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Fossil chironomid d13C as a new proxy for past methanogenic contribution to benthic food-webs in lakes?

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Lake sediments are an important source of atmospheric methane. Methanogenic archaea in lake sediments produce 13C-depleted methane that is partly released to the water column and the atmosphere. Another part is utilized by methane oxidizing bacteria (MOB) that are an important food source for deposit-feeding chironomid larvae (Diptera: Chironomidae). If methane-derived carbon is a significant component of the chironomid diet this will lead to strongly negative d13C in the tissue and exoskeleton of chironomid larvae. Chironomid cuticles, especially the strongly sclerotized head capsules, are well preserved as fossils in lake sediments. If the relationship between modern methane fluxes in lakes and chironomid d13C can be established this would therefore provide an approach for estimating past methane fluxes based on d13C of fossil chironomid remains.

Using culturing experiments we show that the stable carbon isotope signature of MOB and other food sources can be traced in chironomid muscle tissue as well as in the fossilizing exoskeleton. In addition we measured d13C in chironomid larval head capsules and other invertebrate remains from a range of surface and downcore sediment samples. Small intra-specific variability (-27.1 $\pm$ 0.08 permille) was measured in replicate samples of chironomid head capsules of Corynocera ambigua (n=7). d13C of chironomid head capsules from a several different taxa ranged from –28.0 to –25.8 permille, but in some instances we observed d13C values as low as –36.9 to –31.5 permille, suggesting that carbon from MOB can be successfully traced in fossil and subfossil chironomid remains. Our results demonstrate that the stable carbon isotope signature of MOB is incorporated into chironomid head capsules. Future research will focus on quantifying the relationship between methane fluxes, MOB, and head capsule d13C in order to reconstruct past methane fluxes based on the lake sediment record.