AUSTRALIAN AND NEW ZEALAND SOCIETY FOR COMPARATIVE PHYSIOLOGY AND BIOCHEMISTRY

30TH ANNUAL MEETING

26-29 November 2013

University of Melbourne

Australian and New Zealand Society for Comparative Physiology and Biochemistry

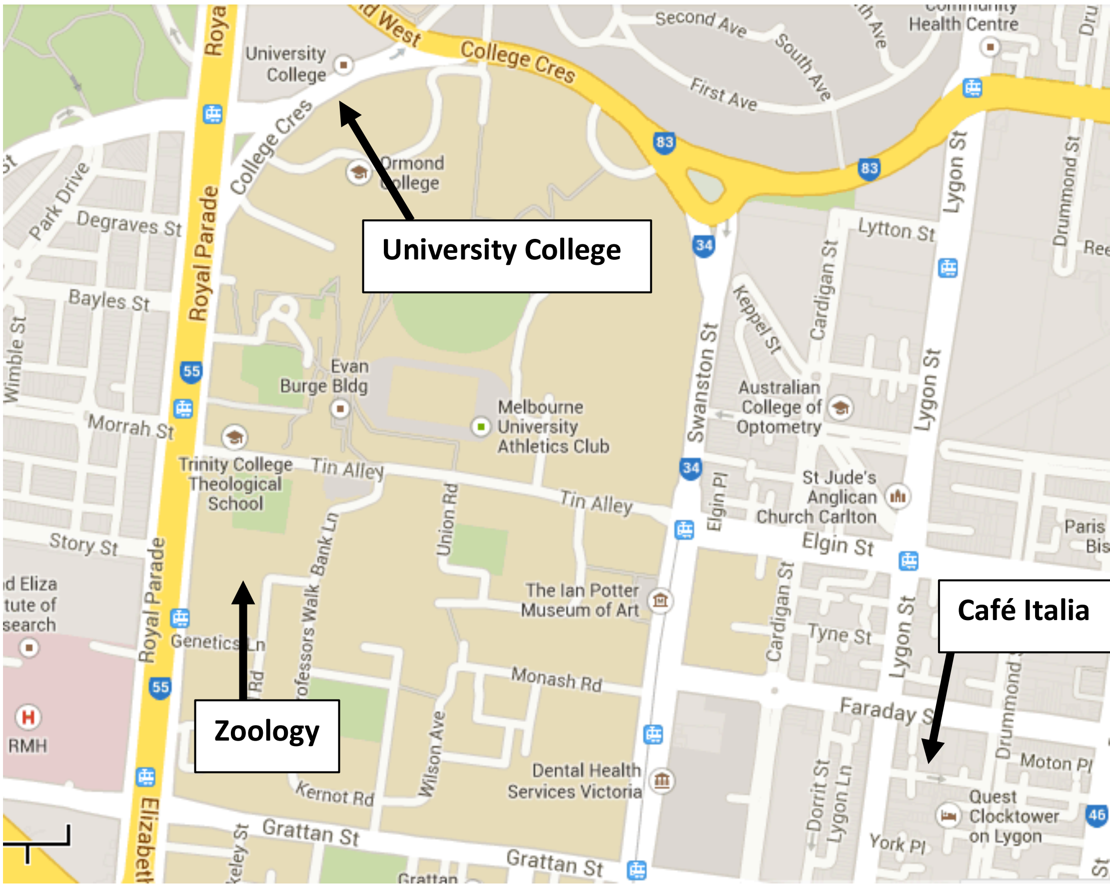
University of Melbourne
26-29 November 2013

Organising committee:
Michael Kearney, Tim Jessop, Candice Bywater

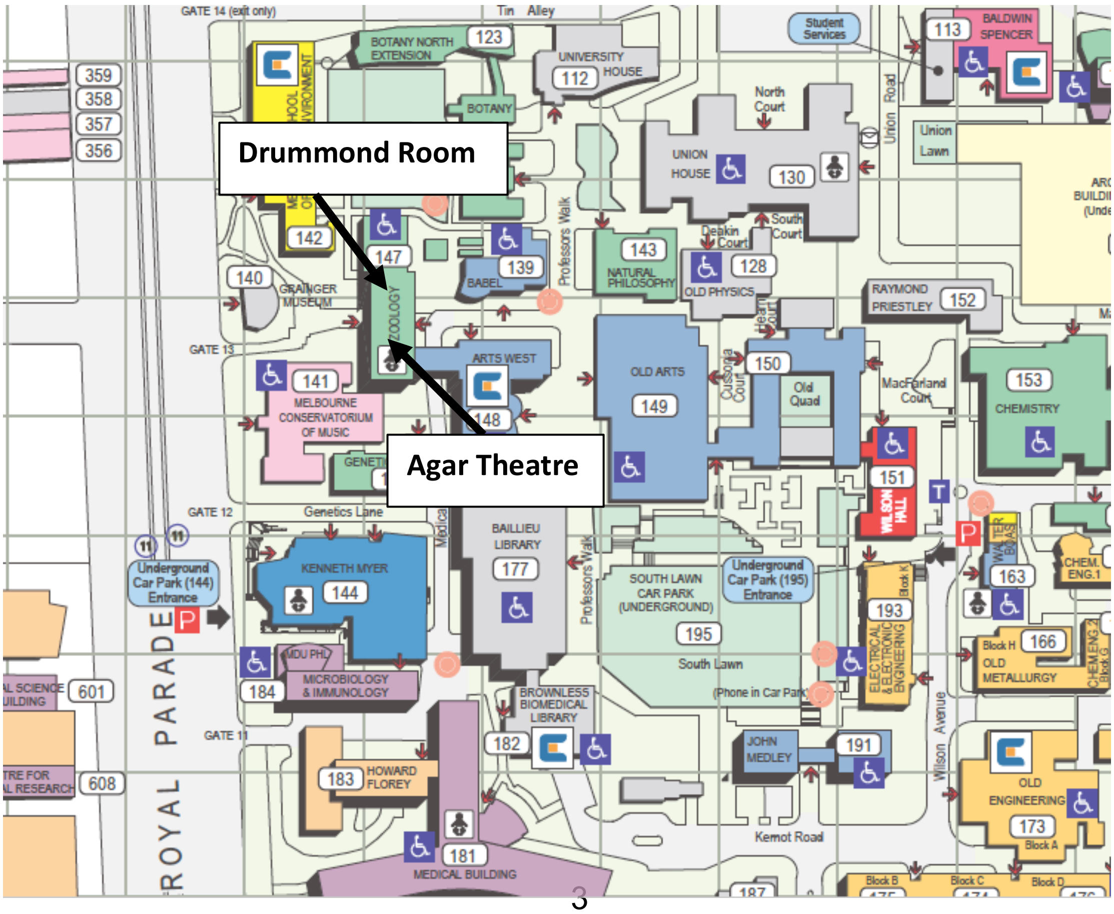
Sponsors:
Department of Zoology, University of Melbourne
Sable Systems
Journal of Experimental Biology
StatistiXL

Contents

Maps



University College
Zoology
Café Italia
College Cres
Second Ave
First Ave
South Ave
Health Centre
Ormond College
Park Drive
Degraves St
Bayles St
Royal Parade
Wimble St
Morrah St
Evan Burge Bldg
Melbourne University Athletics Club
Trinity College Theological School
Tin Alley
Union Rd
Story St
Genetics Ln
Professors Walk
Bank Ln
The Ian Potter Museum of Art
Monash Rd
Wilson Ave
Dental Health Services Victoria
Kernot Rd
Grattan St
RMH
Swanston St
Lytton St
Lygon St
Cardigan St
Keppel St
Australian College of Optometry
St Jude's Anglican Church Carlton
Elgin Pl
Elgin St
Tyne St
Faraday St
Drummond St
Moton Pl
Quest Clocktower on Lygon
York Pl
Dorrit St
Lygon Ln



Drummond Room
Agar Theatre
GATE 14 (exit only)
Tin Alley
BOTANY NORTH EXTENSION
123
UNIVERSITY HOUSE
112
BOTANY
Student Services
113
BALDWIN SPENCER
North Court
UNION HOUSE
130
Union Lawn
South Court
Deakin Court
143
NATURAL PHILOSOPHY
128
OLD PHYSICS
142
147
139
BABEL
140
GRAINGER MUSEUM
ZOOLOGY
RAYMOND PRIESTLEY
152
GATE 13
ARTS WEST
OLD ARTS
149
150
Old Quad
MacFarland Court
153
CHEMISTRY
141
MELBOURNE CONSERVATORIUM OF MUSIC
148
151
GATE 12
Genetics Lane
BAILLIEU LIBRARY
177
Underground Car Park (144) Entrance
KENNETH MYER
144
SOUTH LAWN CAR PARK (UNDERGROUND)
195
Underground Car Park (195) Entrance
South Lawn
193
163
166
OLD METALLURGY
MICROBIOLOGY & IMMUNOLOGY
184
GATE 11
BROWNLESS BIOMEDICAL LIBRARY
182
HOWARD FLOREY
183
JOHN MEDLEY
191
OLD ENGINEERING
173
181
MEDICAL BUILDING
Kernot Road
ROYAL PARADE
Wilson Avenue
359
358
357
356
601
608

Schedule Summary

Time	Tuesday 26 November	Wednesday 27 November	Thursday 28 November	Friday 29 November
8:00		8:45 Announcements	8:45 Announcements	8:45 Announcements
9:00		Plenary Lecture 10-10:30 Presentations	Plenary Lecture 10-10:30 Presentations	Plenary Lecture 10-10:30 Presentations
10:00		10:30-11 Morning Tea	10:30-11 Morning Tea	10:30-11 Morning Tea
11:00		Presentations	Presentations	Presentations
12:00		12:45- 13:45 Lunch	12:45-13:45 Lunch	12:45-13:45 Lunch
13:00		Presentations	Presentations	
14:00				
15:00	Registration + Welcome Drinks and Dinner	15:15-15:45 Afternoon Tea	15:15-15:45 Afternoon Tea	
16:00		Presentations	Speed Talk Session	
17:00		Discussion panel	AGM	
18:00 +		BBQ Dinner	19:00 Conference Dinner	

Conference Program

TUESDAY 26 NOVEMBER

Drummond Room	
3:00	Registration opens
5:00 - 7:00	Welcome drinks and food

Conference Program

WEDNESDAY 27 NOVEMBER

*indicates students eligible for prizes

Agar Theatre	
Chair: Michael Kearney	
8:45	**Announcements**
9:00	**Plenary Lecture** Macrophysiological forecasting and the fitness consequences of variation across thermal performance curves **Steven L. Chown**
10:00	Integrating thermal physiology with the pace-of-life syndrome hypothesis **Christopher Turbill**
10:15	Capacity and regulation of thermal acclimation vary between generations in the short-lived mosquitofish (*Gambusia holbrooki*) **Frank Seebacher**, Julian Beaman and Alexander G. Little
10:30 - 11:00	**Morning Tea – Drummond Room**
Chair: Craig White	
11:00	Metabolic scope and swim performance in zebrafish (*Danio rerio*) **Kate McShea***
11:15	Exploring constraints on insect metabolism using Dynamic Energy Budget (DEB) theory **James Maino***, S.A.L.M. Kooijman and Michael Kearney
11:30	Among- and within-individual correlations in a suite of physiological and behavioural traits **Vincent Careau**, Kate L. Buchanan and William A. Buttemer
11:45	Sex and survival: The impact of climate change and skewed sex ratios on sea turtle reproduction **Ella Kelly***, Tim Dempster, Michael Kearney and Tim Jessop
12:00	Individual variation in selective brain cooling capacities may buffer the effects of climate change **W. Maartin Strauss**, Robyn S. Hetem, Duncan Mitchell, Shane Maloney, Leith Meyer and Andrea Fuller
12:15	Can behavioural flexibility mitigate the effects of climate change in desert lizards? Part 1: thermoregulation **Elia Pirtle***, Jenny Todd, Fran C. Sandmeier, C. Richard Tracy and Christopher R. Tracy
12:30	Can climate warming explain recent lizard extinctions? **Michael R. Kearney**
12:45 - 1:45	**Lunch – Drummond Room**

Chair: Terry Dawson	
1:45	Modelling a lizard's life history and population responses to current and novel environments **Christopher R. Gatto***, Tim S. Jessop and Michael R. Kearney
2:00	Predicting the thermal effects of climate change on developmental phenotypes, offspring viability and natal dispersal of green turtles **Catherine Cavallo***, Tim Jessop and Tim Dempster
2:15	Physiological consequences of selecting shade and becoming inactive: how much do kangaroos save by thermoregulating? **Jessica Roberts***, Natalie Briscoe, Paul Mathewson, Warren Porter, Graeme Coulson, Adam Munn, John Speakman and Michael Kearney
2:30	What do we mean by 'stress'? Using psychological theory to inform ecological and conservation physiology research. **Koa N. Webster**
2:45	Aquaculture physiology in changing climates **Andrea J. Morash**, Sarah J. Andrewartha, Nicholas G. Elliott and Peter B. Frappell
3:00	Using metabolomics to differentiate modes of action of similarly acting chemicals **Sara Long**, Dedreia Tull, David De Souza, Katy Jeppe, Vincent Pettigrove, Malcolm McConville and Ary Hoffmann
3:15 - 3:45	**Afternoon Tea - Drummond**
Chair: Mike Thompson	
3:45	Variation in body size and insulation in the koala: implications for thermoregulation **Natalie J. Briscoe***, Andrew Krockenberger, Kathrine Handasyde, Warren P. Porter and Michael Kearney
4:00	Aestivation in mammals **Fritz Geiser**, Artiom Bondarenco and Clare Stawski
4:15	Cold living is costly for a major insect pest **David T. Booth**, Rebecca Garrad and Mike Furlong
4:30	Scaling of heat production by thermogenic flowers: Limits to floral size and maximum rate of respiration **Roger S. Seymour**
4:45	Cold and thermally variable environments select for a higher metabolic rate in amphibians **Taryn S. Crispin*** and Craig R. White
5:00	**Plenary Panel Discussion Group:** Future Directions in Physiology
6:00	**BBQ Dinner –** University College

Conference Program

THURSDAY 28 NOVEMBER

*indicates students eligible for prizes

Agar Theatre	
Chair: Tim Jessop	
8:45	**Announcements**
9:00	**Plenary Lecture** The gains and pains of exploring the physiology/life-history nexus **William A. Buttemer**
10:00	Corticosterone as a biomarker of stress in amphibians **Edward J. Narayan*** and Jean-Marc Hero
10:15	Monitoring faecal glucocorticoid metabolites in native Australian marsupials **Kerry V. Fanson** and Meredith J. Bashaw
10:30 - 11:00	**Morning Tea – Drummond Room**
Chair: Tony Hulbert	
11:00	Lamprey "transthyretin" – is it transthyretin or 5-hydroxyisourate hydrolase? **Samantha J. Richardson**, Simone De Luca, Damian D'Souza, Kasai Kentaro, Brett Cromer, Vivian Cody and Kiyoshi Yamauchi
11:15	Sequencing of endo-β-1,4-glucanase isozymes in the soldier crab, *Mictyris platycheles,* the grapsid crab, *Paragrapsus laevis* and the gecarcinid land crab, *Gecarcoidea natalis*; implications for the origin and potential form and function of cellulases in arthropods. Michael Gray and **Stuart M. Linton**
11:30	Development of central chemoreceptors and respiratory rhythm in newborn fat-tailed dunnarts (*Marsupialia*: *Sminthopsis crassicaudata*) **Angelina Y. Fong**, Shannon J. Simpson, Peter B. Frappell and William K. Milsom
11:45	Uterine epithelial cell changes during pregnancy in a marsupial (*Sminthopsis crassicaudata*; Dasyuridae) **Melanie K. Laird***, Michael B. Thompson, Christopher R. Murphy and Bronwyn M. McAllan
12:00	Changes in desmoglein-2 during pregnancy: understanding the evolution of viviparity in a marsupial (*Sminthopsis crassicaudata*; Dasyuridae) **Jessica S. Dudley***, Bronwyn McAllan, Michael B. Thompson, Christopher Murphy
12:15	The genomic basis of male pregnancy in seahorses and pipefish **Camilla M. Whittington***, Oliver W. Griffith and Anthony B.

