Impact of multiple stressors on freshwater biota: A case study of climate warming and pharmaceuticals

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Abstract

Predicting the effects of combined stressors on ecosystems is an urgent task, given the increasing anthropogenic pressures on the Earth's biota. Climate warming and chemical pollution, two of the widespread stressors of freshwater biota, cause rapid environmental change and pose a major threat to biodiversity and the functioning of freshwater ecosystems. The impact of the latter is likely to increase due to the widespread use of cocktails of various chemical compounds and their low removal efficiency in water plants, particularly relevant for many pharmaceutical active compounds (PhACs).
We investigated the combined effects of warming (+4∘C above ambient) and a mixture of 15 commonly used pharmaceutically active compounds (PhACs), applied at environmentally relevant concentrations, on a pelagic invertebrate community in outdoor mesocosms, representative of small freshwater ponds. The experiment was conducted twice (in winter and summer) to assess the seasonality of the stressors' impacts.

The effects of warming and PhACs differed greatly between seasons and across scales and trophic levels. The PhAC mixture reduced phytoplankton biomass. Interestingly, we observed opposite effects of PhACs on insect emergence and survival patterns, and contrasting effects of PhACs on key zooplankton groups (copepods vs cladocerans) in summer, while the PhAC mixture had only marginal effects on the community in winter. Warming reduced the survival of predatory aquatic insects in winter and accelerated their development in summer, partially releasing large zooplankton from top-down control. Finally, phytoplankton biomass increased with warming in the summer and in the winter experiments.
Our results show that (1) warming can either mask or amplify the effects of anthropogenic pollutants on freshwater communities and (2) the effects of combined stressors on freshwater communities are context-dependent and differ across scales of biological organization, stressing the importance of considering seasonality in risk assessment studies.

Keywords: Warming, Pharmaceutical mixture, Aquatic invertebrates, Mesocosm, multiple stressors, tri trophic food web

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