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The influence of beavers on phytoplankton communities in three forest rivers in the district of St. Petersburg, NW Russia

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ABSTRACT: Phytoplankton communities were studied at different sampling sites in active beaver (*Castor fiber*) ponds and after beaver dams in three forest rivers, in August 1998. A total of 24 species of phytoplankton were identified. The taxa present were all broadly distributed and no indicator species were found. For the ponds studied taxa such as *Cryptomonas erosa* and *C. ovata* (Cryptophyceae) were the most typical and dominant. Diversity and abundance of phytoplankton species were, in all rivers studied, much higher in the beaver ponds (with the highest values in the beaver outlets) than downstream of the ponds. Cluster analyses based on the phytoplankton data did not allow a clear distinction between the sampling sites in the ponds, in beavers outlets or downstream of the ponds. The results obtained did not indicate any significant patterns in phytoplankton species distribution related to the beaver ponds. The only pattern detected was the total absence of Cryptophyceae downstream of the ponds in all three rivers investigated.

KEYWORDS: phytoplankton, river ecology, beaver

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Introduction

The capability of beavers to influence the hydrologic regime of flowing water and create wetland habitats is well known (e. g. BROWN & al. 1996, MCCALL & al. 1996). The beavers dam building activity causes a decrease in current velocity and an increase in stream depth and in the concentration of fine particulate organic matter (WALLACE & al. 1995). A beaver pond can significantly affect the river downstream from it and often acts as a site for storage of different chemical elements in sediments (BURNS & MCDONNEL 1998). The capability of beaver ponds to neutralize acid ions has also been well documented (CIRMO & DRISCOLL 1993, NAIMAN & al. 1994). Previous studies show that beavers activity can lead to self purification processes in ponds which improve water quality downstream of the pond. Quantitative and qualitative characteristics of zooplankton communities were different above, within, and below beaver ponds (KRILOV & ZAVJALOV 1998). Specific species were encountered in the pond in comparison with sampling sites before the entrance in the pond and after the dam (LEGEIDA & ROGOZJANSKAJA 1980, KRILOV & ZAVJALOV 1998). However, information about the influence of beaver activity on phytoplankton assemblages is limited (YEARSLEY & al. 1992). Phytoplankton is a primary producer in aquatic ecosystems and contributes considerably, due to photosynthesis, to the enrichment of the water with oxygen. Oxygenation processes are essential for decomposition of organic matter and, consequently, for self purification. Phytoplankton species are also prey for zooplanktonic organisms. It is clear that, considering the important role of planktonic algae in aquatic communities, the knowledge of successions and trends in phytoplankton communities is needed. The aim of the present study was to investigate the influence of beaver (*Castor fiber*) activity on phytoplankton communities in three forest rivers in the St. Petersburg district (NW Russia). We also tried to reveal if it can be distinguished between different areas of beaver ponds above and downstream of dams with the aid of phytoplankton data matrices.

Materials and Methods

Three forest rivers - Kamenka, Gubenka and Poima - near to the city Luga (St. Petersburg district, NW Russia) were sampled before the entrance to beaver ponds, in ponds and after beaver dams three times during August 1998 (Figure 1). All rivers flow through a peat area and consequently have acidic pH in the range 5.0-6.2 and a similar hydrologic regime. The rivers breadth varied between 1.5 and 3.1 m. Beaver ponds investigated were active and three - five years old. The sampling was normally carried out 15 cm under the surface where the total depth was 0.5 m. Exceptions were beaver outlets (active beaver channels penetrating the land), where the total depth of sampling did not exceed 20 cm. From each sampling station two 500 ml PVC bottles of water were taken for qualitative and quantitative analyses. The samples for quantitative analyses were fixed in 1% Lugol’s solution immediately after collection. Later, in the laboratory,

