Zooplankton community structure in relation to environmental factors and ecological assessment of water quality in the Harbin Section of the Songhua River*

LI Xiaoyu (李晓钰), YU Hongxian (于洪贤)**, MA Chengxue (马成学)
College of Wildlife Resource, Northeast Forestry University, Harbin 150040, China

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Abstract To study the relationship between zooplankton community structure and environmental factors and water quality in the Harbin Section of the Songhua River, investigations were carried out in June, August, and October 2011. Canonical correspondence analysis (CCA) and saprobic indices were used to process and analyze the data. Seasonal variability was identified as a significant source of variation, which explains the fluctuation in zooplankton density. In autumn, the dry season, water residence time increased and zooplankton biomass and abundance accumulated in the slow flowing waters. Zooplankton abundance increased when food conditions improved. Therefore, the total zooplankton abundance in autumn is much higher than that in spring and summer. According to the saprobic indices, all the sample sites had mesosaprobic water and water quality was worse in autumn. CCA revealed that temperature accounted for most of the spatial variation in the zooplankton community. Moreover, pH, dissolved oxygen saturation, and turbidity were important factors affecting zooplankton community distribution.

Keyword: zooplankton; canonical correspondence analysis (CCA); Saprobic index; Harbin; Songhua River

1 INTRODUCTION Zooplankton plays an important role in matter and energy flow in most river ecosystems. It is also indispensable in maintaining the balance of river ecosystems, zooplankton occupy an important intermediate link of food chain between phytoplankton and plantivorous fish and adjusting the water self-purification capacity. The interaction between zooplankton and environment forms a special community distribution pattern. Because of environmental selectivity, plankton species composition varies from one habitat to another. Temperature and salinity are important factors in explaining the interannual variability of the copepod Eurytemora affinis (Valérie et al., 2005). Low dissolved oxygen concentration has little influence on zooplankton (Yang et al., 2012). Increasing zooplankton density in rivers depends mainly on biotic factors, but increasing zooplankton reproduction in rivers depends to a large extent on physical factors (Basu and Pick, 1996; Viroux, 2002; Thorp and Casper, 2003; Thorp and Mantovani, 2005). Zooplankton community density is significantly positively correlated with temperature, turbidity, conductivity, and total phosphorus (Kobayashi et al., 1998). Temperature and conductivity have the strongest impact on zooplankton abundance (Czerniawski and Domagala, 2010; Czerniawski et al., 2013).

Canonical correspondence analysis (CCA) has been used to relate spatiotemporal species composition to environmental parameters; regression with environmental parameters was then performed on the results (Li, 2008). CCA is an effective method for exploring the complex relationship between zooplankton communities and environmental factors (Komárková et al., 2003). Zhang et al. (2012) reported that spatial variability in the distribution of...
zooplankton species, abundance, and biomass can be significantly affected by changes in the aquatic environment.

The Songhua River is an important surface water resource in north China, with many functions such as household, industrial, and agricultural water use. In 2005, after a PCB-contamination event, China made more of an effort to monitor the water quality and protect the water sources of the Songhua River. The Harbin Section of the river has two tributaries (the Ash and Hulan Rivers) and is important to people’s daily lives in Harbin. Many zooplankton species respond to changes in the water, making them useful for water quality bio-monitoring (Zhang et al., 2012). The aim of the present study was to determine the qualitative and quantitative composition of zooplankton in the Harbin Section of the Songhua River. In addition, we combined saprobic indices and CCA to explore which environmental factors significantly influence the riverine zooplankton communities. The results will provide useful guidance for the management and ecological restoration of this resource.

2 MATERIAL AND METHOD

2.1 Study site

The Harbin Section of the Songhua River runs from Sanjia Village to Dadingzi Mountain (total length=66 km). A zooplankton survey was carried out in June, August, and October 2011. Six stations were selected as sampling sites (specimens were collected from the center and the north river bank). A map of the study area showing sampling locations is shown in Fig.1.

2.2 Sampling and processing

Dissolved oxygen, temperature, ammonium, conductivity, turbidity, chloride, and nitrate were recorded using a multi-parameter probe (YSI6600, http://wwwysi.com, calibrated before every survey). Water transparency was determined with a Secchi disc; for the other physicochemical indices, refer to the water and wastewater monitoring method IV, State environmental protection administration of water and wastewater monitoring method editorial board, 2002.

Samples from each site were collected using a zooplankton net (25 cm diameter, 55 cm length, 112 μm mesh) by sub-surface (0.5–1 m depth) horizontal hauls. All samples were back-washed into 30-mL polyethylene bottles and preserved immediately in 5% formalin for further enumeration and species identification. Individuals within each taxon were counted and their individual mass estimated based on morphometric features with an image analysis technique (Zhao, 2005). All species were identified according to current taxonomy in light microscopy. The zooplankton community was described from both a qualitative and a quantitative perspective using data expressed in terms of density (ind./L) and biomass (mg/L) (Wang, 1961; Shen et al., 1979; Chen, 1981; Huang, 1981; Huang and Hu, 1986; Shen et al., 1990; Shannon, 2001).

2.3 Data analysis

Saprobic index (Saether, 1979) was calculated as:

\[ SI = \frac{\sum S \times h}{\sum h} \]

where \( S \) is the saprobic value of all species ranging from 1–4 for oligo- to polysaprobic, and \( h \) is the occurrence value: 1 for occasional, 3 for common, and 5 for mass occurrence.

CCA was performed in CANOCO 4.5 to explore the distribution of zooplankton communities in relation to environmental parameters and sampling sites. Species whose occurrence frequency and relative abundance were less than 25% and 0.1% (in 2011), respectively, were arbitrarily excluded from the CCA analysis. All continuous environmental variables were log \((1+x)\) transformed (Zhang et al., 2012).

3 RESULT

3.1 Zooplankton community composition

A total of 53 zooplankton species (Table 1) were