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Short research contribution

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PHYTOPLANKTON OF TWO RIVER LAKES IN RELATION TO FLOODING PERIOD (RIVER BUG, EASTERN POLAND)

ABSTRACT: Studies were carrying out in two shallow (mean depth ≈ 0.3 m) and small (area 2.7–8.2 ha) river lakes, which were flooded by water of River Bug (Eastern Poland) once a year (in spring). The species composition, biomass of phytoplankton and concentration of chlorophyll *a* were studied. Samples were taken in June (after flooding) and in August (after three months of isolation from river water). About 150 species of phytoplankton were determined. After the flood period phytoplankton biomass was dominated by nannoplankton belonging to Cryptophyceae and Chrysophyceae (strategy-r) and in the stabilization period by microplanktonic green and blue–green algae (strategy-K). The higher biomass and concentration of chlorophyll *a* values were noted in August than in June. The differentiation of phytoplankton was also stated between near-by stations in both lakes.

KEY WORDS: river lakes, floodplain lakes, phytoplankton, nannoplankton, microplankton, River Bug

The valley of the River Bug (Eastern Poland) is considered as one of the last natural river valleys of Central Europe. The middle part of River Bug (Lublin province) is unregulated and runs in a valley differing in width. It meanders strongly in many places and tends to form the anastomosis (Chmiel *et al.* 2003).

The valley is rich with many riparian sites. Characteristic components of river valley are river lakes, also called oxbow lakes, which are periodically flooded (usually in spring) by River Bug waters. Majority of river lakes in Europe is under human pressure and under strong eutrophication changes (flooding by nutrient rich water of river, fish farming as well as using lakes for tourism). The decrease of macrophyte density and decline the diversity of phytoplankton are the symptoms of such changes (Van den Brink *et al.* 1994, Amoros 2001).

The aim of the present study was to compare species composition and phytoplankton biomass in the period after the flood phase (inflow of Bug River waters to river lakes) and in the period of stabilization of conditions (isolation phase) in 2004 year.

Studies were carried out in two river lakes (Jama Roma and Orchówek) located in the middle part of the Bug Valley and distant from each other by 22 km. They belong to meander lakes (Chmiel *et al.* 2003) with mean depth ≈ 0.3 m, they are permanent water bodies, filled by water all over year. The morphological parameters are presented in Table 1 and bathymetry at Fig. 3.

These lakes are supplied with water during a short-lasting, springtime flooding by river, when the level of river water reaches 220 cm (Fig. 1). The total exchange of water in lakes took 28 days. The first phase of the hydrological activity in river lakes (inflow and outflow) continued since 27th of March until 14th of April. The second phase, a weaker one, was characterizes only by outflowing water from river lakes and it continued from 15th until 23rd of April (Fig.1). In the remaining part of the year, lakes were supplied with water from their own catchment area.

The catchment area of Lake Orchówek (124.8 ha) is managed and built-up (Fig. 2). The meadows and the farms are reaching the river. In the lake itself, fish farming is performed.

The catchment area of Lake Jama Roma (55 ha) has a more natural character; it is covered with pine and alder trees (Fig. 2).

Records of River Bug water levels from water-gauge of Institute of Meteorology and Water Management were used. Bathymetric maps were done in summer period by sonic depth finder "Sonel" and measurements points were localized by GPS with GARMIN apparatus.

Biological and chemical studies (species composition and biomass of phytoplankton, concentration of chlorophyll *a*, TN and TP) were conducted two times in 2004 year. One set of samples was taken in 1th of June (the period after filling lakes by Bug waters) and a second one at 30thAugust (after three months of isolation from river water, the period of summer stabilization). In each of lake two stations were selected which differed in a depth (Fig. 3). Samples were taken using Patalas-type water sampler and poured into a collective sample from whole water column at each station.

Total nitrogen and phosphorus (TN and TP) were analyzed by spectrophotometric methods after earlier mineralization as described by Hermanowicz *et al.* (1999).