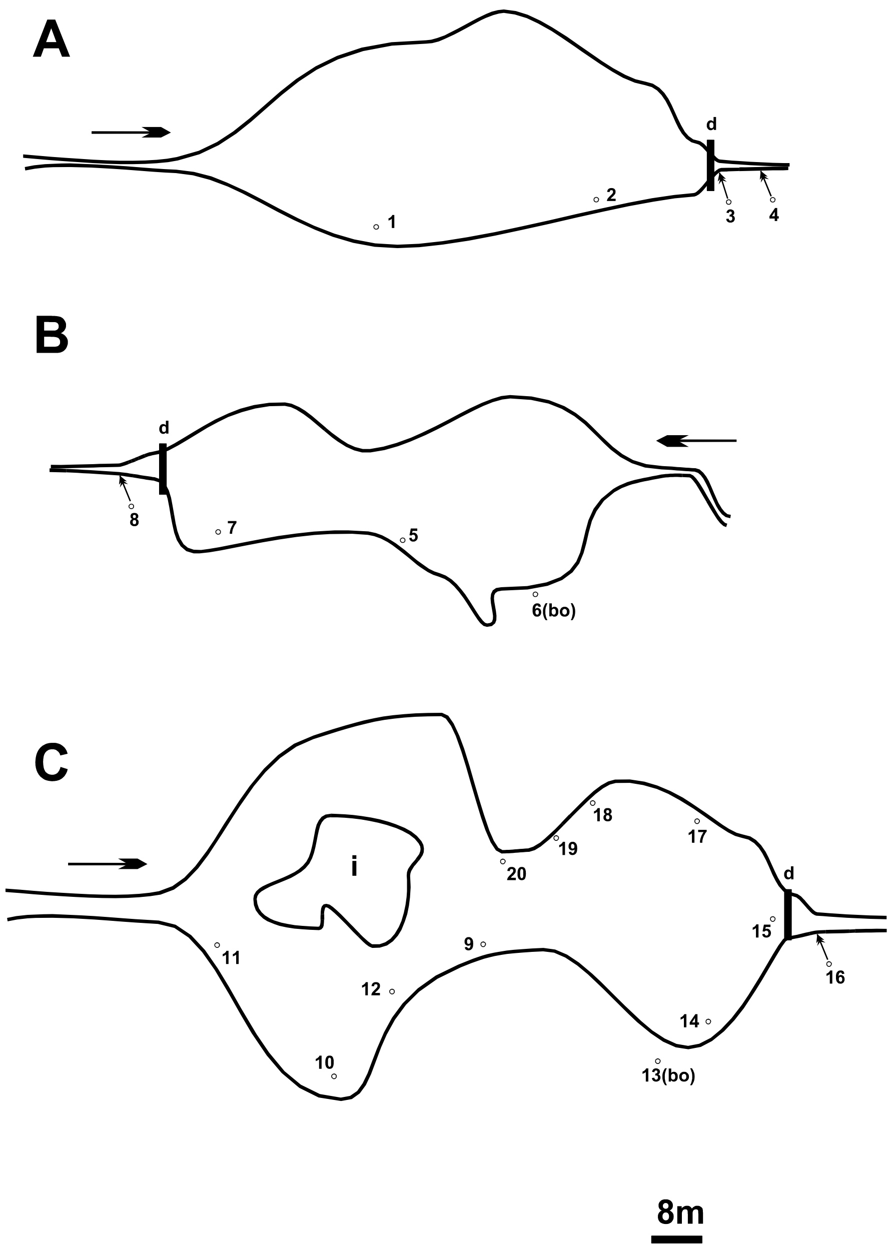

Figure 1. Location of the phytoplankton sampling sites within the studied rivers in the St. Petersburg district, Russia. a) Gubenka; b) Kamenka; c) Poima. The arrows indicate the flow direction, i - island, d - dam, bo - beaver outlet.

the preserved samples were left for 24 hours to achieve sedimentation of algal cells. After sedimentation the samples were concentrated, initially to 50 ml by careful sucking off 450 ml of the sample through plankton nets with 3 μm mesh size. Then, the 50 ml were centrifuged for 20 sec at 4000 rpm, the liquid phase was immediately removed and the pellet was resuspended in approximately 10 drops (sample water) with a Pasteur pipette. When the exact identification of species was not possible from the fixed samples, unfixed samples were used for assistance. A traditional algal system was used for the classification of the found taxa (VAN DEN HOEK & al.1995). Frequency of each species present in the fixed samples was determined according to relative units: 1 - occasional, 2 - rare, 3 - frequent, 4 - dominant (e. g. KANGAS & al. 1993, SMOLAR & al. 1998).

For each sampling site saprobic index (S) based on indicator species was calculated according to the equation:

$$S = \frac{\sum s_i \cdot n_i}{\sum n_i}$$

where n_i = the number of individuals and s_i = saprobic value of an indicator species *i*, respectively (PANTLE & BUCK 1955). Saprobic values given by MAUCH (1976) were used as a reference.

The data about biological oxygen demand (BOD_5) and pH (measured in the middle of the inlet, pond and outlet) were kindly supplied by the Technological Institute in St. Petersburg.

Cluster analyses were performed by using the average linkage distance algorithm in the computer package Minitab 11. Sampling stations were clustered according to similarities in species diversity and their abundance.

