

## Short communication

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# Terrestrial vegetation and lake aquatic communities diversity under climate change during the mid-late Holocene in the Altai Mountains (Ulagan plateau) based on the pollen and cladocera data

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**ABSTRACT.** The present study is focused on the reconstruction of plant and cladocera diversity in the paleo-record of Lake Balyktukel (Ulagan Plateau) for the past 7 kyr.

**Keywords:** pollen, cladocera, climate, biodiversity, vegetation, Holocene, Altai

## 1. Introduction

The issue of global biodiversity decline has recently been actively discussed in both scientific and public communities. Mountain regions with high biodiversity are of interest for investigations on the biodiversity change and causes that affect biodiversity (Rudaya et al., 2021). Lake sediments containing proxies such as pollen and remains of organisms that lived in the lake can be analysed using statistical methods and at a high resolution. The taxonomical composition of lacustrine biotas such as cladoceran can provide valuable information not only about environmental changes in the lakes but also about biodiversity changes and species turnover over time. Pollen data is an important proxy for studying the terrestrial vegetation biodiversity over long time scales (Birks et al., 2016; Felde et al., 2020; Rudaya et al., 2020; 2021).

The main objective of this study is the reconstruction of plant and cladocera diversity in the paleo-record of Lake Balyktukel (Ulagan Plateau) for the past 7 thousand years.

## 2. Materials and methods

The studied object - Lake Balyktukel (N 50.53°, E 87.70°, 1842 m asl) is located on the high-mountain

Ulagan Plateau in the northeastern part of the Altai Mountains. Bottom sediment core *BK2018-1* (2.35 m, 50.53411 N, 087.70788 E) was sampled in 2018 with a gravity corer from the lake's deepest point of 23.9 m. The age-depth model is based on the 12 radiocarbon dates obtained from bulk sediments; pollen and cladocera analyses were provided for the paleorecord. The richness and diversity of all bioproxies were calculated as the effective taxon numbers of Hill (Hill, 1973). DCCA with species assemblage changes constrained to sediment age as the sole environmental variable, was used to develop quantitative estimates of compositional turnover, scaled in standard deviation (SD) units for each taxonomic group (according to Birks, 2007).

## 3. Results and discussion

The core, according to the age-depth model, covers the last 6.95 kyr. The rate of sedimentation is estimated at 0.35 mm per year.

The pollen record covering the last 6.95 kyr BP can be divided into three pollen zones. PZI (237-150 cm; 6.95-4.3 kyr BP) is characterized by a dominance of *Pinis sibirica* and *P. sylvestris*; a slightly higher percentage of *Betula* and *Amarantaceae*, and a slightly lower abundance of *Poaceae* than the overlying PZII. PZI is also characterized by the abundance of green algae

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*Botryococcus* remains, which may indicate a warming of the reservoir. PZII (150-85 cm; 4.3-2.2 kyr BP) is characterized by a slight increase in the abundance of Poaceae, a slight decrease in *Picea* pollen, and a marked decrease in the abundance of *Botryococcus*. Stomata of *Larix* are found in this zone. Pines also dominate in this zone; after 3.3-3 kyr BP, *Pinus sylvestris* increases its abundance, and the percentage of *Betula* sect. *Apterocaryon*, on the contrary, decreases. PZIII (85-0 cm; 2.2 kyr BP - AD 2018) is characterized by a slight decrease in the share of arboreal pollen, a slight decrease in the abundance of *Abies* pollen, and an increase in the abundance of Poaceae. Pines also prevail in this zone; evidence of presence of pine and fir close to the lake is finding their stomata in this zone. *Betula* sect. *Apterocaryon* increases slightly after 0.5 kyr BP.

Alpha-diversity indices of the terrestrial plants based on the pollen reveal large amplitudes among dominant (N2) and common (N1) species. The highest N1 and N2 indices are observed in the interval of 6.95-3.7 kyr BP. The indices of plant diversity increase 0.4-0.2 kyr BP that can be attributed to the Little Ice Age. The calculated pollen diversity indices show significant positive correlations with the calculated amount of annual precipitation (not published) at the N1 and N2 levels.

