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DIEL VERTICAL DISTRIBUTION OF *CLADOCERA* IN MESOTROPHIC LAKE PIASECZNO AND ITS CAUSES

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Summary: *Cladocera* diel vertical distribution in lake Piaseczno was analysed. The cladocerans were concentrated in the upper layers of the water column throughout the study period. Diurnal vertical migration was observed in small-bodied filter-feeders *C. sphaericus* and *B. longirostris.* Some kind of vertical migration showed *D. cucullata* by gathering in the epilimnion during the day. The rest of cladocerans showed no diel migration pattern. Diurnal changes of temperature and dissolved oxygen influenced clearly cladoceran vertical distribution. They probably can be an indirect factor for zooplankton used to recognize the danger of being preyed upon.

Keywords: lake, cladoceran zooplankton, diel vertical distribution

INTRODUCTION

The phenomenon of diurnal changes in zooplankton vertical distribution has been known for more than a century and many hypotheses explicating that process have arisen since that time. Generally they all can be divided into three groups: those based on directly acting cues: temperature, light and food; those based on evolutionary conditioned forces: predator avoidance and metabolic advantage hypotheses; and those based on system consequences of vertical migrations. In fact diel vertical distribution is distinct for different species and under different external conditions. In the case of Lake Piaseczno (Łęczna-Włodawa Lakeland) *Cladocera* are classified among groups of animals which are recognized in the highest degree [5-8] but it is little known about their diel vertical distribution. Therefore the aim of the study was to investigate what taxa present diel vertical migrations and to characterize impact of some physical and chemical factors to vertical migration patterns.

MATERIAL AND METHODS

The study was carried out on 10 July-13 July 2001 in the deepest part of the Piaseczno basin (water depth 38.8 m) at 5:00, 1:00, 17:00, 21:00 and 1:00 each day. Oxygen, temperature and pH profiles were measured with a hydrolab 4 sounder. Samples for cladocerans were taken with „Toń" sampler (volume 10 l) from twelve levels in the water column down to 35 m. Samples were filtered through a 50 μm plankton net and preserved with formalin and glycerin solution. In the laboratory cladocerans were enumerated using an inverted microscope and identified to species. The number of individuals per 1 litre of water was calculated for each sample.

RESULTS

At 0-5m depth, the water temperature was mainly between 20-23°C (Fig. 1).

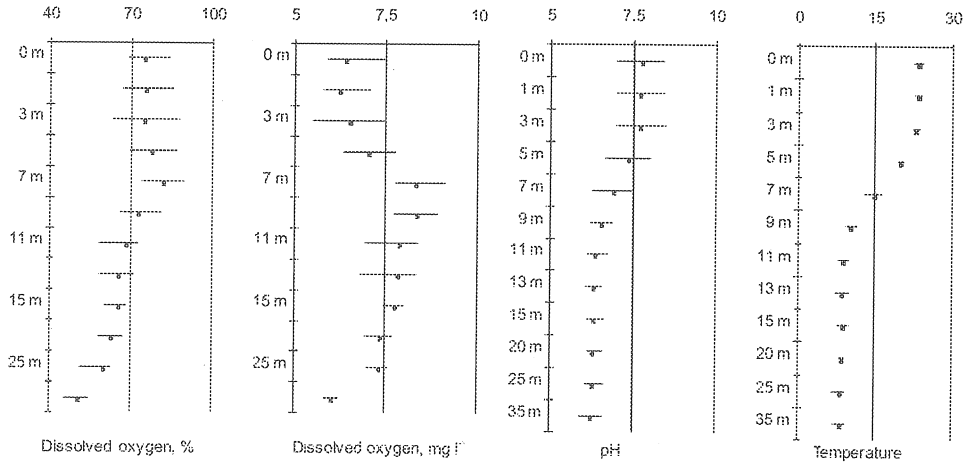


Fig.1. Max., min. and mean values of temperature, pH and dissolved oxygen in the vertical profile of Lake Piaseczno

The termocline was at 5-9 m depth, water temperature being 8-10°C at 11 m depth, thereafter decreasing steadily. The concentration of dissolved oxygen in the epilimnion was 6-8 mg l^{-1} (63-88%). It's maximum was at 7-11 m depth at 17:00, when it reached 9.1 mg l^{-1} (90.5%) and 8.9 mg l^{-1} (81.5%) respectively, and below to 25 m depth the oxygen concentration was 7.0-8.4 mg l^{-1} (50.7-73%), decreasing to 5.8 mg l^{-1} (45%) at 35 m depth. Mean values of pH stayed near 7.5 in the epilimnion and near 6 in the metalimnion and hypolimnion throughout the