	Wilson
12:30	Thyroid hormone regulates metabolism, muscle function and cardiac performance during cold acclimation in zebrafish (*Danio rerio*) **Alexander Little*** and Frank Seebacher
12:45 - 1:45	**Lunch – Drummond Room**
	Chair: Chris Johnstone
1:45	Conditions favouring the evolution of placentotrophy in a viviparous skink: hungry moms and infanticidal cannibalism **James U. Van Dyke**, Oliver W. Griffith, and Michael B. Thompson
2:00	Incubation temperature, morphology and performance of loggerhead (*Caretta caretta*) turtle hatchlings. **Elizabeth L. Sim***, David T. Booth and Colin J. Limpus
2:15	Retreat site selection and exploitation of thermal microhabitats by juvenile spiders **Francesca T. van den Berg***, Dieter F. Hochuli and Mike B. Thompson
2:30	Physiological consequences of constant light exposure, and the role of melatonin in the Australian cricket, *Teleogryllus commodus* **Joanna Durrant***, Ellie Michaelides, Thusita Rupasinghe, Dedreia Tull, Mark Green and Therésa Jones
2:45	Cerebral blood flow in Primates and Diprotodontia: the carotid foramen as an indicator of brain metabolism and primate brain evolution **Sophie Angove***
3:00	Blood flow for bone remodelling correlates with locomotion in living and extinct birds **Georgina H. Allan***
3:15 - 3:45	**Afternoon Tea - Drummond**
	Speed Session Chair: Tim Jessop
3:45	Physiological responses to environmental stress in abalone: Why is being a hybrid an advantage? **Katharina Alter***, Peter B. Frappell, Andrea J. Morash, Sarah J. Andrewartha, Nicholas G. Elliott
3:50	*Drosophila melanogaster* show no evidence of metabolic cold adaptation when allowed to evolve in a range of thermal environments. **Lesley A. Alton**, Catriona C. Condon, Craig R. White and Michael J. Angilletta Jr.
3:55	The long and the short of it: climatic correlates and physiological implications of body size variation in *Diplodactylus granariensis* **Elisabeth Barber***, Michael Kearney and Paul Oliver
4:00	Gene expression associated with the recent evolution of viviparity in a reproductive bimodal skink (*Lerista bougainvillii*)

	Matthew Brandley, Oliver Griffith and Mike Thompson
4:05	It's costly to be honest: the metabolic expense of maintaining a reliable signal of strength for crustaceans **Candice Bywater**, Craig White and Robbie Wilson
4:10	Physiological and behavioural responses of mammals to fire **Clare Stawski**, Jaya Matthews, Gerhard Körtner and Fritz Geiser
4:15	Scaling of gross heart development in the kangaroo *Macropus fuliginosus* **Edward P. Snelling**
4:20	The chilly side of global warming: can food or water restriction depress the thermal preferences of the Australian tawny dragon lizard (*Ctenophorus decresii*)? **Samantha Walker***, Devi Stuart-Fox and Michael Kearney
4:30 - 5:30	**Annual General Meeting**
7:00+	**Conference Dinner –** Café Italia

Conference Program

FRIDAY 29 NOVEMBER

*indicates students eligible for prizes

Agar Theatre	
Chair: Michael Kearney	
8:45	**Announcements**
9:00	**Plenary Lecture** Nutritional homeostasis in ecological and evolutionary context **David Raubenheimer**
10:00	Sex and age-related differences of torpor use by free-ranging antechinus **A. Daniella Rojas***, Gerhard Körtner and Fritz Geiser
10:15	Cardiac function of heterothermic bats **Shannon E. Currie***, Gerhard Körtner and Fritz Geiser
10:30 - 11:00	**Morning Tea – Drummond Room**
Chair: John Lesku	
11:00	Prickly heat **C.E. Cooper**, C.J. Clemente, P.C. Withers, J.M. Barker
11:15	Intraspecific variation in torpor use by the fat-tailed dunnart **Christine B. Wacker*** and Fritz Geiser
11:30	The chilling effect of cold and hypoxia acclimation of rats **Viviana Cadena** and Glenn J. Tattersall
11:45	Burrowing energetics of the Giant Burrowing Cockroach: an allometric study **Liangwen Xu***
12:00	Correcting metabolic rate of animals to a common body temperature: two ways to do it but which is right? **Philip C. Withers**
12:15	Adrenocortical stress responses influence an invasive vertebrate's fitness in an extreme environment **Tim S. Jessop**, Mike Letnic, Jonathan K. Webb and Tim Dempster
12:30	Body temperature and activity of free-living aardvark facing climate change Benjamin Rey, Robyn Hetem, Andrea Fuller, Anna Haw, Leith Meyer and **Duncan Mitchell**
12:45 - 1:45	**Lunch – Drummond Room**

PLENARY LECTURES (A-Z)

The gains and pains of exploring the physiology/life-history nexus

William A. Buttemer

Centre for Integrative Ecology, Deakin University, Geelong, Victoria, 3217

It is often forgotten that the rapid emergence of ecology during the early 20th century had a strong connection to comparative physiology. Unfortunately, the trajectory of ecological disciplines quickly departed from their physiological associations and realignments were slow to be reestablished. This is unfortunate, as many of the prominent ecological and evolutionary hypotheses proposed over the past decades invite mechanistic examination of potential underlying causes. I will advance the argument that comparative physiology has much to offer ecological and evolutionary studies and will use four case studies for illustration: 1) foraging behaviour in Galapagos marine iguanas, 2) functional appraisal of the immunocompetence handicap hypothesis, 3) testing predictions of the ‘slow-fast‘ life-history continuum, and 4) an examination of the oxidative-stress theory of aging. I will call attention to the insights to be gained from attempting to experimentally validate presumed bases of life-history tradeoffs, but also the frustration in trying to publish negative results.

Abstracts

PLENARY LECTURES (A-Z)

Macrophysiological forecasting and the fitness consequences of variation across thermal performance curves

Steven L. Chown

School of Biological Sciences, Monash University, Victoria 3800, Australia

The International Energy Agency has recently projected more than a 30% growth in global energy demand over the next several decades, most of it to be met by fossil fuel consumption. The net result will be an on-going rise in global temperatures and extreme high temperature events. Several approaches exist for forecasting the fitness consequences of these changes, especially in the context of other environmental change drivers. Doing so simultaneously across an ensemble of species is most readily achieved through macrophysiology. Here I discuss the fitness consequences of responses to selection across the full thermal performance curve, and their broader ecological implications. Critical thermal minima show much variation and strong responses to selection, in ways that might be predicted – low temperature environments appear to select for reductions in critical limits. Responses in optima are more complicated, being influenced both by temperature and by unexpected variables such as precipitation. Rate-temperature relationships also show considerable variation, but how they respond to selection is less certain, as is their overall phenotypic plasticity. By contrast, critical thermal maxima are more constrained and less responsive. The implications of such variation are profound not only for the responses of organisms to changing thermal environments, but also for improving the capability of current forecasting tools. Future exploration of these implications will benefit from a combination of phenotyping and informatics approaches in the context of a broader conservation physiology.

PLENARY LECTURES (A-Z)

Nutritional homeostasis in ecological and evolutionary context

David Raubenheimer

Charles Perkins Centre and Faculty of Veterinary Sciences and School of Biological Sciences, The University of Sydney, Sydney, NSW 2006, Australia

Successful nutrition results from the fine-tuned interactions within a tightly integrated network of behavioural, physiological, morphological and developmental traits. Despite the considerable progress that has been made in understanding each of these categories of traits separately, substantial challenges remain for understanding the integrated output that results from their interaction. This is a high priority in biology, because these systems-level outputs provide the crucial link between nutrition and most components of fitness, from growth and reproduction to predator avoidance and immune responses. Consequently, they provide a focus for understanding both the mechanisms through which nutrition influences animals and the adaptive diversification of nutritional strategies. I present a framework for defining and measuring such integrated nutritional phenotypes, which is based on the dynamic concept of homeostasis. I first show how the framework has been used to characterize nutritional phenotypes and their links to fitness in laboratory studies, and then present examples of its application in non-invasive studies of free-ranging wild animals. I close by demonstrating how the framework can help to understand instances where evolved nutritional strategies operate maladaptively in altered environments, using as an illustration the relationship between human nutrition and the major global health problem of obesity.

REGULAR PRESENTATIONS (A-Z)

Blood flow for bone remodelling correlates with locomotion in living and extinct birds

Georgina H. Allan

Earth and Environmental Sciences, University of Adelaide, Adelaide, South Australia 5005, Australia.

The nutrient arteries of the limb bones are required for bone remodelling in response to mechanical loading and the dynamic forces imposed by locomotion. The cross-sectional area of the nutrient foramen of the femur represents an index of blood flow rate to the shaft and provides insight into the animal's level of activity. Morphometric data on femoral foramen size from 100 extant bird species and eight extinct moa species are analysed allometrically and phylogenetically. Nutrient foramina blood flow index (Q_i) increases with body mass (in birds according to the equation, $Q_i = 8.90 \times 10^{-9} M_b^{1.00\pm0.10}$). The avian equation is not significantly different from previous data from mammals, but when differences in blood pressure are accounted for, blood flow is 1.35 – 2 times higher in birds than in mammals ranging in body mass of 1 – 100 kg. Both endothermic groups are about 50 times higher than for ectothermic reptiles. Thus the long bones of active endotherms are apparently more susceptible to micro-fractures and so require a greater blood flow for remodelling and repair. Cursorial birds that presumably place more strain on their leg bones have significantly larger femora and foramina than volant birds.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Cerebral blood flow in Primates and Diprotodontia: the carotid foramen as an indicator of brain metabolism and primate brain evolution

Sophie Angove

Earth and Environmental Sciences, University of Adelaide, Adelaide, South Australia 5005, Australia.

Primates have relatively large brain sizes and are considered more intelligent compared to other mammals, including diprotodont marsupials (e.g. kangaroo, sugar glider). An increase in brain size is likely to result in an increase in brain metabolism. Cerebral cortex metabolism is linearly proportional to cerebral blood flow in the carotid artery, which influences artery diameter and consequently the area of the carotid foramen. This study analyses brain volume (V_{br}) and carotid blood flow index (Q_c) in 34 Haplorhini (e.g. simians) and nine diprotodonts ranging in body mass (M) between 116 g and 145 kg, and 14 g to 30 kg, respectively. The allometric equation for Q_c in relation to body mass in simians is $Q_c = 1.60 \times 10^{-4} M^{1.13}$, while in diprotodonts $Q_c = 1.90 \times 10^{-4} M^{0.95}$. However, body mass is not a good indicator of differences in Q_c. Brain volume is a good indicator, because it is related to brain metabolism, which is influenced by neuron number. In primates neuron density is independent of body mass as body mass continues to increase after brain enlargement has ceased, while in non-primate mammals, neuron size and density changes in relation to brain volume, not body mass. The allometric equation for carotid blood flow index in relation to V_{br} in simians is $Q_c = 2.67 \times 10^{-3} V_{br}^{1.60}$. Conversely the diprotodont exponent is 20% lower and scales isometrically with V_{br}, $Q_c = 0.094 V_{br}^{1.33}$. This implies that an increase in brain volume in primates requires a greater increase in Q_c compared to diprotodonts. The extent of brain gyrification, which is the folding of the cerebral cortex, influences both white matter and grey matter volume. Primate brains have higher rates of gyrification than diprotodont brains. Species-specific brain cellular scaling characteristics influence Q_c. Primate absolute neuron number increases with increased brain volume, while in diprotodonts neuron density decreases. Among simians, the phylogenetically young humans and great apes clearly have the largest brains and highest Q_c, while phylogenetically old new world monkeys have the smallest brains and lowest Q_c, reflecting the evolution of a relatively large brain and increased cognition in primates.

Supported by the Australian Research Council.

REGULAR PRESENTATIONS (A-Z)

Cold living is costly for a major insect pest

David T. Booth[1], Rebecca Garrad[1] and Mike Furlong[1]

[1]School of Biological Sciences, The University of Queensland, Qld 4072, Australia.

Temperature is well known to influence insect life history characteristics much as growth and development rate. However rarely have studies examined the energetic of development of insect development over a range of temperatures. In this study we reared the widespread and globally significant crop pest the diamond-back moth (*Plutella xylostella*) at temperatures of 10, 15, 20, 25 & 30^{o}C and measured the influence of rearing temperature on larval period, mass before pupation, total oxygen consumed during the larval period, the production cost of development of the larval period (total amount of energy consumed divided by the dry mass of tissue), and the number of eggs laid by females. We found larval period and total oxygen consumed to increase as temperature decreased, that 4th instar mass increased as temperature decreased, and production cost to be minimal at temperatures of 20^{o}C and 25^{o}C but to increase at temperatures above and below this range. We also found what within a rearing temperature the number of eggs laid increased with female pupal mass, but across temperatures female fecundity was greatest at 15^{o}C, least at 10^{o}C, and intermediate at temperatures of 20, 25 and 30^{o}C. Our data suggest that as global warming occurs this pest species will be able to spread and persist for longer in high latitude areas where currently this species dies-off over winter.

