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Stable carbon isotopes of invertebrate remains as potential indicator for methane fluxes from lakes

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Lakes and lake sediments are an important source of atmospheric methane. Methanogenic archaea in lake sediments and the anoxic part of the water column produce 13C-depleted methane that is partly released to the atmosphere. Another part is utilized by methane oxidizing bacteria (MOB) in the oxic part of the water column. MOB can be an important food source for filter-feeding aquatic invertebrates, such as planktonic *Daphnia*, and deposit-feeding benthic chironomid larvae. If methane-derived carbon is a significant component of the diet of these invertebrates this will lead to strongly negative δ13C in their tissue and fossilizing structures. Strongly sclerotized cuticles, such as those forming the resting eggs (ephippia) of *Daphnia* and the larval head capsules of chironomids, are well preserved in lake sediments. If a systematic relationship between modern methane fluxes in lakes and invertebrate δ13C could be established this would provide an approach for estimating past methane fluxes based on δ13C of fossil invertebrate remains preserved in lake sediments.

Using culture experiments we demonstrate that the stable carbon isotopic signature of MOB is incorporated into chironomid head capsules. Next, diffusive methane fluxes from lakes and δ13C-values of invertebrate remains from surficial lake sediments in NE Siberian thermokarst lakes and Swedish softwater lakes were measured. Observed δ13C-values of *Daphnia* ephippia from these sediments are decreasing with increasing methane fluxes, ranging from -28.2 to -37.6 ‰ PDB. Chironomids with different feeding strategies show varying correlations with methane fluxes. Tube-dwelling and deposit feeding Chironomini tend to ingest MOB and the δ13C-values of their head capsules show a strong relation with methane fluxes and range from -27.6 to -36.8 ‰ PDB. Surface-dwelling Orthocladiinae are mostly deposit and periphyton feeders and the δ13C-values of their head capsules do not correlate well with methane fluxes. Similarly low correlations are found for predacious Tanypodinae. δ13C-values in the head capsules of Tanytarsini, that have a mixed feeding type, have a correlation of intermediate strength with methane fluxes.

Future research will focus on quantifying the relationship between methane fluxes, MOB, and δ13C-values of invertebrate remains to assess the potential of *Daphnia* and chironomid δ13C to reconstruct past methane fluxes based on sediment records.