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Effects of climate change on zooplankton community structure of the middle stretch of the Daugava river over the last 50 years

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Abstract

The aim of this research was to evaluate dynamics of the zooplankton community in the middle stretch of the Daugava river over the last 50 years and the possible impact of the climate change namely variability of temperature and hydrology on zooplankton community fluctuations. Quantitative (abundance, biomass, number of taxa), qualitative (species composition) characteristics, species diversity (Shannon–Wiener index) and saprobity index (S) were employed for the analysis of zooplankton community structure in the Daugava river. For determination of zooplankton community correlated similarity Renkonen percentage similarity (Renkonen index) was used. Historic hydrological and air temperature data were analysed. A tendency for the total abundance of zooplankton and species diversity to decrease has been recorded. Relevant changes in species structure have been stated. There are also changes in the species occurrence according to seasons. Such changes could be attributed to the long-term changes in climate, namely variability of temperature and hydrology of the Daugava drainage basin.

Key words: large river, long-term changes, Rotifera, Cladocera, Copepoda

1. Introduction

During the last 50 years in the world the mean temperature has increased for about 0.7 ± 0.2°C, but in Europe – for about 1°C (Kļaviņš, Spriņģe 2010). The annual mean air temperature increase in the last 100 years in Latvia in total is about 3°C. Since 1955 the mean annual air temperature in Daugavpils has raised for about 1.3°C or for about 0.8°C during the last 35 years (National Research Program 2008). It has been predicted that in Latvia till 2100 the mean temperature in comparison with the mean temperature in 2000 will rise for about 5-7°C (Kļaviņš, Spriņģe 2010). The effect of climate warming on freshwater ecosystems is an urgent topic for investigation in the last years all over the world. Climate, as a regulator of water flow, initiating changes in river hydromorphology, exerts an important control over fluvial communities, and natural disturbances are the cause of large variations between rivers, as well as within and between reaches and years of the

same river (Lair 2006). River discharge regimes in the Baltic countries during last century, as shown by the example of Latvia, have been subjected to major changes – highly possibly attributable to the climate change, but also changes of land-use patterns and development of hydro technical buildings could have affected the river regime (Kļaviņš *et al.* 2008b). Higher water temperature, shorter ice crust and stagnancy periods, longer short water period these are the factors that influence the freshwater hydroecosystems' status (Kļaviņš *et al.* 2008a).

Because of a general lack of data, it is difficult to assess the state of inland water biodiversity. However, the evidence of biological impoverishment in aquatic systems is pervasive, and when available, the data are very disturbing (Leveque *et al.* 2005). It has been stated that long-term warming has an influence on the Northern hemisphere, the thermal regime of the freshwater hydroecosystems, the structurally-functional individuality of hydrobiocenosis, including biological diversity, trophic structure and the dynamics of the population (National Research Program 2006). Environmental changes that lead to either increased or decreased year-to-year variation in temperature, precipitation, or other climatic variables can have a direct impact on the amount of biotic diversity (whether species richness or genetic variation) maintained in the future (Nelson, Hairston 1996). There is increasing evidence that the global climate change is already having measurable biological impacts (Daufresne *et al.* 2004).

The assessment of the influence of climate changes on freshwaters is especially vital because of the EU and Latvian Republic (LR) position to the securing of the water long-term availability that is provided by the Water Framework Directive (WFD) (EU 2000) and from that following LR Water Management Law (LR 2002). At the same time the WDF that concerns the main water quality indices, defines biological not traditional chemical parameters. With the help of chemical methods it is not possible to gain any data about separate substance influence, and, what is essential, its common impact on hydroecosystem. Furthermore, chemical-analytical analysis of data is, expensive and the number of chemical combinations that pollute the environment is so large that it is difficult to control it. At the moment only about 0.3% of known chemical substances are being controlled (Bakaeva, Nikanorov 2006). For that reason the findings obtained during the biomonitoring provide more extensive and precise information about the influence of polluting substance on ecosystem. A great number of authors are drawing attention to possibilities of the use of zooplankton for assessing the river water quality (Kutikova 1976; Marneffe *et al*. 1996; Vandish 2000; Krylov 2005; Bakaeva, Nikanorov 2006; Mathivanan *et al*. 2007; Mulani *et al*. 2009; Vanjare *et al*. 2010).

The long-term systematical records are vital in order to gain a veritable ecosystem structure and its natural varying outlook in assessment of ecosystem. Precise and frequent zooplankton research is a precondition of precise calculation of productivity in rivers, zooplankton quantitative and qualitative fluctuations enable to make conclusions about the changes in environmental factors and its impact on zooplankton organisms. In the same way long-term surveys are essential in order to reveal the long-term tendencies to changes. The findings are also topical for further long-term surveys, because lotic system is very changeable and the conditions that influence zooplankton are varying and inconsistent, as a result data can considerably vary from year to year. Therefore, long-term studies are required in order to get fundamental conclusions about investigated lotic system. Detecting and forecasting the effects of changing climate on natural and exploited populations makes a major challenge to ecologists and resource managers. The findings could be local, but their solutions are connected with the world global problems.

A number of authors (e.g. Brodeur *et al.* 1999; Kitaysky, Golubova 2000; Batchelder *et al.* 2008; Mackas *et al.* 2008a; O'Brien *et al.* 2008; 2008b; Verheye *et al.* 2008) draw attention to the effects of climate change on the zooplankton communities in the oceans, seas and lakes. Still there are only few long-term research on lotic zooplankton.

The aim of this research was to evaluate dynamics of the zooplankton community in the middle stretch of the Daugava river over the last 50 years and the possible impact of the climate change, namely variability of temperature and hydrology, on zooplankton community fluctuations.

2. Materials and methods

2.1. Study sites

The Daugava has the total length of 1005 km. Its basin with watershed area 87 900 km^2 lies on the territories of five countries (Russia, Belarus, Lithuania, Estonia and Latvia), and 24 700 km^2 or 39% of the total area belongs to Latvia. At its source (the Lake Dvineca), the river is only 6 to 8 m wide, but further on the width of the valley reaches 50 m in some places. Upstream and downstream of the city of Vitebsk (Belarus), the river flows through dolomite rocks, and there are many rapids with the depth varying from 0.8 to 3 m. On the Latvian border, the river runs along the 0.5 km wide ancient valley and the riverbed is up to 200 m wide. The section from Krāslava to Daugavpils is highly curved and has many rapids. The longitudinal gradient changes from 0.1 to 0.15 m km^{-1}, and the stream velocity from 0.3 m sec^{-1} to 0.7 m sec^{-1} in most sections.