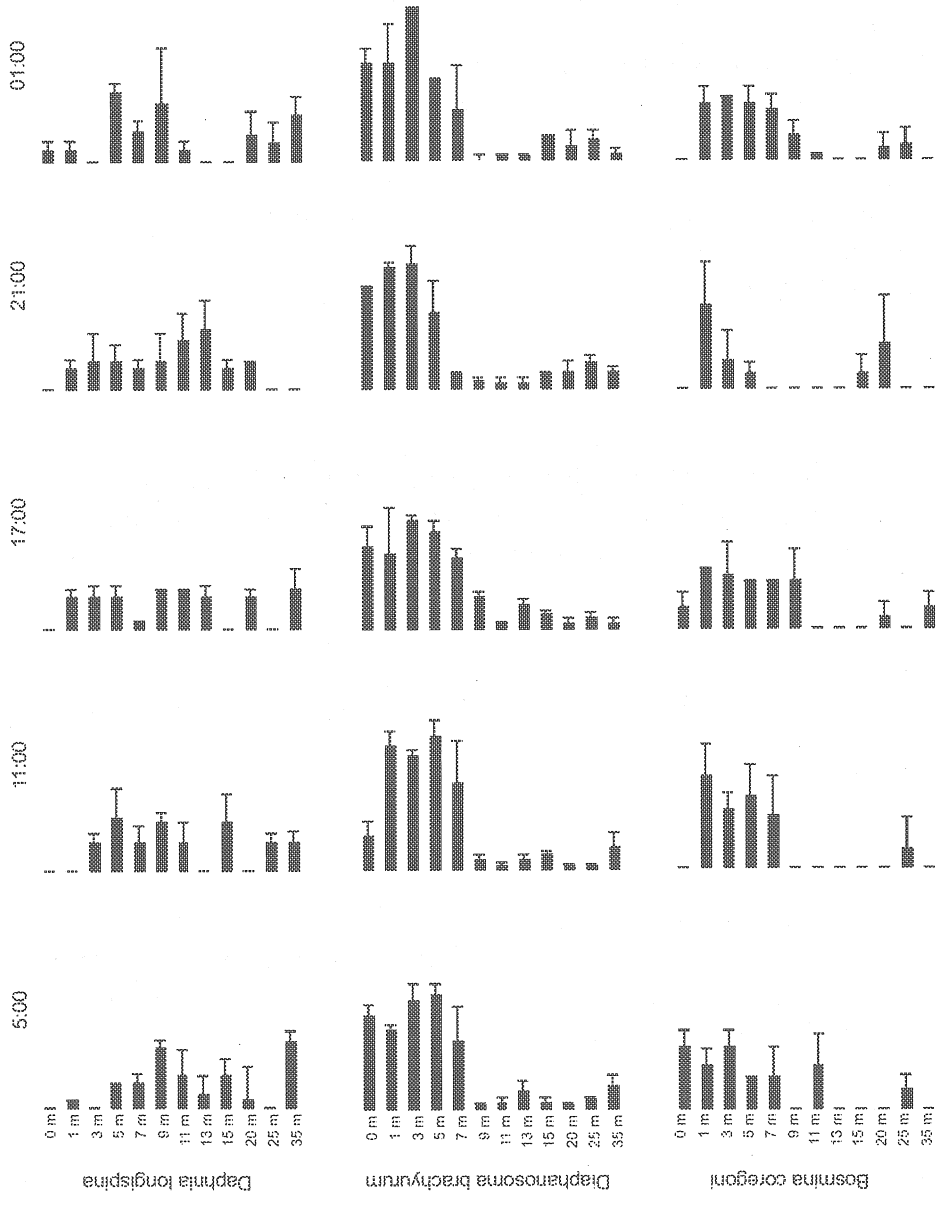
study period. In the upper layers it was changing considerably during daytime, reaching the highest values at 17:00 and 21:00 (above 8) and lowest values at 1:00 (below 7). There were no clear diel differences of pH in the metalimnion and hypolimnion.

