The bioenergetic cost of metal resistance and its consequences for reproduction in the harbour ragworm, *Nereis diversicolor*.

Submitted by Christopher Pook to the University of Exeter as a thesis for the degree of *Doctor of Philosophy* in the biological sciences, September 2009.

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract:

The population of harbour ragworms, *Nereis diversicolor*, inhabiting the upper reaches of Restronguet Creek in the Fal Ria, UK, are known to be resistant to the acute, toxic effects of copper, zinc and cadmium. This research aimed to establish whether metabolic and reproductive performance costs were associated with the resistance phenomenon and what the biochemical mechanisms of resistance were, by comparing animals from the Creek with two comparable study sites in the South West of England: Froe Creek and the Teign estuary. There was a significant metabolic cost, measured as a reduction in Scope for Growth, associated with the resistance phenomenon. As no differences in energy intake or uptake were found between resistant and non-resistant animals it was concluded that this cost was covered by demand-side regulation of energetics. A reduction in the amount of biochemical energy reserves in the form of lipids and sugars was also observed in resistant animals suggesting that resource allocation had been shifted away from this endpoint and towards maintenance and activity.

The perturbed metabolism and physiology of resistant *N. diversicolor* is shown to have detrimental consequences for their life-history. Sexually mature, resistant females were significantly smaller than non-resistant ones, indicating that they had either matured at a younger age or grown more slowly. Both total fecundity and mass-specific fecundity were significantly reduced in resistant females, likely as a direct result of the metabolic costs of resistance reducing the resources available to fuel gametogenesis. No differences were found in the energetic reserves stocked within each gamete by resistant and non-resistant animals, suggesting that this trait is heavily selected for.

Synthesis of reduced glutathione [GSH] in resistant animals' tissues appeared to be elevated. Glutathione peroxidase activity was also increased, likely to remediate the effects of Reactive Chemical Species [RCS] that result from the inevitably incomplete binding of intracellular metals. As GSH functions in metal detoxification to covalently binding metals entering resistant animals' cells, preventing their involvement in toxic interactions and their catalysis of the production of RCS, it is proposed that together there two phenomena comprise the fundamental mechanism of resistance to metal toxicity.

Ultimately, this research revealed a hierarchy of health and reproductive performance across the three study populations, with significant associations evident between measured biological endpoints and the degree of metal contamination, illustrating the consequences of anthropogenic pollution for the biology of wild animals.

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