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Fecal stanols in sediments of Lake Shira (Siberia, Russia) as a proxy of human impact on surrounding territory in the Late Holocene

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ABSTRACT. The analysis of biochemical markers of fecal intake is one of the newest trend in paleolimnology. Stanols (cholestanol, stigmastanol, etc.) produced by the intestinal microflora from sterols are indicators of fecal influx into a water body. Coprostanol is synthesized in the human intestine, therefore, the presence of coprostanol in bottom sediments can be used to reconstruct the dynamics of the population in the lake watershed and to evaluate the dynamics of fecal pollution. Using the gas chromatography method, we were the first to estimate the content of cholestanol and coprostanol in the dated core layers of the bottom sediments of Lake Shira. The raised proportion of coprostanol indicates an increase in fecal anthropogenic inflows into the lake in the modern period, as well as in earlier periods of the history of Khakassia, in particularly during the existence of the Yenisei Kyrgyz state (VIII - XIII centuries CE).

Keywords: fecal stanols, coprostanol, gas chromatography, lake sediments, Lake Shira

1. Introduction

The study of fecal compounds in lake sediments as a biochemical marker is one of the newest trend in paleolimnology. These markers include stanols, which are produced by the intestinal microflora from sterols. Stanols persist in bottom sediments for thousands of years that is why they are valuable proxy of animal and human presence in lake watershed (White et al., 2019; Vachula et al., 2019).

Despite similar stanols are synthesized in mammals, the percentage of different stanols varies in humans and animals. Coprostanol and epicoprostanol are produced mostly by human microflora. Therefore, these specific stanols are used to reconstruct the population history of water bodies as well as to assess the anthropogenic load (D'Anjou et al., 2012; Argiriadis et al., 2018).

2. Materials and methods

Lake Shira (54°30' N, 90°11' E) is located in the Republic of Khakassia, 15 km from the regional center Shira. The lake has oval shape, its size is 5.3 × 9.3 km, its area is 35.9 km², its maximum depth is 25.4 m (2021). Zhemchuzhny settlement and the resort "Lake

Shira" are located on the lake shore. In summer, the lake is a popular place for vacation. Many campsites are based on its shores. A core 80 cm long was sampled using a UWITEC gravity sampler (Austria). The age of the bottom sediments was previously determined for another core based on radioisotope analyzes (Kalugin et al., 2013). Stanols were extracted from dried samples with ethanol: chloroform (3:7) followed by silylation (Andaluri et al., 2017). The stanols were analyzed on an Agilent 6890N gas chromatograph using an Agilent 5975C mass spectrometer as a detector. External standards for cholestanol and coprostanol were used to estimate concentrations.

3. Results and discussion

Cholestanol and coprostanol were found along all core depth. Cholestanol is an indicator of general fecal contamination, while coprostanol is a characteristic of human feces. The proportion of coprostanol in the total amount of coprostanol + cholestanol increased in the layers of the VIII - XII centuries AD in the heyday of the Yenisei Kyrgyz state, and in the XVII - XIX centuries during the development of these lands by the Russian population (Fig.). The largest proportion of coprostanol was observed in the modern period, which relates

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obviously to an increase in anthropogenic load because of the resort and the use of the lake as a place for summer vacation (Fig.).

4. Conclusions

The raised proportion of coprostanol in the modern period indicates an increase in anthropogenic fecal influx into Lake Shira. In earlier periods of the history of Khakassia, particularly during the existence of the Yenisei Kyrgyz state (VIII - XIII centuries AD), an increase in coprostanol share indicates a possible increase in human presence in the Lake Shira drainage basin.

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Conflict of interest

The authors declare no conflict of interest.

References

- Andaluri G., Suri R.P.S., Graham K. 2017. Steroid hormones in environmental matrices: extraction method comparison. *Environmental Monitoring and Assessment* 189: 626. DOI: [10.1007/s10661-017-6345-0](https://doi.org/10.1007/s10661-017-6345-0)
- Argiriadis E., Battistel D., McWethy D.B. et al. 2018. Lake sediment fecal and biomass burning biomarkers provide direct evidence for prehistoric human-lit fires in New Zealand. *Scientific Reports* 8(1): 12113. DOI: [10.1038/s41598-018-30606-3](https://doi.org/10.1038/s41598-018-30606-3)
- D'Anjou R.M., Bradley R.S., Balascio N.L. et al. 2012. Climate impacts on human settlement and agricultural activities in northern Norway revealed through sediment biogeochemistry. *Proceedings of the National Academy of Sciences* 109(50): 20332-20337. DOI: [10.1073/pnas.1212730109](https://doi.org/10.1073/pnas.1212730109)

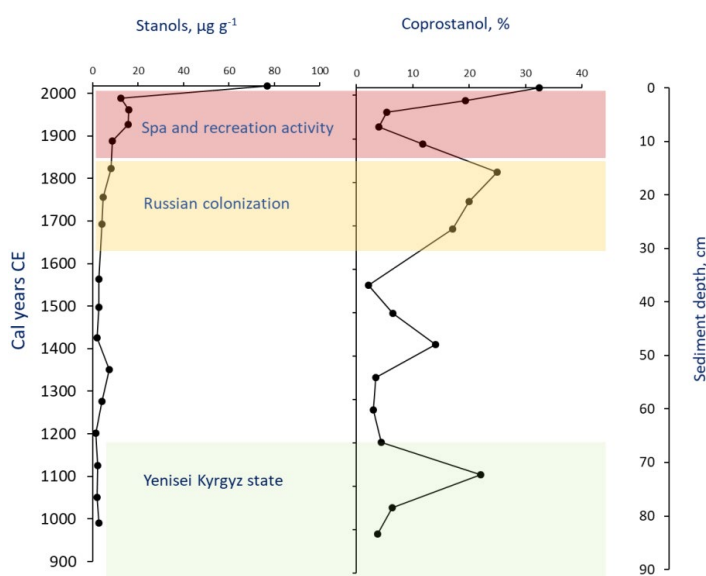


Fig. Distribution of fecal stanols and proportion of coprostanol in the core from Lake Shira. The periods of the history of Khakassia are highlighted in color.

- Kalugin I., Darin A., Rogozin D. et al. 2013. Seasonal and centennial cycles of carbonate mineralisation during the past 2500 years from varved sediment in Lake Shira, South Siberia. *Quaternary International* 290-291: 245-252. DOI: [10.1016/j.quaint.2012.09.016](https://doi.org/10.1016/j.quaint.2012.09.016)

- Vachula R.S., Huang Y., Longo W.L. et al. 2019. Evidence of Ice Age humans in eastern Beringia suggests early migration to North America. *Quaternary Science Reviews* 205: 35-44. DOI: [10.1016/j.quascirev.2018.12.003](https://doi.org/10.1016/j.quascirev.2018.12.003)

- White A.J., Stevens L.R., Lorenzi V. et al. 2019. Fecal stanols show simultaneous flooding and seasonal precipitation change correlate with Cahokia's population decline. *Proceedings of the National Academy of Sciences* 116: 5461-5466. DOI: [10.1073/pnas.1809400116](https://doi.org/10.1073/pnas.1809400116)