REGULAR PRESENTATIONS (A-Z)

Variation in body size and insulation in the koala: implications for thermoregulation

Natalie J. Briscoe[1], Andrew Krockenberger[2], Kathrine Handasyde[1], Warren P. Porter[3] and Michael Kearney[1]

[1]Department of Zoology, University of Melbourne, Australia; [2] School of Marine and Tropical Biology, James Cook University, Cairns, Australia; [3] Department of Zoology, University of Wisconsin, USA

Many species exhibit geographical variation in morphological traits such as body size and insulation. For endotherms, traits such as body size and insulation influence the range of environmental conditions under which an individual is able to maintain their body temperature within physiological limits, while also influencing the energetic and hydric costs of doing so. We quantified geographic and sexual variation in body size and fur characteristics of the koala, *Phascolarctos cinereus*, one of Australia's most broadly distributed marsupials. Using specimens from northern and southern koala populations we measured the effect of variation in fur properties on heat transfer via the fur. To evaluate the impact of this variation in body size and fur properties on costs of thermoregulation in koalas, we developed a biophysical model of heat exchange. This model was used to calculate daily energy and water costs of koalas with different combinations of body size and fur properties under climate experienced at sites at the northern and southern edges of their range. These simulated 'reciprocal transplants' show that in northern tropical regions the northern phenotype (small body size and short fur) is optimal across the year, while in southern temperate regions the southern phenotype (large body size and long fur) reduces predicted energy requirements in winter, but results in higher predicted water costs during summer. The combined effect of morphological variation on predicted energy and water use of koalas is substantial and is likely a key factor that helps this species persist across such a broad climatic range.

Supported by Holsworth Wildlife Endowment to NJB.

Abstracts

REGULAR PRESENTATIONS (A-Z)

The chilling effect of cold and hypoxia acclimation of rats

Viviana Cadena and Glenn J. Tattersall[1]

[1]Department of Biological Sciences, Brock University, Canada

Thermoregulation at extreme environmental conditions presents a challenge for homeothermic organisms such as mammals. Such challenges are exacerbated when two of these stressors are experienced simultaneously and the physiological responses to each stimulus is opposite to the other. This is the case of cold, which induces an increase in metabolic heat production, and hypoxia, which suppresses metabolism in an attempt to conserve oxygen and prevent oxygen deficit in the tissues. In this study I examined changes in different body temperature parameters in Srague-Dawley rats to acclimation to cold, hypoxia or simultaneous cold and hypoxia. A decrease of 0.5 °C was observed in hypoxia acclimated rats. Cold and hypoxia exacerbated this effect inducing a body temperature decrease of 1.4 °C. The circadian variations in body temperature were also blunted with hypoxic exposure, an effect that was more pronounced in cold/hypoxia acclimated rats than in hypoxic/room temperature rats. Interestingly ultradian variations in body temperature exhibit circadian rhythmicity that disappear in hypoxic room temperature or hypoxic cold environments but not in cold normoxic environments which might suggest that changes in the control of temperature regulation are at play during hypoxic exposure. The changes in body temperature during short and long term exposure to hypoxia and cold and hypoxia are in agreement with the hypothesis that a decrease in the body temperature set-point occurs upon hypoxic exposure. A partial re-establishment of the pre-hypoxic body temperature set-point with chronic hypoxia (more than 24 h) which might reflect adjustments at the cellular level, such as an increase in haematocrit concentration, that would allow the organism to better deal with low oxygen levels. The more pronounced effect of hypoxia on body temperature observed at low ambient temperatures might reflect a decrease in heat production during hypoxia and an increase in heat loss due to a larger ambient – body temperature gradient. Cold and hypoxia are conditions characteristic of high altitude environments. Understanding how small mammals are able to cope with changes in these conditions and are able to acclimate to such stressors will shed light into the ability of these animals to colonise new environments along altitudinal clines and increase our understanding of how body temperature is regulated under contrasting stimuli.

Supported by CGS NSERC and Queen Elizabeth grants to VC and a Discovery NSERC grant to GJT

Abstracts

REGULAR PRESENTATIONS (A-Z)

Among- and within-individual correlations in a suite of physiological and behavioural traits

Vincent Careau[1], Kate L. Buchanan[1] and William A. Buttemer[1]

[1]Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, Waurn Ponds, Victoria, Australia

According to the “pace-of-life syndrome” concept, slow-fast life-history strategies favoured under different ecological conditions should lead to co-adaptations among personality traits (e.g., activity, exploratory behaviour) and several physiological traits, including resting metabolic rate (RMR) or basal metabolic rates (BMR). Recent empirical studies have revealed that relationships between personality traits and RMR or BMR vary among species, but also among sexes, reproductive state, and food abundance within a species. Most research showing correlations between personality and metabolism are based on phenotypic correlations, and thus do not permit evaluation of the relative importance of within-individual correlation between the traits being studied (reflecting phenotypic plasticity) vs. among-individual correlation (reflecting an actual syndrome). Furthermore, no study has investigated the hormonal mechanisms that may underlie these apparently context-dependent associations. The objectives of this study were to test the among- and within-individual correlations between a suite of metabolic, hormonal, and behavioural traits in wild-derived zebra finches. We repeatedly measured activity and feeding in a novel environment (first day, 4h), activity and feeding in a familiar environment (second day; 10h), nighttime BMR, daytime RMR, haematocrit, and stress-induced corticosterone levels. We used multivariate mixed models to partition phenotypic variance and covariances at the among-individual and within-individual levels. Our results reveal the importance of applying analytical methods developed within the quantitative-genetics framework to estimate among-individual correlations separately from phenotypic correlations and provides insight into understanding context-dependent relationships between metabolism and behaviour.

Supported by an Alfred Deakin Postdoctoral Research Fellowship to V. C.

REGULAR PRESENTATIONS (A-Z)

Predicting the thermal effects of climate change on developmental phenotypes, offspring viability and natal dispersal of green turtles

Catherine Cavallo[1], Tim Jessop[1] and Tim Dempster[1]

[1]Department of Zoology, University of Melbourne, Australia

During this century, rising temperatures due to climate change are expected to affect development of ectotherm phenotypes and hence performance and survival. To protect vulnerable species, it is imperative we understand the nature and extent of these effects. In endangered sea turtles, successful development and dispersal away from natal beaches are determinants of early life-cycle survival, and key to overall population dynamics. Using an individual-based integrative modelling framework, we modelled the effects of past, current and future sand and sea surface temperatures on offspring viability and dispersal ability in green sea turtles nesting on Melville Island in northern Australia. Results indicate complex and bidirectional developmental responses to the synergistic effects of rising sand and sea surface temperatures. Higher sand temperatures produced smaller, slower and weaker hatchlings, which may be subject to higher rates of predation and inshore retention than the current mean phenotype. Furthermore, a 20-40% reduction in offspring viability is predicted by 2070. Combined, these results imply losses to annual offspring recruitment from this beach, which may have consequences for population viability. More broadly, this study shows that climate warming has the potential to significantly affect ectotherm traits in ways that disrupt key life history stages. Integrative frameworks such as this will become increasingly valuable forecasting tools in the management of temperature-sensitive species.

Supported by Holsworth Research Endowment to C.C. and Mazda Foundation to T.J., in partnership with the Tiwi Land Council.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Prickly Heat

C.E. Cooper[1,2], C.J. Clemente[3], P.C. Withers[1,2], J.M. Barker[1]

[1]Department of Environment and Agriculture, Curtin University, Perth, Western Australia
[2]Zoology, School of Animal Biology, University of Western Australia, Perth, Western Australia
[3]School of Biological Sciences, University of Queensland (St. Lucia Campus), Brisbane, Australia

Echidnas supposedly have low heat tolerance, but they can inhabit regions where ambient temperatures routinely exceed their purported thermal limits. Consequently, we examined the activity, light exposure, ambient and body temperature of free-ranging echidnas during 6 days where maximum temperatures were above 32.5 °C. Echidnas were exclusively nocturnal, with activity periods of only 2 h 56 min ± 44 min. However, echidnas did not avoid exposure to high daytime ambient temperatures; on average they experienced temperatures above 34°C for 5h 12 min ± 25.8 min per day, and the highest ambient temperature experienced by an echidna was 41.6°C. Some echidnas also experienced significant periods of solar radiation while inactive; they did not move to avoid this. Ambient temperature exceeded echidna body temperature for 6 h 25 min ± 8.4 min per day, suggesting that echidnas must physiologically regulate body temperature, despite previous suggestions that they rely on behavioural thermoregulation.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Cold and thermally variable environments select for a higher metabolic rate in amphibians

Taryn S. Crispin[1] and Craig R. White[1]

[1]School of Biological Sciences, The University of Queensland, Australia

Metabolic rate (MR) is the rate of all biochemical processes that underlie an animals'energetic demand to sustain life. For ectotherms, much of the variation in MR is directly attributable to variation in body temperature, which influences the rates of energy turnover from the molecular level to the level of the whole animal. The metabolic cold adaptation (MCA) hypothesis predicts that, when compared at the same body temperature, ectotherms from cold environments should have higher metabolic rates than those from warm environments. To test this hypothesis, data for metabolic rate of amphibians (Lissamphibia: Anura, Caudata and Gymnophiona) were compiled from peer-reviewed literature, and related to environmental variables using a phylogenetically informed approach. We show that amphibian resting metabolic rate (RMR) is negatively correlated with mean annual temperature, and aerobic maximum metabolic rate (MMR) is positively correlated with the seasonality of temperature. Because amphibian RMR and MMR both positively correlated with colder and thermally variable climates, we argue that this finding supports the MCA hypothesis.

REGULAR PRESENTATIONS (A-Z)

Cardiac function of heterothermic bats

Shannon E. Currie, Gerhard Körtner, Fritz Geiser

Centre for Behavioural and Physiological Ecology, Zoology, University of New England, Armidale NSW 2351, Australia

Torpor use is essential for the survival of many small species of Australian bats. While previous studies have centred around thermal energetics of torpor, little attention has been paid to the maintenance of cardiac function at low body temperatures. It is known that heart rate (HR) decreases with metabolic rate (MR) during torpor, but the precise quantitative relationship and viability of HR as an estimate of energy expenditure has not been established for heterothermic bats. Furthermore, the majority of research on torpor has been on insectivorous species which hibernate and express multiday torpor, whereas detailed knowledge about daily heterothermy in the Pteropodidae ('fruit bats') is scant. We therefore aimed to quantify cardiac physiology of nectarivorous blossom bats (*Syconycteris australis; Sa*), daily heterotherms, and to compare this with a similar-sized hibernating insectivorous bat (*Nyctophilus gouldi; Ng*). We simultaneously measured HR, MR, and subcutaneous temperature (T_{sub}), at rest and during torpor at a range of ambient temperatures (T_a). At a T_a = 10-15°C HR of normothermic resting bats was 501 ± 31bpm (*Sa*; T_{sub}=33.1°C ; *n*=3), and 470 ± 76bpm (*Ng*; T_{sub}=34.5°C; *n*=6), whereas during torpor (T_{sub} ~16°C) HR fell to an average of 91 ± 30bpm (*Sa*; *n*=3), and 32± 13bpm (*Ng*; *n*=15). HR and MR were strongly correlated both at rest (r^2= 0.71 *Sa* and r^2= 0.64 *Ng*) and during torpor (r^2= 0.98 *Sa* and r^2= 0.84 *Ng*) with no overlap between the two states ($p<0.01$). Therefore HR may be used to reliably estimate MR. Although the thermal response of cardiac function of torpid *S. australis* was qualitatively similar to that of hibernating *N. gouldi*, the HR of the hibernator was only 35% of that in the daily heterotherm at the same T_{sub}. Moreover, the slope and the intercept of the relationship between HR and MR differed significantly. Our study provides the first quantitative data of HR as a function of temperature for a 'fruit bat' during torpor and demonstrates a clear difference of the relationship between HR and MR during daily heterothermy and hibernation at least in bats.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Changes in desmoglein-2 during pregnancy: understanding the evolution of viviparity in a marsupial (*Sminthopsis crassicaudata*; Dasyuridae)

Jessica S. Dudley[1], Bronwyn McAllan[2], Michael B. Thompson[3], Christopher Murphy[4]

[1]Faculty of Veterinary Science, The University of Sydney, NSW 2006, Australia
[2] Department of Physiology, School of Medical Sciences, The University of Sydney, NSW 2006, Australia
[3]School of Biological Sciences, University of Sydney, Camperdown, NSW 2006, Australia
[4]Department of Anatomy and Histology, University of Sydney, NSW 2006, Australia

Successful implantation of the blastocyst during pregnancy is dependent on structural and cellular changes occurring to the uterine epithelium and in particular to the plasma membrane of these cells. In rodents, desmosomes occur along the lateral plasma membrane of uterine epithelial cells where they are responsible for cell adhesion. Desmosome expression decreases during pregnancy in eutherians and some squamates, which presumably allows for remodelling of the uterine epithelium and invasion of the trophoblast during implantation. Marsupials have a unique reproductive biology, with a short implantation period and varying levels of invasive placentation and are therefore a crucial model to test the hypothesis that molecular changes are conserved among mammals for the remodelling of the uterus in preparation for implantation during pregnancy. We characterised the distribution of desmosomes the uterine epithelial cells of a marsupial, *Sminthopsis crassicaudata* and found that the number of desmosomes does not change during pregnancy. However, desmosomes redistribute towards the apical region of the lateral plasma membrane as pregnancy proceeds, which is similar to what occurs during pregnancy in eutherian mammals. The lower level of maternal investment in pregnancy and structure of foetal membranes in marsupials may require less remodelling of adhesion molecules and explain the lack of a significant change in desmosome numbers across pregnancy. The similarities in redistribution of desmosomes along the plasma membrane and changes to the morphology of the uterine epithelial cells suggest that similar plasma membrane changes occur across all lineages of amniote vertebrates. Therefore, this study supports the hypothesis that some mechanisms for the remodelling of the uterus in preparation for implantation are conserved among mammals during the early stages of pregnancy.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Physiological consequences of constant light exposure, and the role of melatonin in the Australian cricket, *Teleogryllus commodus*

Joanna Durrant[1], Ellie Michaelides[1], Thusita Rupasinghe[2], Dedreia Tull[2], Mark Green[1] and Therésa Jones[1]

[1]The Department of Zoology, The University of Melbourne, Australia
[2]Metabolomics Australia, Bio21, Melbourne

