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Vertical distribution of zooplankton in a strongly stratified hypertrophic lake

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Abstract

The vertical and temporal distribution of metazooplankton in the small hypertrophic, strongly stratified, temperate Lake Verevi (Estonia) was studied during 1998–2001. The zooplankton of Lake Verevi is characteristic of hypertrophic lakes, with a small number of dominant species, rotifers being the main ones, and juveniles prevailing among copepods. In 1999–2001, the average abundance of metazooplankton in the lake was 1570×10^3 ind m^{-3}; in the epilimnion 2320×10^3 ind m^{-3}, in the metalimnion 2178×10^3 ind m^{-3}, and in the hypolimnion 237×10^3 ind m^{-3}. The average biomass of metazooplankton was 1.75 g m^{-3}; in the epi-, meta- and hypolimnion, accordingly, 2.16, 2.85 and 0.26 g m^{-3}. The highest abundances – $19{,}136 \times 10^3$ ind m^{-3} and $12{,}008 \times 10^3$ ind m^{-3} – were registered in the lower half of the metalimnion in 24 May and 5 June 2001, respectively. Rotifer *Keratella cochlearis* f. *typica* (Gosse, 1851) was the dominating species in abundance. In biomass, *Asplanchna priodonta* Gosse, 1850, among the rotifers, and *Eudiaptomus graciloides* (Lilljeborg, 1888), among the copepods, dominated. According to the data from 2000–2001, the abundance and biomass of both copepods and rotifers were highest in spring. Zooplankton was scarce in the hypolimnion, and no peaks were observed there. During the summers of 1998 and 1999, when thermal stratification was particularly strong, zooplankton was the most abundant in the upper half of the metalimnion, and a distinct peak of biomass occurred in the second fourth of the metalimnion. Probably, the main factors affecting the vertical distribution of zooplankton in L. Verevi are fish, *Chaoborus* larvae, and chemocline, while food, like phytoplankton, composition and abundance may affect more the seasonal development of zooplankton.

Introduction

Processes and interactions, including the role of zooplankton in the whole ecosystem, in the shallow, well-mixed lakes, have been intensively investigated in the last decades. A growing attention has been paid also to those in stratified lakes. Matter circulation is particularly complicated in the stratified lakes, and there occur specific biotic communities. Many deep but formerly non-stratified lakes have become stratified due to eutrophication. For predicting of the future changes in their ecosystem, it is extremely important to understand the processes taking place in the metalimnion of the lakes. In the Estonian lakes, increase of oxygen-deficient zone and even more distinct stratification were observed in the last decades (Ott, 1996; Ott et al., 1997); therefore, the processes in the metalimnion acquire steadily increasing importance. The metalimnion can be the most nutrient- or food-rich layer in some stratified lakes (Wetzel, 1983). In Lake Verevi, the summer stratification is formed quickly

due to the weak spring water circulation, even lacking completely in some years; therefore, the epilimnion remains poor in nutrients. As a result of the temperature gradient, the water density is different in the different layers; this impedes sedimentation and concentrates organic matter in the metalimnion. Nutrients accrue to the metalimnion also from the hypolimnion by diffusion.

Distribution of zooplankton in the water column of a lake is determined mostly by light, temperature, the concentration and availability of food (Miracle, 1977; Andronikova, 1989; Carpenter & Kitchell, 1993; Kizito & Nauwerck, 1995), also by diurnal vertical migration for avoiding predation, and seasonal vertical distribution induced by life cycles. Fish are the determining predators for zooplankton (Lammens, 1990; Van Donk et al., 1990; Herzig, 1994; Jeppesen et al., 1996; Stransfield et al., 1997), while the meroplanktic *Chaoborus* larvae have a remarkable role, too (Leibold, 1990). The herbivorous zooplankton is located mostly in the epilimnion at the maximum of phytoplankton. In stratified lakes, the vertical distribution of herbivorous zooplankton could be different, depending mostly on the more structured distribution of phytoplankton. In deeper layers, the food of zooplankters consists mainly of detritus, bacteria, and heterotrophic protozoans (Kizito & Nauwerck, 1995).

The very first data on the zooplankton of Lake Verevi were presented in the manuscripts of Prof. H. Riikoja based on the samples collected from July 1928 to October 1929. The next exhaustive investigations on L. Verevi were carried out in 1985 (May–October), 1988–1989 (June–April), 1991 (January–October), and 1993 (March–December). The results on zooplankton have been presented by Timm & Mäemets (1991) and Kübar (1994). More than 50 taxa of zooplankton have been identified in the pelagial of L. Verevi, including over 26 species of rotifers, 15 cladocerans, and 9 copepods (Timm & Mäemets, 1991; Kübar, 1994; Olt, 2001). *Chaoborus* larvae also occur in the plankton. *Keratella cochlearis* (Gosse, 1851), *Polyarthra* sp. and nauplii dominate in abundance, while *Asplanchna* sp., *Eudiaptomus graciloides* (Lilljeborg, 1888) and the cyclopoid copepods dominate in biomass.

The vertical distribution of zooplankton is still not much investigated in the Estonian lakes. As the zooplankton, especially crustaceans, occupy a functionally central position in the matter circulation of a lake (Viitasalo, 1994; Lampert, 1997), it is important to know its distribution in the water column.

The aim of the present work is to describe the vertical and temporal distribution of zooplankton estimating the role of metazooplankton in the hypertrophic stratified Lake Verevi.

Materials and methods

Lake Verevi is a small (12.6 ha, maximum depth 11 m, mean depth 3.6 m; for more details see Ott et al., 2005a), hard water, hypertrophic lake located in the town of Elva, South-Eastern Estonia. It is characterized by weak water exchange (0.63 times per year), strong stratification, and anoxic hypolimnion.

Samples were collected during four years from 1998 to 2001. In 1998 and 1999, L. Verevi was sampled in summer from 8 layers (2 in epi-, 4 in meta- and 2 in hypolimnion). In 2000, the lake was sampled during the whole vegetation period, more frequently in spring and autumn, from 3 layers (epi-, meta- and hypolimnion), except 23 October, when only epi- and hypolimnion was studied. In 2001, the lake was investigated during spring from 3 layers (epi- meta- and hypolimnion) until 26 April, and since 30 April from 4 layers (epi-, 2 meta- and hypolimnion layers). On 29 March, 2 layers (epi- and hypolimnion) were sampled. The number of samples collected from the water column was flexible following the formation of lake stratification and degradation.

Altogether 116 samples of metazooplankton were collected from the lake in the centre of the larger southern part of the lake, at its deepest point. The depth of the layers was chosen taking into account the vertical profiles of temperature and oxygen – the change of temperature by 1.5 °C m^{-1} was considered as the upper boundary of the metalimnion (Nõges & Nõges, 1998). Van Dorn sampler (volume 2 l) was used. 10 l of water from every layer were filtered through 48 μm plankton net; as an exception, 85 μm net was used in 1998. It is generally accepted that the use of plankton nets with mesh sizes larger than 50 μm leads to under-estimation of rotifer numbers