Diurnal changes of phytoplankton vertical distribution in a shallow floodplain pool

Diurnální změny vertikální distribuce fytoplanktonu v mělké tůni

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Abstract

The study focused on measurements of selected environmental variables and phytoplankton abundance in a shallow floodplain pool. Vertical gradients of temperature, pH, dissolved oxygen and nutrients and their diurnal changes were found although the depth of the pool was only 80 cm (or 140 cm). Diurnal changes in vertical distribution were observed in the case of Euglenophyta, Cryptophyta, and Chrysophyceae.

Introduction

Alluvial pools belong to the most influenceable freshwater habitats. The studies of floodplain waters are sparse, moreover, these waters often have a character of lager lakes (BONETTO et al. 1994, UNREIN & TELL 1994, IZAGUIRRE et al. 2001, IZAGUIRRE, O'FARRELL 1999). Comparable floodplain pools have been previously studied in the Czech Republic, usually from different points of view (KYLBERGEROVÁ et al. 2002, PITHART 1999, KOPECKÝ, KOUDELKOVÁ 1997). Although the lake stratification is considered to play an important role in the functioning of lake ecosystems, the stratification of small water bodies has been evaluated only occasionally (PITHART & PECHAR 1995).

This study describes vertical and diurnal changes of selected environmental variables and phytoplankton distribution in a small, shallow floodplain pool.

Material and methods

Diurnal changes of phytoplankton vertical distribution and selected environmental variables were studied in a small floodplain pool Kolečko in the Litovelské Pomoraví Protected Landscape Area (Central Moravia, Czech Republic) in 1999 and 2001.

Kolečko is a man-made shallow water body with a circular shape, 11 m in diameter, and maximum depth of 150 cm in wet season. The locality is surrounded by meadows, the periphery is overgrown by *Typha latipholia*. The pool bottom is covered with *Utricularia australis*.

Samples were taken from the surface and depths 20, 40, 60, 80 (100, 120, 140) cm during one day in May 1999 and 2001. Water was sampled with a vacuum system (Fig 1). Selected environmental variables were measured in situ by mobile instruments of WTW company (temperature, pH, conductivity, and dissolved oxygen). Nutrients were analysed with a DR 2000 spectrophotometer by HACH (HEKERA 1999). Quantification of algae was carried out by counting in a Bürker chamber after centrifugation (1500 rpm, 5 minutes) of samples.

Results and discussion

Thermal and chemical stratification

While temperature, pH and oxygen decreased with increasing depth (Figs 1,2), nutrients showed the opposite tendency (Fig 2). This pattern is typical for shallow waters where phytoplankton is strongly influenced by sediments (POULÍČKOVÁ & KRŠKOVÁ 2000). Although diurnal changes of nutrient concentrations were insignificant, in the case of temperature, pH and dissolved oxygen they can be conspicuous, especially in the surface layers (Figs 1,2). The latest two parameters are influenced by photosynthesis and respiration of submersed higher plants and phytoplankton.

These results are in good agreement with previously published data obtained from deeper localities (PITHART & PECHAR 1995). According to this study, the most important factor is not an absolute depth but a relative depth in proportion to the surface area. Small surface area with high relative depth values and the presence of surrounding vegetation, acting as a wind-barrier, protect backwaters from wind-mixing and, hence, enhance their stratification (PITHART & PECHAR 1995). In general, pools of the River Morava floodplain can be characterised by some differences in comparison to other previously studied pools. They have smaller maximum and relative depths, higher concentrations of dissolved oxygen and total phosphorus when compared with Lužnice floodplain pools. Moreover, they are not regularly flooded (KYLBERGEROVÁ et al. 2002). Both thermal and chemical stratifications were observed in the River Lužnice floodplain (PITHART & PECHAR 1995). Winter stratification starts with freezing over of the pools at the end of November, and ends at the beginning of March. Spring circulation and floods cause a short period of homoiothermic water column. Summer stratification is present from the beginning of May to the middle or the end of July. This stratification is not permanent, but may be both disturbed and re-established very quickly (within 24 hours). In July, the whole water column begins to warm up gradually and the stratification disappears (PITHART & PECHAR 1995).

Our data verified the presumption that vertical gradients of environmental variables can be established in Moravian shallow pools too. The experiments were correctly timed to the period of summer stratification. The investigated locality is a very small rounded pool surrounded by *Typha latipholia*, which represents probably sufficient wind protection.

