Uncoupled eelpouts -
the thermal sensitivity of UCP2 expression in Antarctic & boreal zoarcids

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Introduction
Mitochondrial uncoupling protein 1 (UCP1) is known to be crucial in thermoregulatory processes in various endothermic animals, and its homologues are widely distributed among vertebrates, invertebrates and plants. Mitochondria are essential in the adaptation of poikilothermic animals to changing environmental temperature. The increase in mitochondrial densities frequently observed in cold adapted ectotherms may contribute to higher energetic demands through mitochondrial maintenance costs and the intrinsic energy dissipation through proton leakage.

To investigate whether uncoupling proteins are possibly involved in the thermal adaptation of ectothermic animals, we isolated and characterised the entire genes of UCP2 for two closely related zoarcid fish species from Antarctic (Pachycara brachycephalum) and boreal (Zoarces viviparus) waters.

Identification of the UCP2 genes
UCP2 gene structure Z. viviparus

UCP2 mRNA levels in liver: A. UCP2 mRNA levels in liver. B. UCP2 mRNA levels in muscle. C. UCP2 protein levels in liver. D. UCP2 protein levels in muscle.

Western Blot detection of UCP2 in enriched mitochondrial fractions of liver samples of the two zoarcid P. brachycephalum and Z. viviparus, acclimated to 0°C, 5°C and 10°C, respectively. Each lane contained 50μg of protein pooled from five individuals, lanes were run in duplicates. The UCP2 antibody bound to a protein band of approximately 38kDa. UCP2 expression rose above and below habitat temperatures.

Expression at the protein level

Conclusions
In this study, we characterised zoarcid UCP2 and for the first time investigated temperature dependent UCP2 expression in fish. Upon cold and warm acclimation, we found different phenomena. Following cold acclimation, there was a general upregulation of UCP2 expression levels in the temperate common eelpout Z. viviparus, in line with evidence for cold-induced mitochondrial proliferation provided by other authors. During warm acclimation of the cold adapted Antarctic eelpout P. brachycephalum, UCP2 expression underwent as yet undocumented changes: in muscle and liver tissue we found a putatively regulated increase in UCP2 levels, both at mRNA and protein levels.

Our findings suggest that in ectotherms UCP2 plays a role in the mitochondrial energy metabolism, especially at temperatures at the edge of the thermal tolerance range. During thermal stress it may support control of the mitochondrial membrane potential and balance ROS formation and ATP production.


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