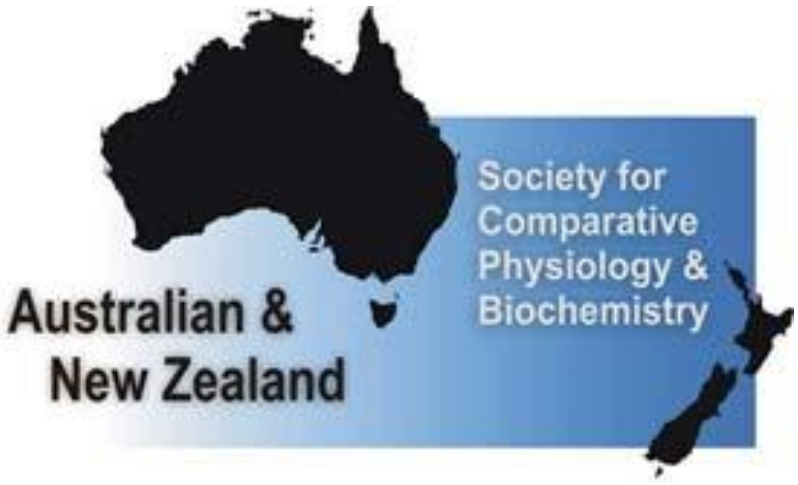

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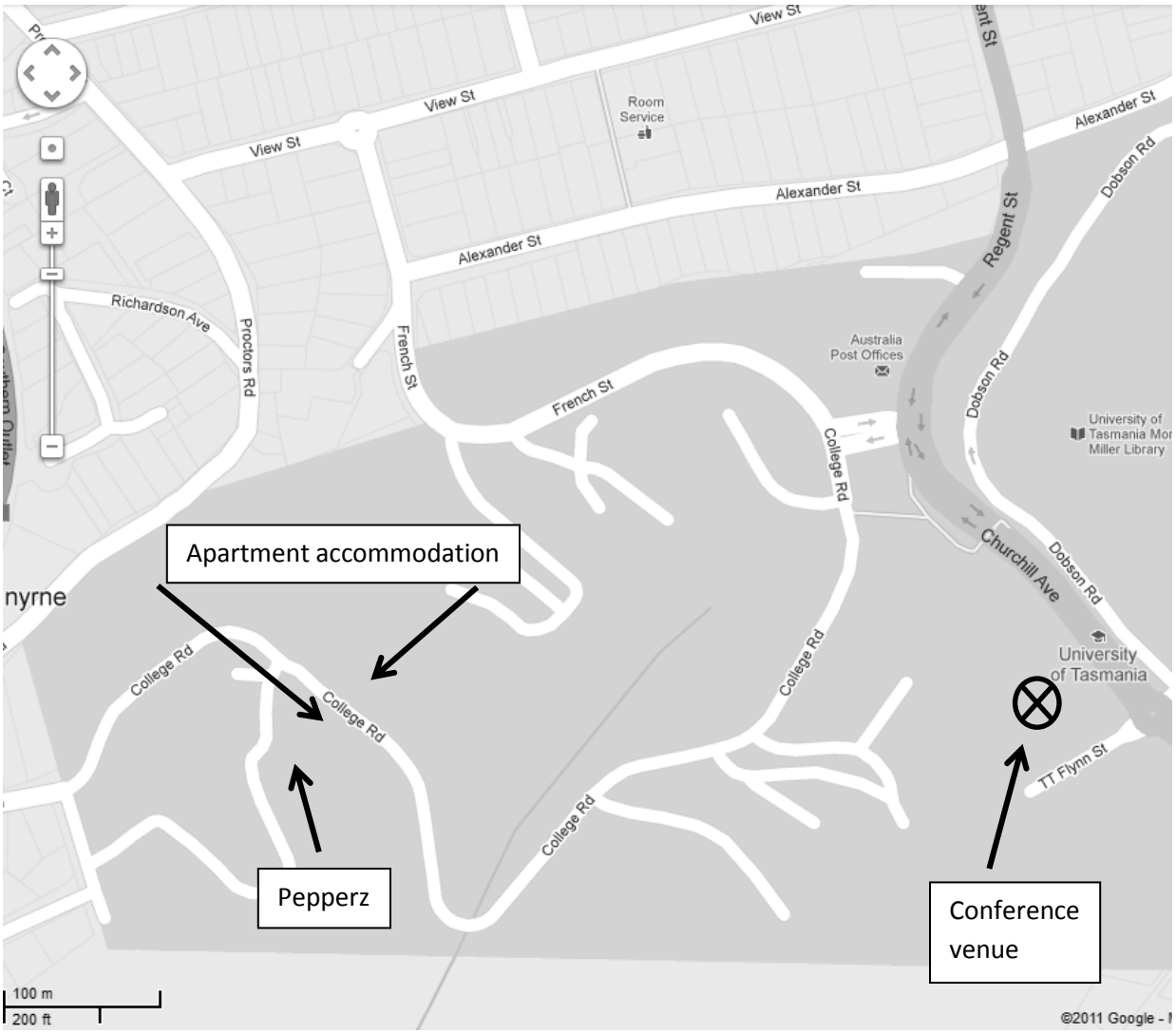
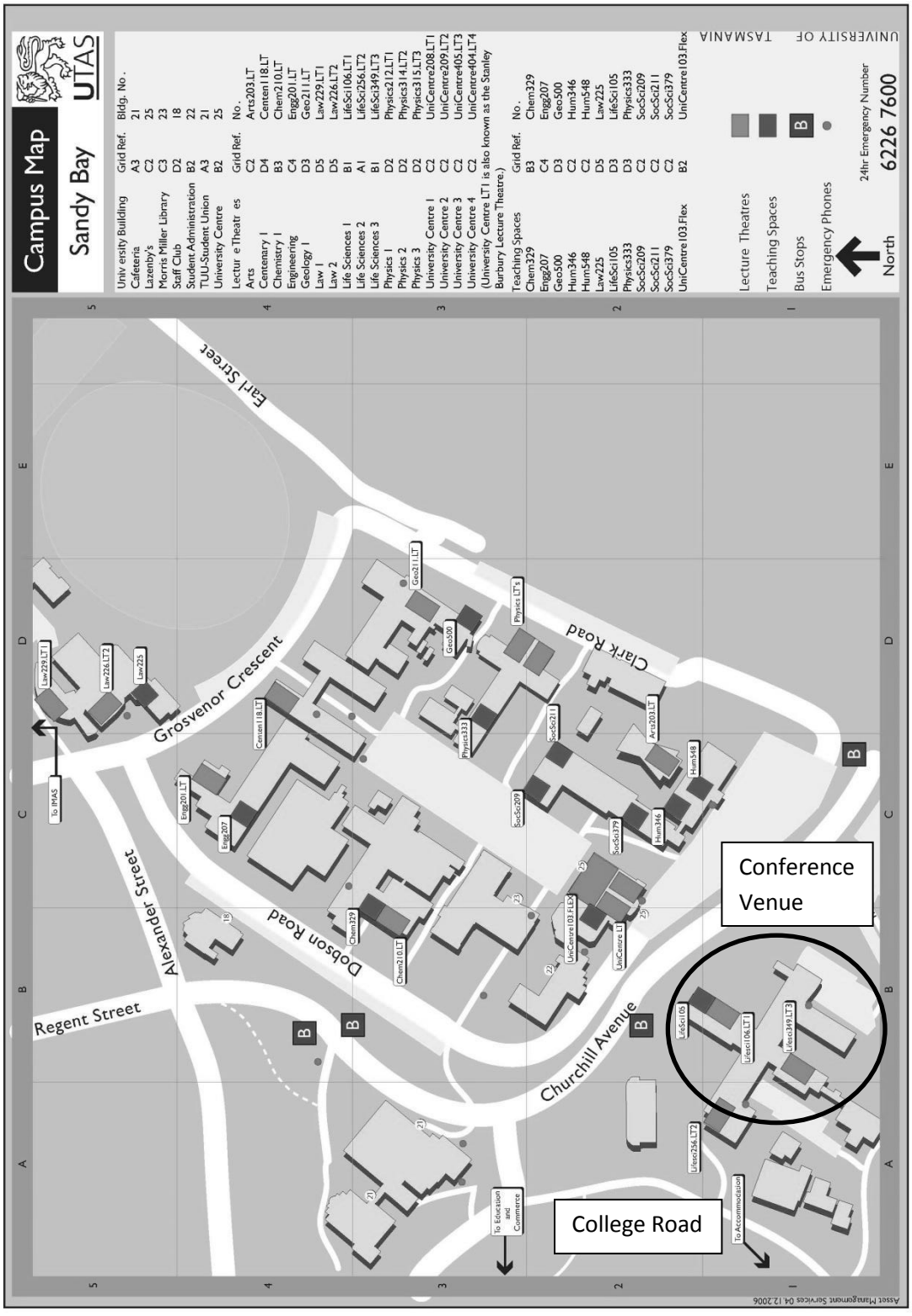
The committee would like to thank Ms Tina Stephens and Mrs Felicity Wilkinson for administrative support, and the student volunteers (Jodie Gruber, Ben Halliwell, Gemma Morrow, Elias Polymeropoulos, Amy Saunders, Chloe Scammell, Jillian Smith). Special thanks to Christine Cooper for web page and mailing list support, and to Ms Katrina Smith from accommodation services.

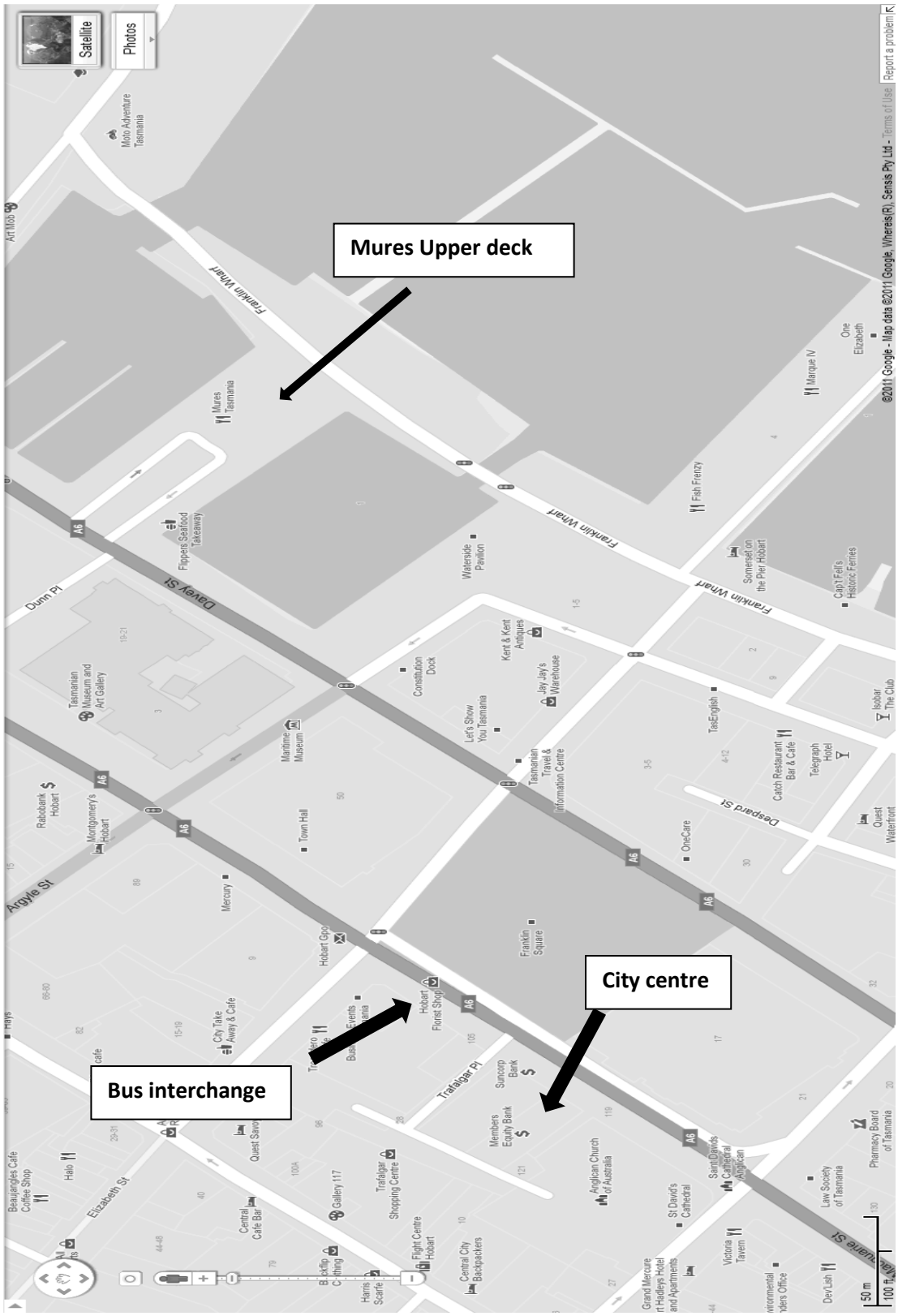
Accommodation and conference venues



Conference venue



Map – dinner venue



House keeping

Breakfasts are at Pepperz (Café Bar Restaurant) which will open at 7.30am. Pepperz is located alongside the conference accommodation and will have a list of names of those who have prepaid for breakfast. If you later decide to eat breakfast at Pepperz you can simply pay as a regular customer at the time. Pepperz is open for dinner week nights until 8pm, including Thursday 8th December.