The presence of artificial light at night is one of Earth's least understood forms of environmental pollution. Increased exposure to light at night is correlated with a range of physiological processes including reduced immune function, and it is proposed that melatonin (a key biological hormone and powerful antioxidant) could be the underlying mechanism driving these negative impacts. This study examined the effect of constant light exposure on melatonin levels and three key indicators of immune function, using a model invertebrate species, the Australian black field cricket, *Teleogryllus commodus*. Firstly, crickets were reared through to adults under either a 12hr light:12hr dark cycle or under a constant 24hr light cycle. Immune function and melatonin level were assessed in individual adult crickets through the analysis of haemolymph, allowing the direct correlation of these parameters. Secondly, to assess whether exogenous melatonin had an immune enhancing effect, I experimentally manipulated melatonin levels through dietary supplementation of crickets in a constant light environment. Results show that constant light negatively affected both melatonin level and several components of immune function in crickets, although no direct correlation was found between endogenous melatonin levels and immune function. Dietary administration of melatonin had a positive effect on immune function (haemocyte number and lysozyme-like activity). In summary, immune function was modulated by both light exposure and melatonin, although a single pathway involving both these factors was not confirmed. This suggests these two mechanisms may be independent of one another, but that both light exposure and melatonin level contribute to overall immune function

REGULAR PRESENTATIONS (A-Z)

Monitoring faecal glucocorticoid metabolites in native Australian marsupials

Kerry V. Fanson[1,2] and Meredith J. Bashaw[2,3]

[1]Centre for Integrative Ecology, Deakin University, Australia
[2]Wildlife Reproductive Centre, Taronga Conservation Society, Australia
[3]Department of Psychology, Franklin and Marshall College, USA

Australia hosts a unique mammalian fauna, including the majority of the world's marsupial species. However, many of these native marsupials are threatened with extinction. Monitoring stress physiology provides insight into how animals perceive their environment, and therefore provides a useful tool for improving animal welfare, understanding behaviour, assisting conservation efforts, and increasing general knowledge about a species. The goal of this study was to validate assays for monitoring adrenal activity via faeces in 13 native Australian marsupial species. We compared the performance of five glucocorticoid (GC) assays to identify which were most effective for monitoring stress physiology in each species. We used a combination of adrenocorticotropic hormone (ACTH) administration and stressful events (e.g., transfer) to establish biological validation. At least one assay was biologically validated for each of the species tested. However, the assays varied in effectiveness, yielding different estimates of the magnitude and timing of the GC response for the same individual. In general, antibodies that targeted GC metabolites yielded stronger signals of adrenal activity than antibodies that targeted circulating GCs.

REGULAR PRESENTATIONS (A-Z)

Development of central chemoreceptors and respiratory rhythm in newborn fat-tailed dunnarts (*Marsupialia*: *Sminthopsis crassicaudata*)

Angelina Y. Fong[1], Shannon J. Simpson[2], Peter B. Frappell[3], William K. Milsom[4]

[1]Department of Physiology, University of Melbourne, Parkville, Vic, Australia
[2]Telethon Institute for Child Health Research and Respiratory Medicine, Princess Margaret Hospital, Subiaco, WA, Australia
[3]School of Zoology, University of Tasmania, Tasmania, Australia
[4]Department of Zoology, University of British Columbia, BC, Canada

The fat-tailed dunnart produces one of the smallest newborn mammals (~4mm long weighing 13-15mg) following a short gestation period of 13.5 days. The newborn dunnarts rely predominantly on cutaneous gas exchange to meet metabolic demands (Mortola *et al.*, 1999) with lung ventilation emerging several days later. We have previously shown that neonatal fat-tailed dunnarts display no hypercapnic ventilatory responses *in vivo* at any age (Simpson *et al.*, 2012), possibly due to reduced chemosensitivity of the relatively immature neonates. This current study aims to 1) determine whether the respiratory rhythm is present in the neonatal dunnart before its expression *in vivo*, and 2) whether respiratory rhythm could be stimulated by increased respiratory drive with hypercapnia. We utilised the isolated *in vitro* brainstem-spinal cord preparation to examine the emergenc of respiratory rhythm in postnatal day (P) 0, 5, 12 and 21 neonatal dunnarts. Interestingly, 100% of *in vitro* brainstem-spinal cord preparations from P0 dunnarts produced episodic bursting (fictive breathing) under basal conditions (5% CO_2, pH 7.4), even though respiratory rhythm is typically not expressed in the whole neonate at this age. Activation of central chemoreceptors with high CO_2 (8% CO_2, pH 7.2) increased burst frequency and stabilised the rhythm of *in vitro* P0 preparations. Central chemoreceptor activation increased the burst frequency of *in vitro* preparations taken from all ages in contrast to the *in vivo* observations (Simpson *et al.*, 2012). This difference between the two systems may reflect a strong inhibitory mechanism *in vivo* that overrides the high central neural drive seen *in vitro.*

Abstracts

REGULAR PRESENTATIONS (A-Z)

Modelling a lizard's life history and population responses to current and novel environments

Christopher R. Gatto[1], Tim S. Jessop[1] and Michael R. Kearney[1]

[1] Climatic and Metabolic Ecology Laboratory, Department of Zoology, University of Melbourne, Australia

Environmental variation, particularly thermal, has a major influence on ectotherm life histories and population performance. Activity time, a key component determining animal energy budgets, is a major mechanism by which temperature can affect ectotherm life histories. Changes in ambient temperatures alter thermoregulatory ability thereby altering time spent foraging and defending territories, which can alter growth and reproductive investment. Here, I first investigated relationships between environmental and mechanistically derived parameters to explain range-wide phenotypic variation in key life history traits of the bearded dragon (*Pogona barbata*). Temperature and activity both explained significant body size variation in *P. barbata* but neither were correlated with reproductive output. Instead, body size was found to be the best correlate of female reproductive traits. Next, using an energy budget model integrated with a biophysical model I assessed how three common threatening environmental processes- climate warming, shade restriction and altered mortality rates- influence on lizard activity time and a population response metric (R_o) across *P. barbata's* geographic range. This analysis predicted that shade restriction has a larger effect on ectotherm activity than climate warming but alterations to mortality rates have the largest impact on population performance. The response of populations to climate warming and shade restriction under *ad libitum* food suggested that maintaining high quality habitat is a potential management strategy for mitigating the effects of climate change. Climate warming induced activity restriction is therefore unlikely to generally explanation for current or future ectotherm extinctions with synergistic effects of multiple threatening processes likely to drive population constrictions.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Aestivation in mammals

Fritz Geiser, Artiom Bondarenco and Clare Stawski

Centre for Behavioural and Physiological Ecology, Zoology, University of New England, Armidale NSW 2351, Australia, fgeiser@une.edu.au

Mammalian torpor is widely used in winter whereas many species are strictly homeothermic in summer. However, data on torpor throughout the year including torpor in summer (aestivation) are now available for a number of taxa. Generally it is assumed that variables of torpor expressed in summer largely reflect the higher temperatures experienced, with only minor or no seasonal physiological adjustments. Contrary to this assumption, the data show that heterothermic mammals can use several different seasonal approaches. Some species, such as marsupial dunnarts (*Sminthopsis* spp.) under identical experimental conditions, express longer and deeper torpor in winter than in summer. Australian long-eared bats (*Nyctophilus* spp.) show no significant seasonal changes in the minimum metabolic rate during torpor and, although mean torpor bout duration in *N. bifax* in the wild was ~8-fold longer in winter than in summer, the thermal response of torpor bouts was described by a single regression line for both seasons, suggesting that seasonal changes in torpor bout duration are largely caused by temperature. In subtropical blossom bats (*Syconycteris australis*) on the other hand, torpor bout duration in summer was ~35% longer and the minimum metabolic rate was only ~60% of that in winter under the same thermal conditions, demonstrating a physiological adjustment. Similarly, in free-ranging desert freetail bats (*Mormopterus* sp.), torpor bout duration at the same ambient temperature was 40% longer in summer than in winter. Our comparison shows that, in addition to seasonal changes in torpor patterns due to temperature, mammalian aestivation can involve substantial physiological acclimatisation and that, in contrast to what is widely believed, torpor in several species is more pronounced in summer than in winter.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Adrenocortical stress responses influence an invasive vertebrate's fitness in an extreme environment.

Tim S. Jessop[1], Mike Letnic[2], Jonathan K. Webb[3] and Tim Dempster[1]

[1] Department of Zoology, University of Melbourne, Victoria 3010, Australia.
[2] Australian Wetlands, Rivers and Landscapes Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2052, Australia.
[3] School of the Environment, University of Technology Sydney, NSW 2007, Australia.

Continued range expansion into physiologically challenging environments requires invasive species to maintain adaptive phenotypic performance. The adrenocortical stress response, governed in part by glucocorticoid hormones, influences physiological and behavioural responses of vertebrates to environmental stressors. However, the adaptive role of this response in invasive populations that are expanding into extreme environments remains elusive. We experimentally manipulated the adrenocortical stress response to investigate its effect on phenotypic performance and fitness of invasive cane toads (*Rhinella marina*) at their range-front in the Tanami Desert, Australia. Here, toads are vulnerable to over-heating and dehydration during the annual hot-dry season and display elevated plasma corticosterone indicative of severe environmental stress. By comparing unmanipulated controls with adrenocortical stress response manipulations that increased acute physiological stress responsiveness, we found that control toads had significantly reduced daily evaporative water loss and higher survival relative to more acute stress phenotypes at the range front. The adrenocortical stress response hence appears essential in facilitating complex phenotypic performance and setting fitness trajectories of invasive species during range expansion.

REGULAR PRESENTATIONS (A-Z)

Can climate warming explain recent lizard extinctions?

Michael R. Kearney

Department of Zoology, The University of Melbourne, Victoria 3010, Australia

Correlative analyses predict that climate warming will cause widespread extinction, but the nature and generality of the underlying mechanisms is unclear. Warming-induced activity restriction has been proposed as a general explanatory mechanism for historical extinction in lizards. Here I test this hypothesis using globally-applied biophysical calculations of the effects of warming and shade reduction on potential activity. These calculations show that the activity restriction model cannot mechanistically explain recent lizard extinctions through warming alone. Energy budget analyses show that that warming could cause population declines even under increased activity potential, depending on the life history. However, loss of shade and lower rates of increase in viviparous species can provide alternative explanations for the observed patterns in lizard extinctions. The direct effects of climate warming may be negative in many circumstances but the key challenge is to understand how they will interact with other global change drivers, especially changes in shade.

REGULAR PRESENTATIONS (A-Z)

Sex and survival: The impact of climate change and skewed sex ratios on sea turtle reproduction

Ella Kelly[1], Tim Dempster[1], Michael Kearney[1] and Tim Jessop[1]

[1]Departement of Zoology, University of Melbourne, Australia

Predicted temperature rises over the coming century will drastically skew the sex ratios of reptiles with temperature-dependent sex determination. The severity of the impact should differ among species due to life history variation. Sea turtles will likely experience variation across populations depending on proportional increase of female hatchlings and the species' demographic response. The identification of sex ratio thresholds – beyond which populations become unviable – is imperative for successful mitigation strategies. Using correlative and mechanistic predictive modelling techniques, I evaluated the impact of climate change at a local scale on the hatchling sex ratio of olive ridley sea turtles in northern Australia. At a global scale, I identified sex ratio thresholds across a range of species and population abundances using population viability analyses. The results forecast significant rises in local sand temperatures over the coming century, with complete feminisation of olive ridley hatchlings predicted by 2070 under an extreme emission scenario. Population viability analyses indicated that when sand temperatures rise to levels where 80-90% female hatchlings are produced, a dramatic increase in extinction probability will ensue, with this risk intensifying for populations with small abundances and different species. This study is the first to identify species-specific sex ratio thresholds beyond which the viability of populations is severely impacted and will play a vital role in prioritising global management strategies.

Supported by MAZDA Foundation to T. J. and Holsworth Wildlife Research Endowment to E. K.

REGULAR PRESENTATIONS (A-Z)

Uterine epithelial cell changes during pregnancy in a marsupial (*Sminthopsis crassicaudata*; Dasyuridae)

Melanie K. Laird[1], Michael B. Thompson[1], Christopher R. Murphy[2] and Bronwyn M. McAllan[2]

[1]School of Biological Sciences, University of Sydney, Sydney, NSW 2006, Australia
[2]School of Medical Sciences and Bosch Institute, University of Sydney, Sydney, NSW 2006, Australia

Early pregnancy in eutherian mammals and viviparous (live-bearing) squamate reptiles involves preparation for attachment of the embryo to the surface of the uterus (implantation). Preparation requires substantial remodeling of the epithelial cells lining the uterus, termed the plasma membrane transformation. The common beginning to pregnancy in these diverse viviparous groups suggests the plasma membrane transformation may play a fundamental role in the evolution of amniote viviparity. Recent molecular evidence suggests that the molecular changes, particularly junctional molecules, which underpin the plasma membrane transformation in early pregnancy, differ between viviparous lineages. Hence, uterine changes may have evolved via flexible molecular recruitment. Marsupials, the third viviparous amniote group, may represent an independent lineage of mammalian viviparity, and are thus ideally placed to test theories of amniote viviparity. Here we present the first detailed study of the plasma membrane transformation in a marsupial. We combine electron microscopy and immunohistochemistry to describe morphological and molecular features of uterine epithelial cells during pregnancy in the fat-tailed dunnart (*Sminthopsis crassicaudata*; Dasyuridae). Uterine cell morphology changes dramatically during pregnancy in *S. crassicaudata*, as cells flatten and develop unusual apical projections. Interestingly, timing of expression of occludin, a lateral junctional molecule, in uterine epithelial cells occurs earlier than expected in *S. crassicaudata*, which suggests a different role for occludin during pregnancy in this species, and supports the flexible molecular recruitment hypothesis. Hence the occurrence of a plasma membrane transformation in a marsupial suggests this phenomenon is a ubiquitous and important feature of amniote pregnancy, which likely evolved via diverse mechanisms.

REGULAR PRESENTATIONS (A-Z)

Sequencing of endo-β-1,4-glucanase isozymes in the soldier crab, *Mictyris platycheles,* the grapsid crab, *Paragrapsus laevis* and the gecarcinid land crab, *Gecarcoidea natalis*; implications for the origin and potential form and function of cellulases in arthropods.