The concentration of chlorophyll *a* was measured by a spectrophotometric method (Nusch 1980). Biomass was estimated based on the phytoplankton number using an inverted microscope (by the way of Utermöhl) and making the measurements of species sizes. The calculations were done according to Hillebrand *et al.* (1999). The algae species were grouped in two size groups: nannoplankton ≤30 μm and microplankton above 30 μm according to Pavoni (1963). The species diversity was estimated with Shannon-Weaver index (1949) and evenness index (Lloyd-Ghelardi 1964), according to formulas:

$H' = \Sigma - (n_i/N \bullet \log n_i/N)$

$e = H'/H_{max}$,

where

n_i – numbers of a species i

N – total numbers of phytoplankton

$H_{max} = \log_2 S$, S – number of species

The physico-chemical parameters as SD, pH and conductivity were measured every time.

In both lakes at stations where depth was greater than 3 m, the water transparency was lower in August (0.8 m) than in June (1.5 m).

There was a difference in value of chemical parameters between lakes. The value of water reaction and conductivity was greater in Lake Orchówek. In Lake Orchówek, the mean pH = 7.5, conductivity = 720 μS cm^{-1}, while in Lake Jama Roma – pH = 6.5, conductivity = 550 μS cm^{-1}. The concentration of total phosphorus and total nitrogen were high in both lakes. In Lake Orchówek TP value was about 0.08 mg dm^{-3}, significant greater concentration of total phosphorus was noted in Lake Jama Roma – 0.20 mg dm^{-3}. Total ni-

Table 1. Morphological parameters of studied lakes.

Lake	Area (ha)	Volume (m^3)	Mean depth (m)	Max. depth (m)	Length of shoreline (m)
Orchówek	8.17	27793	0.34	2.85	2618
Jama Roma	2.68	8163	0.30	3.69	1481

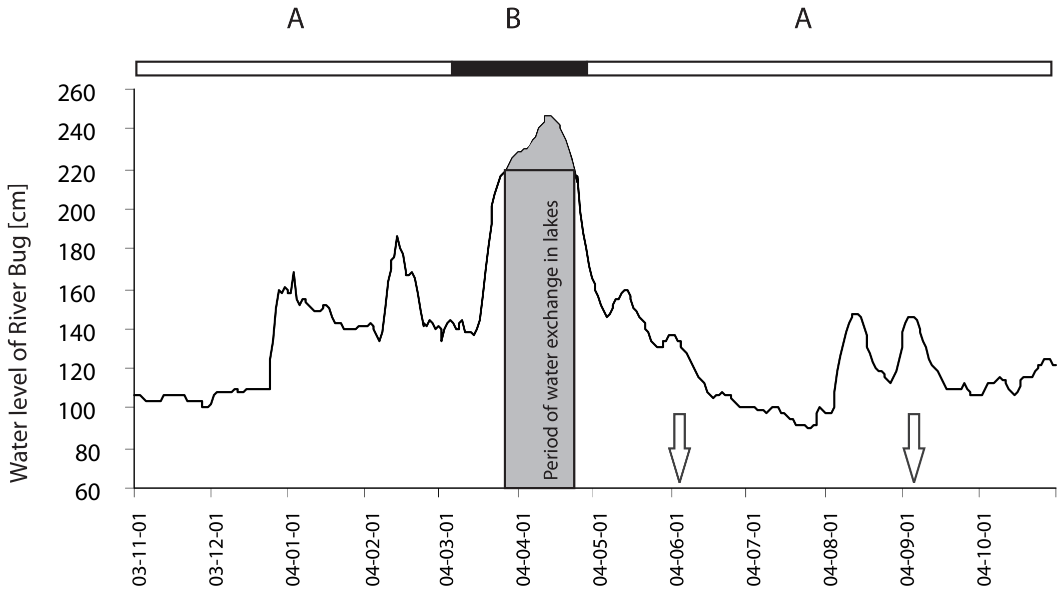

Fig. 1. Changes of water level of River Bug in hydrological year 2004. A – isolation period (lack of contact of lakes with river waters), B – through-flow period (contact of lakes with river waters), Arrows indicate a date of sampling.