Conference dinner venue is Mures Upper Deck, located in town on the water front (see map). Taxi is the best way to get there, but buses are regularly available from Churchill Avenue into the city for approximately $3 each way. Any bus which is going to "city" is appropriate, and the water front, where Mures Restaurant is a prominent feature, is a 5 minute downhill walk from the bus interchange. Number 54 and 55 buses will return to the university from the city. Drinks are included for the 1st hour of dinner, after which time you may purchase additional drinks at your leisure. Aim to be at the venue by 7pm.

First aid There is wall-mounted defibrillator equipment one flight up stairs up from the conference venue very close to the staircase above the photocopier and 1st aid kits are located in all Zoology laboratories.

Internet access is available via computers on the 2nd floor of the Life Sciences building, next to the ladies toilet. No password is required when accessing the internet, and simply leave the "user1" log in name as it appears and hit enter. Alternatively, wireless internet access is available in some areas of the building.

Phones When dialing from inside the building call 7600 for security on any of the internal wall phones. There is a pay phone on the next level up from the conference lecture theatre (2nd floor) very close to the stairs and vending machines.

Poster fixings will be Velcro. Please bring with you the means to attach your poster to large notice boards using Velcro. Posters will be introduced at the end of the first session of talks on Friday morning – take up to 2 minutes and 1 Power point slide to introduce yourself and grab people's attention.

Mixer venue is in the Life Sciences building at Lecture Theatre 1 foyer (See map). Enter the building via Plant Sciences car park entry off College Road if coming from the accommodation.

Recycling The Pickled Pear, which is catering the conference, will be using recyclable materials wherever possible, and left over food will be collected by Second Bite for distribution to those in need.

Room key arrangements – if arriving on Thursday afternoon between 2- 5 pm, go directly to the University apartments at the top of College Rd. Keys will be available from a conference representative in Pepperz Café until 5 pm. After this, keys will be available from the conference mixer venue until 8pm. For later arrivals, keys can be collected from the after-hours Accommodation Services staff member on duty (help phone opposite the office door at housing reception). To use the help phone you need to press and hold the reception button (button number 1). An accommodation map is attached with this message as PDF file.

Taxi Call 13 2227 for a taxi and ask to be collected from 1) the bus stop on Churchill Ave which is at the base of the cat walk overpass, or 2) from the Plant Science car park off College Road. Direct taxis to deliver you to the University apartments at the top of College Rd, UTAS.

Toilets are located alongside the main conference lecture theatre close to the staircase, and on the 2nd floor next to the computer room.

Final talk session + AGM will finish just at 1pm Sunday. Farewell nibbles provided Sunday 1-2pm

Program overview

Thursday evening Dec 8th – Registration will begin on Thursday evening at 5:00pm and continue until 8:00 pm in the foyer of the Life Sciences Lecture Theatre. Snacks and drinks available.

	Fri 9 Dec		Sat 10 Dec		Sun 11 Dec
9.00	Welcome Session 1 +poster introductions	9.00	Session 5	9.00	Session 9
10.25	Morning tea	10.20	Morning tea	10.30	Morning tea
11.00	Session 2	11.00	Session 6	11.00	Session 10
12.20	Lunch	12.30	Lunch		Student prizes
1.35	Session 3	1.45	Session 7		AGM
2.55	Afternoon tea + posters	3.20	Afternoon tea + posters		
4.00	Session 4	4.00	Session 8	1.00	Farewell nibbles
	Dinner at your leisure	7.00	Conference dinner at Mures Upper Deck, Salamanca		

Dinner on Friday night will be at your choice of venue, although we recommend Elizabeth St North Hobart (taxi) or Salamanca/waterfront (taxi, or half hour walk each way from college accommodation) as two restaurant hotspots.

Daily program – Friday Dec 9 (morning)

Session 1	**Chair: Bill Buttemer**
9.00-9.10	Welcome
9.10	Mechanical digestion of cellulose by the gecarcinid land crab, *Gecarcoidea natalis* Benjamin J. Allardyce and Stuart M. Linton
9.25	Maybe herbivory isn't so hard after all: Digestion in a minimalist herbivorous fish, the halfbeak (Hemiramphidae) Ryan D. Day**
9.40	Phenotypic plasticity of the gastrointestinal tract in king quail (*Coturnix chinensis*): Fibre content or decreased nutrients? Sean A. Williamson*, and Adam Munn
9.55	No effects of dietary fibre content on the gastrointestinal tract and body condition of adult layer hens (*Gallus gallus domesticus*). Stephanie Courtney Jones*[1], Adam Munn[1] and Aaron Cowieson[2]
10.10	Poster introductions – single slide + 2 minutes each
10.25-11.00	**Morning tea Life Sciences Lecture Theatre 1 foyer**
Session 2	**Chair: Susan Jones**
11.00	Does the nocturnal, viviparous gecko *Woodworthia* "Otago/Southland" vary offspring quality with gestational conditions? Alison Cree and Kelly M. Hare
11.15	Reproductive physiology of the Tasmanian echidna *Tachyglossus aculeatus setosus* Gemma Morrow**, Stewart C. Nicol, Susan M. Jones
11.30	Female hormones: Can a female lizard have too much of a good thing? Laura M. Parsley**, Erik Wapstra and Susan M. Jones
11.45	Placental leucine transfer during mid to late gestation in a highly placentotrophic viviparous lizard Keisuke Itonaga**, Erik Wapstra and Susan M. Jones
12.00	Reproduction in the male Tasmanian Pademelon (*Thylogale billardierii*) Michael Driessen[2], Dorothy McCartney[1], Jan Horak[1], and Randy Rose[1]
12.20-1.30	**Lunch Life Sciences Lecture Theatre 1 foyer**

Daily program – Friday Dec 9 (afternoon)

Session 3	**Chair: Peter Frappell**
1.35	The heart warming impacts of climate change: A mitochondrial insight to heart failure in fish Fathima I. Iftikar** and Anthony J. R. Hickey
1.50	Does decreased mitochondrial free radical production account for the remarkable longevity in birds? Anthony J. R. Hickey, Trishen Pillay, Mark De Lisle and Julia MacDonald
2.05	Transcriptome analysis of pregnancy in a viviparous African skink Matthew C Brandley[1], Michael B. Thompson[1], and Günter P. Wagner[2]
2.20	Vitamin D Receptor (*VDR*) Polymorphisms (*Fok*1 and *Bsm*1) and Breast Cancer Risk in Pakistani Population Muzaffar (Murbarak) M**[1, 2], Muhammad N[1], Ali F[1], Faiz S[1], Hamann U[3] and Rashid MU[1,2,3]
2.35	Vision and Innovation in Biology Education (VIBEnet) Susan M. Jones[1], Charlotte Taylor[2], Pauline Ross[3] and Elizabeth Johnson[4]
2.55-4.00	**Afternoon tea Life Sciences Lecture Theatre 1 foyer – POSTERS +PHOTO**
Session 4	**Chair: Alison Cree**
4.00	Non-invasive amphibian endocrinology: a new tool for fundamental biology and ecological research Edward Narayan[1], F. Molinia[2], J.F. Cockrem[3] and J-M.Hero[1]
4.15	Macro-stress: Developing and testing predictions to evaluate glucocorticoid stress response variation in vertebrates Tim Jessop and Romy Woodford
4.30	Physiological consequences to elephant sharks (*Callorhinchus milii*) of capture and handling in fishing gear Camila Martins**[1], Terence Walker[2] and Richard Reina[1]
4.45	Interpreting indices of physiological stress in free-living vertebrates Christopher Johnstone, Richard D. Rein, and Alan Lill
5.00	Swimming activity of rainbow trout (*Onchorhynchus mykiss*) during simulated capture by hook-and-line Peter S. Davie[1] and R Keller Kopf[2]
	Evening at leisure

Daily program – Saturday Dec 10 (morning)

Session 5	**Chair: Suzy Munns**
9.00	The physiological birth of Atlantic salmon: A focus on metabolic rate, hypoxia induced hatching and the effects of egg size Elias Polymeropoulos**[1,2], Nick Elliott[3] and Peter Frappell[1]
9.15	Locust breathing patterns in hyperoxia do not support the oxidative damage hypothesis Philip G. D. Matthews[1], Edward Snelling[1], and Craig R. White[2]
9.30	Anaemia adjusts the aerobic physiology of snapper (*Pagrus auratus*) and modulates hypoxia avoidance behaviour during oxygen choice presentations Denham Cook[1**], Rufus Wells[2] and Neill Herbert[1]
9.45	Are all athletes 'created' equal? Aerobic features of the muscles of kangaroos, rat-kangaroos and athletic placental mammals Koa Webster[1] and Terry Dawson[2,3]
10.00	The structural bases of the energetic capabilities of marsupials: An overview Terry Dawson[1,3], Koa Webster[1,2], Enhua Lee[1] and Bill Buttemer[3]
10.20-11.00	**Morning tea Life Sciences Lecture Theatre 1 foyer**
Session 6	**Chair: Elias Polymeropoulos**
11.00	Resting and maximum metabolic rate during tethered-flight in the adult locust *Locusta migratoria* Edward Snelling[1], Roger Seymour[1], Philip Matthews[2], Sue Runciman[3] and Craig White[2]
11.15	Going underground: testing the energetic advantage of limbless versus limbed locomotion in fossorial lizards Brett Goodman and Roger Seymour
11.30	Comparative physiology of the Australian water rat (*Hydromys chrysogaster*) Amanda Page[1**], Christine Cooper[1,2] and Philip Withers[1,2]
11.45	Environmental constraints on oviparity and viviparity Michael R. Kearney[1] and Lin Schwarzkopf[2]
12.00	Contrasting Metabolic Theories: divergent explanations, parallel predictions James Maino[1]**, Craig White[2] and Michael Ray Kearney[1]
12.15	Applying Dynamic Energy Budget (DEB) theory to kangaroo energetics Jessica Roberts[1**], Bas Kooijman[2], Adam Munn[3], and Michael Kearney[1]
12.30-1.45	**Lunch Life Sciences Lecture Theatre 1 foyer**

Daily program – Saturday Dec 10 (afternoon)

Session 7	**Chair: Koa Webster**
1.45	An overview of the effect of body size and microclimate on the thermal and structural properties of avian nests Caragh B. Heenan[1 **], Roger S. Seymour[1], David C. Paton[1], Craig R. White[2] and Brett A. Goodman[1]
2.00	Behavioural responses to environmental variation in cool temperate reptiles and the implications for species persistence under projected climate change. Mandy Caldwell[1**], Geoff While[1, 2] and Erik Wapstra[1]
2.15	The developmental environment determines the capacity to thermally acclimate in a freshwater fish, *Gambusia holbrooki* Julian Beaman* and Frank Seebacher
2.30	Influence of incubation temperature on physiological, morphological, and behavioural phenotypes of Japanese quail (*Coturnix japonica*) Lisa M. Trotto, BriAnne A. Addison and William A. Buttemer
2.45	Altitudinal variation in the performance traits of the spotted skink *Niveoscincus ocellatus* Luh P.E. Kusuma Yuni**, S.M. Jones., E. Wapstra
3.00	Bigger, fitter, faster: ontogenetic trade-offs in developmental rate and body size of the spider, *Morebilus plagusius.* Francesca van den Berg[**], Dieter Hochuli and Mike Thompson
3.20-4.00	**Afternoon tea Life Sciences Lecture Theatre 1 foyer – POSTERS**
Session 8	**Chair: Christine Cooper**
4.00	Thermal and hygric physiology of Australian burrowing mygalomorph spiders (*Aganippe* spp.) Leanda Denise Mason[1], Sean Tomlinson[1,2], Philip C. Withers[1], Barbara York-Main[1]
4.14	Effects of nest and water temperature on swimming of green turtle hatchlings David Booth and Andrew Evans
4.30	Blood flow to long bones indicates activity metabolism in mammals, reptiles and dinosaurs Roger S. Seymour[1], Sarah L. Smith[1], Craig R. White[2], Donald M. Henderson[3], Daniela Schwarz-Wings[4]
4.45	The ecological significance of dormancy: torpor, survival and life-histories of mammals Christopher Turbill[1,3], Fritz Geiser[2] and Thomas Ruf[3]
5.00	Physiological mechanisms for sex ratio adjustment in mammals Elissa Cameron
7.00	**DINNER MURES seafood restaurant, Hobart waterfront**