Michael Gray and Stuart M Linton

School of Life and Environmental Sciences, Deakin University, Waurn Ponds, Victoria

Arthropods such as higher termites, wood eating cockroaches and herbivorous gecarcinid land crabs digest cellulose and hemicellulose using endogenously produced cellulase enzymes. The evolutionary origin of these enzymes is unclear; did the arthropods evolve specific cellulases or do they use a general ancestral enzyme which hydrolyses β-1,4-glycosidic bonds? To answer this question, cDNA for the gene encoding for a glycosyl hydrolase family 9 (GHF9) enzyme ("classic arthropod cellulase") was sequenced from crustacean species that represent a gradient colonising land and adopting a terrestrial plant diet. The species ranged from the amphibious deposit feeding soldier crab, *Mictyris platycheles,* a detritivore, *Paragrapsus laevis*, and an herbivorous gecarcinid land crab, *Gecarcoidea natalis.* The catalytic and binding residues within the putative amino acids of the crustacean sequences matched those within the cellulases from termites and wood eating cockroaches. Since *M. platycheles* does not consume plant material; its diet consists mainly of protozans, bacteria and single cell algae, the GHF9 enzyme cannot be a cellulase. It is therefore suggested that it may hydrolyse cellulose-like polymers within the cell walls of these organisms. The commonality of the important amino acid residues within GHF9 enzymes between aquatic and terrestrial species suggests that this same enzyme has been used with little change to degrade plant cellulose in terrestrial arthropod species. Thus the cellulase enzymes of terrestrial arthropods may not be the result of specific evolution but rather the re-purposing of an existing enzyme. Any adaptation may be in the form of gene duplication to increase the amount and hence the activity of the enzyme.

REGULAR PRESENTATIONS (A-Z)

Thyroid hormone regulates metabolism, muscle function and cardiac performance during cold acclimation in zebrafish (D*anio rerio*)

Alexander Little[1] and Frank Seebacher[1]

[1]School of Biological Sciences, The University of Sydney, Australia

Despite the importance of thermal acclimation for physiology, ecology and conservation, the overarching mechanisms coordinating this process remain unknown. Thyroid hormone (TH) could be such a regulatory mechanism, because it mediates thermal responses in mammals, and its effects are similar across vertebrates. It is unknown, however, whether its role in thermal response is derived in mammals, or whether it also exists in earlier vertebrates. We hypothesized that TH regulates locomotor performance during cold acclimation in ectotherms, and that changes in metabolism, muscle function and cardiac performance underlie this process. We induced hypothyroidism pharmacologically in zebrafish (*Danio rerio*) during 3 weeks acclimation to 18˚C or 28˚C. We measured an array of whole animal and tissue specific performance parameters. We verified the role of TH by supplementing hypothyroid fish with TH metabolites. TH regulated swim performance during cold acclimation, but not warm acclimation. TH regulated the transcription of important metabolic genes differentially in animals with different thermal histories. It also increased muscle performance, possibly by enhancing the transcription and activity of SERCA, a main regulator of calcium handling. Spectral analysis showed that TH increased sympathetic tone on the heart during rest, and enhanced maximum heart rate during exercise. This is the first time that an environmental factor as pervasive as temperature has been shown to determine not just the magnitude of hormone-mediated response, but also the direction. We suggest ancestral function(s) of TH predisposed its central regulatory role in the evolution endothermy, and that toxicities of TH-disrupting pollutants may change with temperature.

Supported by ARC Grant to F. S.

REGULAR PRESENTATIONS (A-Z)

Using metabolomics to differentiate modes of action of similarly acting chemicals

Sara Long[1], Dedreia Tull[2], David De Souza[2], Katy Jeppe[1], Vincent Pettigrove[1], Malcolm McConville[2] and Ary Hoffmann[1]

[1] Centre for Aquatic Pollution Identification and Management (CAPIM), Bio 21 Institute, The University of Melbourne, Parkville, Victoria 3010, Australia
[2] Metabolomics Australia, Bio 21 Institute, The University of Melbourne, Parkville, Victoria 3010, Australia

One of the challenges for biomonitoring programs is to develop sensitive, cost effective and chemical- or class-specific methods to detect contaminant exposure among resident biota. This talk will describe work we have carried out to develop novel methods for detecting pollution effects in Australian organisms. Heavy metals are common contaminants detected in waterways in Australia and worldwide. Copper and zinc are toxic to aquatic invertebrates at high concentrations. Environmental metabolomics is an emerging area of research which draws upon experience of medical research and complements the traditional approaches to understanding the interactions between organisms and their environment. The aim of the work was to identify small metabolite biomarkers in the aquatic invertebrate *Chironomus tepperi* that were specific to metal exposure, which may have the potential to be used in biomonitoring programs. A number of metabolites were identified that were significantly different between treatments. Two metabolites in particular were significantly lower in abundance following exposure to copper and significantly higher in abundance following exposure to zinc compared to controls. These metabolites show promise for use as metal-specific biomarkers in biomonitoring programs. Further work has focused on understanding the physiological significance of these metabolites which will extend our understanding of the mechanisms of toxicity between these common aquatic contaminants which will have implications for their use in detecting exposure and effects of metals in a range of taxa.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Exploring constraints on insect metabolism using Dynamic Energy Budget (DEB) theory

James Maino[1], S.A.L.M Kooijman[2] and Michael Kearney[1]

[1]Department of Zoology The University of Melbourne
[2]Vrije Universiteit Amsterdam

Design constraints imposed by increasing size cause metabolic rate in animals to increase more slowly than mass. This ubiquitous biological phenomenon is referred to as metabolic scaling. Mechanistic explanations for interspecific metabolic scaling do not apply for ontogenetic size changes within a species implying different mechanisms for scaling phenomena. Here we show that the Dynamic Energy Budget theory approach of compartmentalizing biomass into reserve and structural components provides a unified framework for understanding ontogenetic and inter-specific metabolic scaling. We formulate the theory for the insects and show that it can account for ontogenetic metabolic scaling during the embryonic and larval phases, as well as the U-shaped respiration curve during pupation. After correcting for the predicted ontogenetic scaling effects, which we show to follow universal curves, the scaling of respiration between species is approximated by a ¾ power law, supporting our theoretical predictions and past empirical studies on insect metabolic scaling. The ability to explain ontogenetic and interspecific metabolic scaling effects under one consistent framework suggests that the partitioning of biomass into reserve and structure is a necessary foundation to a general metabolic theory.

REGULAR PRESENTATIONS (A-Z)

Metabolic scope and swim performance in zebrafish (*Danio rerio*)

Kate McShea

Evolutionary and Ecological Physiology Laboratory, School of Biological Science, University of Sydney, Australia.

According to the World Health Organisation worldwide obesity has more than doubled since 1980, with over 200 million men and 300 million women considered obese in 2008. Obesity is known to affect physiological function and performance. This study tested the hypothesis that there will be a decrease in physiological performance between obese and lean zebrafish phenotypes and that this will be reversed once the obese phenotype become lean again. There was an increase in resting metabolic rate and a decrease in maximum metabolic rate for the obese phenotype. This was reversed once the obese phenotype became lean again. Swimming performance was significantly reduced in the obese phenotype compared to the lean, and swimming performance did not recover after the obese phenotype became lean again. The increased resting metabolic rate and reduced maximum metabolic rate indicates a physiological cost of obesity. A reduction in swimming performance in the obese zebrafish is potentially linked to a decrease in muscle function. In tackling obesity and the associated affect on physiological function and performance, weight loss can reverse the changes in resting and maximum metabolic rate but the reduction in swimming performance is not reversed and additional training may be required.

REGULAR PRESENTATIONS (A-Z)

Body temperature and activity of free-living aardvark facing climate change

Benjamin Rey[1], Robyn Hetem[1], Andrea Fuller[1], Anna Haw[1], Leith Meyer[2, 1], and Duncan Mitchell[1,3]

[1]Brain Function Research Group, School of Physiology, University of the Witwatersrand, Johannesburg, South Africa. [2]Department of Paraclinical Science, Faculty of Veterinary Science, University of Pretoria, Pretoria, South Africa. [3] School of Anatomy Physiology and Human Biology, University of Western Australia, Perth, Australia.

Aardvark (*Orycteropus afer*) are elusive burrowing mammals, which predominantly are nocturnal [1], and distributed widely throughout Africa except for the deserts. Their future may be threatened by climate change via effects of increasing heat and aridity on themselves and their prey; they eat only tunnelling termites and ants. Because of their longevity (20 years), their survival will depend on phenotypic plasticity. We predict that they will have to expand their foraging time, potentially having to adopt more-diurnal activity, and therefore being more exposed to heat. To measure their current thermoregulatory competence, and foraging activity, we captured seven adult aardvark at Tswalu Private Nature Reserve in the Kalahari Desert, implanted internal thermometer and motion biologgers and tracking telemeters while the aardvark were under ketamine-medetomidine-midazolam and isoflurane anaesthesia, and released them at their capture sites. The aardvark resumed normal foraging and burrowing within hours. We observed the aardvark occasionally, but mostly they functioned free of human presence. Only one of the seven survived the planned full year of the study; Tswalu experienced a particularly dry and hot summer, perhaps prescient of consequences of climate change. We recovered biologgers from the remains of some of those which did not survive, and explanted them from the survivor. The temperature records showed good homeothermy initially but heterothermy increased progressively through the summer (amplitude of daily body temperature rhythm increased from 1.9 ± 0.1°C to 3.2 ± 1.2°C, n = 3 aardvark), with declining troughs in the nychthemeral rhythm of body temperature before death (minimum daily body temperature decreased from 35.4 ± 0.1°C to 32.2 ± 3.9°C, n = 3 aardvark), indicating probable starvation. The activity loggers indicated more diurnal foraging activity than had been anticipated. Our results do not bode well for the future of aardvark facing climate change.

Supported by the South African National Research Foundation and the Tswalu Foundation

REGULAR PRESENTATIONS (A-Z)

Aquaculture physiology in changing climates

Andrea J. Morash[1], Sarah J. Andrewartha[2], Nicholas G. Elliott[2] and Peter B. Frappell[1]

[1]University of Tasmania, Hobart, Australia
[2]Commonwealth Scientific and Industrial Research Organization, Hobart, Australia

Suboptimal animal health is often associated with culturing conditions, and this is predicted to become more prevalent and unpredictable with changing climate. Typically, health is monitored through growth rate and survival which is usually done retrospectively using invasive sampling techniques that do not give any indication of the animal's physiology. The development of in-situ biosensors has now enabled us to collect real-time data from intensively reared aquaculture species (abalone, oysters, salmon) which has helped fill the gaps which exist in our knowledge of their physiology. In particular, the effects and interactions of environmental (elevated water temperature and decreased oxygen) and production stressors (diet, handling, and air exposure) on their physiology have been relatively unexplored. We use novel biosensors to measure real-time physiological parameters (heart rate, body temperature, and movement) in conjunction with environmental data to determine the response of these animals to farming and climate stresses to guide optimal physiological growth conditions for the animals.

REGULAR PRESENTATIONS (A-Z)

Corticosterone as a biomarker of stress in amphibians

Edward J. Narayan[1]* and Jean-Marc Hero[1]

[1]Environmental Futures Research Institute, School of Environment, Griffith University, QLD 4222, Australia. Email: e.narayan@ga.griffith.edu.au; m.hero@ga.griffith.edu.au

Corticosterone is the main glucocorticoid hormone that mediates the physiological stress response of amphibians to short-term and long-term changes in their environment. This physiological endocrine response also alters important behaviour such as locomotion and breeding. Manual restraint mimics the acute stress response to naturalistic stressors (such as predators, thermal variation and disease) that can be quantified at individual and population levels. Comparisons of the magnitudes and patterns of acute stress responses between individuals, sexes and populations can increase understanding of the role of corticosterone in amphibian ecology. Using model species in Australia, Fiji and India, we have been able to show that baseline and short-term corticosterone responses are expressed differently with respect to reproductive state, body condition, predator exposure and the intensity of experimental stressors. We discuss the ecological significance of corticosterone in relation to the Cort-fitness and Cort-adaptation theories. In conclusion, the sensitivity of corticosterone as a stress biomarker is dependent on the harshness of the biological and environmental stressors and the physiological limitations of the stress endocrine system (hypothamalo-pituitary interrenal axis).

Supported by Griffith University Research Grant and the Australian Academy of Science (Australia-India) ECR Fellowship awarded to E.J.N.

REGULAR PRESENTATIONS (A-Z)

Can behavioural flexibility mitigate the effects of climate change in desert lizards? Part 1: thermoregulation

Elia Pirtle[1], Jenny Todd[2], Fran C. Sandmeier[2], C. Richard Tracy[2], Christopher R. Tracy[3]

[1]Department of Zoology, University of Melbourne
[2]University of Nevada Reno, USA
[3]University of Fullerton California, USA

Others have predicted that climate change will cause mass extinctions of lizards because hotter thermal environments will preclude lizards from thermoregulating to optimal body temperatures. Several lizard species are able to adjust their preferred body temperatures or their behaviour in the different thermal conditions of warm and cool activity seasons, and that ability can mitigate adverse effects of climate change. We studied the common chuckwalla (*Saromalus ater*) to assess its flexibility to change body temperatures in the cool and hot seasons at two study sites: a cooler high-elevation site (Granite Mts, CA) and a hot low-elevation site (Amboy Crator). In a laboratory thermal gradient, chuckwallas selected the same body-temperature range (34-39°C, corresponding to temperatures at which lizards can sprint maximally) regardless of season or site, and that Tb range is that previously observed in 1970. We also looked for flexibility in activity patterns across season and elevation. Lizards in the field emerged from their rock shelters in spring when their preferred body temperatures were possible. In the high-elevation site, lizards were active in springtime during only 70% of the hours when preferred body temperatures were possible, and on 98% of activity-season days, while lizards at Amboy (where food was scare due to a drought) were active only 20% of the hours when preferred temperatures were possible, and on only 54% of activity-season days. These results suggest considerable flexibility for chuckwallas to adjust to predicted change in thermal environments due to global climate change.

REGULAR PRESENTATIONS (A-Z)

Lamprey "transthyretin" – is it transthyretin or 5-hydroxyisourate hydrolase?

Samantha J. Richardson[1], Simone De Luca[1], Damian D'Souza[1], Kasai Kentaro[2], Brett Cromer[1], Vivian Cody[3] and Kiyoshi Yamauchi[2].

[1]School of Medical Sciences, RMIT University, Australia. [2]Department of Biological Science, Shizuoka University, Japan. [3]Hauptman-Woodward Medical Research Institute, USA.

