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Energetic mismatch induced by warming decreases leaf litter decomposition by aquatic detritivores

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Abstract:

1. The balance of energetic losses and gains is of paramount importance for understanding and predicting the persistence of populations and ecosystem processes in a rapidly changing world. Previous studies suggested that metabolic rate often increases faster with warming than resource ingestion rate, leading to an energetic mismatch at high temperature. However, little is known about the ecological consequences of this energetic mismatch for population demography and ecosystem functions.
2. Here, we combined laboratory experiments and modelling to investigate the energetic balance of a stream detritivore *Gammarus fossarum* along a temperature gradient and the consequences for detritivore populations and organic matter decomposition.
3. We experimentally measured the energetic losses (metabolic rate) and supplies (ingestion rate) of *Gammarus* and we modelled the impact of rising temperatures and changes in *Gammarus* body size induced by warming on population dynamics and benthic organic matter dynamics in freshwater systems.
4. Our experimental results indicated an energetic mismatch in a *Gammarus* population where losses via metabolic rate increase faster than supplies via food ingestion with warming, which translated in a decrease in energetic efficiency with temperature rising from 5 to 20°C. Moreover, our consumer–resource model predicts a decrease in the biomass of *Gammarus* population with warming, associated with lower maximum abundances and steeper abundance decreases after biomass annual peaks. These changes resulted in a decrease in leaf litter decomposition rate and thus longer persistence of leaf litter standing stock over years in the simulations. In addition, *Gammarus* body size reductions led to shorter persistence for both leaf litter and *Gammarus* biomasses at low temperature and the opposite trend at high temperature, revealing that body size reduction was weakening the effect of temperature on resource and consumer persistence.
5. Our model contributes to identifying the mechanisms that explain how thermal effects at the level of individuals may cascade through trophic interactions and influence important ecosystem processes. Considering the balance of physiological processes is crucial to improve our ability to predict the impact of climate change on carbon stocks and ecosystem functions.

Keywords: detritivores, ectotherms, energetic mismatch, global warming, litter decomposition, metabolic theory of ecology, Temperature-size rule

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