Daily program - Sunday Dec 11

Session 9	**Chair: John Donald**
9.00	Effects of temperature on sloughing frequency in frogs and implications for the regulation of cutaneous microbial loads Rebecca K. McPhee, Rebecca L. Cramp, Edward A. Meyer and Craig E. Franklin
9.15	Metabolic cold adaptation in fish occurs at the level of whole animal, mitochondria, and enzyme Craig R. White[1], Lesley A. Alton[1] and Peter B Frappell[2,3]
9.30	Leptin biology in the Spinifex hopping mice, *Notomys alexis*: a role for skeletal muscle N.K.A. Hamid**[1,3], Janet Mc Leod[1,2] and John Donald[1]
9.45	Xenobiotic metabolism by the Malpighian tubules of insects, a new hepatic function Samuel Parry**, Stuart Linton, Paul Francis and Xavier Conlan
10.00	The regulation of vascular tone via the activation of potassium channels in amphibians Melissa Cameron**[1], Annalise Stanley[1], Yoshio Takei[2] and John Donald[1]
10.15	Influence of salinity on the expression and distribution of ion transporters in the gills of the bull shark (*Carcharhinus leucas*) Beau D. Reilly[1*], Rebecca L. Cramp[1], Jonathan M. Wilson[2], Hamish A. Campbell[1] and Craig E. Franklin[1]
10.30-11.00	**Morning tea Life Sciences Lecture Theatre 1 foyer**
Session 10	**Chair: Michael Thompson**
11.00	Thermal energetics and torpor in tropical long-eared bats Fritz Geiser[1], Clare Stawski[1,2], Artiom Bondarenco[1], and Chris R. Pavey[3]
11.15	Thermal physiology of the world's smallest mammalian glider, the feathertail (*Acrobates pygmaeus*) Victoria Inman[1], Philip C. Withers[1,2] and Christine E. Cooper[1,2]
11.30	Thermoregulation by an Australian rodent, the ash-grey mouse (*Pseudomys albocinereuse*) Justine M. Barker[1], Christine E. Cooper[1,2], Philip C. Withers[1,2] and Ariovaldo P. Cruz-Neto[1,2,3]
11.45	Can the cricket salivary gland act as an alternative pathway for delivery of hormones? Paul Cooper
12.00	The evolution of vascular NO signalling in vertebrates John Donald[1], Sofie Trajanovska[1], Rachel Becker[1], Melissa Cameron[1] and Leonard Forgan[2]
12.15	Craig Franklin short spot
12.20	Student prizes
12.30	AGM
1.00-200	**Farewell nibbles Life Sciences Lecture Theatre 1 foyer**

Mechanical digestion of cellulose by the gecarcinid land crab, *Gecarcoidea natalis*

Benjamin J. Allardyce and Stuart M. Linton

School of Life and Environmental Sciences, Deakin University, Pigdons Road, Waurn Ponds, Victoria, 3217

Digestion of cellulose requires 2 steps; the mechanical fragmentation of plant material into small particles and the subsequent enzymatic digestion of these fragments. In the gecarcinid land crab *Gecarcoidea natalis*, the gastric mill is thought to be primarily responsible for mechanical fragmentation. The gastric mill, found at the posterior of the cardiac stomach, consists of three teeth, a pair of lateral teeth and a medial tooth. The morphology of these teeth varies between different families of crustaceans. Although this variation may be the result of phylogenetic differences, some features of the gecarcinid mill appear to result from adaptation to a fibrous plant diet. In particular, the lateral teeth of *G. natalis* possess ventral cusps and ridges that interlock with each other while the medial tooth has transverse ridges which complement the cusps and ridges of the lateral teeth. Together these features would efficiently shred fibrous plant material. By determining the size of particles produced through mastication, the efficiency of the gastric mill was also examined. To do this, crabs were fed an artificial cellulose diet and the stomach contents removed at various time points post ingestion. This material was then passed through progressively smaller sieves to determine the distribution of various sized particles. Within an hour, the crabs quickly reduced the artificial diet to particles which were mainly less than 53 µm. Similarly material sampled from the stomach of field animals consisted mainly of particles less than 53 µm. Small particles would increase the surface area available for enzymatic attack.

Thermoregulation by an Australian rodent, the ash-grey mouse (*Pseudomys albocinereuse*)

Justine M. Barker[1], Christine E. Cooper[1,2], Philip C. Withers[1,2] and Ariovaldo P. Cruz-Neto[1,2,3]

[1]Department of Environment and Agriculture, Curtin University, [2]Animal Biology, University of Western Australia, [3]Departmento de Zoologia, Universidade Estadual Paulista.

We present the first evidence of torpor use by an Australian murid rodent. One individual ash-grey mouse entered torpor at ambient temperatures of 15°C and 25°C, with minimal body temperatures of 28.6°C and 27.9°C respectively, before spontaneously arousing. Torpor was associated with a reduction in metabolic rate and evaporative water loss of up to 87% and 49% (at T_a = 25°C) of normothermic values respectively. Other mice remained normothermic, with thermoregulatory responses typical of endothermic mammals, although they became hyperthermic at high ambient temperatures. Although ash-grey mice have the physiological ability to use torpor, it is used rarely, presumably due to other behavioural and physiological adaptations that promote survival in a semi-arid habitat. Their higher-than-expected basal metabolic rate (181% of the allometrically-predicted value) indicates that these mice do not have a frugal approach to energy expenditure, and other physiological variables were typical of a generalised rodent. A readily-available omnivorous diet, nocturnal activity, semi-fossorial habit and social behaviour presumably allow this high energy lifestyle. A reluctance to use torpor despite a clear physiological ability to do so highlights the potential disadvantages of a heterothermic thermoregulatory strategy.

The developmental environment determines the capacity to thermally acclimate in a freshwater fish, *Gambusia holbrooki*

Julian Beaman* and Frank Seebacher

School of Biological Sciences, University of Sydney

Phenotypic plasticity most likely plays an important role in the response of organisms to environmental change. Energy metabolism and locomotion are crucial for fitness, and both are affected by fluctuations in environmental temperature. In response to longer-term (weeks to months) temperature changes, many ectotherms adjust their physiological functions to compensate for the potentially negative effect of changing temperatures. These changes may occur during development (developmental plasticity), when they are often irreversible, or reversibly during adulthood (thermal acclimation). The aim of the project was to investigate whether there is an interaction between developmental plasticity and thermal acclimation in the eastern mosquito fish (*Gambusia holbrooki*). *G. holbrooki* are short-lived and reproduce within 1-2 months of birth. At Manly Dam, Sydney, individuals experience markedly different thermal variation during their lifetime depending on whether they are born in spring or summer. Juveniles were collected from Manly Dam in spring and summer, and then kept at either 15˚C or 25˚C for five weeks. Metabolic capacity and locomotory performance were tested at 15˚C, 20˚C and 25˚C to determine if individuals had acclimated to the different thermal regimes. Individuals born in early spring acclimated metabolic capacity and sustained swimming performance to both cool (15˚C) and warm (25˚C) temperatures. In contrast, individuals born in early summer did not acclimate to cool temperatures but maximised metabolic capacity and sustained swimming performance at warm temperatures. The interaction between developmental plasticity and thermal acclimation may match individuals born at different times of the year to the prevailing thermal environment they experience after birth.

Effects of nest and water temperature on swimming of green turtle hatchlings

David Booth and Andrew Evans

School of Biological Sciences, The University of Queensland

We discovered that both mean nest temperature and water temperature influenced the swimming performance of green turtle hatchlings from the Heron Island rookery on the Great Barrier reef, but in opposite directions. Hatchling swum in 30^{o}C water had greater swimming performance than hatchlings swum in 26^{o}C water, with hatchling turtles swum in warm water having a faster stroke rate during a power-stroking bout. On the other hand hatchling emerging from warmer nests (mean nest temperature 30-32^{o}C) exhibited a decreased swimming ability than hatchlings from cooler nests (mean nest temperature 27-30^{o}C), with hatchlings from warm nests producing less thrust per power-stroke. Overall, the decrease in swimming performance (in terms of average thrust production) due to warm nest temperatures was greater than the increase in swimming performance due to warm water, so any anticipated increase in global temperatures may cause an overall decrease in swimming performance of green turtle hatchlings.

Transcriptome analysis of pregnancy in a viviparous African skink

Matthew C Brandley[1], Michael B. Thompson[1], and Günter P. Wagner[2]

[1]School of Biological Sciences (A08), University of Sydney, NSW 2006, Australia, [2]Department of Ecology and Evolutionary Biology, Yale University, New Haven, CT 96520, USA

Although much is known about the morphological and physiological changes involved in reptilian pregnancy, the genetic architecture that underlies them is not known. Recent technological advances in sequencing and completion of the *Anolis* genome provide the first opportunity to both identify and quantify most of the genes expressed in the reptilian uterus. We used the viviparous African ocellated Skink, *Chalcides ocellatus*, as a model to identify a near complete gene expression profile associated with pregnancy. There are clear parallels between the genetic processes associated with pregnancy in mammals and *Chalcides* in expression of genes related to tissue remodeling, angiogenesis, immune system regulation, and nutrient provisioning to the embryo. Pregnancy is associated with upregulation of uterine genes involved with metabolism, cell proliferation and death, and cellular transport. In particular, the pregnant uterine transcriptome is dominated by expression of proteolytic enzymes that we speculate are involved both with remodeling the chorioallantoic placenta and histotrophy in the yolk sac placenta (omphaloplacenta). Elements of the maternal innate immune system are downregulated in the pregnant *Chalcides* uterus, indicating a potential mechanism to avoid rejection of the embryo. The unexpected downregulation of estrogen and progesterone receptors and Major Histocompatability Complex loci in the pregnant uterus provides evidence that the gene expression profiles of pregnant mammalian and reptilian uteri are not identical.

Behavioural responses to environmental variation in cool temperate reptiles and the implications for species persistence under projected climate change.

Mandy Caldwell[1**], Geoff While[1, 2] and Erik Wapstra[1]

[1]School of Zoology, University of Tasmania, [2]Edward Grey Institute of Field Ornithology, University of Oxford.

The rapid rate of climate change is predicted to exceed the speed of biological response, such as migration or evolutionary change, driving many species extinct. As ectotherms, reptiles are expected to suffer significantly under changing climates. Specifically, extinction risk has been predicted to be greatest at altitudinal extremes where thermal physiology limits species distributions. In line with this, correlative models predict the extinction of Tasmania's alpine snow skinks in the next 50 years, with a significant range reduction of lowland species. However, reptiles have the potential to buffer climate change impacts by altering their basking behaviour, and thereby offset the costs of increasing temperatures. We assessed the potential for alpine and lowland snow skink species to display behavioural compensation via mediation of selected body temperatures in response to variation in the thermal environment under controlled laboratory conditions. We also assessed the consistency of individual basking behaviour to establish the upper limit of behavioural compensation. Compensation via altered body temperatures differed between alpine and lowland species, and between populations and individuals, suggesting past selection on behaviour specific to prevailing local conditions.

Physiological mechanisms for sex ratio adjustment in mammals

Elissa Cameron

School of Zoology, University of Tasmania

Adaptive theories predict systematic variation in the sex ratio when the profitability of producing sons and daughters varies between individual parents. Studies investigating sex ratio variation in mammals produce notoriously inconsistent results, although recent literature reviews suggest that variation in methodology may explain some inconsistencies, and that consistent support is shown in relation to condition at conception. However, the lack of a known mechanism for sex ratio adjustment hampers our understanding and interpretation of results. Several hypothetical physiological mechanisms have been proposed, including variation in hormone and glucose levels. Furthermore, recent research has shown surprising rates of pre-implantation embryonic sexual dimorphism which have implications for sex ratio manipulation. I discuss the implications of pre-implantation embryonic sexual dimorphism for each of the hypothesized mechanisms of sex ratio adjustment, and review the evidence to support each hypothesis.

The regulation of vascular tone via the activation of potassium channels in amphibians

Melissa Cameron**[1], Annalise Stanley[1], Yoshio Takei[2] and John Donald[1]

[1]School of Life and Environmental Sciences, Deakin University, Geelong, Victoria, 3217
[2]Atmosphere and Ocean Research Institute, University of Tokyo, Japan

The nitric oxide (NO)-cGMP signalling pathway has a pivotal role in the regulation of vascular tone by mediating vasodilation. Generation of the second messenger, cGMP, leads to the activation of potassium (K) channels, and the subsequent K fluxes causes vasodilation. In mammals, the role of K channels in cGMP-mediated vasodilation has been extensively studied, but this is unknown in amphibians. The aim of this study was to determine if K channels are involved in NO and atrial natriuretic peptide (ANP)-mediated vasodilation using myography; both ANP and NO generate cGMP via different receptors. The effect of various K channel inhibitors was performed on *Bufo marinus* iliac and brachial arteries and *Xenopus laevis* lateral aorta. In the iliac artery of *B*. *marinus*, both NO and ANP-mediated vasodilation was significantly inhibited by the K_V channel blocker, 4-AP. However, in the brachial artery cGMP-mediated vasodilation was unaffected by each of the K channel inhibitors. Interestingly, in *X. laevis,* NO-mediated vasodilation was significantly inhibited by the K_{Ca} channel blocker, clotrimazole, but ANP-mediated vasodilation was unaffected. The data indicate that cGMP-mediated vasodilation may involve a range of K channels or that NO and ANP use different signalling pathways. Molecular biology demonstrated mRNA expression of a K_{Ca} channel in *X. laevis* aorta, supporting the physiological findings. However, no molecular evidence for K_V channels was found in *B. marinus* but K_{ATP} channel expression was found. Further study is needed to understand the exact role of K channels in cGMP signalling in amphibians.