Results and Discussion

A total of 24 species were identified. Cyanophyceae (7 species) and Chlorophyceae (6 species) were the most abundant groups. Bacillariophyceae, Chrysophyceae, Cryptophyceae, Dinophyceae und Euglenophyceae were represented with 3, 1, 3, 1 and 4 species, respectively (Table 1). The taxa present were all broadly distributed and no habitat specific species were found. This result coincides with the data for a diatom population of a beaver dam creek, reported by YEARSLY & al. (1992). For the ponds investigated in the present study, taxa such as *Cryptomonas erosa* and *C. ovata* (Cryptophyceae) were the most typical and dominant. In the river Poima *Oocystis borgei* (Chlorophyceae) was also abundant at many sampling sites before the dam.

In all rivers studied the diversity and abundance of phytoplankton species were much higher in the ponds before the dams (with the highest values in the beaver outlets) than after the dams (Figure 2). These results agree with those obtained for zooplankton (LEGEIDA & ROGOZJANSKAJA 1980, KRILOV & ZAVJALOV 1998) and support the importance of the accumulatory role of the dams (WALLACE & al. 1995). However, we did not find species which could be seen as indicators for the beaver ponds, as was reported for zooplankton (LEGEIDA &

ROGOZJANSKAJA 1980). The only significant pattern in phytoplankton distribution we detected was the total absence of Cryptophyceae in outlets after the dams in all three rivers investigated. The species composition and their abundance values were highly conservative during all three sampling events.

Tab. 1. List of taxa identified at the studied sampling stations in three rivers in the St. Petersburg district, Russia in August 1998.

BACILLARIOPHYCEAE
Eunotia lunaris (Ehrenberg) Grunow
Navicula sp.
Synedra ulna (Nitzsch) Lange-Bertalot
CHLOROPHYCEAE
Asterococcus limneticus (Cienkowski) Scherffel
Chlamydomonas sp.
Dactylococcopsis raphidioides Hansgirg
Oocystis borgei Snow
Scenedesmus ecornis (Ehrenberg) Chodat
Schroederia sp.
CHRYSOPHYCEAE
Chrysococcus rufescens Klebs
CRYPTOPHYCEAE
Cryptomonas erosa Ehrenberg
Cryptomonas marssonii Skuja
Cryptomonas ovata Ehrenberg
CYANOPHYCEAE
Anabaena constricta (Szafer) Geitler
Oscillatoria limnetica Lemmerman
Oscillatoria sp.
Pseudanabaena catenata Lauterborn
Pseudanabaena mucicula Bourelly
Spirulina major Kützing
DYNOPHYCEAE
Gymnodinium sp.
EUGLENOPHYCEAE
Euglena acus Ehrenberg
Euglena sp.
Euglena variabilis Ehrenberg
Trachelomonas volvocinopsis Swirenko

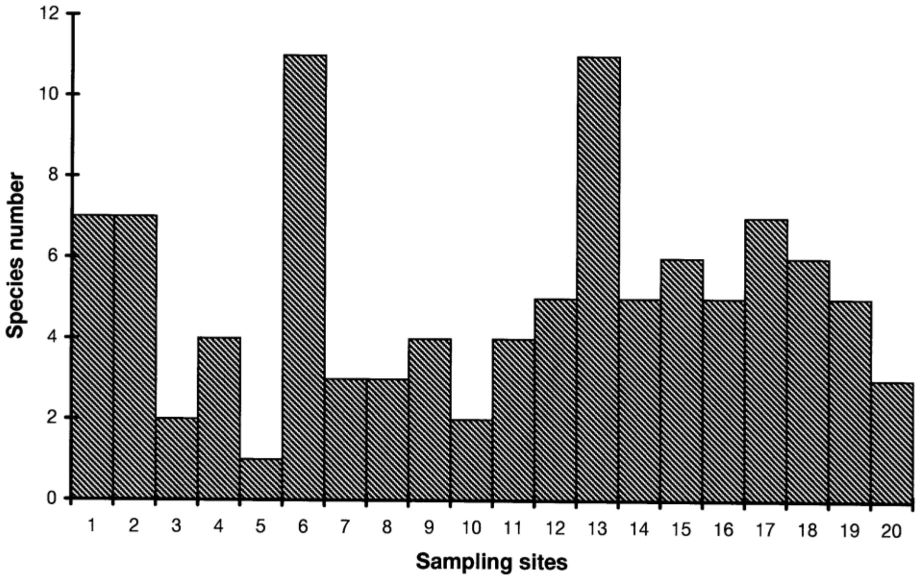

Figure 2. Number of phytoplankton species at different sampling sites from the studied rivers in the St. Petersburg district, Russia. Sampling sites 1 - 4 belong to Gubenka, 5 - 8 to Kamenka and 9 - 20 to Poima.