Thyroid hormones are involved in the regulation of growth and development, including vertebrate metamorphosis (anurans, salamanders) and smolting in salmonids. Vertebrate metamorphosis and smolting are characterised by an increase in thyroid hormones in the blood. Transthyretin (TTR) is a plasma protein that binds and distributes thyroid hormones in the blood and cerebrospinal fluid. We have previously shown that TTR is up-regulated around the time of metamorphosis in amphibians and smolting in salmon. The amino acid sequence of TTR has been very highly conserved during evolution. We believe the TTR gene arose as a duplication of the TTR-Like Protein gene, which is present in all kingdoms. Our previous work revealed that in (at least) some species, the TTR-Like Protein does not bind thyroid hormones, but is a 5-hydroxyisourate hydrolase (5-HIUase), involved in uric acid metabolism. Lampreys are one of the most primitive extant vertebrates. They undergo metamorphosis, which, in contrast to that in all other vertebrates, is driven by a *decrease* in thyroid hormones in the blood. Lamprey (*Lethenteron reissneri*) "TTR" cDNA was cloned, sequenced and its amino acid sequence was determined. This was aligned with amino acid sequences from known TTRs and known TTR-Like Proteins. Lamprey "TTR" had 6 of the 13 key residues required for thyroid hormone binding and 2 of the 5 key residues required for 5-HUIase activity. Furthermore, the protein lacked the "YRGS" signature of TTR-Like Proteins. Homology modelling against either a known TTR structure or a known TTR-Like Protein structure was unable to clarify if lamprey "TTR" was more likely to bind thyroid hormones or 5-HIU. Recombinant lamprey "TTR" has been purified. Assays for the determination of function and structure are underway. Initial results indicate binding of T3.

REGULAR PRESENTATIONS (A-Z)

Physiological consequences of selecting shade and becoming inactive: how much do kangaroos save by thermoregulating?

Jessica Roberts[1], Natalie Briscoe[1], Paul Mathewson[2], Warren Porter[2], Graeme Coulson[1], Adam Munn[3], John Speakman[4], Michael Kearney[1]

[1]Department of Zoology, The University of Melbourne
[2]Department of Zoology, The University of Wisconsin
[3]School of Biological Sciences, The University of Wollongong
[4]School of Biological Sciences, The University of Aberdeen
[5]School of Anatomy, Physiology, and Human Biology, The University of Western Australia

Endotherms in hot, dry environments manage tight energy and water budgets but can employ behavioural adjustments to buffer themselves against weather fluctuations. We developed and applied a process-based mechanistic model of energy and mass balance for the western grey kangaroo (*Macropus fuliginosus*), a large herbivore endemic to semi-arid environments of Australia. After successfully validating the model against data from the literature and from the field, we quantified the energetic and hydric benefits gained from seeking shade and changing activity states, whilst allowing physiological thermoregulation. By quantifying the benefits kangaroos gain from seeking shade versus changing activity, we demonstrate that changes in activity, and associated lower heat production, had a greater impact on minimizing hourly water loss rates than microclimate selection. By predicting hourly energetic and water costs for active and inactive kangaroos across a year, we show how nocturnal / crepuscular activity may reduce water costs during hot months and may reduce energy expenditure during cold months (assuming activity-thermoregulatory heat substitution). This mechanistic approach grants insight into how climate conditions currently constrain a species' activity and will enable subsequent studies to quantify the extent to which an endotherm can buffer itself against extreme weather.

REGULAR PRESENTATIONS (A-Z)

Sex and age-related differences of torpor use by free-ranging antechinus

A. Daniella Rojas, Gerhard Körtner and Fritz Geiser

Centre for Behavioural & Physiological Ecology, Zoology, University of New England, Armidale NSW, Australia

Antechinus are small, insectivorous, heterothermic marsupials that use torpor in autumn/early winter and reproduce once a year in late winter/early spring. Males die after mating, most females produce only a single litter, but some survive a second winter and produce another litter. Little is known about how females are able do so, especially considering the high energetic costs associated with antechinus reproduction (i.e. large litter size and long lactation). Captive antechinus have been shown to employ daily torpor. This strategy is used mainly by small individuals for winter survival and also for energy conservation during other energetically demanding periods such as development and reproduction. We aimed to provide the first data on thermal biology of free-ranging antechinus, and in particular, to determine whether 2nd year females differ from 1st year females in their use of daily torpor. Using temperature telemetry, body temperature (T_b) of males and 1st year and 2nd year females was measured in the wild during autumn to early winter. Torpor use differed between the sexes; males rarely employed torpor (6.3 ± 10.9% of days observed) and exhibited only shallow (minimum T_b 28.2°C) and short (<2h) bouts of torpor. In contrast, females employed frequent, longer and deeper bouts than males, and importantly, in 2nd year females torpor was more pronounced than in 1st year females. Heavier 2nd year females (24.9 ± 1.3g) employed frequent (93 ± 2.6%) and long (5.5 ± 3.3h) torpor bouts, whereas in the lighter 1st year females (20.7 ± 0.5g) torpor was less frequent (49.3 ± 17.7%) and short (3.2 ± 2.2h). Our study provides evidence of the effect of age on daily torpor patterns in antechinus, suggesting that torpor is used to not only cope with immediate energy demands, but also to deal with previous energetic history and to increase reproductive success.

REGULAR PRESENTATIONS (A-Z)

Capacity and regulation of thermal acclimation vary between generations in the short-lived mosquitofish (*Gambusia holbrooki*)

Frank Seebacher, Julian Beaman and Alexander G Little

School of Biological Sciences A08, University of Sydney, NSW 2006, Australia

Environmental variability can influence population persistence. It is therefore important to understand whether and how animals can compensate for environmental variability, and thereby increase resilience of natural populations. Evolutionary theory predicts that in fluctuating environments selection should favour developmental modifiers that reduce phenotypic expression of genetic variation. The expected result is that phenotypes are buffered from environmental variation across generations. We tested this prediction in the mosquitofish (*Gambusia holbrooki*). We hypothesised that the spring generation (cool environment) would acclimate by increasing the concentration of regulatory transcription factor mRNA and activities of rate-limiting enzymes (hierarchical regulation) to compensate for the negative thermodynamic effects of lower temperatures on metabolic and locomotor performance. In contrast, the summer-born generation (warm environment) would show less capacity for acclimation and hierarchical regulation. We show that fish from both generations acclimated, but that there were significant differences in the phenotypic consequences of acclimation. The overall result was that sprint performance, metabolic scope, and the activities of cyctochrome c oxidase and lactate dehydrogenase were buffered from environmental change, and did not differ between spring and summer fish at their natural water temperatures of 15^{o}C and 25^{o}C, respectively. We used metabolic control analysis to show that regulation of metabolic scope and locomotor performance was primarily hierarchical in spring fish, but less so in summer fish. We show that the interaction between developmental and reversible acclimation can render physiological performance of a natural population independent from climate variation.

REGULAR PRESENTATIONS (A-Z)

Scaling of heat production by thermogenic flowers: Limits to floral size and maximum rate of respiration

Roger S. Seymour

Earth and Environmental Sciences, University of Adelaide, Adelaide, South Australia 5005, Australia.

The flowers of certain plants produce significant heat by elevated mitochondrial respiration during blooming. There is high diversity among the 14 families of seed plants, including inflorescences (e.g. aroids with many florets on a spadix stalk), cones (e.g. cycads) and true flowers (e.g. lotus, magnolias). This study analyses maximum respiration rate ($\dot{M}_{CO_2}$, µmol s^{-1}) in 23 species of thermogenic plants ranging in mass (M, g) between 1.8 – 600 g. The allometric equation for respiration is $\dot{M}_{CO_2} = 0.48\ M^{0.58}$ in 15 aroid species. Thermal conductance (C, mW °C^{-1}) for spadices scales according to $C = 18.5\ M^{0.73}$. Mass does not significantly affect the difference between floral and air temperature. Aroids with exposed spadices and high surface area have high thermal conductance, consistent with the need to lose heat while vaporizing attractive scents. Conversely, true flowers have significantly lower heat production and thermal conductance, because closed petals retain heat that benefits resident insects. The florets on aroid spadices, either within a floral chamber or spathe, have intermediate thermal conductance, consistent with mixed roles. Mass-specific rates of respiration are variable between species, but reach 900 nmol s^{-1} g^{-1} in aroid male florets, exceeding rates of all other plants and all animals, except flying bees. Maximum mass-specific respiration appears to be limited by oxygen delivery through individual cells. Experiments relating respiration rate to P_{O_2} show that the diffusive pathway becomes limiting in highly thermogenic aroid species. The study also includes measurements of P_{O_2} within thermogenic tissues with O_2-sensitive fibre optics, and reveals that the diffusion pathway is complicated. Reducing mass-specific respiration may be one selective influence on the evolution of large size of thermogenic flowers.

Supported by the Australian Research Council.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Incubation temperature, morphology and performance of loggerhead (*Caretta caretta*) turtle hatchlings.

Elizabeth L. Sim[1], David T. Booth[1] and Colin J. Limpus[2]

[1]School of Biological Sciences, The University of Queensland, Brisbane
[2]Aquatic Threatened Species, Department of Environment and Heritage Protection, Brisbane

Marine turtle populations are vulnerable to climate change in all stages of their lifecycle, but particularly during egg incubation, as there is a narrow range of temperatures at which eggs can develop. Additionally incubation temperature can affect a range of hatchling attributes including sex, emergence success, morphology and locomotor performance. Hatchlings often experience high predation in the first few hours of their life, and increased size or locomotory ability may improve their chances of survival. This study investigates the effect of incubation temperature on the emergence, morphology and locomotor performance of loggerhead (*Caretta caretta*) hatchlings at the Mon Repos rookery in Queensland. Between 2010 and 2013 we monitored the temperature of *in situ* nests, and used this data to calculate a mean 3 day maximum temperature (T3dm) for each nest. We calculated the emergence success for each nest, then measured the mass, size, scute pattern of the hatchlings that emerged, and subjected the hatchlings to experiments to measure their self-righting ability, crawling speed and swimming ability. Nests with a T3dm greater than 34°C experienced a lower emergence success than those with a T3dm lower than 34°C ($F_{1,12}$ = 12.88, p = 0.003), and also produced smaller hatchlings ($F_{1,6}$ = 10.65, p = 0.01). Hatchlings from nests with a T3dm greater than 34°C were also poorer crawlers ($F_{1,7}$ = 6.18, p = 0.04) and swimmers ($F_{1,589}$ = 2.23, p = 0.03) than those from nests with a T3dm below 34°C. This suggests that even non-lethal increases in global temperatures may detrimentally affect the survival of marine turtle hatchlings.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Individual variation in selective brain cooling capacities may buffer the effects of climate change

W. Maartin Strauss[1,2], Robyn S. Hetem[1], Duncan Mitchell[1], Shane Maloney[1,3], Leith Meyer[1,4] and Andrea Fuller[1]

[1]Brain Function Research Group, School of Physiology, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa
[2]Department of Environmental Sciences, University of South Africa, Roodepoort, South Africa
[3]School of Anatomy, Physiology and Human Biology, University of Western Australia, Perth, Australia
[4]Department Paraclinical Science, Faculty of Veterinary Science, Onderstepoort, University of Pretoria, South Africa

In those species that can implement it, selective brain cooling attenuates the drive for evaporative heat loss, potentially providing an important mechanism for conserving body water. Selective brain cooling is present in species with a carotid rete, such as artiodactyls, and absent in species without a carotid rete, including perissodactyls, primates and most small mammals. This distinction possibly provided a selective advantage to past and present climate change in artiodactyls. To determine if selective brain cooling differs between free-living artiodactyls with varying water dependencies, we used implantable temperature-sensitive tags to measure brain and carotid arterial blood temperatures at 5-min intervals in four oryx (*Oryx gazella gazella*, a water-independent species), five red hartebeest (*Alcelaphus buselaphus*, a species of intermediate water dependency) and six blue wildebeest (*Connochaetes taurinus*, a water-dependent species). Using generalised linear mixed-effect models we investigated the effects that carotid arterial blood temperature, brain temperature, black globe temperature, and species had on attributes of selective brain cooling. We found that mean daily carotid and brain temperatures had significant opposing effects on both the mean daily magnitude of selective brain cooling (carotid: $z=7.94$, $P<0.001$, brain: $z=-7.32$, $P<0.001$) and the mean daily proportion of time that animals employed selective brain cooling (carotid: $z=14.09$, $P<0.001$, brain: $z=-11.75$, $P<0.001$). Maximum magnitude of daily selective brain cooling increased with maximum daily carotid blood temperature ($z=10.76$, $P<0.001$), and decreased with increasing maximum daily brain temperature ($z=-6.65$, $P<0.001$). Neither daily black globe temperature nor species had any effect on the attributes of selective brain cooling. In their natural arid-zone habitat, with access to drinking water, our three study species expressed similar selective brain cooling capabilities. Indeed, variability in selective brain cooling was greater within a species than between species. Those individuals with a greater capacity for selective brain cooling may be advantaged under the hot and dry conditions predicted for many arid-zones under future climate change scenarios.

Supported by a South African National Research Foundation / Thuthuka grant to W. M. S.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Integrating thermal physiology with the pace-of-life syndrome hypothesis

Christopher Turbill[1]

[1]Hawkesbury Institute for the Environment, University of Western Sydney, Hawkesbury Campus, Richmond 2753, New South Wales, Australia.

The pace-of-life syndrome hypothesis proposes that variation in single traits, such as metabolic rate, cannot be understood in isolation because selection has favoured the expression of correlated networks of behavioural, physiological and life-history traits. Constraints and feedbacks limit phenotypic variation along a continuum of optimal trait combinations, which ranges between 'incompatible alternative states'. The idea of a nexus between behaviour and physiology is not new, but recent theoretical and empirical studies have reinvigorated interest in an individual-based research paradigm. Here, I make the case that the pace-of-life syndrome hypothesis can also explain why individuals within a population commonly exhibit consistent differences in thermal physiology and behaviour. Moreover, there is growing evidence that individual differences in thermoregulation have functional significance to behaviour, physiology and life-history ecology that reaches far beyond the immediate energy budget. Thermal physiology provides a mechanism that allows some individuals to 'live fast' and die young and others to 'slow down' and live longer. The fitness consequences of contrasting pace-of-life syndromes is hypothesised to depend on individual state and/or environmental conditions, particularly food availability and predation risk. I aim to demonstrate the value of an integrated individual-based perspective on variation in thermoregulation using some examples of research on both homeothermic and heterothermic mammal species.