Anaemia adjusts the aerobic physiology of snapper (*Pagrus auratus*) and modulates hypoxia avoidance behaviour during oxygen choice presentations

Denham Cook[1**], Rufus Wells[2] and Neill Herbert[1]

[1]Leigh Marine Laboratory, University of Auckland, [2] School of Biological Sciences, University of Auckland

The effect of altered oxygen transport potential on behavioural responses to environmental hypoxia was tested experimentally in snapper, *Pagrus auratus*. Standard metabolic rate was indifferent in anaemic and control groups, whereas maximum metabolic rate, and hence aerobic scope, was consistently reduced in the anaemic treatment group at all levels of water PO_2. These adjustments resulted in an elevated critical oxygen limit (P_{crit}) in anaemic fish (8.6 ± 0.6 kPa) when compared to normocythaemic fish (5.3 ± 0.4 kPa). Oxygen transport potential influenced hypoxia avoidance behaviours, with anaemic individuals avoiding hypoxic conditions at 6.6 ± 2.5 kPa compared to 2.9 ± 0.5 kPa for controls ($P<0.01$). Behavioural avoidance, in either treatment, was not associated with modulation of swimming speed. Interestingly, both groups avoided low PO_2 just below their P_{crit}, indicating that avoidance was triggered consistently when AS limits were reached and anaerobic metabolism was unavoidable. This was confirmed by high levels of plasma lactate in both treatments at the point of avoidance. This is the first experimental demonstration of hypoxia avoidance behaviour being modulated by internal physiological state.

Can the cricket salivary gland act as an alternative pathway for delivery of hormones?

Paul Cooper

Evolution, Ecology and Genetics, Research School of Biology, Australian National University

Salivary glands of insects are typically associated with feeding and the subsequent processing of food, by supplying fluids to solubilise food particles and enzymes that aid in the initial stages of digestion. Using the black field cricket, *Teleogryllus commodus* Walker, I have been studying this role of the salivary glands, as well as the mechanism of stimulation of the glands by amines and peptide hormones. Crickets have lobular glands that are mostly contained within the thoracic region and appear to be activated by serotonin, dopamine and the peptide, PDVDHVFLRFamide. However, during the course of this work, I have found a potential novel role of the glands, as a direct path link between retrocerebral complex and the thoracic region. A pair of lobes with connecting duct loop from the main salivary duct and into the head. The two lobes are located on either side of the retrocerebral complex (hypocerbral ganglion, corpora cardiaca and corpora allata) that has several roles in delivering many of the hormones that control many physiological processes in insects. The glands may be able to transfer hormones directly from the complex region in the brain to the thoracic region rather than the slower process via the open circulation.

No effects of dietary fibre content on the gastrointestinal tract and body condition of adult layer hens (*Gallus gallus domesticus*).

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We compared digestive capabilities of layer hens on high-quality, low fibre diets, with those fed poorer-quality, high fibre diet balanced for energy and protein (HFB) and those fed high fibre, unbalanced (HFU) diet. The HFU diet had lowest apparent DM metabolisability (57.83±6.1%), followed by HFB (66.01±3.50%), and LF diet (70.38±7.10%). Despite significant differences between apparent metabolisabilities of diets, no morphometric changes in gastrointestinal tract (GIT) were observed. Conversely, body mass losses were recorded for animals on HFU diet, while those on LF and HFB diets actually gained body mass over 14-days. We suggest body mass losses seen in animals fed HFU diets were attributed to losses in adipose tissue, however was not quantified. Assuming body mass losses were mainly adipose tissue (fat); this loss may act to buffer environmental challenges like shortfalls in nutrient acquisition when dietary energy requirements are not met. Further, it was suspected allometric scaling may influence rate of flexibility, with previous studies on smaller species reporting changes in GIT morphology within 14-days. We suspect larger body size of layer hens may present a greater safety margin before changes in the GIT are needed. Therefore, to exhibit GIT changes, longer experimental periods or higher dietary fibre contents may be required. This study identified several issues in current research that should be addressed, including lack of congruence between fibre sources and analysis methodology and fibre description. Further, we propose that phenotypic plasticity research involving domesticated or 'improved' species may not be representative for wildlife feeding ecology and physiology.

Does the nocturnal, viviparous gecko *Woodworthia* "Otago/Southland" vary offspring quality with gestational conditions?

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Previous studies show that season and size at birth (or hatching) influence the future prospects of young lizards. Although offspring of diurnal lizards often differ in response to thermal conditions during gestation, little information exists for nocturnal species, or for species that can delay the delivery of fully developed offspring. Here, we investigate the effect of maternal thermoregulatory opportunity during pregnancy on gestational outcomes and offspring quality in a primarily nocturnal gecko. Additionally, we explored whether offspring that were hormonally induced, from females that delay birth, are inherently of different quality from those that are spontaneously delivered. Female *Woodworthia* "Otago/Southland" (formerly *Hoplodactylus maculatus*) were maintained under three regimes offering different levels of access to preferred temperature. Developmental success and offspring survival were high under all regimes. Gestation length for spontaneous deliveries was temperature-dependent, but under all regimes, some females delayed delivery. However, offspring characteristics (size, initial growth rate, use of warm retreats and sprint speed) were not consistently affected by either maternal temperature regime or by the spontaneity of birth. Offspring size was affected by maternal size, but delivery mode was not affected by either maternal size or maternal basking behaviour. A large drop in preferred temperature of females near the end of pregnancy may assist the continued survival of fully developed offspring in utero. In conclusion, offspring of this primarily nocturnal gecko appear relatively unaffected by thermal conditions during gestation, which is perhaps advantageous given the decades-long lifespan of this species.

Swimming activity of rainbow trout (*Onchorhynchus mykiss*) during simulated capture by hook-and-line

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To investigate why fishes swim away when hooked we studied the effects of hook impalement on fish swimming activity during simulated capture of rainbow trout *Oncorhynchus mykiss* (Walbaum). Patterns of swimming activity, as measured by tension on the line, and post-capture physiological disturbances were compared between two experimental treatments. Trout were tethered by an elastic line to a fixed force transducer by: (1) a hook impaled through the upper jaw (Hook) or (2) a previously implanted mouth anchor (No-hook) Regardless of hooking treatment, trout (N = 18) exerted the same tension pattern and post-capture physiological stress responses after 20 minutes of simulated capture. Swimming activity was highest during min 0 – 5 with most activity during minute one. Tensions exerted during the final 5 min of the Hook treatment were typically less than tensions exerted during the final 5 min of the No-hook treatment. Contrary to popular belief, hook impalement did not explain the swimming activity or physiological stress responses of rainbow trout in our simulated hook-and-line capture. Our data suggest that restricting the fish's ability to swim away freely, rather than hook impalement *per se*, elicited an escape response by rainbow trout. Efforts targeted at improving the welfare of fish should focus on aspects of capture other than impalement including capture time and handling.

The structural bases of the energetic capabilities of marsupials: An overview

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Our understanding of the energetic capabilities of marsupials relative to those of placentals has been long in coming. This, in part, was actually due to a limited appreciation of the situation in placentals. In our previous presentation (Webster and Dawson) we demonstrate that aerobic capacities (VO_2 max) of the kangaroos and rat-kangaroos match those of the most aerobic (athletic) placentals. The structure/function relationships in the oxygen cascade from lungs to muscle mitochondria that underpin such abilities are also essentially the same in the two groups. Are the very successful kangaroos and their relatives unique within the marsupials in their aerobic capacities? Of note, many relatively sedentary placentals do have lower VO_2 max and total muscles mitochondrial volumes relative to those seen in 'athletic' species. For the marsupials we have considered the overall energetic characteristics of two small non-hopping marsupials. It appears that there is also variability in marsupial aerobic profiles. From these data we can further appreciate the overall energetic capabilities of marsupials relative to their lower levels of basal metabolism. Our new appreciation touches on aerobic scope, locomotory abilities, fuel supply and field metabolism.

Maybe herbivory isn't so hard after all: Digestion in a minimalist herbivorous fish, the halfbeak (Hemiramphidae)

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Herbivory is a challenging trophic specialisation, resulting in a number of adaptations to facilitate a diet of plants. In fishes, such adaptations include a variety of stomach morphologies, very long intestines, microbial fermentation and long retention times. The halfbeak (Hemiramphidae) is an unusual herbivorous fish, as it has none of these – it lacks a stomach; has a short, straight gut; and a rapid gut passage rate – making it a novel subject in which to study the minimum requirements of herbivory. To better understand the relative costs and benefits of the hypertrophied pharyngeal mill, which provides the majority of mechanical treatment of food, we estimated the energetic cost of food processing using sound and video recordings of feeding events along with measurements of energy consumption of the muscles powering the pharynx. The latter was compared to the energy cost of the intestinal tissue to compare the energetic demand of the two components of digestion. Rheometric analyses of the unusually abundant mucus along the gut were used to characterise how food is moved along the gut and to better understand the role played by mucus in food processing. Finally, the biochemical component of digestion was examined using assays of digestive enzyme activity along the gut to determine how particular nutrients are being targeted and whether there are any localisation patterns along the gut. The results of these investigations are presented in what we suspect is the first attempt at comprehensive integrated model of herbivory in a teleost.

The evolution of vascular NO signalling in vertebrates

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The role of the endothelium as the primary source of nitric oxide (NO) that mediates vasodilation is well-established in mammals. Endothelial NO is primarily generated by an isoform of NO synthase (NOS) called NOS3. In addition, NO can be generated by two additional NOS isoforms called NOS1 and NOS2, respectively; NOS1 is also called neuronal NOS and is expressed in nitrergic nerves. It is now clear that endothelial NO signalling is not ubiquitous in vertebrates. In fact, comparative genomics and molecular cloning have shown NOS1 and NOS2 are present in all vertebrates, but that NOS3 has arisen in the tetrapod lineage. NOS3 is found in amphibians but is not found in the vascular endothelium. A key question is when NOS3 was first expressed in the endothelium of tetrapods to provide NO signalling to tissues, and whether this is linked to vasomotor control or provision of NO to tissues from the capillary endothelium for metabolic regulation. In the absence of endothelial NO signalling in amphibians, NO control of vascular tone is provided by perivascular, nitrergic nerves. Interestingly, the majority of the perivascular, nitrergic nerves are also adrenergic as NOS1 and tyrosine hydroxylase are colocalised in many nerve terminals. Thus, the same neuron could release vasodilator and vasoconstrictor signalling molecules.

Thermal energetics and torpor in tropical long-eared bats

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Although bats are most diverse in the tropics, there are no quantitative data on torpor use in free-ranging tropical bats and no measurements of thermal energetics of tropical bats capable of deep, multiday torpor (hibernation). Free-ranging *Nyctophilus* bats, known to hibernate in southern Australia, were studied in the tropics using radio-telemetry; open-flow respirometry was used to measure metabolic rates of captive bats. Although the average yearly ambient temperature (T_a) at the Northern Territory field site was 28ºC (~1ºC below TNZ), bats in winter, when T_a ranged from 16.5 to 34ºC,used torpor on every night and rewarmed largely passively in the late morning; bats were active for more than half the night. Contrasting with the south, tropical bats always remained torpid for <10 hours. Thermal energetics of *Nyctophilus* bats captured in northern Queensland were very similar to those measured previously in temperate regions, but torpid tropical bats defended body temperatures (T_b) at higher values (minimum T_b~7ºC) than temperate bats (minimum T_b~1ºC). Importantly and against predictions made from tropical primates, the minimum metabolic rates of torpid tropical bats at T_a ~9ºC, were almost identical to those predicted for similar-sized temperate hibernators (~0.5% of normothermic, resting bats at the same T_a). Our study shows that despite the mild thermal conditions, torpor contributes substantially to balancing energy budgets of tropical bats. Although torpid tropical bats defend their T_b at somewhat higher values than their temperate congeners, their minimum metabolic rates are reduced to the same extremely low levels as those of cold-climate hibernators.

