Costs and benefits of cold acclimation in field released Drosophila – Associating laboratory and field results**.**

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C5.15

Thermal effects on cephalopod energy metabolism — A case study for *Sepia officinalis*

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Cephalopods are the largest, most active invertebrates and there is considerable evidence for their convergent evolution with fishes. However, most active cephalopods display standard and active metabolic rates that are several-fold higher than comparably sized fishes. Shifting habitat temperatures due to climate change will therefore affect a cephalopod's energy metabolism much more than that of a fish. Prediction of the probable outcome of cephalopod fish competition thus requires quantitative information concerning whole animal energetics and corresponding efficiencies. Migrating cephalopods such as squid and cuttlefish grow rapidly to maturity, carry few food reserves and have little overlap of generations. This "live fast, die young" life history strategy means that they require niches capable of sustaining high power requirements and rapid growth.

This presentation aims to draw a bottom-up picture of the cellular basis of energy metabolism of the cuttlefish *Sepia officinalis*, from its molecular basis to whole animal energetics based on laboratory experiments and field data. We assessed the proportionality of standard vs active metabolic rate and the daily energetic requirements using field tracking data in combination with lab based respirometry and video analysis. Effects of environmental temperature on mitochondrial energy coupling were investigated in whole animals using *in vivo* ^{31}PNMR spectroscopy. As efficient energy turnover needs sufficient oxygen supply, also thermal effects on the blood oxygen-binding capacities of the respiratory pigment haemocyanin and the differential expression of its isoforms were investigated. Supported by NERC grant NERC/A/S/2002/00812.

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C5.16

Molecular mechanism which underlie the development of endothermy in birds (*Gallus gallus*)

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The evolution of endothermy is associated with high metabolic rates and internal heat production. During embryogenesis endotherms cannot regulate their body temperature metabolically and are therefore similar to ectotherms. The transition from ectothermy to endothermy occurs by the development of metabolic capacity during embryogenesis. Transcriptional control is an important mechanism that regulates metabolic capacity to establish endothermy. Recently we have shown that PGC-1a known as a metabolic master regulator in mammals, as well as its target PPARγ is upregulated during embryogenesis in birds. Interestingly, upregulation of PGC1a during embryogenesis coincides with upregulation of plasma triiodothyronine levels, and functional maturation of thyroid hormones is an important component in the development of endothermy. Additionally, heat production in endotherms is facilitated by greater mitochondrial membrane proton conductance due to higher rates of basal proton leak across the inner mitochondrial membrane compared to ectotherms. Therefore, the aims of this study were to determine firstly to what extent the increase in metabolic capacity during embryogenesis in a bird (*Gallus gallus*) is associated with an increase in uncoupling of the electron transport chain from oxidative phosphorylation. We show that suppression of palmitate stimulated uncoupling by blocking ATP/ADP-antiporter is significantly greater after hatching. Secondly, we investigated whether thyroid hormones are important to establish thermogenic capacity via regulating PGC-1a gene expression. Our preliminary results show that following pharmacologically induced hypothyroidism, PGC-1a gene expression is significantly reduced. Our findings elucidate the interaction between different mechanisms that lead to the development of endothermy.

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C5.17

Seasonal acclimatization of body temperature and metabolic capacities in an Australian rat (*Rattus fuscipes assimilis*)

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The energetic cost of maintaining the relatively high and stable body temperatures (T_b) of endotherms increases with decreasing environmental temperatures (T_e). Small mammals that remain active during winter may offset this cost by decreasing T_b, and may also increase metabolic capacities to facilitate internal heat production. The aim of this project was to determine whether seasonal fluctuations in environmental temperature influence body temperature and metabolic regulation in a rat (*Rattus fuscipesassimilis*). In the wild, winter mean T_b (36.66 °C±0.02) was significantly lower than in summer (37.01 °C±0.06), and T_b amplitude (T_{bmax}-T_{bmin}) was significantly greater in winter (3.42±0.10) than summer (3.01±0.12). States 3 and 4 mitochondrial oxygen consumption was significantly higher in winter rats as were cytochrome c-oxidase and lactate dehydrogenaseactivities. The thermal sensitivity of enzyme activities was reduced in winter acclimatized rats. When acclimated to cold (12 °C) and warm (24 °C) conditions in the laboratory, running performance and metabolic scope were significantly increased at low temperatures in the cold acclimated rats compared to the warm acclimated rats. Hence, rather than regulating to a fixed body temperature, mammals can maintain performance and reduce energetic cost in cooler thermal environments by regulating to a lower body temperature and concurrently increasing metabolic heat production capacity and shifting thermal sensitivities of metabolic pathways.