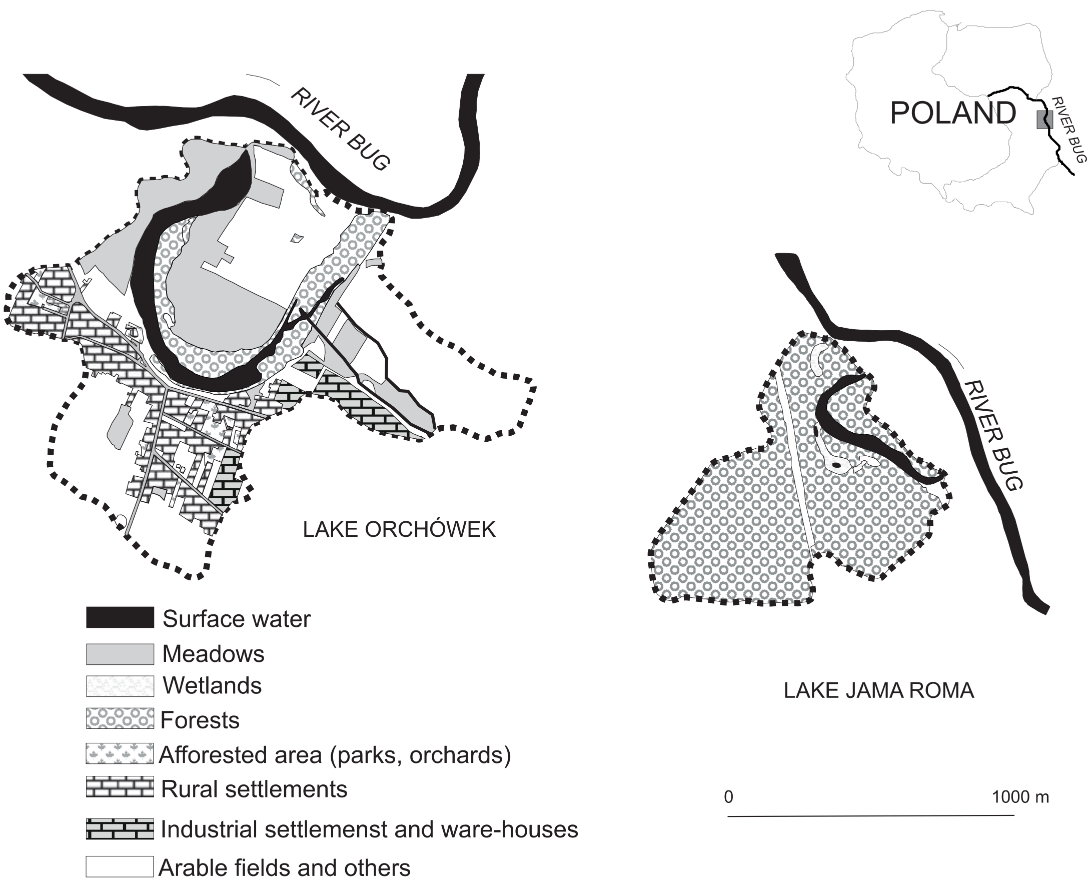

Fig. 2. Land use in the catchments of studied river lakes.