Going underground: testing the energetic advantage of limbless versus limbed locomotion in fossorial lizards

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Animals with a fossorial (burrowing) life-style face many functional and physiological challenges, in particular, the need for locomotion through fluid media of varying density and complexity. In reptiles, the evolution of a fossorial life-style has occurred in nearly all Squamate lineages world-wide, and is typically associated with the evolution of a reduction or complete loss of limbs and an increase in body length. Thus, an unexplored question in the evolution of fossorial lizards is whether limb-reduction and body elongation *per se* provides an adaptive benefit via a functional, and / or, energetic advantage for fossorial locomotion. Moreover, while most fossorial lizards display a reduction in limb length and an increase in body length, a small number of species have retained the ancestral terrestrial lizard body-form and possess well-developed limbs and typical terrestrial lizard short body from. These species provide a rare opportunity to examine the putative adaptive benefits of limb reduction and body elongation for fossorial locomotion. This paper quantifies the energetics of burrowing and terrestrial locomotion, and sprint and endurance locomotion using representatives of both limbed and limbless fossorial lizards. The results of this work are discussed with reference to the repeated evolution of fossoriality in lizards of the family Scincidae.

Leptin biology in the Spinifex hopping mice, *Notomys alexis*: a role for skeletal muscle

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Leptin is an anorexigenic hormone that is considered to be expressed predominantly in the white adipose tissue of mammals. Following secretion into the plasma, it crosses the blood-brain barrier and acts on the hypothalamus to induce appetite suppression and regulate energy balance. Previous studies have shown that the Spinifex hopping mice (*Notomys alexis*) can maintain fluid balance in the absence of drinking water. In water deprivation experiments, hopping mice show a cyclical food intake in which a hypophagia is followed by sustained food intake. The mice lose body weight primarily due to fat loss but then weight stabilises and increases as water deprivation is prolonged. This study used quantitative PCR and ELISA to examine leptin mRNA expression and plasma leptin at various time points of water deprivation. It was found that after an initial decrease, plasma leptin increased as water deprivation was prolonged, despite the absence of white adipose tissue as determined by DEXA. Interestingly, leptin mRNA is expressed in skeletal muscle and heart in addition to white adipose tissue, which suggests that these tissue may be an important source of plasma leptin in hopping mice.

An overview of the effect of body size and microclimate on the thermal and structural properties of avian nests

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The nest microenvironment is a widely studied area of avian biology; however the manner in which microclimate variables influence nest design, as well as the contribution of nest conductance (the inverse of insulation) to the energetics of the incubating adult, has largely been overlooked. The thermal properties and nest dimensions of 36 species of Australian birds were measured to determine the influence of adult size and microclimate on nest design. The effect of wind and water saturation on heat loss from avian nests of 3 selected species was determined through experimental manipulation. Nest conductance scales with parent mass but there is variation within a species that is attributable to the breeding climate. Birds breeding in cooler climates construct well insulated nests; however there is a relaxation in the need for insulation in warmer climates. When a tawny crowned honeyeater (*Phylidonyris melanops*) nest is saturated with water, the rate of heat loss is two and a half times greater than when the nest is dry, a result of the increased thermal conductivity. However birds breeding in warm and wet regions use poorly-insulating materials that may facilitate the drying out process and hence reduce the total quantity of heat lost. Increasing the rate of convection through spiny-cheeked honeyeater (*Acanthagenys rufogularis*) and yellow-throated miner (*Manorina flavigula*) nests results in a near-doubling in the heat production required by the parent. This provides confirmation that selecting a sheltered nest site and constructing an appropriate nest to minimise heat loss is important for avian reproductive success.

Does decreased mitochondrial free radical production account for the remarkable longevity in birds?

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Mitochondrial free radical production plays a significant role in numerous pathological states, and many include ageing. Data generated using avian mitochondria support the concept that mitochondrial reactive oxygen species (ROS) production drives oxidative stress and promotes ageing processes. Under specific conditions, e.g. non-phosphorylating respiration and/or in the presence of specific inhibitors, isolated avian mitochondria produce up to ten-fold less net ROS than those from rats. Notably most birds live more than four times longer than mammals of equivalent body mass. However, such experimental conditions are far from those in living cells. Moreover, birds are generally 5^{o}C hotter than most mammals, a fact largely ignored in all published avian mitochondrial work to date. Here we show that when experimental temperatures are 42^{o}C avian mitochondria release equivalent amounts of ROS in phosphorylating and non-phosphorylating states as mammals. While these data may negate the role of mitochondrial ROS production in ageing, few have considered the role of mitochondria as potential sinks for ROS *in vivo*, as mammalian hepatocyte mitochondria probably consume 90% of all cellular ROS. High avian metabolisms necessitate greater mitochondrial masses. In addition, avian endocrinology probably hardwires birds to elevate mitochondrial mass. In part, aerobic drive may bolster defenses against oxidative stress and ageing.

The heart warming impacts of climate change: A mitochondrial insight to heart failure in fish

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In aquatic species, the heart is extremely temperature sensitive, and often the critical temperature for heart failure (HF) is only a few degrees above species' upper habitat temperatures (T_{max})[1]. Predictions of climate change mediated rises in ocean temperatures also suggest that ectothermic hearts may constrain many marine species distributions. HF at high temperature may result from disrupted ion transport, oxygen and substrate supply disruptions to and from energy supplying mitochondria in cardiac cells[2]. This study targets mitochondria, as damaged mitochondria may increase their reactive species production and trigger apoptosis, or they may fail to produce enough ATP to sustain a heartbeat. Using an endemic New Zealand fish species, *Notolabrus celidotus*, or "the Spotty", we assessed cardiac function and determined the T_{HF}. We then used high-resolution respirometers to explore temperature-mediated changes in cardiac mitochondrial function and ROS production, and overlaid these changes with that of heart function and T_{HF}. A drop in phosphorylation efficiency (inferred from RCR) was apparent at temperatures prior to T_{max} suggesting mitochondrial ATP supply may compromise heart function at elevated temperatures. We also assessed substrates and found that the apparent K_M for pyruvate rises from ca. 10 uM to over 1.2 mM at 32.5^{o}C. These data suggest that mitochondrial function and integrities could play a significant role in thermal stress tolerance and perhaps limit species distributions.

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Thermal physiology of the world's smallest mammalian glider, the feathertail (*Acrobates pygmaeus*)

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The feathertail glider (*Acrobates pygmaeus*) is a marsupial with a novel combination of small size (10–15g), specialised diet (nectarivorous) and locomotion (gliding) that might be expected to influence its physiology. Flow-through respirometry and whole-body plethysmography were used to measure thermal balance, metabolism, ventilation and water loss for normothermic and torpid feathertails at ambient temperatures from 10 - 35°C. Basal metabolic rate (1.37 ± 0.04 ml $O_2\,g^{-1}\,h^{-1}$) was similar to previously reported values for this species but body temperature (32.6 ± 0.27°C) was significantly lower. Respiratory physiology closely matched metabolic requirements. Both wet and dry thermal conductance were relatively constant at low ambient temperatures and similar to predicted values, despite the additional surface area of the gliding membranes; conductance increased significantly above 30°C, indicating both evaporative and non-evaporative cooling mechanisms. The feathertails had a low point of relative water economy (13.7°C), which is unsurprising given their mesic habitat and high water-content diet. Despite a unique biology, the physiology of the feathertail glider does not differ from that predicted for a generalised marsupial, supporting the idea that marsupials are physiologically conservative.

Placental leucine transfer during mid to late gestation in a highly placentotrophic viviparous lizard

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Placentotrophy is the nourishment of embryos by resources provided via the placenta during gestation. The magnitude and timing of placental nutrient support during pregnancy are important for embryonic growth, especially in highly placentotrophic animals such as mammals. However, no study has yet investigated how placental organic nutrient support may change during pregnancy in highly placentotrophic viviparous reptiles. Amino acids are essential nutrients for embryonic growth and leucine is a common amino acid. The magnitude and timing of placental leucine transfer may affect embryonic growth and mass and, therefore, offspring phenotype. In this study, females of *Pseudemoia entrecasteauxii*, a highly placentotrophic viviparous skink, were collected throughout gestation. We injected ^{3}H-leucine into these gravid females and assessed the transfer of ^{3}H- leucine into maternal compartments (i.e. the blood and the liver), and into embryonic compartments (i.e. the embryo, the yolk and the amniotic fluid). At either 60 or 120 min post-injection, the radioactivity in each sample was extracted and then counted, and the transfer ratio was calculated. Our results provide direct evidence that circulating maternal leucine passes through the placenta into the embryos in this species. The relative rate of placental leucine transfer did not alter during mid to late gestation. This suggests the steady somatic growth of the embryos during mid-late pregnancy is dependent upon the placental transfer of nutrients rather than yolk stores. This pattern of placental nutrient support may determine offspring body size at birth and, therefore, offspring fitness in *P. entrecasteauxii*.

Macro-stress: Developing and testing predictions to evaluate glucocorticoid stress response variation in vertebrates

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Natural and human disturbances are pervasive in the animal world. How animals respond to stressful disturbances has a major bearing on their survival, reproduction, range distributions and even extinction proneness. Yet animals exhibit remarkable variation in their physiological capacity to respond to and endure stress. The Hypothalamic-Pituitary-Adrenal axis via release of glucocorticoid hormones is a key component for how animals respond to and adapt to stress. This project aims to test specific predictions that could underpin variation in the glucocorticoid stress response of reptiles and birds. The predictions extend the concepts provided by two contemporary individual based stress theories: 1) the Allostatic and 2) Reactive Scope models to among species variation in stress hormones. These models suggest that stress responsiveness of organisms should be related to reconciling homeostasis in response to "energetic" and "wear and tear" factors that are specific to species and their environment. Phylogenetic independent generalised least square models incorporating species specific traits and associated measures of environmental stress pervasiveness were competed to evaluate their relationship to variation in species glucocorticoid stress responsiveness. The results indicated a number of potential factors correlated with differences in stress responses. Further stress related research is needed to identify and even manipulate physiological tolerances of animals to current and future environmental challenges (eg. climate change).

Interpreting indices of physiological stress in free-living vertebrates

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When vertebrate physiological ecologists use the terms 'stress' or 'physiological stress', they typically mean the level of hypothalamus-pituitary-adrenal (HPA-) axis activation. Measurements of stress hormone concentrations (e.g. glucocorticoids in blood, urine or faeces), leukocytes (e.g. the neutrophil-lymphocyte ratio or heterophil equivalent), immunocompetence (e.g. innate, cell-mediated or humoral immunity measures) and regenerative anaemia (e.g. mean erythrocyte volume and red blood cell distribution width) have all been used to estimate HPA-axis activity in free-living vertebrates. Stress metrics have provided insights into aspects of autecology or population regulation that could not easily have been obtained using other indices of population wellbeing, such as body condition or relative abundance.

However, short- and long-term stress (often problematically termed acute and chronic stress, respectively) can interact in unpredictable ways. When animals experience trapping and handling stress before tissue, faeces and/or urine is sampled, the interaction of short- and long-term stress can confound interpretation of the data, a fact not always acknowledged in studies of stress in free-living vertebrates.

This talk briefly examines how stress metrics can be confounded when estimates of HPA-axis activation are collected for free-living vertebrates and outlines some approaches that can be used to help circumvent the influence of potentially confounding factors.

Vision and Innovation in Biology Education (VIBEnet)

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Biology includes a broad group of approaches to studying the natural world, from the molecular to the whole ecosystem scale. The explosion of content in the biological sciences requires educators and students to select and focus on the big ideas that are the core concepts of our discipline. Biology educators therefore need to develop an integrated vision of the knowledge and skills needed to equip students for study in the life sciences. We hear repeated calls for future graduates to have an understanding of inter- and multidisciplinary approaches as well as flexible and rigorous computational and modeling skills to deal with a complex world. What, then, are the current priorities for biology education in Australia? What should a graduate of biology know, understand, and be able to do? We successfully applied for ALTC funding to support the development of a Discipline Network for Biology. Our project aims to create a national identity and network (VIBEnet) of university biology educators. Our priorities include developing a set of Biology Threshold Learning Outcomes; mentoring the next generation of biology educators; and creating a Vision and Innovation Statement that reflects our collective understanding about the direction of the biology curriculum. This presentation will outline the scope of the project and show how you can be involved.

Environmental constraints on oviparity and viviparity

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The transition from egg-laying to live-bearing is one of the most ecologically significant life history changes. It has occurred with high frequency in squamate reptiles in strong association with cold climates. Although a number of explanations for this environmental association have been proposed and empirically tested, the selective benefits of the transition to viviparity in cold climates are not fully understood. This reflects in part the logistical constraints of empirical tests, which are typically limited in spatial and temporal extent. Mechanistic niche modeling using gridded climatic and terrain data provides an alternative approach to assessing the environmental constraints and consequences of oviparity and viviparity. We applied an integration of the Dynamic Energy Budget (DEB) theory and the Niche Mapper biophysical modeling package to simulate the consequences of oviparous and viviparous reproduction as a function of environmental gradients across Australia. Specifically, we simulated environmental constraints on egg development at different depths, shade levels and oviposition dates as well as the environment experienced by the eggs are simulated to be within a thermoregulating mother (i.e. viviparity). We illustrate the impacts of these different scenarios across Australia in terms of relative development rates, temperature extremes experienced, and annual clutch frequency.

