Adaptive phenotypic plasticity and local adaptation for temperature tolerance in freshwater zooplankton

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Author(s) Yampolsky, Lev Y.; Schaer, Tobias M. M.; Ebert, Dieter
Author(s) at UniBasel Ebert, Dieter ;
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Many organisms have geographical distributions extending from the tropics to near polar regions or can experience up to 30řC temperature variation within the lifespan of an individual. Two forms of evolutionary adaptation to such wide ranges in ambient temperatures are frequently discussed: local adaptation and phenotypic plasticity. The freshwater planktonic crustacean Daphnia magna, whose range extends from South Africa to near arctic sites, shows strong phenotypic and genotypic variation in response to temperature. In this study, we use D. magna clones from 22 populations (one clone per population) ranging from latitude 0ř (Kenya) to 66ř North (White Sea) to explore the contributions of phenotypic plasticity and local adaptation to high temperature tolerance. Temperature tolerance was studied as knockout time (time until immobilization, Timm) at 37řC in clones acclimatized to either 20řC or 28řC. Acclimatization to 28řC strongly increased Timm, testifying to adaptive phenotypic plasticity. At the same time, Timm significantly correlated with average high temperature at the clones' sites of origin, suggesting local adaptation. As earlier studies have found that haemoglobin expression contributes to temperature tolerance, we also quantified haemoglobin concentration in experimental animals and found that both acclimatization temperature (AccT) and temperature at the site of origin are positively correlated with haemoglobin concentration. Furthermore, Daphnia from warmer climates upregulate haemoglobin much more strongly in response to AccT, suggesting local adaptation for plasticity in haemoglobin expression. Our results show that both local adaptation and phenotypic plasticity contribute to temperature tolerance, and elucidate a possible role of haemoglobin in mediating these effects that differs along a cold-warm gradient.
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