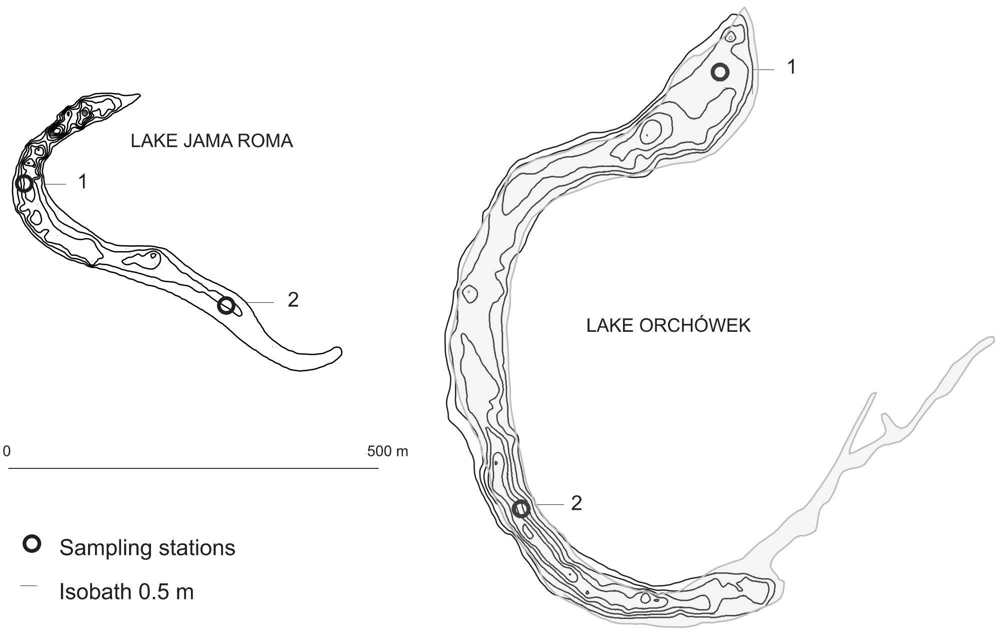

Fig. 3. Bathymetric maps of river lakes and location of sampling stations.

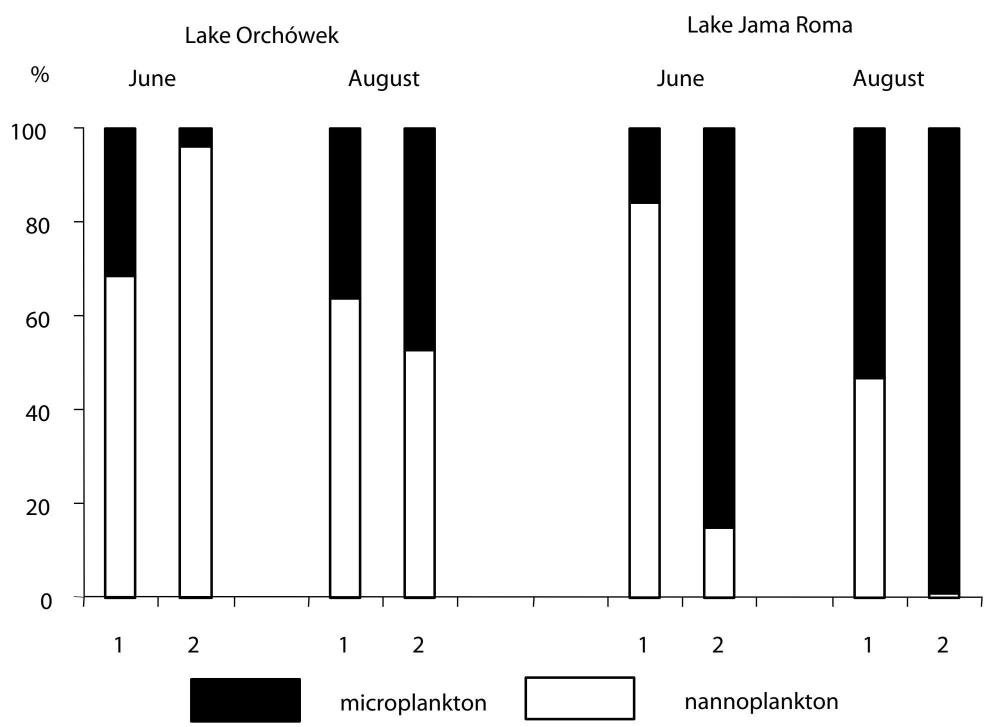

Fig. 4. The share of nanno- and microplankton biomass in phytoplankton at 1–2 stations of both lakes.

Table 2. Number of phytoplankton species in studied lakes.