Altitudinal variation in the performance traits of the spotted skink

Niveoscincus ocellatus

Luh P.E. Kusuma Yuni**, S.M. Jones., E. Wapstra

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Lizards are ectotherms, so their performance is strongly influenced by temperature. Conspecific lizard populations occurring along an altitudinal gradients therefore offer an excellent opportunity to study the potential physiological tolerances of animals to climate change. This study investigated whether the different climatic conditions experienced along an altitudinal gradient affect the optimal temperature (T_{opt}) and the thermal performance breadth (B_{80}) for key performance traits in the spotted skink *Niveoscincus ocellatus.* T_{opt} varied along the altitudinal gradient. The higher T_{opt} for performance of the low-altitude and mid-altitude populations may reflect the higher mean temperatures experienced by these populations under natural conditions. The high-altitude population had a wider B_{80} which probably reflects the greater variation in environmental temperature experienced by this population. The lower bound of the performance breadth showed significant geographic variation but the higher bound remained consistent among populations. Geographic variation in the lower bound reflects adjustment of performance at lower temperatures, which suggests a potential adaptation to cold temperatures in high altitude population. This result also suggests that there is a reduced performance capacity at higher temperatures. *Niveoscincus ocellatus* therefore shows local differences in physiological tolerances that allow this species to inhabit different climatic zones along an altitudinal gradient. The low-altitude populations with narrower B_{80} and living closer to their T_{opt} may be constrained by warming temperatures. Conversely, the high-altitude population that has a broader thermal tolerance may better tolerate a warming climate.

Contrasting Metabolic Theories: divergent explanations, parallel predictions

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Body-size dependent scaling of metabolic traits - such as biomass turnover, life expectancy, growth rate, or reproductive output - is an area of comparative physiology that has fascinated biologists for over a century. On the search for universal mechanisms that appear to be constraining the evolution of organisms across all size-scales, a suite of different metabolic theories have emerged. However, as more and more theories attempt to explain the pervasiveness of body-size scaling relationships it is increasingly apparent that similar predictions can emerge from theories founded on very different assumptions of the underlying mechanisms and processes at work. Assessing different frameworks in relative terms is one way forward in the development of the field of metabolic theory. The process of contrasting theories and highlighting where predictions overlap and diverge makes model differences explicit, reveals relative strengths and weaknesses, and provides a benchmark to assess usefulness. However, this has rarely been attempted in the context of metabolic theories. In this talk we a present a comparison of two very widely used theories that are seldom discussed in detail together - the West, Brown and Enquist nutrient supply model and Kooijman's Dynamic Energy Budget theory – exposing divergent predictions amid startling similarities.

Physiological consequences to elephant sharks (*Callorhinchus milii*) of capture and handling in fishing gear

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In southern Australia, the elephant shark population has been severely depleted by fisheries, which also release a large number of this species alive after capture, because of bag limits and quotas. Elephant sharks are a sensitive species that can easily be traumatized by fishing gear and handling, which can cause severe physiological stress which can lead to delayed mortality. Our objective was to investigate some physiological consequences of capture to elephant sharks and to determine their post-release survival. To monitor the condition of the animals after stress-related capture and handling, we simulated capture for 4h in gillnet and longline under laboratory conditions and obtained repeated blood samples during 72h post-stress (recovery period). We also obtained a single blood sample from animals after angling capture. To determine possible effects of repeated handling and sampling, a control group didn't experience capture in fishing gear. We found elevated plasma lactate concentration to be a good indicator of stress after gillnet and longline capture and also after handling and sampling for the control group, returning to baseline after the recovery period. No animals died after simulated capture. Plasma lactate was very low after angling capture probably because of the short time of capture and a delayed plasma lactate peak that could not be detected with only one blood sample. The results showed that stress-related handling and blood sampling caused physiological changes on elephant sharks which were aggravated by capture in fishing gear. Elephant sharks needed more than 12h to recovery from the physiological stress.

Locust breathing patterns in hyperoxia do not support the oxidative damage hypothesis

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The discontinuous gas exchange cycle (DGC) displayed by some insects has variously been interpreted as a mechanism to reduce oxidative damage, reduce respiratory water-loss, or to indicate a change in respiratory control during periods of quiescence. Of these hypotheses, the oxidative damage hypothesis ascribes an adaptive significance to the low tracheal oxygen partial pressures (PO_2 ~2-5 kPa) that occur periodically during the DGC, since low PO_2 may reduce the production of damaging oxygen free-radicals. Assuming oxygen-guarding is the primary role of the DGC, then tracheal PO_2 should be regulated at low levels even in hyperoxia. In contrast, the water-loss and respiratory control hypotheses do not require the maintenance of tracheal hypoxia. The observation that diapausing moth pupae regulate their tracheal PO_2 at ~5 kPa during much of their DGC, even in hyperoxia (PO_2 < 50 kPa), supports the oxidative damage hypothesis. To test the generality of this observation in non-diapausing insects, we implanted fibre-optic oxygen optodes within the tracheal systems of adult migratory locusts *Locusta migratoria* exposed to hyperoxia and hypoxia. In hyperoxia the minimum tracheal PO_2 achieved during a DGC increased in parallel with ambient levels, increasing to 30.1 kPa in 40.5 kPa. In normoxia and hypoxia, the minimum tracheal PO_2 varied between 3.4 and 1.2 kPa. The differences in respiratory behavior between locusts and moth pupae in hyperoxia can be explained by differences in tracheal volume. Thus, these results are consistent with a respiratory control mechanism that functions to prevent tracheal hypoxia, not guard against hyperoxia.

Effects of temperature on sloughing frequency in frogs and implications for the regulation of cutaneous microbial loads

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Amphibian populations worldwide are currently experiencing unprecedented declines due to the effects of emerging infectious diseases and climate change. The skin represents the first line of defence in preventing establishment of pathogens and associated infections. This study assessed the role of sloughing in regulating cutaneous microbial loads in the Green Tree frog (*Litoria caerulea*) and determined the effects of temperature on sloughing frequency and cutaneous microbial growth. We found that cutaneous bacterial populations were significantly reduced by sloughing events. Additionally, temperature was found to have a significant effect on sloughing periodicity, with frogs at 23 – 33^{o}C sloughing almost twice as frequently as those maintained at 13 – 23^{o}C. The length of the intermoult interval, however, remained constant over time, suggesting that sloughing frequency is not subject to thermal compensation. To examine the combined effect of temperature and sloughing frequency upon microbial communities, bacterial loads over the course of an intermoult interval were quantified. Frogs within the cooler temperature treatment with an extended intermoult interval showed an increasing trend in microbial abundance over time, whereas frogs within the warmer temperature tightly regulated microbial loads. These findings expand upon our knowledge regarding the regulatory effects of sloughing on cutaneous microbes, and may have implications for understanding regulation of skin-based diseases.

Thermal and Hygric Physiology of Australian burrowing mygalomorph spiders (*Aganippe* spp.)

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Mygalomorph spiders are of high conservation value as many are short-range endemics. This study investigated the metabolic (SMR) and water loss (EWL) responses of three Australian trapdoor-constructing mygalomorph spider species (*Aganippe* sp. nov. 'Tropicana A', *A.* sp. nov. 'Tropicana B' and *A. rhaphiduca*) to acute environmental regimes of temperature (T_a) and relative humidity (RH). The SMR of all species increased generally with increasing T_a. The SMR of *A. raphiduca* (mesic-dwelling) was not higher across the T_a range than either of the Tropicana species (arid-dwelling). EWL was significantly higher at incurrent RH lower than 100%, and these data suggest that EWL in mygalomorphs are more susceptible to influences of ambient RH than T_a. Mesic species had significantly higher EWL across the Ta range than the arid species. This suggests an environmental effect, implying that EWL is a more heavily selected evolutionary factor than SMR. These data indicate that mygalomorphs are highly vulnerable to desiccation at any ambient RH lower than saturation, and the burrow microclimate provides a crucial refuge in ameliorating the effects of the environment upon the spider. As a result, we conclude that they are highly susceptible to the effects of disturbance, especially the local environmental changes that might result from mining activity. It is imperative that fragility of these mygalomorph species is considered with regard to conservation management.

Reproductive physiology of the Tasmanian echidna *Tachyglossus aculeatus setosus*

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The short-beaked echidna (*Tachyglossus aculeatus*) is one of only three monotremes (egg-laying mammals) and hence reproduction is the most interesting feature of its life history. However, due to its cryptic nature and the limited success of captive breeding, much of the echidna's reproductive biology remains unknown. In Tasmania, the echidna breeding season follows an annual period of hibernation. Male echidnas emerge from hibernation one month before females (which reflects the time required for the completion of spermatogenesis) and often enter females' hibernacula and mate with females that are still hibernating. The majority of females in our population become pregnant before or just prior to ending hibernation. A major focus of this study was the relationship between hibernation and reproduction. I used a multidisciplinary approach (endocrine analysis, cytology and ultrasonography) to examine the female oestrous cycle and changes in male reproductive physiology (in particular, the change in size of testes and crural glands) over multiple breeding seasons in wild free-ranging Tasmanian echidnas (*T. a. setosus*).

Vitamin D Receptor (*VDR*) Polymorphisms (*Fok*1 and *Bsm*1) and Breast Cancer Risk in Pakistani Population

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Recent biological and epidemiological data propose that *VDR* polymorphisms may modulate the breast cancer risk. Most of these studies have been carried out in Caucasians and few among Asians, however with inconsistent results. Since nothing is known in Pakistan, a country with one of the high rate of breast cancer in that region, we conducted a hospital-based case-control study to investigate the association of two frequently analyzed *VDR* polymorphisms (*Fok*1 and *Bsm*1) with breast cancer. 131 breast cancer cases and 131 age- and ethnic-matched controls were recruited at the SKMCH & RC in Lahore, Pakistan. Clinical and pathological data as well as blood samples for the isolation of genomic DNA were collected. Genotyping of *Fok*1 and *Bsm*1 polymorphisms was performed using a polymerase chain reaction-based restriction fragment length polymorphism analysis. Allele frequencies were determined and p value was calculated using Chi square test for Hardy Weinberg equilibrium. The mean age of cases and controls was 28.6±4.3 years and 28.5±4.4 years, respectively (p=0.87). *Fok*1 and *Bsm*1 were not found to be associated with breast cancer risk (p=0.52 for the *ff* genotype; p=0.45 for the *bb* genotype). However, when compared with other populations, the allele frequencies of *Fok*1 (*f* and *F*) and *Bsm*1 (*b* and *B*) differ in our population supporting the evidence of ethnic variation among populations. Our findings show no association of *Fok*1 and *Bsm*1 polymorphism with breast cancer in Pakistani population suggesting the involvement of other genetic factors. Additional larger studies with inclusion of vitamin D levels are warranted.

Non-invasive amphibian endocrinology: a new tool for fundamental biology and ecological research

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Traditionally, blood hormone analyses have been used by wildlife physiologists to assess reproductive hormone cycles and physiological stress responses of animals. Non-invasive sampling, especially the use of urine samples, offers a more practical method to assess breeding cycles and stress physiology in amphibians. It can also provide a useful tool for exploring basic questions in amphibian physiology and behaviour. Here, we present applications of urine hormone methods to address questions in amphibian endocrinology. We explored the stress physiology of Fiji's only two native frogs of the *Platymantis* genus, the abundant cane toad (*Rhinella marina*) and some native Australian frogs including the Stony Creek frog (*Litoria wilcoxii*) and the Great Barred frog (*Mixophyes fasciolatus*). Our research was established with the non-invasive measurement of reproductive and stress hormones in captive and wild native Fijian ground frogs (*P. vitiana*), which provided data for its successful captive breeding program. Urinary corticosterone enzyme-immunoassay (EIA) was applied and biologically validated using adrenocorticotropic hormone (ACTH) challenges in *P. vitiana*, *R. marina*, *L. wilcoxii* and *M. fasciolatus*. Baseline and short-term stress responses of *P. vitiana* and the Fiji tree frog (*P. vitiensis*) provide new information on the seasonality of stress responses in amphibians. Individual variation and repeatability in corticosterone responses of amphibians to short-term capture and captivity were examined in Cane toads. Recently, our research has extended to field endocrinology studies, with a study that demonstrated an ethical cost associated with toe-clipping in amphibians. These studies clearly demonstrate the value of non-invasive endocrine approaches in amphibian endocrinology.

Comparative physiology of the Australian water rat (*Hydromys chrysogaster*)

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The Australian water rat (*Hydromys chrysogaster*) is a large, semi-aquatic rodent found throughout Australia and New Guinea. We used open-flow through respirometry to measure standard physiological variables (metabolic rate, body temperature, evaporative water loss and thermal conductance) of six water rats captured in the south west of Western Australia. Semi-aquatic rodents in general have a significantly higher BMR than terrestrial rodents, presumably reflecting a greater metabolic capacity for heat production in an aquatic environment. However, basal metabolic rate of the water rat was 0.58 ± 0.04mL O_2 $g^{-1}h^{-1}$, which was as predicted (100.5%) for a 635.83 ± 54.83g rodent. Standard T_b (35.3 ± 0.28°C) and EWL (0.87 ± 0.08 mg H_2O g^{-1} h^{-1}), also conformed to predicted values for rodents, being only 1.68°C lower than, and 111.2 % of, allometrically predicted values respectively. Minimum C_{wet} was 0.04 ± 0.003 mL O_2 g^{-1} h^{-1} $°C^{-1}$, and was 106.8% of predicted. Behavioural adaptations to a semi-aquatic habitat may be more significant than physiological adaptions for the water rat.

