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Past evolutionary responses of Chydoridae (Cladocera) under oxygen depletion in an Austrian Alpine lake

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Chydorid (Cladocera, Chydoridae) reproduction in nature consists of asexual and sexual reproduction periods. The asexual reproduction period prevails during most of the open-water season and sexual reproduction, resulting in renewal of genotypes and diapause, is induced by environmental stimuli associated with seasonal (or aperiodic) environmental stress, such as the oncoming winter. The abundance of the two reproduction strategies is reflected in lake sediments as fossil carapaces (asexual reproduction) and ephippia (sexual reproduction) and can be reconstructed, even population-specifically, via these sedimentary remains and used in paleolimnological studies. To investigate changes in chydorid reproduction strategies as evolutionary responses in relation to previously observed environmental changes (climate fluctuations, nutrient enrichment) in an Austrian Alpine lake, a high-resolution sediment core from Oberer Landschitzsee (2076 m a.s.l.), covering approximately the past 500 years, was examined for its fossil chydorids (Chydoridae, Cladocera) and their ephippia. In addition, a quantitative chironomid (Chironomidae)-based late-winter hypolimnetic oxygen inference model was applied to an independent chironomid stratigraphy from the same sediment core to detect past changes in oxygen concentrations. The common benthic chydorids Alona affinis and Alona quadrangularis dominated the community until the middle part of core, after which their relative proportions decreased noticeably as Acroperus harpae, Chydorus sphaericus s.l., and Alonella excisa increased. Corresponding to changes in the chydorid community, the chironomid-inferred dissolved oxygen reconstruction suggested that the lake exhibited severe oxygen depletion during the upper part of the sediment sequence. Furthermore, since ephippia of A. affinis and A. quadrangularis were most abundant, their population-specific reproduction patterns were evaluated using relative proportions of their asexual and sexual remains. The reproduction patterns of these two chydorid species exhibited clear and gradual shifts from the dominance of asexual to sexual reproduction from the middle part of the core onwards that were strongly related to decreasing oxygen levels. Hence, it likely that the chydorids reproduced predominantly sexually in order to renew their genotypes under environmentally unfavorable period of the oxygen depletion and, accordingly, used sexual reproduction as a vigorous mechanism to adapt to changing environmental conditions in Lake Oberer Landschitzsee. In overall, the present results propose that sexual reproduction and resting eggs provide significant means to increase adaptation potential in local chydorid populations under environmental perturbations. When using chydorids in paleolimnology, it may be reasonable to expect that at least some species exhibit rapid evolutionary responses by the means of their changing reproduction strategies that accordingly influence their genetic population structure.