# LATITUDINAL COLD ADAPTATION VERSUS SEASONAL COLD ACCLIMATISATION IN LUGWORMS (*A. MARINA*)

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The temperature dependence of mitochondrial functions were investigated in cold adapted intertidal lugworms, *Arenicola marina* (polychaeta), from the White Sea (subpolar summer) and cold (winter) or warm (summer) acclimatised lugworms from the North Sea (boreal). Mitochondria were isolated from the body wall tissue after animals were killed by decapitation.

Eurythermal adaptation to lower mean annual temperatures in White Sea animals is reflected by an increase in aerobic capacity compared to North Sea summer animals. Mitochondria from subpolar lugworms are characterised by a higher activity of cytochrome c-oxidase and NADP dependent isocitrate dehydrogenase as well as a rise of their maximal rates of substrate oxidation ($nmol \cdot min^{-1} \cdot mg^{-1}$ mitochondrial protein) and a reduction of the value of activation energy (Ea) for the oxidation of cytochrome c. Moreover, White Sea lugworms display 2.4 times higher mitochondrial volume density in the muscle tissue than summer animals from the North Sea. The rise in aerobic capacity is mirrored by a downward shift of the low critical temperature (Tc). However, the oxygen demand of the whole animal increases due to the rise in mitochondrial maintenance costs, followed by a shift of the high Tc to lower temperatures. We hypothesise that this shift is minimized by a rise in Ea values for the decarboxylation of isocitrate and a lower activity of citrate synthase (CS). In contrast to cold adaptation in a latitudinal cline, seasonal acclimatisation to winter conditions in North Sea lugworms led to a rising activity of CS. Phosphorylation efficiency and mitochondrial coupling were also higher in winter than in summer specimens (both from the North and the White Seas). State 4 respiration in the presence of oligomycin (state 4ol), an inhibitor of mitochondrial $F_0F_1$-ATPase, quantifies the proton leakage rates through the inner mitochondrial membrane. No difference between proton leakage rates were seen in cold adapted White Sea lugworms and cold acclimatised winter animals from the North Sea. However, state 4ol respiration rates in summer animals from the North Sea were significantly reduced. Nevertheless, the percentage of oxygen needed to feed the proton leakage during state 3 respiration was lowest in winter animals compared to summer animals from the North or White Seas due to elevated state 3 respiration rates in winter lugworms. Cold adaptation or acclimatisation leads to a decrease in the low critical temperature threshold, which is characterised by the onset of anaerobic metabolism. It seems that a rising efficiency of aerobic energy production in winter animals is associated with metabolic depression at the expense of regulatory flexibility. In contrast, adaptation of White Sea lugworms to lower mean annual temperatures and to larger temperature fluctuations leads to an increased aerobic capacity, but at the expense of a higher metabolic rate.

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