Hydrobiologia (2005) 547:163–174
I. Ott & T. Kõiv (eds), Lake Verevi, Estonia – A Highly Stratified Hypertrophic Lake
DOI 10.1007/s10750-005-4157-7


# Vertical and seasonal dynamics of planktonic ciliates in a strongly stratified hypertrophic lake

Priit Zingel[1,2]
[1]*Centre for Limnology, Institute of Agricultural and Environmental Sciences, Estonian Agricultural University, Rannu, 61101 Tartumaa, Estonia*
[2]*Institute of Veterinary Medicine and Animal Sciences, Estonian Agricultural University, 1 Kreutzwaldi St., 51014 Tartu, Estonia*
*E-mail: pzingel@zbi.ee*

*Key words:* ciliates, protozooplankton, vertical distribution, seasonal dynamics

## Abstract

Seasonal population dynamics and the vertical distribution of planktonic ciliates in a hypertrophic and strongly stratified temperate lake were studied from April to October in 2000 and from April to June in 2001. In the epi- and metalimnion the ciliate abundance peaked in spring and late summer, reaching maximum values in the metalimnion (86 cells $ml^{-1}$) on 7th August 2000. In the epilimnion, the highest biomass content (414 $\mu$g C $l^{-1}$) was observed on 8th May 2000. In the hypolimnion only a late summer peak occurred and the ciliate numbers were always lower than in the epi- and metalimnion. Five groups dominated the community of ciliates: *Oligotrichida, Gymnostomatea, Prostomatida, Hymenostomata* and *Peritrichia*, and the community composition varied greatly with depth. In the epilimnion the ciliate numbers were dominated by oligotrichs but small algivorous prostomatids, peritrichs and gymnostomes were also numerous. In the metalimnion these groups were gradually replaced by scuticociliates and mixotrophic *Coleps* spp. In the hypolimnion scuticociliates and species known as benthic migrants dominated. In the epilimnion and upper metalimnion in spring large herbivores and in summer small bacterivores were more numerous.

## Introduction

Ciliates (*Ciliophora*) are one of the largest groups of protozoans – over 7000 species of ciliates have been described and they can be found in almost every aquatic environment. Studies in the two last decades have highlighted the importance of planktonic ciliates in freshwater ecosystems. Ciliates have an important role in the 'microbial loop' (Azam et al., 1983) as they prey upon bacteria and microflagellates. They consume also pico- and nanoalgae (Sherr & Sherr, 1984; Fenchel, 1987; Gonzales et al., 1990; Kisand & Zingel, 2000) that are not efficiently grazed by larger metazooplankters. There is plenty of evidence that planktonic ciliates are an important food resource for large metazoan zooplankton (Stoecker & Capuzzo, 1990; Dolan & Coats, 1991; Gifford, 1991). Thus, planktonic ciliates may be a critical link between microbial and macroscopic components of pelagic food webs. In lakes, planktonic ciliates can at times constitute over 50% of the biomass of zooplankton (Zingel, 1999).

In the past years the number of studies that deal with freshwater ciliates have increased rapidly. Still there is lack of detailed studies about the temporal and vertical distribution of ciliates in strongly stratified lakes. During the formation of

the metalimnion, an adaptation of organisms to changeable conditions will take place. In summer stagnation the vertical distribution of organisms differs essentially from that in the moment of circulation. In the relatively narrow metalimnetic layer, a temporary microbial loop will form, in which aerobic, microaerobic and anaerobic conditions occur. In addition, vertical gradients of temperature, oxygen and radiation will develop inside the metalimnion, and cause a succession of microniches and -environments in time and space. A great variety of microbes will allow for the functioning of a microbial loop. This metalimnetic circulation of matter consists of microalgae, bacteria, heterotrophic nanoflagellates, ciliates and other microzooplankton; the organic matter produced by this loop can in principle return into classical matter circulation (Steenbergen et al., 1993). Little is known about the role of ciliates in the described pattern.

The aim of our study was to describe the vertical and temporal distribution and community structure of planktonic ciliates in a hypertrophic temperate lake.

## Materials and methods

Lake Verevi is a small (12.6 ha; mean depth 3.6 m; maximum depth 11 m) hypertrophic lake (tot P > 100 $\mu$g $l^{-1}$; tot N > 1500 $\mu$g $l^{-1}$; chl $a$ > 40 $\mu$g $l^{-1}$) with very small water exchange, situated in Southern Estonia. It is characterized as a strongly stratified water body with an anoxic hypolimnion. The ice cover lasts usually from November to April. During the vegetation period, the Secchi depth usually does not exceed 1 m. For more thorough description of lake and study methods see Ott et al., 2005.

The lake was sampled from April to October in 2000 and from April to June in 2001, altogether in 12 and 9 occasions, respectively. In the year 2000, at every occasion eight subsamples were collected from different depths for ciliate counts: two from the epi- and hypolimnion and four from the metalimnion. In October, the deepest hypolimnion layer was not sampled. In 2001, three or four subsamples were collected: one from the epi- and hypolimnion and one (in April) or two (May and June) from the metalimnion.

The samples from the surface were taken directly into a bottle, the others using a special vacuum probe (similar to the one used by Guerrero et al., 1985). A masterflex pump (model N 7533–60) with an 'easy-load' pump-head (model 7518–12) was used for pumping water to the surface through a Ø 8 mm hose. The lower end of the vertical hose was connected to a 7-cm long horizontal tube in order to get water from horizontal layers as precisely as possible. The flow of the device was $\sim$2 l $min^{-1}$. Collected samples were preserved and fixed with acid Lugols solution. The ciliate biomass and community composition were determined using the Utermöhl (1958) technique. Samples were stored at 4 °C in the dark. Volumes of 50 ml were settled for at least 24 h in plankton chambers. Ciliates were enumerated and identified with an inverted microscope (mainly Olympus IX50) at 400–1000 × magnification. The entire content of each Utermöhl chamber was surveyed. Ciliates were usually identified to genus on the basis of several sources (Kahl, 1930–1932, 1935; Patterson & Hedley, 1992; Foissner & Berger, 1996). The first 20 measurable specimens encountered for each taxon were measured. Biovolumes of each taxa were estimated by assuming geometric shapes and converted to carbon weight using a factor of 190 fg C $\mu m^{-3}$ (Putt & Stoecker, 1989). For statistical analysis nonparametric methods were used. For bacterial and metazooplankton data used in analyses see Tammert et al., 2005 and Kübar et al., 2005.

## Results

In 2000, the mean abundance of ciliate protozoa in L. Verevi was 29.7 cells $ml^{-1}$ and in 2001 27.6 cells $ml^{-1}$. The mean biomass was 110 $\mu$gC $l^{-1}$ and 116 $\mu$gC $l^{-1}$ in 2000 and 2001, respectively. Throughout the investigation period the ciliates species composition consisted mainly of five groups: oligotrichs, gymnostomes, scuticociliates, peritrichs and prostomatids (Fig. 1). The highest abundance (85.9 cells $ml^{-1}$) was registered on 7 August 2000 in the metalimnion (Fig. 2) and the highest biomass (414 $\mu$g C $l^{-1}$) on 8 May 2000 in the epilimnion (Fig. 3). In spring 2001, the highest abundance (68.6 cells $ml^{-1}$) and highest biomass (406 $\mu$gC $l^{-1}$) were recorded on 7 May (Fig. 4).