Taxonomic diversity relative to the time gradient (species turnover) based on the pollen data has relatively high values from the beginning of the paleorecord to about 3.2 kyr BP with maxima at 6.2 kyr BP (0.7SD) and 3.3 kyr BP (0.6 SD). Thereafter, the indices decrease to the minimum and only in the last 0.8 kyr BP increases steadily. The period between 3 and 1 ka BP beta-diversity indices are minimal.

Twenty-four Cladocera taxa are encountered from the sediment profile, of which 17 relate to Chydoridae, other to *Daphniidae*, *Bosminidae*, *Euryercidae* and *Ophryoxidae*. The most cladoceran assemblages are dominated by *Daphnia longispina* agg. Pelagic organisms dominate the record in abundance. The stratigraphy was divided into five cladoceran zones (CZ). CZI (234-212 cm; 6.95-6.2 kyr BP) is characterized by the dominance of pelagic taxa *Daphnia longispina* agg. and *D. pulex* agg.; the littoral taxa have a maximal abundance. Toward the top of the zone, the increase of littoral phytophilous macrophyte-associated *Alonella nana* and *Alona guttata/rectangular* is observed. Only in this zone, littoral cladoceran species *Leydigia leydigia* and *Alona quadrangularis* have a constant high abundance. This period seemed more productive than the upper zones, according to the higher relative abundance of cladoceran species related to the meso-eutrophic condition (*L. leydigia*, *A. quadrangularis*). *Daphnia longispina* agg. is dominated in CZII (212-146 cm; 6.2-4.2 kyr BP), whereas *D. pulex* group decreases to very low values to the upper part of the zone. *Alonella nana* and *Alona guttata /Coronatella rectangular* are present at lower abundances. Percentages of *Alona intermedia* increase; *Oxyurella tenuicaudis* and *Alona guttata tuberculata /Coronatella rectangular pulchra* occur in this zone. It is recorded a slight increase in the

proportion pelagic/littoral taxa. In CZIII (146-80 cm; 4.2-2.0 kyr BP) *Daphnia longispina* increases *Alonella nana* is steadily present in all the layers CZ. Abundance of *Alona affinis* in the community begins to increase slightly, while the value of pelagic *Daphnia pulex* decreases to very low values. CZIV (80-16 cm; 2.0-0.3 kyr BP) is characterized by the largest species diversity. *Daphnia longispina* gr. is still dominant. The secondary species is *Alona guttata/ Coronatella rectangular*. The small *Alonella nana* decreases distinctly and *Alona affinis* increase slightly towards the top of the zone. A most considerable dramatically change occurred in CZV (16-0 cm; 0.3 kyr BP- 2018 CE) in the planktonic cladoceran assemblages. Dominant in all previously zones, *Daphnia longispina* agg. begins to decrease to near extirpation in the uppermost layer and a respective rise occurred in *B. longirostris*, a small planktonic cladoceran common also in the littoral zone. Especially the abundance of the taxon increases in the upper samples of the core (up to 96%) related to the 20th century.

Alfa diversity of cladocera based on the Hill numbers reveal highest values at ca 6.5 kyr BP and about 0.12 kyr BP (1830 CE); the lowest value is noted on modern time when community becomes monodominant. Relatively low values of N1 and N2 are recorded about 1.53 – 1.2 kyr BP. Beta diversity in above 1 SD from the beginning of the record and to ca 1.8 kyr BP. The maximal meaning of species turnover is about 6.7 kyr BP (1.8 SD).

## 4. Conclusions

Alfa diversity of pollen taxa show positive correlation with the amount of precipitation but pollen record has not shown any significant species turnover during the last 7 kyr. The cladocera diversity shows a different pattern of biodiversity change with a significant change in taxonomic composition from the beginning of the paleorecord to 1.8 kyr BP.

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## Conflict of interest

The authors declare no conflict of interest.

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