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C5.18

Costs and benefits of cold acclimation in field released *Drosophila* — Associating laboratory and field results

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Physiological and evolutionary responses to thermal variation are often investigated under controlled laboratory conditions. However, this approach may fail to account for the complexity of natural environments. Here we investigated the costs and benefits of developmental or adult cold acclimation using the ability of field released *Drosophila melanogaster* to find a resource as a proxy of fitness. Measurements were carried out on two continents across a range of temperatures. Cold acclimation improved the flies' ability to find resources at low temperatures. However, this came at a cost at higher temperatures where cold acclimated flies were up to 36 times less likely to find a resource under warm conditions. These costs were not detected in standard laboratory tests but indicate that physiological acclimation may improve fitness only over a narrow set of thermal conditions while it may have the opposite effect once conditions extend outside this range. In a second study we released 10,000 flies from a single population under cold field conditions. Flies caught at either the release or the resource station were subsequently compared with respect to cold performance. This study showed that the ability to locate a field resource has a genetic basis with a high heritability since only round of selection on parental flies (F0) revealed clear differences in the ability of offspring (F1 and F2) to locate field resources at cold temperatures. Again we found a poor association between field and laboratory performance emphasising the importance of testing thermal resistance under relevant/natural conditions.

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C5.19
The changes of vertical plant distribution in West Carpathians Mountains

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The floristic study for determination of new upper limits of vertical distribution of vascular plant species were realised by Garmin GPS-system during 2003–2007 years at West Carpathians Mountains (Slovakia). We determined new altitudinal maxima or upper limits of vertical distribution of 21 plant species for Slovak flora (f.e. *Amaranthus retroflexus*, *Atriplex patula*, *Balotta nigra* subsp. *nigra*, *Bassia scoparia* subsp. *scoparia*, *Betonica officinalis*, *Cerasus avium*, *Impatiens parviflora*, *Iva xanthifolia*, *Lepidium ruderale*, *Loranthus europaeus*, *Mimulus guttatus*, *Pastinaca sativa*, *Polygala major*, *Potentilla anserina*, *Prunella laciniata*, *Rhamnuscatharticus*, *Sisymbrium*) at Kremnické vrchy Mts. and also 20 new altitudinal maxima of vertical plant distribution for Slovak flora at Starohorské vrchy Mts. Progressive distribution of synanthrope species is influenced by mankind activities as abiotic changes of environmental conditions, tourism, stock feast, transport development and at least is it effect of graduated climate change.

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C5.20
Anatomy and eco-physiology of leaves and twigs of *Cistus incanus* L.: Adaptive strategies to the environmental constraints of the Mediterranean ecosystems

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Plants of Mediterranean-type ecosystems are exposed to climatic conditions that may limit carbon metabolism resulting in limitation of productivity and growth. During springtime, photosynthetic activity and plant growth are promoted, while they are constrained by aridity in summer and by low temperatures in winter. To overcome such stressful conditions, Mediterranean species have developed strategies expressed by phenological, physiological and structural modifications. Among the various woody species of the Mediterranean maquis in Southern Italy, *Cistus incanus* L. shows its phenology and cambial activity strictly related to the annual fluctuations of the environmental conditions.

In this study, several structural, functional and eco-physiological characteristics were investigated on plants of *C. incanus* sampled during the autumn development in the Castevolturno Nature Reserve (NA, Italy). Anatomical and cytological features of leaves and twigs were analysed through light and fluorescence microscopy, mainly focusing on traits associated to a) regulation of water relations and b) protection of tissues from excessive irradiation and permanent injuries due to drought and predation. Efficiency and safety of the vascular system were evaluated on the basis of a detailed analysis of the xylem cell types. As regards eco-physiological behaviour, simultaneous measurements of gas exchange and chlorophyll fluorescence were conducted on fully expanded leaves at midday under saturating light intensity. The following parameters were analyzed: net photosynthesis (P_N), stomatal conductance (g_{tH_2O}), water use efficiency (A/E) and quantum yield of PSII electron transport (Fe). All data were interpreted under ecological and functional perspectives.

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C5.21
Symmorphosis and temperature adaptation: Testing the theory of oxygen limitation

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The theory of symmorphosis (Wiebel, 2000) predicts that an animal's physiological systems will evolve to match, but not exceed, the demands of their environment. For the oxygen supply cascade, theory predicts that the circulatory and ventilatory systems of aquatic organisms will have a limited capacity to meet oxygen demand beyond their normally experienced environment. As upper temperature limits are approached, aerobic scope becomes fully utilized and the available energy reduces, despite the short-term recruitment of anaerobic pathways. This leads to a hierarchy of function loss with whole animal processes, such as locomotion, being lost before cellular or molecular systems (Pörtner and Knust, 2007). Temperature limits should therefore depend on the partial pressure of available oxygen.

The ability of Antarctic limpets, *Nacella concinna*, to right themselves, was used to investigate the thermal limits of a critical activity. Under normoxia(21% O_2) 50% loss of righting ability depends on the depth of collection, 4.6 °C in limpets collected from 6 m and 0.7 °C for limpets collected from 30 m. This could either be linked to variation in shell shape or physiological differences between limpets from different depths. The hypothesis that temperature limits are defined by oxygen limitation was tested through comparisons of thermal tolerance under hypoxia (27% O_2) and hyperoxia (10% O_2). Hyperoxia increased righting capacity by 15% increasing the temperature limit to 7.0 °C. Hypoxia had no effect on righting ability. A model that describes the hierarchy of response loss through differential energy allocation was used to explain this result.

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