

Survival Tactics in a Warming World: *Daphnia*'s Response to Thermal Stress and Predation

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Abstract

Global warming presents significant challenges to the growth and development of organisms. To cope with rising temperatures, organisms must develop corresponding adaptive mechanisms. As an important component of freshwater ecosystems, *Daphnia* (water fleas) exhibit high sensitivity to both biotic and abiotic environmental changes. *Daphnia* employs various adaptive strategies to cope with elevated temperatures, including physiological, behavioral, and morphological changes. However, temperature increases may also indirectly affect *Daphnia* by altering predator and subsequent predator-prey interactions. Under normal conditions, *Daphnia* develops effective anti-predator strategies through phenotypic plasticity. However, temperature changes may influence the formation of defensive mechanisms or weaken their effectiveness, exposing *Daphnia* to the dual challenge of thermal stress and shifting predation risk. Understanding these combined stressor responses is therefore essential for predicting *Daphnia*'s adaptive capacity under climate change. In this study, we assessed how *Daphnia longicephala* adjusts its responses to *Notonecta* kairomones when reared at optimal (20 °C) versus multi-generational elevated (28 °C) temperatures. We focused on four key adaptation markers including thermal tolerance, life history traits, morphological changes, and swimming behavior modifications. Our results demonstrate that under the combined pressures of elevated temperature and predator cues, *Daphnia* exhibited a suite of coordinated adaptive responses. First, we observed an increase in thermal tolerance. Second, regarding life history traits, exposure to these dual stressors resulted in a reduction in somatic growth rate as measured by wet body weight. Furthermore, stressed individuals displayed delayed attainment of sexual maturity and produced fewer offspring in their first reproductive clutch. At the morphological level, *Daphnia* developed effective defensive adaptations at sexual maturity. Behaviorally, the stressed *Daphnia* displayed a reduction in swimming speed, an increase in inter-individual distance, and a decrease in movement directionality, resulting in a more dispersed swimming pattern. In conclusion, *Daphnia* exhibits enhanced thermal tolerance and defensive morphology under the dual pressures of temperature and predation, but these benefits come at the cost of reduced performance in life history traits and behavior. This trade-off suggests a complex resource allocation strategy, where survival and defense take priority over reproduction and behavior under combined climatic and ecological stresses.

Keywords

Adaptive Strategies, Thermal Acclimation, Predator-Prey Interaction, Physiological Adaptation, Freshwater Crustacean, Phenotypic Plasticity, Behavior Response