Xenobiotic metabolism by the Malpighian tubules of insects, a new hepatic function

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Recent genetic evidence showing a high expression of genes for detoxification enzymes such as Cytochrome P450, suggest that the Malpighian tubules may be capable of significant detoxification of xenobiotics. However this detoxification ability has yet to be demonstrated biochemically. The study examined how the model organic compound, morphine, was metabolised as it was transported across the cells of the Malpighian tubules from model flies, *Drosophila melanogaster, Calliphora stygia* and *Calliphora vicina*, as well as the Coleopteran *Tenebrio molitor*. This displays a novel hepatic function in addition to the tubule's well characterised excretory and osmoregulatory functions. Morphine was collected from the insects and analysed using high performance liquid chromatography (HPLC) with chemiluminescence detection, and HPLC/ mass spectroscopy. The resulting chromatograms indicated that morphine was metabolised by the Malpighian tubules into different metabolites. The Malpighian tubules of Dipterans metabolised morphine into 3 metabolites: the major metabolite was an unknown metabolite with a molecular weight of 330, in addition to normorphine and morphine sulphate. The Malpighian tubules of *T. molitor* predominantly metabolised the morphine into morphine sulphate; normorphine and morphinone were also detected. Further examinations were made into the enzymatic pathways of the tubule that would allow for the transport of morphine, permitting the insect to remove the toxin from its haemolymph, and prevent effects on growth rate and behaviour.

Female hormones: Can a female lizard have too much of a good thing?

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Many chemical contaminants have been reported to interfere with the endocrine system in both vertebrates and invertebrates. One of the most potent EDCs is the triazine herbicide atrazine. Atrazine increases circulating concentrations of oestradiol, causing feminization in amphibians, oviparous (egg-laying) reptiles, fish, birds and cultured human cells. To date, no study has assessed the potential impacts of EDCs on viviparous (live bearing) reptiles. Viviparous reptiles support embryonic development via both a placenta and, usually, a large yolk. They are therefore of particular interest because there are several potential routes through which embryos may be exposed to chemical contaminants, including yolk contamination, direct maternal transfer via the placenta and altered placental function. *Niveoscincus metallicus*, a Tasmanian viviparous lizard, is an ideal model species with which to assess the impacts of atrazine on viviparous reptiles as the species' reproductive physiology and endocrinology are well understood and it uses both yolk and placenta to nourish its embryos. Pregnant lizards were exposed to a single dose (at 10µg/kg) of atrazine, during the early stages of embryonic gonad development; control groups received placebo or no treatment. Atrazine did not affect the duration or success of pregnancy and gross morphology of offspring appeared phenotypically normal, however, gonads from female neonates born of atrazine-treated mothers exhibited ovaries with overt abnormalities such as polyovular follicles. These results suggest that atrazine has affected sexual differentiation via endocrine disruption.

The physiological birth of Atlantic salmon:

A focus on metabolic rate, hypoxia induced hatching and the effects of egg size

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In some vertebrates, hatching is triggered by low environmental oxygen levels (hypoxia), i.e. low partial pressures of oxygen (PO_2). The physiological mechanisms underlying hypoxia induced hatching have not been fully resolved. Here, we investigated the metabolic response of Atlantic salmon eggs and newly hatched yolk sac alevins to hypoxia at 8°C and the maternal effect of differences in egg size. We furthermore elucidate how metabolic rate ($\dot{V}O_2$) is altered during hatching under hypoxic conditions. In eggs and yolk sac alevins, acute hypoxia induces metabolic depression, the depression being greater the more severe the hypoxia. At all PO_2, the $\dot{V}O_2$ of yolk sac alevins remains proportionally higher (2x) than of eggs. Eggs show a decrease in mass specific $\dot{V}O_2$ with increasing mass, while yolk sac alevins show no mass dependent differences in $\dot{V}O_2$. Hatching was observed at an average critical PO_2 of ~14%. The $\dot{V}O_2$ of these newly hatched yolk sac alevins was maintained constant as the PO_2 decreased; reducing the difference in $\dot{V}O_2$ in comparison to yolk sac alevins. These results are indicative for improved pathways of O_2 delivery and/or changes in O_2 demand during hatching that enable the newly hatched alevin to increase its $\dot{V}O_2$ in comparison to the egg. Mass specific differences in $\dot{V}O_2$ in eggs are likely due to increasingly hypoxic perivitelline fluids, serving as an O_2 diffusion barrier towards the embryo that is absent in the alevins. When hypoxia induces hatching, it occurs below a critical PO_2 where the oxygen demand can no longer be accommodated.

Influence of salinity on the expression and distribution of ion transporters in the gills of the bull shark (*Carcharhinus leucas*)

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The bull shark (*Carcharhinus leucas*) is one of the few species of elasmobranchs that lives in both marine and freshwater environments. Euryhaline species face significant physiological challenges associated with movement between seawater and freshwater, due to the large changes in osmotic and ionic gradients between internal body fluids and the external medium. The mechanisms allowing euryhaline elasmobranchs to maintain ionic homeostasis between seawater and freshwater are not entirely clear. In teleost fishes the gills are well known to be the principal site for active salt excretion and uptake. By comparison, little is known regarding the mechanisms of ion transport in the gills of elasmobranchs and how they are affected by osmoregulatory challenges. We evaluated gill ion-regulatory mechanisms in *C. leucas* by identifying putative ion-transporters (Na^+/K^+ -ATPase, Na^+/H^+ exchanger 3, H^+ -ATPase and anion exchanger pendrin) and determining whether their gene expression is influenced by environmental salinity. Using antibodies, Na^+/H^+ exchanger 3 and pendrin were localised to the apical surface of gill epithelial cells that expressed basolateral Na^+/K^+ -ATPase and H^+ -ATPase, respectively. Quantitative PCR was then used to demonstrate that gene expression levels of Na^+/K^+ -ATPase and Na^+/H^+ exchanger 3 were increased in *C. leucas* captured from freshwater relative to seawater-captured sharks. We suggest that Na^+/H^+ exchanger 3 and Na^+/K^+ -ATPase may be important for Na^+ uptake when bull sharks are resident in freshwater, whereas pendrin and H^+ -ATPase could contribute to branchial Cl^-/HCO_3^- exchange in *C. leucas*.

Applying Dynamic Energy Budget (DEB) theory to kangaroo energetics

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Metabolic theories formally quantify how animals acquire, use, and allocate energy and other materials in a mechanistic and parameter sparse manner. These models are constrained by the laws of thermodynamics and provide a framework for understanding ecological processes beginning at the level of the individual. Dynamic Energy Budget (DEB) theory is one such approach which links food availability with an organism's maintenance, development, growth, and reproduction across its lifespan. Unlike the more commonly applied 'static' energy budgets, Dynamic Energy Budget theory considers the flow and allocation of energy continuously as the organism grows through ontogeny. We discuss some challenges of applying DEB theory in the case of income breeding mammals, including the processes of pregnancy and lactation, using kangaroos as an example. We then assess the capacity for DEB theory to predict energetics of kangaroo species in the context of varying nutritional and climate environments as well as interspecific changes in body size.

Reproduction in the male Tasmanian Pademelon (*Thylogale billardierii*)

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The Tasmanian Pademelon, *Thylogale billardierii,* is a common, small to medium wallaby found only in Tasmania. It is a seasonal breeder with the majority of births occurring in late Autumn/ early Winter. After a 7-month pouch life the young vacates the pouch in early summer and may be replaced by another young though this 'birth peak' is much smaller than the autumn peak. It was unclear whether this secondary peak is due to activation of the dormant blastocyst produced at post-partum mating in Autumn OR because of a summer mating and pregnancy. Rose & McCartney (1978) surmised that in all likelihood, the latter was correct as not all females carried a blastocyst throughout pouch life. To test this required knowledge of seasonal male fertility. We have measured seasonal changes in testes and prostate weight. Little seasonal change occurred in testes weight; however, two significant prostate peaks occurred with maximal weights one month before autumn births and one month before the summer birth 'peak'. This suggests males are fertile when young leave the pouch hence are able to fertilise females at that time.

Blood flow to long bones indicates activity metabolism in mammals, reptiles and dinosaurs

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The area of a nutrient foramen of long bones is related to blood flow requirements of the internal bone cells that are essential for dynamic bone remodelling. Greater stress during locomotion is associated with more micro-fractures, intensified remodelling and blood flow rate. Foramen area increases with body size in parallel among living mammals and non-varanid reptiles, but is significantly larger in mammals. An index of blood flow rate through the foramina is about ten times higher in mammals than in reptiles, and even higher if differences in blood pressure are considered. The scaling of foramen size correlates well with maximum whole-body metabolic rate during exercise in mammals and reptiles, but less well with resting metabolic rate. This relates to the role of blood flow associated with bone remodelling during activity. Mammals and varanid lizards have high aerobic metabolic rates and exercise-induced bone remodelling, while non-varanid reptiles are the opposite. Foramina of ten species of dinosaur from five taxonomic groups are generally larger than from mammals, indicating a routinely highly active and aerobic lifestyle. The simple measurement holds possibilities to assess other groups of extinct and living vertebrates in relation to body size, behaviour and habitat.

Resting and maximum metabolic rate during tethered-flight in the adult locust *Locusta migratoria*

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Flying insects achieve the highest mass-specific aerobic metabolic rates of all animals. However, few studies have attempted to maximise the metabolic cost of flight and so many estimates could be sub-maximal, especially where insects have been tethered. To address this issue, oxygen consumption was measured during tethered-flight in adult locusts *Locusta migratoria*, some of which had a weight attached to each wing (totalling 30-45% of body mass). Metabolic rates increased from 28 $\pm$ 2 μmol O_2 g^{-1} h^{-1} at rest, to 896 $\pm$ 101 during flight in weighted locusts, and 1032 $\pm$ 69 in unweighted locusts. Allometrically, tethered-flight metabolic rate of locusts follows the equation, MMR = $994M_b^{0.75 \pm 0.19}$ μmol O_2 h^{-1}, whereas published metabolic rates of moths and bees during free-flight is approximately 2.8-fold higher, MMR = $2767M_b^{0.72 \pm 0.08}$. The modest flight metabolic rate of locusts is unlikely an artefact of individuals failing to exert themselves because mean maximum lift was 90 $\pm$ 14% of body mass and mean wing-stroke frequency was 23.9 $\pm$ 0.8 Hz, which are close to free-flight values. Instead, the low cost of flight could reflect the relatively small size of the locust flight motor, which probably minimises weight and energy costs, while still delivering enough power for forward-flight.

Influence of incubation temperature on physiological, morphological, and behavioural phenotypes of Japanese quail (*Coturnix japonica*)

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There is emerging evidence that incubation temperature can influence offspring phenotype in birds, with suggested immune and behavioural consequences. Most studies, however, are limited in the type and number of traits that they measure. We incubated fertilized eggs of Japanese quail, *Coturnix japonica*, to temperatures 1°C above and 1°C below the optimal 37.5°C to examine the effect of thermal history on incubation period, hatching success, growth rate, stress sensitivity, immune performance, and behaviour. In terms of behaviour, chicks incubated at 36.5°C were more reactive in an open field test and displayed enhanced locomotor activity. Incubation temperature also significantly affected time to hatching as well as magnitude of inflammatory response to subcutaneous injection of phytohaemagglutinin. Despite small differences in growth rates, hatchling mass and final body mass and size were unaffected by incubation temperature, as were adaptive immunity (as measured by antibody response to novel antigens) and stress sensitivity (as measured by extent of corticosterone secretion during capture-handling).

The lack of incubation temperature effects on overall immunity and stress sensitivity in quail differs from previous studies of passerine birds and ducks. One major difference between these studies, however, is that all other species examined nest within cavities or fully enclosed nests, whereas quail are open-ground nesters. Thus quail are likely to experience larger thermal excursions, perhaps selecting for reduced thermal sensitivity of trait expression in their embryos compared to those of cavity-nesting species.