While the thermal stratification of pools can be rapidly disrupted, the other investigated variables can remain stratified in this type of pools (PROKEŠOVÁ 1959, PITHART & PECHAR 1995). The chemical and biological gradients were detected in a homoiothermic water column; thus the authors assume their relative independence on thermal stratification. Obviously, three situations may occur: 1. Neither thermal nor chemical stratification is present, 2. Both stratifications are present, 3. Chemical stratification is present, while thermal is not (PITHART & PECHAR 1995). Our observation in the pools of the River Morava floodplain can be characterised as the situation 2. Chemical stratification develops by oxygen depletion at the bottom (Fig 1). The values of pH ranged from 6.6 to 7.5 (1999, Fig 1) or 6.8 – 7.3 (2001, Fig 2). The surface value was higher than the bottom one. The concentration of nutrients reached its maximum at the bottom, similarly to the previously published observations (PITHART & PECHAR 1995).

Phytoplankton stratification

Although the measured ecological variables were similar during two independent experiments, the composition of phytoplankton species was different in two investigated years. The phytoplankton in 1999 was dominated by *Synura* sp., *Mallomonas* sp., *Dinobryon divergens*, *Trachelomonas* sp., *Euglena* sp., and *Cryptomonas* sp. On the contrary, *Cryptomonas curvata*, *Trachelomonas volvocina*, and *T. hispida* were present in 2001.

The differences in phytoplankton composition between the River Morava floodplain pools and other basins in the Czech Republic have been published previously (KYLBERGEROVÁ et al. 2002). The differences are represented by a higher proportion of diatoms at the expense of green algae and a higher proportion of Chrysophyceae and Chlamydophyceae. The River Morava floodplain pools have four times higher average phytoplankton biovolume than the River Lužnice floodplain pools (KYLBERGEROVÁ et al. 2002). The authors recorded the lowest species richness (57 species) in the River Morava floodplain pools. In contrast, we found over 200 species in total in this region (KOČÁRKOVÁ & POULÍČKOVÁ 2001).

With respect to the previously mentioned chemical and thermal stratification, the differences in algal vertical distribution were expected in the pool Kolečko. The distribution of different phytoplankton groups is influenced by their different ecology and ability to control their position in the water column.

Monadoid algae (e.g. Euglenophyta, Cryptophyta, Chrysophyceae), with their ability to move actively, are the best model organisms for the studies of diurnal vertical migrations. Although their accumulation at the surface during a light period is frequently observed (Figs 3,4), their behaviour is species specific (BÍLÝ & PITHART in press). Cryptophyta tolerate even anoxic conditions near the bottom at night (PITHART et al. 2000). Figures 3 and 5 present several examples of the species specific behaviour.

Planktonic cyanophytes with aerotopes represent the second fast migratory group of phytoplankton and frequently form water blooms in fishponds or reservoirs (KOŘÍNEK et al. 1987). Although the occurrence of such cyanophytes have been previously recorded in floodplain pools (VAN DEN BRINK et al. 1994), they have not been found in the Litovelské Pomoraví Protected Landscape Area, even though more then 20 pools were observed (KOČÁRKOVÁ & POULÍČKOVÁ 2001).

Diatoms live by both planktonic and benthic ways of life. Pennate diatoms, especially large species, are benthic with heavily silicified forms. Planktonic forms are represented by *Asterionella formosa* and several species of the genus *Fragilaria*, usually forming colonies (POULÍČKOVÁ & KRŠKOVÁ 2000). Centric diatoms are adapted for the life in the water column by their size and shape and usually live in plankton. They are not capable of active movement and their persistence in the water column depends on water turbulences caused by wind (WILLEN 1991). That is why the euplanktonic diatoms are rare in unmixed pools (POULÍČKOVÁ 2000). The accumulation of pennate diatoms near the bottom (Fig 4) and the absence of centric diatoms are in agreement with previous theses.

