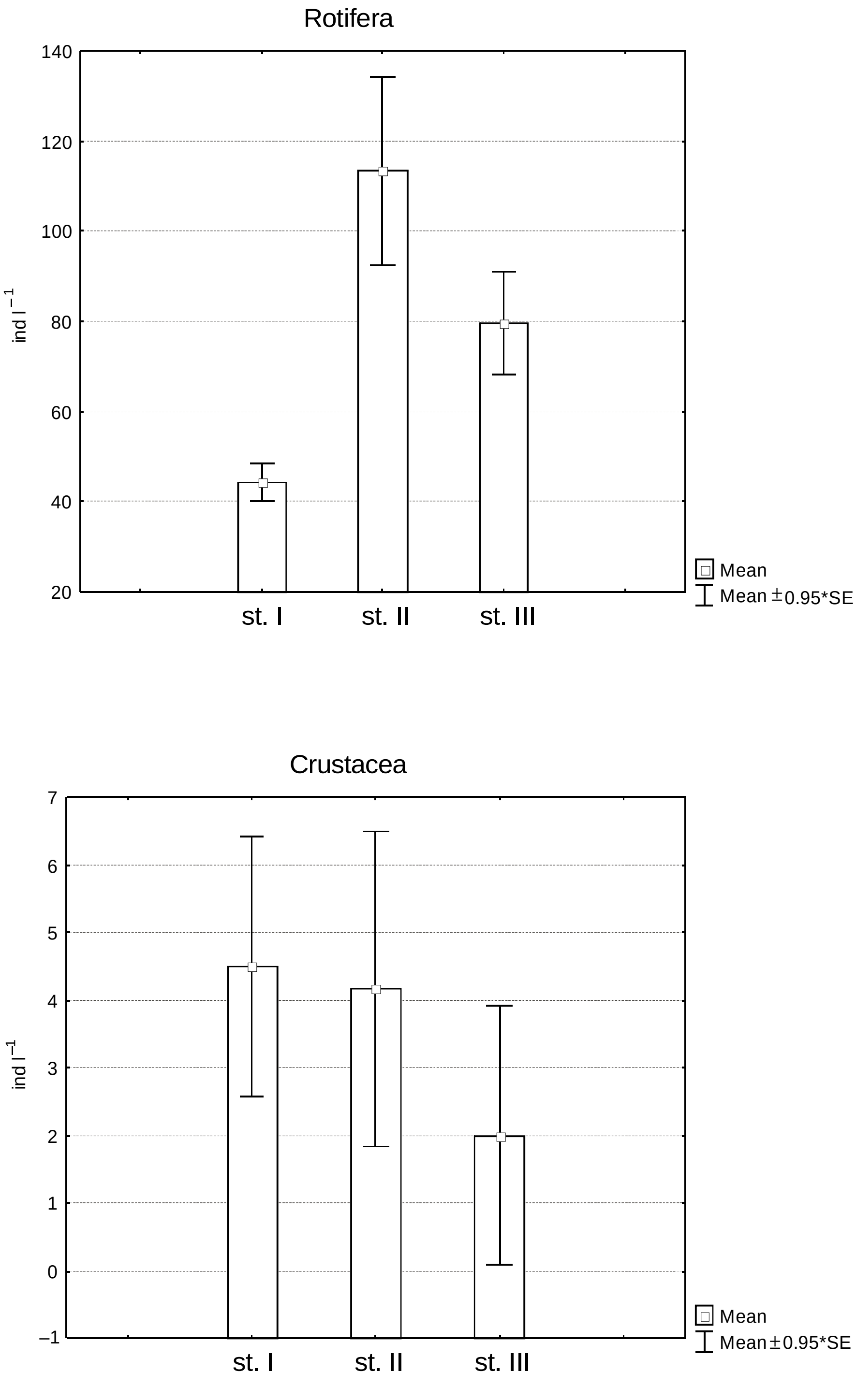


Fig. 4. The density distribution between particular sampling stations of the examined oxbow

much more complex than non-vegetated areas and owing to their heterogeneity, which is positively and strongly associated with varying degrees of habitat complexity, such macrophyte-dominated zones often support more diverse and abundant organisms within various types of water bodies with fish predation present (Blindow et al. 1993, Rennie & Jackson 2005, Kuczyńska-Kippen 2007). In the examined water body the occurrence of young stages of roach (*Rutilus rutilus* L.), pike (*Esox lucius* L.), ide (*Leuciscus idus* L.), common bream (*Abramis brama* L.) and representatives of *Carassius* sp. was noticed. Macrophytes may constitute a refuge against predators, especially in the case of shallow and non-stratified water bodies such as the examined oxbow, and the effectiveness of such concealment depends on the spatial and morphological complexity of a plant as well as on the predation pressure relating to the fish crop (Balayla & Moss 2003, Rybak & Węgleńska 2003).

Zooplankton structure will also rely on the available food conditions, which also differ between the pelagic and littoral zones of water bodies. The main component of a nutritional source for both rotifers and crustaceans usually consists of different forms of phytoplankton along with bacteria and protozoans (Crowder et al. 1998, Degans & De Meester 2002). Moreover, periphyton together with detritus built up in the epiphytic coverage (Van Dijk 1993) may also serve as food for organisms inhabiting the littoral zone.

The dominant community was created by only 3 zooplankton species (2 of Rotifera and 1 of Crustacea). It was observed that only one rotifer species *Synchaeta pectinata* dominated at all three examined stations, while the cladoceran *Chydorus sphaericus* (O.F. Müller) dominated at stations I and III and finally the rotifer *Proales* sp. dominated at stations II and III. *Chydorus sphaericus* is a species of cosmopolitan distribution and a wide range tolerance to a multiplicity of environmental factors such as pH (3.2–10.6) or temperature. This is why this cladoceran may occur even in water bodies which would be avoided by other species of narrower tolerance or worse adaptation (Flößner 1972, Deneke 2000). Therefore, the numbers of *Chydorus sphaericus* were greatest among the crustacean community.

The mean Shannon-Weaver biodiversity index values ranged from 2.7 to 3.2 in the examined water body, however, it differed slightly between particular sampling stations. The lowest values were obtained for station II and the highest for station I. The biodiversity index obtained for station III reached the value of 2.93.

To sum up it was found that the heterogeneity of the habitat created by macrophytes (st. I and st. III) is responsible for the greatest species diversity of the Rotifera communities, while the presence of visual predators – fish in the investigated water body may have had the greatest impact on finding the most abundant communities of Crustacea in the macrophyte-dominated zones of this oxbow lake.

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