The ecological significance of dormancy: torpor, survival and life-histories of mammals

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A wide range of mostly small mammals can drastically reduce their resting energy costs by entering bouts of torpor. Ecophysiologists have long been fascinated by the thermal physiology of torpor, but its ecological significance has been somewhat overlooked. Mammals that can use torpor seem to be less vulnerable to extinction, for example, compared to strictly homeothermic species: of the 61 recently extinct mammals, only four probably were heterothermic. In extant hibernating species, monthly survival probability is much higher during winter compared to active season. We argue that hibernation has evolved as a strategy not solely for energy savings but to facilitate seasonal dormancy, which allows small mammals to cease activity and evade predation when conditions are unsuitable for reproduction. Hibernating species also have greater *annual* survival rates compared to non-hibernating species, and furthermore, small hibernating species generally have longer maximum lifespans, slower rates of reproduction and mature at older ages compared to similar-sized non-hibernators. Thus, like other mammalian groups with traits that enhance survival (e.g. bats), small hibernating mammals have evolved a suite of co-varying traits that is indicative of a relatively slow life history.

Bigger, fitter, faster: ontogenetic trade-offs in developmental rate and body size of the spider, *Morebilus plagusius.*

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Temperature is one of the main factors that influence fitness-related processes like growth, developmental rates and ultimately reproduction in ectotherms. For nocturnal ectotherms, temperatures experienced are limited to the thermal environment available within their diurnal retreats. Flat rock spiders, *Morebilus plagusius,* use exfoliated rocks on sandstone outcrops as diurnal retreats. We surveyed the thermal and physical properties of retreat rocks being used by different ontogenetic stages and found juveniles were able to occupy a smaller subset of rocks than those used by adults. Smaller rocks are hotter, do not retain their heat as long and experience more rapid temperatures changes than larger rocks. We investigated the impacts of 5 constant temperature regimes on egg sac success, developmental rate, body condition, body size and survival. Eggsac success and survival was highest at 28°C. No eggsacs were successful at 14, 35 or 42°C. Developmental rates were faster at 28 and 35°C, however juveniles were larger and had better body condition at 21°C. We thus show that a thermal trade off exists between developmental rate, body size and body condition. Our results show that the type of retreat rock juvenile flat rock spiders occupy will affect life history and fitness-related processes. As retreat rocks are limited on the outcrops, this should increase competition between developing flat rock spiders.

Are all athletes 'created' equal? Aerobic features of the muscles of kangaroos, rat-kangaroos and athletic placental mammals

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In extensive studies of placental mammals, it has been shown that allometric variations in aerobic capacities are correlated with variation in structural and functional aspects of the cardiorespiratory system. Variation in maximal oxygen consumption (VO_2max) is tightly associated with the aerobic capacity of the locomotor muscles, with the scaling exponents for VO_2max, the total volume of mitochondria, and the volume of capillaries being very similar. In more athletic species VO_2max is tightly linked to a proportionally larger total mitochondrial and capillary erythrocyte volumes in animals of the same size. We performed comparable studies on red kangaroo and brush-tailed bettong (rat-kangaroo) skeletal muscles. In the red kangaroo, total skeletal muscle mass was around 50% of body mass, and the majority of the muscles sampled had relatively high mitochondrial volume densities (8.8-10.6%) in the major locomotor muscles. In the brush-tailed bettong, muscle mass was 44% of body mass and mitochondrial volume densities in the major locomotor muscles were similarly high (7.1-11.9%). In both species, the relationship between total mitochondrial and capillary volumes in skeletal muscle and VO_2max during exercise was identical to that in quadrupedal placentals. Despite their hopping mode of locomotion and extreme body form, the kangaroos and rat-kangaroos present characteristics equivalent to those seen in the most athletic placental mammals, such as dogs and pronghorns. These results suggest that fundamental aerobic/muscular relationships may be common to both marsupials and placentals and that the evolution of such metabolic relationships predates the divergence of the therian groups in the Jurassic.

Metabolic cold adaptation in fish occurs at the level of whole animal, mitochondria, and enzyme

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Metabolic cold adaptation (MCA), the hypothesis that species from cold climates have relatively higher metabolic rates than those from warm climates, was first proposed nearly 100 years ago and remains one of the most controversial hypotheses in physiological ecology. In the present study we test the MCA hypothesis in fish at the level of whole animal, mitochondria, and enzyme. When normalised to a common temperature, species with ranges that extend to high latitude (cooler climates) have high aerobic enzyme (citrate synthase) activity, high rates of mitochondrial respiration, and high standard metabolic rates. Metabolic compensation for the global temperature gradient is not complete, however, so when measured at their habitat temperature species from high latitude have lower absolute rates of metabolism than species from low latitudes. Evolutionary adaptation and thermal plasticity are therefore insufficient to completely overcome the acute thermodynamic effects of temperature, at least in fish.

Phenotypic plasticity of the gastrointestinal tract in king quail (*Coturnix chinensis*): Fibre content or decreased nutrients?

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Changing organ size (phenotypic plasticity) is one strategy used by animals to cope with fluctuations of resources in the environment. This study examines the phenotypic plasticity of king quail (*Coturnix chinensis*) using a fibre-manipulation feed trial. Quail were offered either a control low-fibre food (8% neutral-detergent fibre; NDF), or one of two experimental diets which were higher in fibre content, containing approximately 15% NDF. Additionally one of the experimental diets was balanced with extra nutrients (HFB) to match the protein and energy contents of the low-fibre control, and the other unbalanced (HFU). Half of the quail then remained on their treatment diet for 14 days (period 1), the other half remained on the treatment diet for 28 days (period 2). Morphometery of the gastrointestinal tract, liver and adipose tissue were observed via dissections after each experimental period. Diet had varied effects upon organs in the king quail. As a whole, the total empty wet mass of the gastrointestinal tract differed significantly with diet and period of exposure (d.f.= 3, 35; F= 6.96, p= 0.004). After 14 days, animals on the HFU diet had significantly larger guts than animals on the LF diet after 14 or 28 days. There were also significant increases in size of the crop, proventriculus, gizzard, small intestine, and caeca exhibited in animals on HFU (low quality) diet compared with LF diet. Conversely, animals on the high-fibre, but higher quality diet (HFB) diet did not exhibit the same upward regulation of the gastrointestinal tract. These results suggest that the level of nutrients in the diet is most important for eliciting phenotypic changes in the gut, and not the level of fibre in the diet *per se*. This study revealed that king quail's digestive physiology is phenotypically flexible in response to diet change.

Poster

Summer torpor use, activity patterns and roost preferences by a free-ranging inland freetail bat in the Australian arid zone

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Torpor is an integral part of the survival strategies of many insectivorous bats. However, although bats are one of the most successful groups of Australian arid zone mammals, data on their thermal biology are currently not available. Therefore, temperature radiotelemetry was used to examine the thermal physiology, torpor patterns and behaviour of 5 adult tree-roosting inland freetail bats (*Mormopterus species 3* (short penis form), 9.1g) at Sturt National Park in summer 2010/11 when insects were abundant. Bats conducted several short (64.2±9.5min) foraging bouts/night beginning ~45min after sunset and ending ~80min before sunrise. The skin temperature (T_{skin}) ranged from 12.3°C to 40.5°C. Bats used torpor when daily minimum ambient temperature (T_a) was 17.4±2.7°C; they avoided torpor when minimum T_a was >23.1±2.0°C. Bats usually employed one torpor bout/day, from near sunrise to around midday; bats were then normothermic until they commenced foraging. The mean torpor bout duration was 7.6±2.3h; the longest bout on a cool and rainy day was 38.5h. *Mormopterus* preferred roosting in crevices of dead coolabahs (*Eucalyptus coolabah*) located in open woodlands along shallow creek beds. All roost trees were hollow with multiple holes and cracks along trunks and branches suggesting that bats may prefer such perforated trees to permit convective cooling during the hot summer (maximum T_a was 42.6°C). Our study provides the first data on thermal biology of an Australian arid zone bat in the wild. It demonstrates that torpor is an important strategy for energy conservation even in summer when T_a is high and food is abundant.

Poster

Thermal and nutritional effects on offspring development and sex in a viviparous lizard (*Niveoscincus ocellatus*).

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Temperature has profound effects on offspring development and life history traits in reptiles. Our field and laboratory studies of a viviparous lizard (*Niveoscincus ocellatus*) have shown that variation in maternal basking influences birth date, sex and size of offspring. Under warm conditions in the laboratory, offspring are born earlier and larger than under cooler conditions, and there is a bias towards female offspring. Our matching field studies reveal sex ratios at birth fluctuated significantly among years and closely tracked thermal field conditions. Maternal nutritional effects on offspring development in reptiles are less well understood. *Niveoscincus ocellatus* is relatively rare amongst viviparous reptiles in having significant placentotrophy (the transfer of nutrients to offspring via the placenta) which provides the potential for adaptive manipulation of offspring phenotype through control of nutritional support during development. Our studies reveal the importance of placentotrophy, suggesting that females are able to compensate for sub-optimal nutritional conditions by manipulating offspring phenotype to best fit the postnatal nutritional environment. Thus, our laboratory and field studies show that temperature and nutrition effect offspring development in isolation, however, how temperature and nutrition will interact to affect either offspring size or sex is unknown. The latest direction of our research uses a multi-factorial approach of both field and laboratory studies to examine the interaction effects of temperature and nutrition on maternal effects including sex allocation which will disentangle some of the complexities inherent in vertebrate sex allocation research.

Poster

Stable staples: Investigating the effects of habitat on trophic position in Tasmanian ant assemblages using stable isotope analysis.

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The trophic structure of ant communities may be dependent on environmental factors including competition and resource availability. While various studies have considered the effects of these factors on trophic position within a habitat, few studies have investigated trophic responses to changes in habitat. We investigated trophic position and basal carbon source of ant assemblages from 5 distinct habitats using stable isotope analysis of ^{15}N and ^{13}C. We found significant variation in ^{15}N and ^{13}C isotope signatures across ant species and habitat. Habitat was shown to be more influential on N enrichment than species, with some species such as *Rytidoponera tasmaniensis* and *Iridomyrmex bicknelli* ranging over three trophic levels. Mean δN was highest in the improved pasture and lowest in the woodland habitat. The assemblage from C4 dominated kangaroo grassland displayed a noticible yet statistically insignificant enrichment in δC towards values of *Themeda triandra* i.e. Kangaroo grass. A lack of significance for interaction effects between species, habitat and δN suggests that intra-guild competition may be more explanatory of trophic configuration than resource availability. These results indicate that although the trophic position of ant assemblages may shift in response to resource availability, the relative positions of species within an assemblage remain consistent.

Poster

Relationship between energy reserves, and endocrine system in the immune system of male cane toad

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The purpose of this study was determine in which extend immune system is influenced by energy resources as well as by the endocrine system in amphibian. To determine these relationships, the incidence of lungworm parasites, spleen mass, energy reserves (fat deposit and plasma free fatty acids), and levels of corticosterone and testosterone, were determined in male cane toads captured from the field during reproductive season from two selected zones in Australia (Brisbane, QLD ; and Kununurra, WA) and one located in Mexico (Los tuxtlas region of Catemaco, Veracruz, Mexico). The results showed that energy reserves have a negative effect in the intensity of parasitism. In addition, levels of corticosterone and testosterone not only have a negatively effect in the levels of energy reserves but also animals with the highest levels of testosterone and corticosterone have the highest intensity of parasitism. No effect was found between spleen mass and testosterone levels but corticosterone has a negative effect in the mass of spleen.

During a host-parasite interaction the immune system is crucial to determine the endurance of the host to the infestation. Extensible studies conducted mainly in wild birds have showed that glucocorticoids and androgens have a direct effect on the ecology and evolution of host-parasite interactions, as well as in energy trade off, and the immune response. But the information regardless to this area is scarce in amphibian. Therefore this study will contribute to better understanding of the fundamental process between the relationship of energy and the immune-endocrine system in amphibian and the physiological factors involved in determine the success of a particular species and its long term survival.

Poster

Energetic performance and swimming behaviour of hatchling sea turtles during the frenzy swim

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Swimming performance influences the dispersal success of sea turtle hatchlings when they first enter the water and engage in a swimming frenzy. We simultaneously measured swim thrust and metabolic rate of loggerhead and flatback turtle hatchlings during the first 18 h of the swimming frenzy and compared it with previous data from green turtle hatchlings. Metabolic rate was correlated with swim thrust in all species. On a hatchling mass adjusted basis, swim thrust and metabolic rate was highest for green turtles, intermediate for loggerhead turtles and lowest for flatback turtles. Additionally, we analysed how swim thrust is produced in terms of powerstroke rate, mean maximum thrust per powerstroke and percentage of time spent powerstroking. Loggerhead and green turtle hatchlings had similar powerstroke rates and percentage of time spent powerstroking throughout the trial, although mean maximum thrust was always significantly higher in green hatchlings. Flatback hatchlings, however, had overall lower values in all three variables. Metabolic rate, swim thrust and its three components was similar in loggerhead and green turtles: a) sharply decreased during the first 2 hours; b) decreased less steeply until 12 hours; and c) remained relatively constant until 18 hours. Flatback hatchlings had a similar trend although all swimming variables kept significantly decreasing until the end of the trial. This finding suggests that flatback hatchlings have a different dispersal behaviour to that of loggerhead and green hatchlings and we suggest that the predator pressure in near-shore waters might shape the swimming strategy of sea turtle hatchlings during their offshore dispersal.

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