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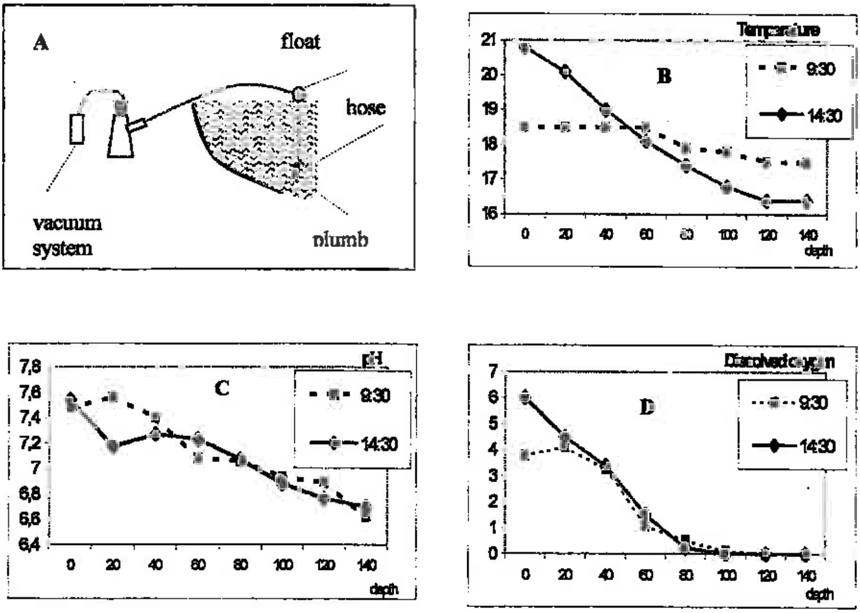

Fig. 1: A Schema of the sampling system;
B- D Selected environmental variables in 1999 (temperature in °C, oxygen in mg.l^{-1}, depth in cm)

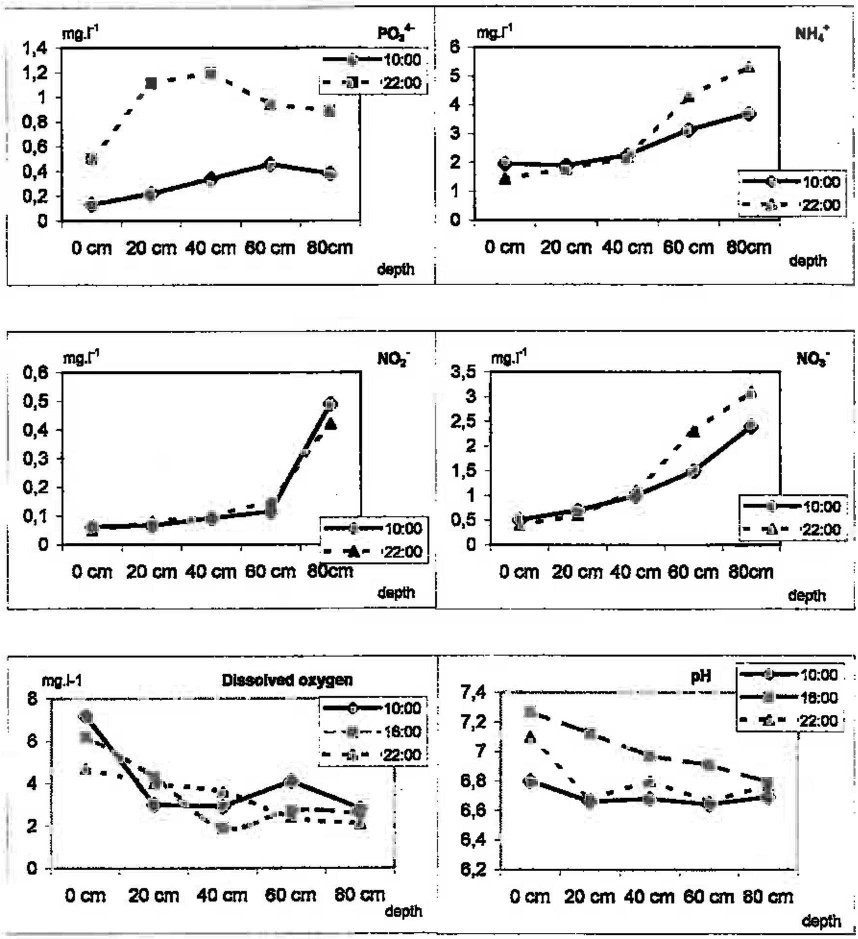

Fig 2: Selected environmental variables in 2001 (temperature in °C, oxygen and nutrients in $mg.l^{-1}$, depth in cm)