Taxonomic group	Number of species	
	Lake Orchówek	Lake Jama Roma
Cyanoprokaryota	9	20
Euglenophyta	0	7
Dinophyceae	2	1
Cryptophyceae	4	6
Chrysophyceae	0	9
Bacillariophyceae	7	26
Chlorophyta	41	23

Table 3. Phytoplankton parameters in studied lakes (mean values for station 1 and 2).

Parameters	Lake Orchówek		Lake Jama Roma	
	June	August	June	August
Chlorophyll a ($\mu g\ dm^{-3}$)	33	65	68	131
Phytoplankton biomass ($mg\ dm^{-3}$)	2	26	5	26
Shannon-Weaver index (H')	1.90	1.49	2.23	1.21
Evenness index	0.54	0.39	0.56	0.30
dominant species (percentage share of the species in total phytoplankton biomass)	*Cryptomonas marssonii* (37%)	*Chlamydomonas globosa* (45%) Pandorina morum (39%)	*Mallomonas semiglabra* (28%) *Mallomonas tonsurata* (17%)	*Anabaena oscillarioides* (53%) *Microcystis flosque* (33%)

trogen content was similar in both lakes and reached about 2.50 mg dm^{-3}.

In both lakes a total of 155 different species of planktonic algae were determined, which belong to seven various taxonomically groups (Table 2).

The difference in composition and quantity of phytoplankton between two studied periods was observed in both lakes. In the first period (after flooding lakes by river water) the fast-growing and disturbance-tolerant nannoplanktonic species (r-strategists) had greater contribution to phytoplankton biomass (Fig. 4). The most of them belong to mixotrophic species (Reynolds 1984). Percentage share of nannoplankton in total biomass was from 68 to 99% (Fig. 4). In Lake Orchówek, Cryptophyceae was a dominate group and Chlorophyta was the second group characterized by great percentage share in biomass (Fig. 5). In Lake Jama Roma Chrysophyceae dominated and Cyanoprokaryota species were the subdominants (Fig. 5). In mentioned above taxonomic groups usually two species were the most abundant, *Cryptomonas marssonii* and *Rhodomonas pusilla* (Cryptophyceae), *Mallomonas semiglabra* and *M. tonsurata* (Chrysophyceae), *Scenedesmus obliquus* and *Staurastrum* sp. (Chlorophyta). Among Cyanoprokaryota the most numerous was a small (2.5 μm in diameter), two-celled species *Synechocystis* sp.

During the isolation period the percentage share of microplankton in total phytoplankton biomass significantly increased in both lakes (Fig. 4). Species belonging to this size-group were composed with mixed morphotypes e.g. colonies or large unicells, all of them are considered K-strategists (Reynolds 1984). In Lake Orchówek microplankton was dominated (40–50%) by two Chlorophyta species – *Pandorina morum* and *Closterium dianae*. Despite microplankton biomass increase, the great contribution

