Short communication

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Day-night differences in crustacean zooplankton in Lake Glubokoe and Mozhaysk Reservoir (European Russia)

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ABSTRACT. We present the first results of our research on day-night differences of crustacean zooplankton in Lake Glubokoe and Mozhaysk Reservoir. We found increases in pelagic crustacean zooplankton density and biomass at night in both lakes. Changes in quantity and species composition were more prominent and statistically significant in Mozhaysk Reservoir than in Lake Glubokoe. We observed only a slight increase in zooplankton density and biomass and a shift between dominant species distribution in Lake Glubokoe. The changes we observed appear to be caused by horizontal zooplankton migration.

Keywords: deep lakes, crustacean zooplankton, plankton density, day-night differences

1. Introduction

Diurnal zooplankton migration can cause significant variation in crustacean zooplankton abundance and community composition depending on the time and location of sampling, and therefore, the methods surrounding traditional zooplankton sampling, is receiving increased attention from limnologists. Cladocera and Copepoda spp. typically descend further from the surface during the day and then ascend at night (Hutchinson, 1967) compared to smaller zooplankton taxa such as rotifers. Furthermore, zooplankton can also exhibit horizontal migration within lakes, where they move into macrophyte vegetation or other littoral refugia during the day and back to the open water at night (Burks et al., 2002; Murby, 2006). The migration itself might be a result of pressure from visual predators (e.g., planktivorous fishes) during the day, or by changes in the structure of the phytoplankton community, which serves as the food supply for pelagic filter-feeding crustaceans (Murby, 2006). However, most research is routinely conducted during the daytime, while studies dedicated to night-time plankton dynamics and behavior are less common (Doubek et al., 2020). Also, the drivers affecting the extent of zooplankton migration patterns are still poorly constrained.

Here, we estimated differences between day and night abundances and biomass of Cladocera and Copepoda zooplankton in the pelagic zone of Lake Glubokoe and Mozhaysk Reservoir in the Moscow Region, Russia. Our work is the first example of such research on Russian lakes, and, if continued, may serve as a basis for many regional and global ecological studies.

2. Materials and methods

Day-night patterns of crustacean zooplankton density and biomass were investigated in August 2019 in open pelagic zones of Lake Glubokoe (0.59 km^2, max depth 32.0 m) and Mozhaysk Reservoir (30.70 km^2, max depth 22.5 m). Three samples were taken at each lake at noon and at midnight with a 70-μm mesh net retrieved from bottom to surface, immediately preserved with 40% formalin, and later identified and enumerated using standard protocols (Bottrell et al., 1976; Thorp and Covich's freshwater invertebrates…, 2019). Day and night values of abundance and biomass were compared using independent two-sample t-test. The confirmed differences between integral samples were used as evidence of the plankton's horizontal migration.

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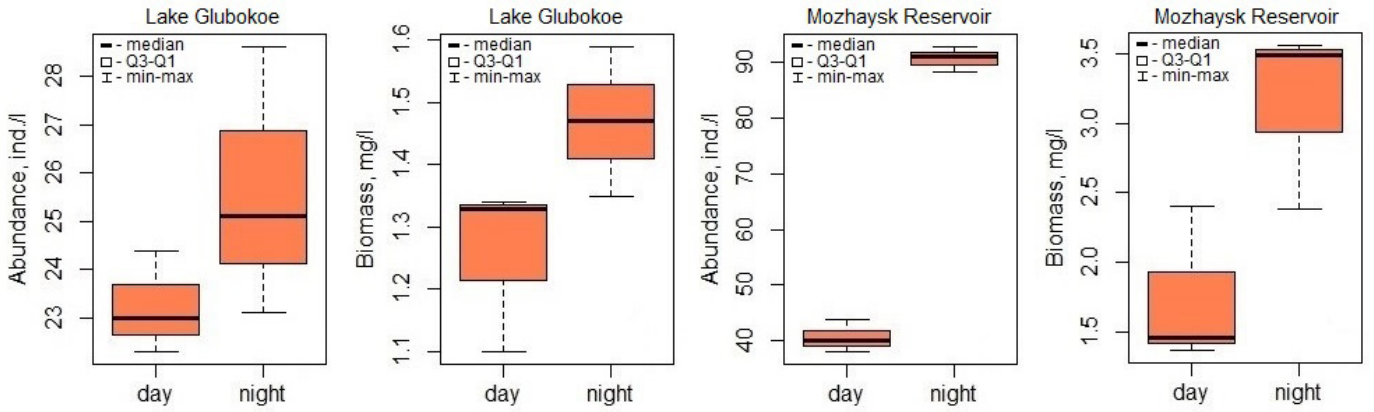

Fig. Day-night differences in crustacean zooplankton (Copepoda & Cladocera) of Lake Glubokoe and Mozhaysk Reservoir in August 2019

3. Results

A total of 14 crustacean species were identified in Lake Glubokoe (Copepoda – 3, Cladocera – 11), and 28 species in Mozhaysk Reservoir (Copepoda – 7, Cladocera – 21).

In Lake Glubokoe, the same species remained dominant during both day and night: *Diaphanosoma brachyurum* (Liévin, 1848), *Eudiaptomus graciloides* (Lilljeborg, 1888), and *Bosmina coregoni* (Baird, 1857). However, the distribution between those species shifted between day and night: the abundance of the pelagic cladoceran *D. brachyurum* increased during the night, while *E. graciloides* became less abundant. The proportion of *B. coregoni* remained similar day and night. The total crustacean zooplankton density and biomass increased by 9% ($t = -1.3917$, $df = 2.5692$, p-value = 0.2723) and 10% ($t = -2$, $df = 3.9597$, p-value = 0.1168) at night, respectively.

In Mozhaysk Reservoir, the dominant species differed significantly between day and night. In daytime, the most dominant species were *Daphnia cristata* (Sars, 1862), *Daphnia cucullata* (Sars, 1862), *Thermocyclops crassus* (Fischer, 1853), and *Eudiaptomus gracilis* (Sars, 1863). At midnight, *D. cucullata, Bosmina longirostris* (Müller, 1785), *Thermocyclops oithonoides* (Sars, 1863) and copepodites became predominant. During the night, the total crustacean zooplankton density and biomass increased by 128% ($t = -23.367$, $df = 3.7883$, p-value = 0.00003) and 127% ($t = -40.275$, $df = 2.2236$, p-value = 0.0003), respectively (Fig).

4. Discussion and conclusions

Some studies suggest that zooplankton might favor diel horizontal migration (instead of vertical) in lakes with hypolimnetic hypoxia (Doubek et al., 2018), but we did not find enough evidence of major horizontal migration in Lake Glubokoe, where the hypoxic layer thickness extended to over 20 m. In Mozhaysk Reservoir, the hypoxic layer at the bottom was 3 m thick, but the day-night differences were much greater than Lake Glubokoe. The tendency of the Glubokoe's plankton to stay in the pelagic zone during the day might be better explained by relatively low littoral area, insufficient littoral vegetation cover for zooplankton refuge, or low predatory pressure.

In Mozhaysk Reservoir, a large littoral area might favor diel horizontal migration. The reservoir's zooplankton community is also generally more diverse, which makes the interaction between different species even more complex. Further research in shallow zones of both lakes should provide better understanding of the factors affecting the zooplankton behavior.

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