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Near-future warming amplifies natural heatwave impacts and reorganizes freshwater communities

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Future climate change may reshape ecological communities not only by increasing mean temperature, but also by altering the consequences of increasingly frequent heatwaves. Predicting these effects requires understanding how background warming interacts with short heatwaves in natural communities, where responses can arise through direct thermal stress and species interactions. We tested this using 32 outdoor freshwater mesocosms exposed to sustained near-future warming while capturing a documented natural heatwave. Warming raised temperature maxima that exceeded the thermal threshold of the pond snail, a main grazer in the community. Warmed communities showed lower grazer abundance, increased macrophyte and insect herbivore abundance, reduced phytoplankton biomass, and lower zooplankton density. Complementary assays showed that heatwave-level temperatures promoted macrophyte growth and reduced grazer survival, whereas reduced zooplankton performance mainly reflected indirect warming effects via food-web cascades. Thus, near-future warming can amplify natural heatwave impacts by exceeding consumer thermal thresholds and propagating through species interactions.

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