REGULAR PRESENTATIONS (A-Z)

Retreat site selection and exploitation of thermal microhabitats by juvenile spiders

Francesca T. van den Berg[1], Dieter F. Hochuli[1] and Mike B. Thompson[1]

[1]School of Biological Sciences, The University of Sydney, Australia

For nocturnal ectotherms, diurnal retreat sites will determine the thermal environment experienced during the day. By selecting a retreat with optimum thermal characteristics, juveniles can maximise their growth rates and size, which is advantageous for animals which engage in intraspecifc competition. Flat rock spiders, *Morebilus plagusius,* use exfoliated rocks on sandstone outcrops as diurnal retreats. Flat rock spiders rarely co-inhabit rocks and juveniles are often found beneath very hot rocks. We determined the effect of 9 constant temperature treatments (24-40°C) on development and found that 30-32°C is optimal for growth. We then tested if juveniles thermoregulate by selecting thermally suitable rocks, and/or shuttling beneath rocks to exploit temperatures available. We set up a non-linear thermal gradient in a constant temperature room with a pre-determined cycling temperature profile. We recorded the temperatures that each spider selected over 14 hours. Spiders tolerated a large range of temperatures, but selected temperatures slightly higher than their thermal optimum for growth. To determine if spiders could select thermally suitable rocks, we put a single juvenile spider into an arena with a choice of two rocks differing in temperature and recorded the rock selected. To quantify effects of intraspecifc competition, the following night we introduced a second spider into the arena and recorded the rock each spider selected and whether there were any fatalities. We repeated the experiment at four ambient temperatures, 20°C, 25°C, 30°C and 35°C. We found that ‘single spiders’ selected warmer rocks at 20, 25 and 30°C but not at 35°C. Fatalities were most common at 20°C and 35°C, with larger spiders winning competition bouts. Our results show that spiders are capable of thermoregulating on a coarse and fine scale and that when the thermal resource value of a retreat rock is high, spiders will engage in risky intraspecific conflict.

REGULAR PRESENTATIONS (A-Z)

Conditions favoring the evolution of placentotrophy in a viviparous skink: hungry moms and infanticidal cannibalism

James U. Van Dyke[1], Oliver W. Griffith[1], and Michael B. Thompson[1]

[1]School of Biological Sciences, A08 Heydon-Laurence Building, University of Sydney NSW 2006

Placentotrophy, the nourishment of offspring via a placenta, has evolved repeatedly in vertebrates, including five times in squamates. Theory has predicted that the evolution of placentotrophy requires that food resources be abundant and stable throughout gestation. If food availability is not consistently abundant enough to permit successful reproduction, theory predicts that placentotrophic females should be pre-adapted to recoup nutrition invested in reproduction.[1] We tested these hypotheses in the placentotrophic skink, *Pseudemoia entrecasteauxii*. We fed females one of four diets (high constant, high stochastic, low constant, and low stochastic) during gestation, and tested the effects of both food amount and stochasticity of food availability on maternal body composition, neonate composition, developmental success, and cannibalism rate. Low food availability significantly reduced maternal and neonate energy, fat, and protein contents, developmental success, maternal growth, and neonate size. Females on low food diets were significantly more likely to cannibalize both undeveloped eggs and developed offspring. Stochasticity of food availability did not significantly affect any maternal or offspring characteristic. Taken together, our results support the hypotheses that placentotrophy is most likely to be a successful strategy of offspring provisioning when food resources are abundant, and that cannibalism allows females to recoup nutrition provisioned to offspring if food resources are too low to permit successful reproduction. Our results did not support the hypothesis that stability of food availability was necessary for the evolution of placentotrophy.

Supported by an NSF International Research Fellowship to JUV and ARC grants to MBT.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Intraspecific variation in torpor use by the fat-tailed dunnart

Chris B Wacker and Fritz Geiser

Centre for Behavioural and Physiological Ecology, Zoology, University of New England, Armidale NSW 2351, cwacker@myune.edu.au

Torpor and basking allow small mammals such as the fat-tailed dunnart (*Sminthopsis crassicaudata*) to balance energy budgets and to survive adverse conditions, but torpor expression varies among individuals. Because age is known to affect torpor use, and the patterns of colour banding in fur (dark proximal, light distal fur bands) vary strongly among individuals and may affect heat exchange, we examined whether the variability of torpor expression is affected by age and fur properties. Dunnarts (n=12) were implanted with small temperature-sensitive transponders between 2 and 3 months of age, while still sharing the nest with their mother. At 2, 3, 4, 5 and 6 months of age oxygen consumption and subcutaneous temperature (T_{sub}) were measured simultaneously for ~ 21 hours and, on half of measurement days, animals had access to a basking lamp during rewarming. Torpor bout duration decreased substantially with age and size (r^2=0.70). Basking behaviour during rewarming from torpor also differed with age with younger animals exposing mainly their head to the heat source whereas older animals exposed their backs. The length of the proximal dark band of the fur affected rewarming rates; animals with longer dark bands warmed faster (r^2=0.63), were able to reach a higher T_{sub} at the end of the torpor bout (r^2=0.70) and used less energy doing so (r^2=0.62). Our data show that fat-tailed dunnarts reduce torpor use during growth. The dark proximal fur bands allow animals to maximise radiant heat gain and to rewarm quickly and economically from torpor, whereas the light distal fur tip can be used for camouflage.

REGULAR PRESENTATIONS (A-Z)

What do we mean by 'stress'? Using psychological theory to inform ecological and conservation physiology research.

Koa N Webster[1]

[1]Department of Biological Sciences, Macquarie University, North Ryde NSW 2109, Australia

As physiologists we often conceptualise 'stress' in purely physiological terms: the physiological stress response is a measurable series of events that starts with the activation of the hypothalamus and results in the secretion of glucocorticoid ('stress') hormones by the adrenal cortex. Glucocorticoid hormone levels are relatively easy to measure both directly (in the blood) and indirectly (e.g. in saliva or as metabolites in faeces or urine), and assays for detecting glucocorticoid hormones are increasingly becoming more affordable. This has led to more researchers investigating the physiological stress response within a conservation or ecological context. However, if we wish to investigate 'stress' from an ecological or conservation perspective, this requires a conceptualisation of stress that is not purely physiological. We need to look beyond the proximate cause of elevated glucocorticoid levels (i.e. activation of the hypothalamus) and examine external conditions that promote activation of the physiological stress response. Theoretical models of conditions that contribute to stress can aid interpretation of observational studies and better inform design of manipulative experiments. While conceptual models of stress have been discussed to some extent in the conservation biology literature, examination of the psychological literature can provide us with easily transferable predictive models. Using examples from my research on Australian mammals (including koalas, flying-foxes and bandicoots), I will illustrate how one such psychological model has provided a useful framework for interpreting physiological data.

REGULAR PRESENTATIONS (A-Z)

The genomic basis of male pregnancy in seahorses and pipefish

Camilla M. Whittington[1,2], Oliver W. Griffith[1], and Anthony B. Wilson[2,3]

[1]School of Biological Sciences, University of Sydney, Australia
[2]Institute of Evolutionary Biology and Environmental Studies, University of Zurich, Switzerland
[3]Department of Biology, Brooklyn College, USA

Male syngnathids (seahorses and pipefish) have specialised brooding structures (pouches) that provide protection, aeration, and possibly osmoregulation and nutrient provisioning to developing embryos. These structures differ widely across the lineage, offering an unprecedented opportunity to study the evolution of reproductive complexity in these viviparous fish. However, despite the novelty of this trait and the utility of this system for evolutionary research, the physiological changes occurring during syngnathid pregnancy are largely unknown. In order to understand the basic biology underlying male pregnancy, we have used transcriptomic technologies (RNAseq) to sequence genes expressed in pouch tissue at key gestational stages across several species. We have identified a number of candidate genes putatively involved in pregnancy in this group, including genes functioning in tissue remodelling and nutrient transfer. Some of these have homology to genes of known reproductive function in mammals, viviparous reptiles, and other live-bearing fish. Our work suggests a common genetic basis for components of the reproductive machinery in divergent evolutionary lineages, and sheds light on the processes and functions within the syngnathid brood pouch.

REGULAR PRESENTATIONS (A-Z)

Correcting metabolic rate of animals to a common body temperature: two ways to do it but which is right?

Philip C. Withers[1]

[1]School of Animal Biology, University of Western Australia, Perth, Western Australia

Body temperature (T_b) is one of the most important factors influencing the physiology of animals. Basal metabolic rate (endotherms) or standard metabolic rate (ectotherms) is an important physiological rate for animals because it reflects their energy requirements for maintenance conditions. Comparative physiologists often wish to compare the energy requirements of different animals, but one of the complications in doing this is to properly account for differences in basal metabolic rate that reflect differences in T_b. A common method used to accomplish the standardisation of standard metabolic rate of ectotherms, and basal metabolic rate of endotherms, to a common body temperature (for example, 37°C) is to apply a Q_{10} correction. The metabolic rate at a body temperature of 37°C is calculated from the metabolic rate measured at another body temperature (T_b) as $MR_{37^oC} = MR_{Tb}\ Q_{10}^{(37-Tb)/10}$. A Q_{10} of 2.5 is often used for this calculation (Q_{10} is generally about 2-3 for biological systems). However, this calculation can be erroneous for endotherms because it implies a change in thermal conductance, calculated as $C = VO_2/(T_b - T_a)$, whereas C is most likely to be constant reflecting the physical heat exchange properties of the animal i.e. the insulation value of its fur or feathers. I argue here that the discrepancy between these two methods of standardising metabolic rate to a common T_b can be substantial if the correction in T_b is more than a few °C. It becomes problematic as to how to best standardise the metabolic rate of animals with a T_b intermediate between a “good” endotherm and a “typical” ectotherm.

Abstracts

REGULAR PRESENTATIONS (A-Z)

Burrowing energetics of the Giant Burrowing Cockroach: an allometric study

Liangwen Xu

Earth and Environmental Sciences, University of Adelaide, Adelaide, South Australia 5005, Australia.

Many organisms occupy burrows as a living strategy to access food or avoid unfavourable living environments. Some semi-fossorial burrowers spend most of time hidden in their burrows and occasionally come to the surface to forage. This study analyses resting and burrowing metabolic rate of the heaviest insect burrowers, the Giant Burrowing Cockroach (*Macropanesthia rhinoceros*), with different sizes, between 1.8 – 23.8 g in five different age groups. The allometric equation for resting metabolic rate (mW) is $MR_R = 0.99\ M^{0.47}$, which is different to an interspecific study on resting metabolic rate of 391 species of insects ($MR_R = 1.8\ M^{0.82}$), as well as other cockroach species (14 species, $MR_R = 1.38\ M^{0.77}$). Burrowing metabolic rate of the GBC can be described by the allometric equation $MR_B = 16.9\ M^{0.44}$, which indicates that burrowing is 6 to 24 (average 15.9) times more expensive than resting, but larger individuals show a lower burrowing metabolic rate on a mass-specific basis. The combination of these findings indicates that, although burrowing a complex chamber is expensive, the large scope of the MR_B/ MR_R ratio of this species is more likely caused by the low MR_R, rather than high MR_B. When converted into the net cost of transport (NCOT, J m^{-1}) by considering the burrowing rate, the results can be described by the equation $NCOT = 120\ M^{0.49}$, which is also low in exponent, but is comparable with a range of burrowing species. Although the energy cost of constructing a long and complex tunnel is high for the GBC, it is not significantly different to burrowers of similar body size. The low MR_R of this species may be associated to their morphological trait as they are flightless, their behaviour trait as they have the longest parenting period, and their long longevity that is associated with avoiding oxidative damage. The net cost of burrowing (NCOB, J cm^{-3}) of this species reveals high individual variation, i.e. burrowing efficiency varies not only between individuals, but more importantly, the largest nymphs and adults generally show lower energy cost per unit excavated.

SPEED PRESENTATIONS (A-Z)

Physiological responses to environmental stress in abalone: Why is being a hybrid an advantage?

Katharina Alter [1,2], Peter B. Frappell[1], Andrea J. Morash[1], Sarah J. Andrewartha[2], Nicholas G. Elliott[2]

[1]University of Tasmania, Hobart, Australia
[2]CSIRO Marine and Atmospheric Research, Hobart, Australia

Selective breeding and hybridisation programs have enabled the production of an abalone hybrid, which shows 25% faster growth, lower mortality rates during live transport and higher meat yields than parental pure species, Haliotis rubra and *H. laevigata*. Current research mainly addresses commercial issues such as meat quality and disease control but little is known about the physiology and behaviour of the hybrid. Changes in behaviour patterns can be triggered by parental origin but may also indicate suboptimal conditions or stress. At non-optimum environmental conditions energy is used to mitigate the stress rather than channelling it into growth. This comparative study will examine how *H. laevigata, H. rubra* and their hybrid cope with environmental stressors that commonly occur during commercial production to reveal the physiological and behavioural strategies which result in the improved fitness of the hybrid. The use of state-of-the-art biosensors will enable the collection of real-time abiotic (temperature, oxygen tension) and physiological (heart rate, movement) data of the abalone. Metabolic and biochemical manalyses of haemolymph and tissues will further reveal physiological responses of abalones to varying environmental parameters. It is hypothesized, that higher growth rates of the hybrids are due to (a) wider abiotic tolerances, (b) less active behaviour, (c) higher metabolic rates, and/or (d) higher energy conversion efficiencies.

SPEED PRESENTATIONS (A-Z)

Drosophila melanogaster show no evidence of metabolic cold adaptation when allowed to evolve in a range of thermal environments

Lesley A. Alton[1], Catriona C. Condon[2,3], Craig R. White[1] and Michael J. Angilletta Jr.[2]

[1]School of Biological Sciences, The University of Queensland, Brisbane, QLD 4072, Australia
[2]School of Life Sciences, Arizona State University, Tempe, AZ 85287, USA
[3]Current address: Department of Entomology and Nematology, The University of Florida, Gainesville, FL 32611, USA

The theory of metabolic cold adaptation (MCA) proposes that, at a given temperature, species from colder environments (higher latitudes or altitudes) will have higher metabolic rates (MRs) than those from warmer environments as a result of biochemical adaptation that occurs to compensate for the thermodynamically depressing effects of low temperature. Despite being first proposed nearly 100 years ago, the MCA hypothesis remains controversial with support being mixed from both intra and interspecific studies. For insects specifically, a global-scale comparative analysis provides support for the MCA hypothesis with insects from higher latitudes having higher MRs than those from lower latitudes. Such comparative analyses, however, do not allow for differences in MR to be attributed solely to temperature because other environmental parameters also vary with latitude. To better assess the validity of the MCA hypothesis, experimental evolution studies are needed. We measured the MR of *Drosophila melanogaster* experimentally evolved for three years in two constant (16 and 25°C) and one variable thermal environment, with flies in the variable environment moved between 16°C and 25°C every four weeks. The MR of flies was measured at three test temperatures (16, 20.5 and 25°C) to examine the effect of environment on the temperature sensitivity of MR. Based on the theory of MCA, it was hypothesised that flies from the constant 16°C environment would have higher MRs than those from the constant 25°C environment when measured at the same test temperature, however, environment did not significantly affect the MR of flies providing no support for the MCA hypothesis.