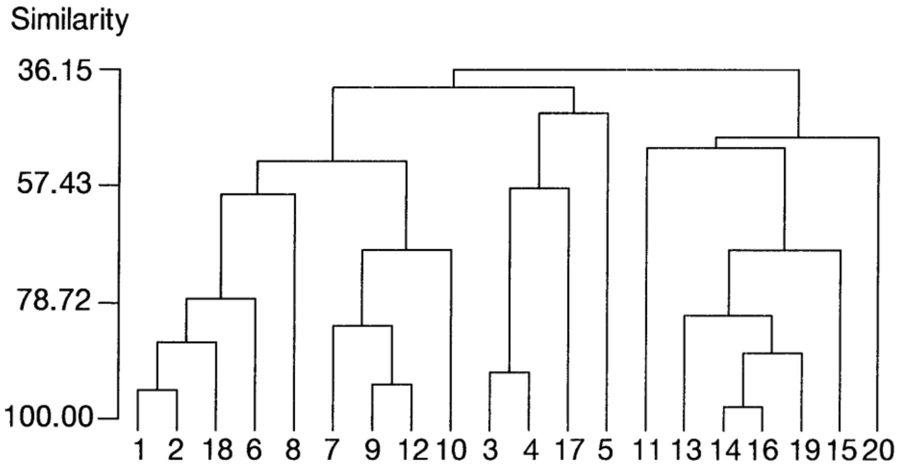

Figure 3. Cluster analysis using a presence-absence with abundance matrix from phytoplankton data at different sampling sites on three rivers studied. Sampling sites 1–4 belong to Gubenka, 5–8 to Kamenka and 9–20 to Poima.

Tab. 2. BOD_5 values for inlets, beaver ponds and outlets after the dams in three river studied in the area of St. Petersburg (Russia).

River	Inlet	Beaver pond	Outlet
Gubenka	3.01	3.38	2.99
Kamenka	3.58	4.02	2.88
Poima	3.80	4.31	3.11

Cluster analyses using a presence-absence with abundance matrix (the matrix can be obtained from authors upon request) did not allow us to distinguish clearly between the sampling sites before the dams, in beavers outlets or in outlets after the dams (Figure 3) as was possible with data from zooplankton (LEGEIDA & ROGOZJANSKAJA 1980, KRILOV & ZAVJALOV 1998). It seems to be impossible to distinguish between beaver ponds in different rivers with the aid of phytoplankton data. For example, most of the sampling sites in river Poima (11, 13, 14, 15, 16, 19 and 20) form a separate cluster. However, sampling sites 9, 10, 12, 17 and 18 are placed together with sampling sites from the other rivers. The dendrographs obtained by cluster analyses were identical during all three sampling events.

BOD_5 values increased in the ponds as compared to the inlets and decreased rapidly in outlets after the dams (Table 2). This fact relates well to the capacity of beaver activity to contribute greatly to the self-purification of water (LEGEIDA & ROGOZJANSKAJA 1980, CIRMO & DRISCOLL 1993, WALLACE & al. 1995, KRILOV & ZAVJALOV 1998). The pH-values varied between 5.0-5.3 in the rivers Gubenka and Kamenka, and between 6.0-6.2 in the river Poima. The pH-values did not change in ponds compared both to inlets and outlets, thus our study does not support acid neutralizing capacity for the rivers investigated, as reported for beaver ponds (CIRMO & DRISCOLL 1993). No significant differences in the water temperature between the sampling sites were observed. The *t*-tests of chemical data performed by the stuff of the Technological Institute, St. Petersburg did not reveal any significant differences between sampling sites in beaver ponds and downstream of ponds in each river studied.

The use of the saprobic index did not reveal clear differences between inlets, ponds and outlets (not shown). The values varied between 1.8 and 2.2. The values of the saprobic index were identical during all three sampling events. Consequently, all three rivers at the range studied belonged to the ß-mesosaprobic level which means moderate pollution (PANTLE & BUCK 1955). However, the saprobic index is related to levels of pollution, dangerous for indicator organisms, and does not indicate eutrophication processes themselves (SLÁDEČKOVÁ & SLÁDEČEK 1994). In this context the rivers should be classified as slightly polluted, while the beaver ponds and dams do not have any detectable influence on the general pollution level of water.

We conclude that the results obtained do not indicate any significant patterns in phytoplankton species distribution related to the beaver ponds in the rivers studied. The only pattern detected was the total absence of Cryptophyceae in outlets after the dams in all three rivers investigated.

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