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Abstract

Thermal Plasticity with Physiological Trade-Offs in the Invasive Cichlid *Australoheros facetus* Under Warming Scenarios in Mediterranean-Type Rivers †

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Abstract

Introduction: Climate warming and drought are intensifying thermal stress in Mediterranean freshwater systems, potentially favoring invasive fish with broad physiological tolerance. Extended environmental tolerance and increased aerobic scope are indicative of the potential to sustain, perform and disseminate in challenging conditions. **Objective:** We aimed to determine the thermal scope of the invasive *Australoheros facetus* inhabiting southern Portuguese drainages using an array of physiological proxies. **Methodology:** We evaluated the thermal biology of the species across a wide temperature gradient to test how warming affects metabolic performance, thermal tolerance, and biochemical status. Fish collected from Algarve watercourses were exposed to 5, 10, 15, 20, 25 and 35 °C (n = 15 per condition, 10-60g) for at least a week, and intermittent respirometry was used to determine standard metabolic rate (SMR), maximum metabolic rate (MMR) and aerobic scope (AS). Group Q10 was derived from metabolic rates. Plasma and tissue biomarkers of energy metabolism and oxidative stress were analyzed. Critical thermal maximum (CTmax) was assessed in fish acclimated for a week at 10, 20 and 30 °C (n = 10) using a 1 °C/min thermal ramp. **Results**: Intermediate temperatures (15–25 °C) supported the best overall physiological performance, combining stronger aerobic capacity with higher antioxidant protection. In contrast, 30–35 °C imposed clear physiological costs: maintenance metabolism increased disproportionately, aerobic scope declined, and cellular protection weakened, indicating the onset of heat stress. Despite this, *A. facetus* showed marked thermal plasticity, with CTmax increasing significantly with acclimation temperature. Fish acclimated to 30 °C had higher CTmax than fish acclimated to 20 °C and 10 °C, although the thermal safety margin decreased progressively as the acclimation temperature rose. Liver antioxidant activity also peaked at intermediate temperatures and declined at the warmest treatments, reinforcing the mismatch between acute tolerance and sustained performance. **Conclusions:** These results show that *A. facetus* is highly heat tolerant but that tolerance comes with energetic and cellular trade-offs near upper thermal limits. Despite this limitation at extreme conditions, the combination of broad tolerance and functional performance under warm intermediate conditions may help to explain its invasion success and stand as a competitive advantage in increasingly hot low-flow Iberian freshwater ecosystems.

Keywords: invasive fish; thermal plasticity; physiological performance; competitive advantage

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