SPEED PRESENTATIONS (A-Z)

The long and the short of it: climatic correlates and physiological implications of body size variation in *Diplodactylus granariensis*

Elisabeth Barber[1], Michael Kearney[1] and Paul Oliver[1]

[1]Department of Zoology, University of Melbourne, Australia

Body size has a substantial effect on many life history traits, exhibits relationships with environmental gradients and physiological processes, and has been comprehensively studied. Most attention has been directed towards studies of endotherms and further investigation is needed into patterns and mechanisms behind intraspecific body size variation in ectotherms. The Western Stone gecko (*Diplodactylus granariensis*) inhabits a wide range of environments across south-western Australia. It exhibits variation in body size across its distribution, yet the extent of this variation, as well as the factors driving it, remains unclear. This study quantified body size variation between populations of the Western Stone Gecko and investigated possible climatic correlates and physiological consequences of this variation. Body size variation was explored through the measurement of museum specimens and subsequently compared with climatic data relating to temperature and rainfall. Metabolism and water loss rates for wild-caught geckos were measured through respirometry. Results suggest that body size variation in the Western Stone Gecko follows a latitudinal trend, with northern populations exhibiting larger overall body size. It was found that higher minimum annual temperatures and longer runs of dry days were correlates of increased body size. Larger geckos were also found to have lower mass-specific water loss rates, suggesting that a larger body size in hotter, arid conditions could be adaptive. This lends support to the desiccation resistance hypothesis and provides a novel example of body size adaptation in ectotherms.

SPEED PRESENTATIONS (A-Z)

Gene expression associated with the recent evolution of viviparity in a reproductive bimodal skink (*Lerista bougainvillii*)

Matthew Brandley[1], Oliver Griffith, Mike Thompson[1]

[1]School of Biological Sciences, University of Sydney, Australia

The transition to viviparity (live-bearing) from oviparity (egg-laying) requires profound morphological and physiological changes in both the mother and embryo, and these changes must be associated with significant changes in gene expression. The skink, *Lerista bougainvilli* offers a rare opportunity to uncover the genetic mechanisms of viviparity because the species has both oviparous and viviparous populations, and therefore this study system has the potential to reveal the genetic changes associated with the evolutionary transition to viviparity "in action". I will present the results of a transcriptomic gene expression study analysing almost all genes expressed in both the maternal and embryonic tissues of both oviparous and viviparous populations of *L. bougainvilli* throughout multiple stages of pregnancy. In particular, I will focus on suites of genes associated with the major physiological changes required to maintain pregnancy and how their expression differs between oviparous and viviparous reproductive modes, including genes associated with nutrient provisioning, placental morphology, and the maternal immune system. Finally, I will compare these genetic changes to another viviparous lizard as a starting point to assessing the convergence of gene expression mechanisms across viviparous squamates.

Supported by an ARC DECRA fellowship to MCB.

SPEED PRESENTATIONS (A-Z)

It's costly to be honest: the metabolic expense of maintaining a reliable signal of strength for crustaceans

Candice Bywater[1], Craig White[2] and Robbie Wilson[2]

[1]Department of Zoology, University of Melbourne, Parkville VIC 3010
[2]School of Biological Sciences, University of Queensland, St Lucia QLD 4072

Handicap costs are predicted to be one of the primary mechanisms for the maintenance of reliable signals that are used during intra-specific communication. However, separating the costs required to unambiguously communicate a message to a receiver (efficacy costs) from the actual costs of producing a reliable signal (handicap costs) is empirically very difficult. Displays of weaponry by crustaceans offer an opportunity to measure the costs directly associated with signal reliability. A unique feature of crustacean morphology is that their claw muscles, which influence their fighting capacity, are concealed beneath an exoskeleton. Thus, it is impossible for competitors to accurately assess the strength of their opponents without physical contact, which is potentially very costly. This feature allows us to separate the signal magnitude (claw size) from its reliability (strength). We quantified the metabolic costs of maintaining claw muscle for reliable and unreliable signals of strength in fiddler crabs (*Uca vomeris*) and slender crayfish (*Cherax dispar*). We found that the original claws of male *U. vomeris* consumed 43% more oxygen than weaker, regenerated claws which is reflective of the quantity of claw muscle present, thus male fiddler crabs with the regenerated claws save by producing a claw with less muscle. Although male and female crayfish both had similar overall costs for claws, the claw muscle of *female C. dispar* consumed more oxygen per gram than that of conspecific males, suggesting that muscle quality drives variation in metabolic costs. Thus, from our studies of crustacean claws, we found that the metabolic costs of maintaining claw muscle could be a powerful incentive for producing weak claws.

SPEED PRESENTATIONS (A-Z)

Scaling of gross heart development in the kangaroo *Macropus fuliginosus*

Edward P. Snelling

Earth and Environmental Sciences, University of Adelaide, Adelaide, South Australia 5005, Australia.

It is commonly thought that heart mass (Mh) increases in direct proportion to body mass (Mb) as mammals grow throughout development (i.e. Mh∝Mb1.00). To test this idea, we joined a planned conservation cull of western grey kangaroos (*Macropus fuliginosus*), and extracted hearts from 29 individuals over a body mass range of 800-fold (0.084–67.5 kg). Two distinct allometric relationships are evident in the dataset: the heart mass (grams) of developing juvenile pouch young scales with body mass (kg) with positive allometry, Mh (in-pouch) = 6.4Mb1.10±0.05, whereas heart mass of free-roaming adults and sub-adults scales with negative allometry, Mh (post-pouch) = 14.2Mb0.77±0.08 (ANCOVA, P<0.0001). Measurements of heart height, width and depth support this finding, with the average of these linear dimensions (mm) in juvenile pouch young scaling as L ¯h (in-pouch) = 23.9Mb0.37±0.03, whereas average linear dimension in adults and sub-adults scales as L¯h (post-pouch) = 30.2Mb0.27±0.04 (ANCOVA, P<0.001). The disproportionate increase in the size and mass of the heart during juvenile in-pouch development is consistent with the likely increase in cardiac demands associated with the transition from a helpless new-born joey to one that is ready to leave the pouch. The decline in the pace of heart growth once independence from the pouch has been gained might reflect a relative decline in the maximum cardiac requirements across this body mass range.

Supported by the Australian Research Council.

SPEED PRESENTATIONS (A-Z)

Physiological and behavioural responses of mammals to fire

Clare Stawski, Jaya Matthews, Gerhard Körtner and Fritz Geiser

Centre for Behavioural and Physiological Ecology, Zoology, University of New England, Armidale 2351

The early start of the 2013-2014 fire season in Australia supports predictions that the frequency and intensity of fires are increasing. Although data are available on the succession of plant and animal communities after fires, the physiological and behavioural responses of individual animals to survive during and after fires are poorly understood. Thus we investigated whether the energy savings and reduced foraging requirements achieved by using torpor play a role in the persistence of small mammals in post-fire environments. The initial response of captive *Sminthopsis crassicaudata* and *Antechinus stuartii* exposed to an ash/charcoal substrate or smoke was a reduction in both activity and torpor use, perhaps as a response to stress and/or to deal with reduced cover and hence increased exposure to predators. In contrast, the long-term post-fire response appears to be frequent use of torpor. For example, *Antechinus flavipes* captured four months after an intense wildfire in Warrumbungle National Park (where they must have survived in situ) expressed torpor on 78% of observed radio-tracking days, well above that previously observed in the species, likely to deal with low availability of prey which was essentially limited to ants (scat analyses). Indeed, at the intense fire site most captured small mammals (mainly small dasyurids, house mice and bats) were heterotherms that can use torpor. Therefore, torpor use might be advantageous for surviving in a post-fire landscape when food and water availability is limited.

SPEED PRESENTATIONS (A-Z)

The chilly side of global warming: can food or water restriction depress the thermal preferences of the Australian tawny dragon lizard (*Ctenophorus decresii*)?

Samantha Walker[1], Devi Stuart-Fox[1] and Michael Kearney[1]

[1]Department of Zoology, The University of Melbourne, Australia

Behavioural thermoregulation is a primary mechanism by which animals buffer themselves against variability in their environment. However, little is known about how an animal's nutrition and hydration states interact separately with this process. With climate change predicted to reduce the frequency of rainfall events in some areas in concert with rising temperatures, understanding the effects of food and water restriction on the behaviour and physiology of animals is vital for predicting and managing their responses to future climate change. We investigated the effects of food and water restriction upon behavioural thermoregulation and activity levels in the Australian tawny dragon lizard (*Ctenophorus decresii*) using a thermal gradient. The body temperature data from this experiment was separated into periods of activity and passivity using change point analysis to detect transition points in the data. Using only the body temperature values when the lizards were active, we compared the thermal preferences of the treatment groups and the relative proportion of time spent active over the day. Our research delivers valuable insight into how water and food intake governs the thermoregulatory behaviour and activity of these lizards, as well as applying the novel approach of viewing body temperature data through change point analysis.

Conference Participants

CONTACT DETAILS

Allan	Georgina	University of Adelaide	georgina.allan@student.adelaide.edu.au
Alter	Katharina	University of Tasmania	katharina.alter@utas.edu.au
Alton	Lesley	University of Queensland	l.alton@uq.edu.au
Angove	Sophie	University of Adelaide	sophie.angove@student.adelaide.edu.au
Barber	Elisabeth	University of Melbourne	elbarber@student.unimelb.edu.au
Booth	David	University of Queensland	d.booth@uq.edu.au
Brandley	Matthew	University of Sydney	mbrandley@gmail.com
Briscoe	Natalie	University of Melbourne	nbriscoe@unimelb.edu.au
Buttemer	William	Deakin University	buttemer@deakin.edu.au
Bywater	Candice	University of Melbourne	candice.bywater@unimelb.edu.au
Cadena	Viviana	University of Melbourne	viviana.cadena@unimelb.edu.au
Careau	Vincent	Deakin University	vcareau@deakin.edu.au
Cavallo	Cathy	University of Melbourne	c.cavallo@student.unimelb.edu.au
Chown	Steven	Monash University	steven.chown@monash.edu
Cooper	Christine	Curtin University	C.Cooper@curtin.edu.au
Courtney Jones	Stephanie	University of Wollongong	skcjones@uow.edu.au
Crispin	Taryn	University of Queensland	t.crispin@uq.edu.au
Currie	Shannon	University of New England	scurrie3@myune.edu.au
Dawson	Terence	University of NSW	t.dawson@unsw.edu.au
Dudley	Jessica	University of Sydney	jdud1448@uni.sydney.edu.au
Durrant	Joanna	University of Melbourne	j.durrant@student.unimelb.edu.au
Fanson	Benjamin	Macquarie University	bfanson@gmail.com
Fanson	Kerry	Deakin University	kerryfanson@gmail.com
Fong	Angelina	University of Melbourne	angelina.fong@unimelb.edu.au
Gatto	Chris	University of Melbourne	c.gatto@student.unimelb.edu.au
Geiser	Fritz	University of New England	fgeiser@une.edu.au
Hulbert	Anthony	University of Wollongong	hulbert@uow.edu.au
Jessop	Tim	University of Melbourne	tjessop@unimelb.edu.au
Johnstone	Christopher	Monash University	christopher.johnstone@monash.edu
Kearney	Michael	University of Melbourne	m.kearney@unimelb.edu.au
Kelly	Ella	University of Melbourne	e.kelly2@student.unimelb.edu.au
Laird	Melanie	University of Sydney	mel.laird@optusnet.com.au
Lesku	John	La Trobe University	j.lesku@latrobe.edu.au
Lill	Alan	Monash University	Alan.Lill@monash.edu
Linton	Stuart	Deakin University	slinton@deakin.edu.au
Little	Alex	University of Sydney	alit2851@uni.sydney.edu.au
Long	Sara	University of Melbourne	hoskins@unimelb.edu.au
Maino	James	University of Melbourne	jamesmaino@gmail.com
McShea	Kate	University of Sydney	kmcs8788@uni.sydney.edu.au
Mitchell	Duncan	University of the Witwatersrand	duncan.mitchell@wits.ac.za
Morash	Andrea	University of Tasmania	andrea.morash@csiro.au

Munns	Suzy	James Cook University	suzy.munns@jcu.edu.au
Narayan	Edward	Griffith University	e.narayan@ga.griffith.edu.au
Pereira	Carla	University of Queensland	carla.limapereira@uqconnect.edu.au
Pirtle	Elia	University of Melbourne	eliapirtle@gmail.com
Raubenheimer	David	University of Sydney	david.raubenheimer@sydney.edu.au
Richardson	Samantha	RMIT University	samantha.richardson@rmit.edu.au
Roberts	Jessica	University of Melbourne	jessridenour@gmail.com
Rojas	Daniella	University of New England	arojas2@myune.edu.au
Seebacher	Frank	University of Sydney	frank.seebacher@sydney.edu.au
Seymour	Roger	University of Adelaide	roger.seymour@adelaide.edu.au
Silva	Ana	Australian National University	anacatarina.as@gmail.com
Sim	Elizabeth	University of Queensland	elizabeth.sim@uqconnect.edu.au
Snelling	Edward	University of Adelaide	edward.snelling@adelaide.edu.au
Stawski	Clare	University of New England	clare.stawski@gmail.com
Strauss	W. Maartin	University of South Africa	strauwm@unisa.ac.za
Thompson	Mike	University of Sydney	Mike.Thompson@sydney.edu.au
Turbill	Christopher	University of Western Sydney	c.turbill@uws.edu.au
van den Berg	Francesca	University of Sydney	francesca.vandenberg@sydney.edu.au
Van Dyke	James	University of Sydney	james.vandyke@sydney.edu.au
Wacker	Christine	University of New England	cwacker@myune.edu.au
Walker	Samantha	University of Melbourne	wasj@student.unimelb.edu.au
Webster	Koa	Macquarie University	koa.webster@mq.edu.au
White	Craig	University of Queensland	craig.white@uq.edu.au
Whittington	Camilla	University of Sydney	camilla.whittington@sydney.edu.au
Williamson	Sean	Monash University	sean.williamson@monash.edu
Withers	Philip	University Western Australia	Philip.Withers@uwa.edu.au
Xu	Liangwen	University of Adelaide	liangwen.xu@student.adelaide.edu.au

Student Prize Winners

29 NOVEMBER 2013

Best Presentation: Melanie K. Laird

1st Runner-up Presentation: Sophie Angove

2nd Runner-up Presentation: Francesca T. Van den Berg