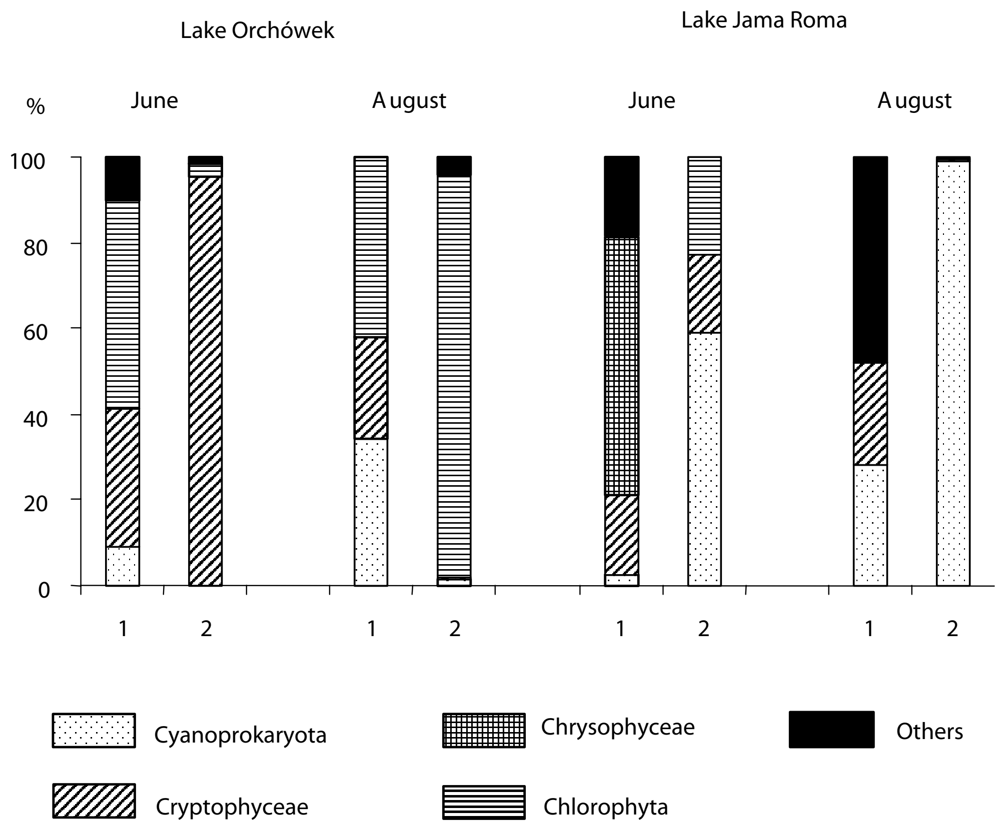

Fig. 5. The share of taxonomic groups in biomass of phytoplankton at 1–2 stations of both lakes.

(≥ 50%) of nannoplankton was observed (Fig. 4). It was the result of the development of nannoplanktonic green alga – *Chlamydomonas globosa*. In Lake Jama Roma the microplankton contribution in biomass was much greater (60–100%) and blue-green algae *Anabaena oscillarioides* and *Microcystis flos-aquae* were dominants (Table 3).

In both lakes the species diversity expressed by Shannon-Weaver and evenness indices was higher in June than in August (Table 3). The higher species richness after the river water flooding in similar type of lakes was observed also by Garcia de Emiliani (1993).

The phytoplankton abundance differs between both studied periods. Total biomass and chlorophyll *a* concentration were characterized by lower values in June (nannoplankton dominance) than in August (microplankton dominance) (Table 3). Total phytoplankton biomass was in June 2 mg dm^{-3} (L. Orchówek) and 5 mg dm^{-3} (L. Jama Roma) and chlorophyll *a* concentration 33 and 68 µg dm^{-3} respectively. In August phytoplankton biomass in both lakes reached the value (26 mg dm^{-3}) many times higher and concentration of chlorophyll in Lake Orchówek was as high as 65 µg dm^{-3} and in Jama Roma – 131 µg dm^{-3}. The increase of phytoplankton biomass and greater percentage share of microplankton in the isolation phase in shallow floodplain lakes was stated by other authors (Garcia de Emiliani 1993, de Oliveira and Calheiros 2000).

In both lakes phytoplankton differed between studied stations (Fig. 5). In both lakes the greater diversity of taxonomic groups occurred at station 1 and clear domination by one taxonomic class was observed at station 2 (Fig. 5). At station 2 in Lake Orchówek the contribution of Cryptophycae (June) or Chlorophyta (August) to total biomass was higher than 90%, while in Lake Jama Roma phytoplankton was dominated only by Cyanoprokaryota species (60–100%). The considerable differentiation between neighboring stations in the oxbow lake was noted by Wilk-Woźniak and Bucka (2004).

The studies of phytoplankton confirmed that river lakes belong to water bodies in which the species diversity to a high degree depends on supplying by river water. The through flow of river water results in water mixing in lakes and the increase of nutrients content (Amoros 2001). According to Reynolds (1984) these conditions favorite the development of small opportunistic r-selected species (like Cryptophyceae and Chrysophyceae in studied river lakes) characterized by rapid growth rate. In the period of summer stabilization (after three months isolation of lakes from the river) species with r-strategy were succeeded by large slow-growing forms of K-strategy (f.e. *Pandorina morum* or *Microcystis flos-aquae*).

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