Developmental plasticity in thermal tolerance is insufficient to compensate for rising temperatures: a meta-analysis

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Abstract

Understanding the factors affecting thermal tolerance is crucial for predicting the impact climate change will have on ectotherms. However, the role developmental plasticity plays in allowing populations to cope with thermal extremes is poorly understood. Here, we meta-analyse how thermal tolerance is acutely and persistently impacted by early thermal environments by using data from 150 experimental studies on 138 ectothermic species. Thermal tolerance only increased by 0.13°C per 1°C change in developmental temperature and substantial variation in plasticity (˜36%) was the result of shared evolutionary history and species ecology. Aquatic ectotherms were more than three times as plastic as terrestrial ectotherms. Notably, embryos expressed weaker but more heterogenous plasticity than older life stages, with numerous responses appearing as non-adaptive. While we did not find universal evidence for developmental temperatures to have persistent effects on thermal tolerance, persistent effects were vastly under-studied, and their direction and magnitude varied with ontogeny. Embryonic stages may represent a critical window of vulnerability to changing environments and we urge researchers to consider early life stages when assessing the climate vulnerability of ectotherms. Overall, our synthesis suggests that developmental changes in thermal tolerance will rarely reach levels of perfect compensation and buffer ectotherms from rising temperatures.

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