Collected cladocerans belonged to 8 species. Their densities ranged from about 470 ind l^{-1} in the case of *Diaphanosoma brachyurum* to below 5 ind l^{-1} for *Leptodora kindti* throughout the study period. The cladocerans were concentrated in the upper layers of the water column; over 70% of all individuals inhabited the 0-9m throughout the study period, and over 50% of the cladocerans were found in the epilimnion.

The results suggest that only *Chydorus sphaericus* and *Bosmina longirostris* represented a typical and clear diurnal migration (Fig. 2). During the day the majority of *C. sphaericus* population inhabited 5-25 m depth, while during the night the population occurred mostly at the 0-5 m depth. *B. longirostris*, in turn, occupied cold and dark hypolimnion during the day and inhabited all water column uniformly at the time of sunset. Similar pattern of diel vertical migration showed *Daphnia cucullata*. In the afternoon and night its distribution was equal in the water column but during the day the majority of the population gathered in the metalimnion. *Daphnia longispina*, *Diaphanosoma brachyurum* and *Bosmina coregoni* showed no diurnal migration pattern. Both *D. brachyurum* and *B. coregoni* were assembled in the epilimnion and metalimnion, while *D. longispina*, on the contrary, showed equal distribution in the water column during the study period.

DISCUSSION

The timing and pattern of vertical distribution are determined by the balance condition between some contradicting factors. On the other hand different species have different rates, mechanisms and other characteristics that need to be quantified for the species. Therefore the causes of migration or non-migration to a certain depth, at exact time and a number of predators are various for each taxa. Gained results demonstrate different patterns of diel, vertical distribution. The great majority of cladocerans inhabited the epilimnion throughout the study period and their vertical movements were restricted until the thermocline. Experimental results demonstrate that low temperature in deep water leads to disadvantage for migrating organisms [10, 11, 13]. Therefore during temperature stratification, thermocline may set a lower boundary of vertical migrations [2, 3, 9].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Daphnia longispina
Diaphanosoma brachyurum
Bosmina coregoni