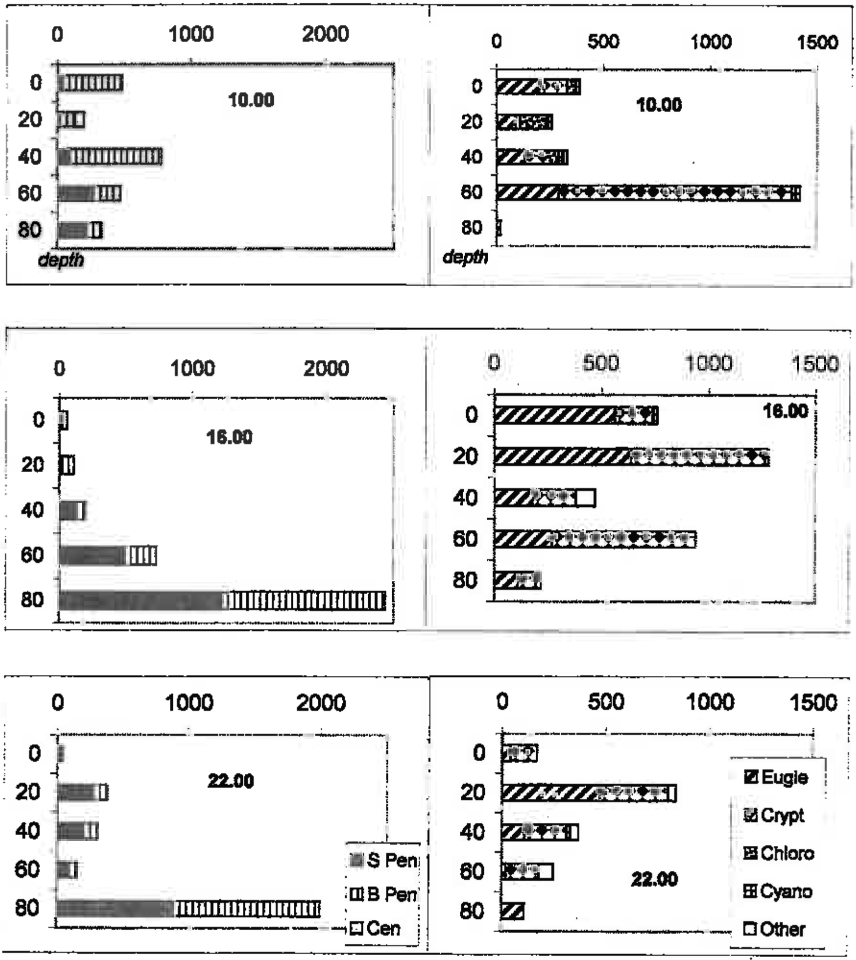

Fig 3: A Diurnal changes in vertical distribution of diatoms in 2001; abundances are in individuals per 1 ml, depth in cm (S Pen – small Pennales, B Pen – big Pennales, Cen – Centrales)

B Diurnal changes in vertical distribution of phytoplankton groups (without diatoms) in 2001; abundances are in individuals per 1 ml, depth in cm (Euglenophyta, Cryptophyta, Chlorophyta, Cyanophyta, Other)