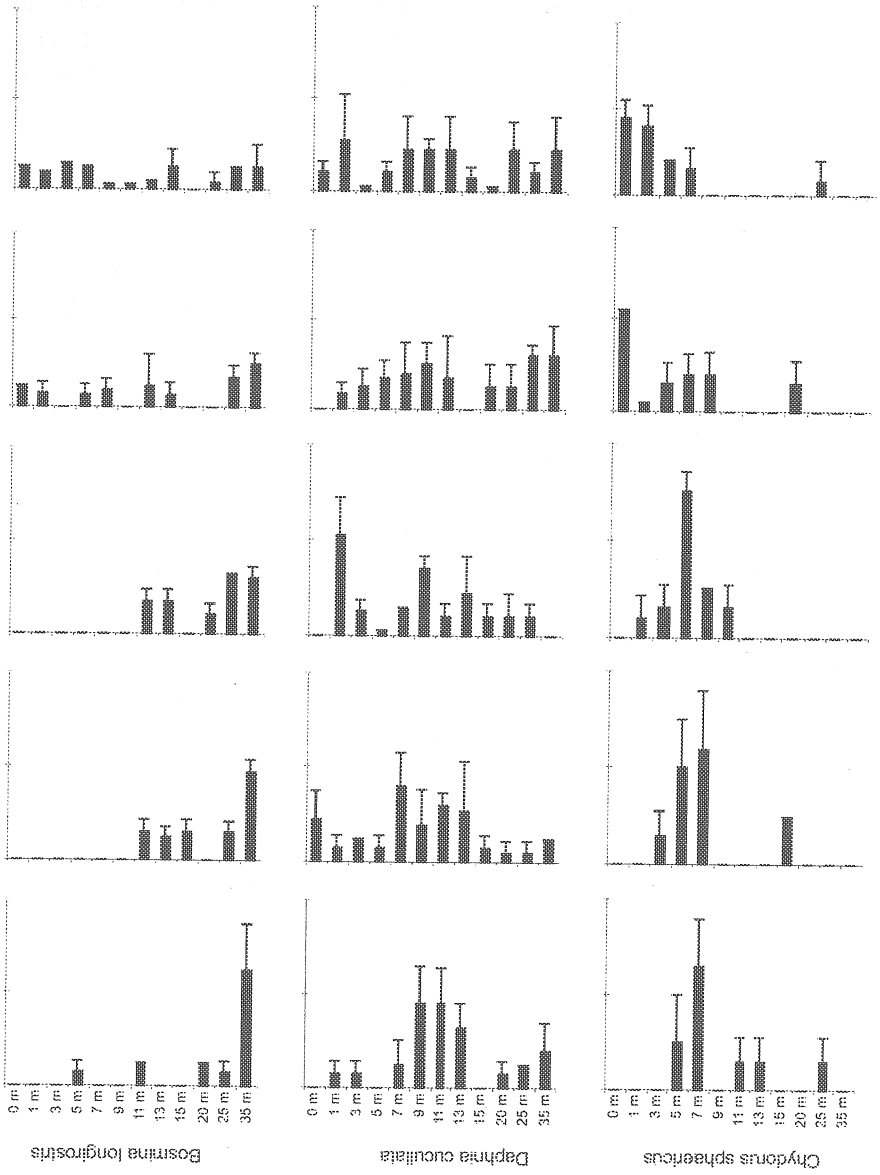

Fig. 2. The vertical distribution (proportion of total population abundance, ±SD) of different cladoceran species during the study period

The received results correspond with Tallberg *et al.* [14] who found that in the 0-5 m depth the zooplankton biomass is considerably higher than in deeper layers. Among investigated cladocerans only *C. sphaericus* and *B. longirostris* ascended to water surface at sunset and descended to deeper water during sunrise. In pelagic zones of lakes low light intensities or low concentrations of dissolved oxygen may work as refuges against predators because cladocerans can tolerate lower oxygen concentrations than fish [12]. However, hypolimnetic low-oxygen layers may favour the coexistence of vertebrate and invertebrate predators, leading to a drop of zooplankton communities [4] and it seems to be an answer why two taxa only conducted migrations to hypolimnetic refuge. The most of *D. cucullata* population inhabited the metalimnion during the day. A common distribution connected with predation abundance in natural aquatic environments is that predation pressure decreases with water depth. *D. cucullata* seems not to follow the layers where the predation pressure is minimum, but the layers where the predation pressure is optimal, the temperature is quite high and food resources are still accessible at the same time. According to the study by Beklioglu and Moss [1] an increase in pH above 9 impairs fish activity, while cladocerans may develop to pH values about one unit higher. Mean value of pH in Piaseczno was about 7 during the study period and it's diurnal changes seem not to have any role for cladocerans vertical distribution.

CONCLUSIONS

1. The results demonstrate different patterns of diel, vertical distribution of *Cladocera.*
2. Thermocline may set a lower boundary of vertical migrations for some taxa.
3. Diurnal changes of temperature and dissolved oxygen can be an indirect factor for cladoceran zooplankton used to recognize the danger of being preyed upon.

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DOBOWE ROZMIESZCZENIE LICZEBNOŚCI WIOŚLAREK (*CLADOCERA*) W MEZOTROFICZNYM JEZIORZE PIASECZNO I JEGO PRZYCZYNY

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Streszczenie. Badania prowadzono na Pojezierzu Łęczyńsko-Włodawskim w głębokim, mezotroficznym jeziorze Piaseczno. Materiał do badań gromadzono od 10 do 13 lipca 2001 roku. Próby pobierano w najgłębszym miejscu jeziora, w pięciu seriach w ciągu doby, o godzinie 9.00, 11.00, 17.00, 21.00 i 1.00. Uzyskane wyniki wskazują, że największa liczebność wioślarek występowała w epilimnionie w ciągu całego okresu badań. Tylko *Chydorus sphaericus* i *Bosmina longirostris* podjęły typowe wędrówki pionowe. Maksimum populacji *Daphnia cucullata* występowała w metalimnionie w ciągu dnia, natomiast nocą jej pionowe rozmieszczenie było równomierne w toni wodnej. Pozostałe gatunki nie podejmowały dobowych wędrówek pionowych. *Diaphanoso-*

ma brachyurum i *Bosmina coregoni* gromadziły się w dwóch górnych strefach termicznych, natomiast *Daphnia longispina* wykazywała równomierne rozmieszczenie w toni wodnej w ciągu całej doby. Zmiany temperatury oraz zawartości tlenu w ciągu doby wpływają wyraźnie na dobowe pionowe rozmieszczenie *Cladocera*. Pełnią one prawdopodobnie rolę czynnika informującego organizmy o bezpośrednim zagrożeniu ze strony drapieżników.

Słowa kluczowe: jezioro, wioślarki, pionowe rozmieszczenie