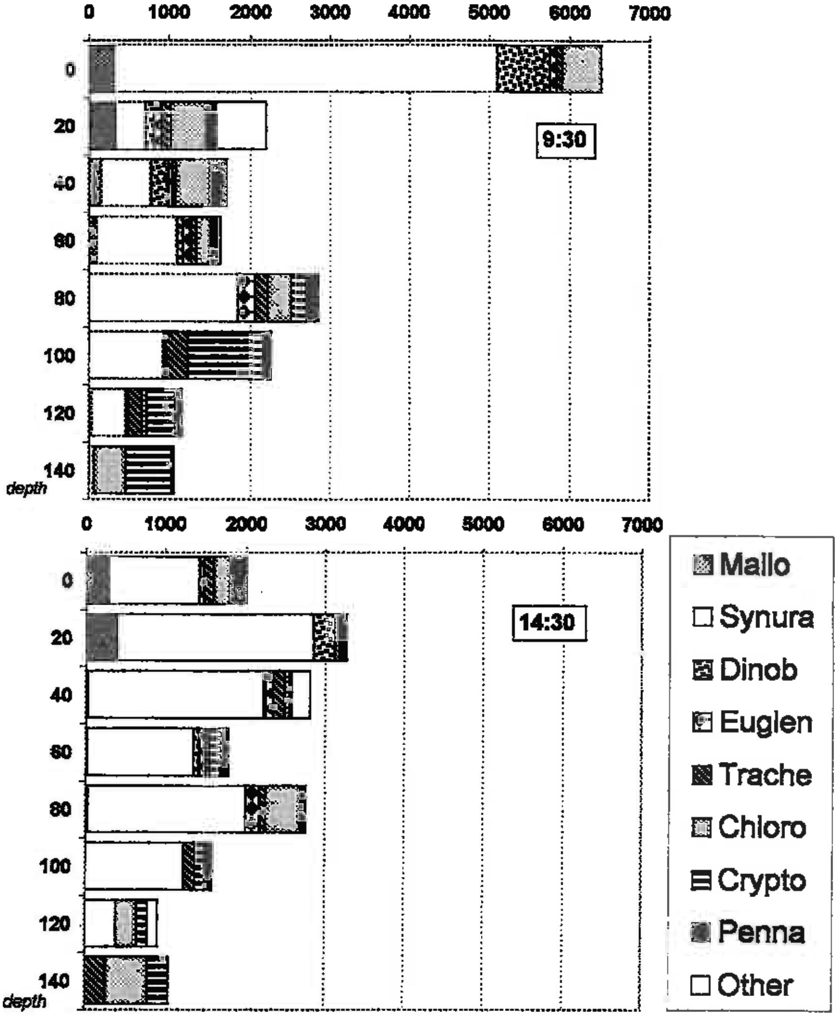

Fig 4: Morning and afternoon vertical distribution of several representatives of phytoplankton in 1999; abundances are in individuals per 1 ml, depth in cm (Mallomonas, Synura, Dinobryon, Euglena, Trachelomonas, Chlorophyta, Cryptophyta, Pennales, Other)

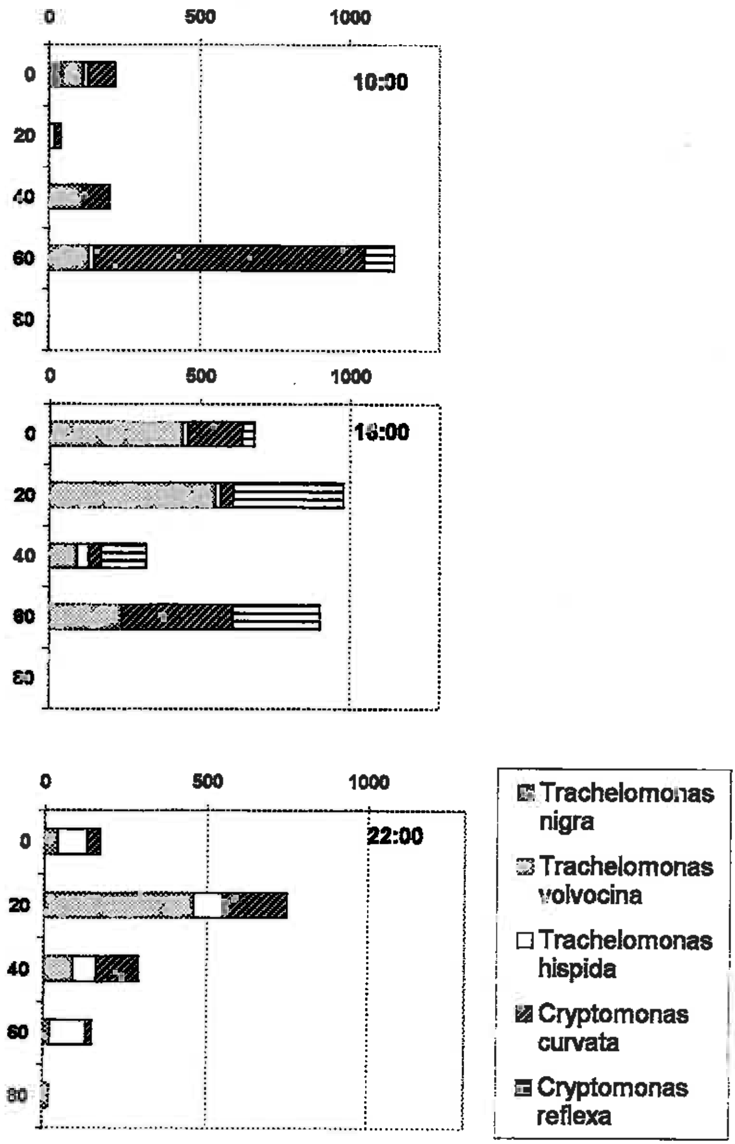

Fig 5: Species specific vertical distribution of several monadoid taxa; abundances are in individuals per 1 ml, depth in cm.