ANZSCPB CONFERENCE 2015
UNSW

Fowlers Gap

ARID ZONE RESEARCH STATION

32nd Annual Meeting
3 – 6 December 2016

PROGRAM AND ABSTRACTS

Society for Comparative Physiology & Biochemistry
Australian & New Zealand

UNSW
AUSTRALIA

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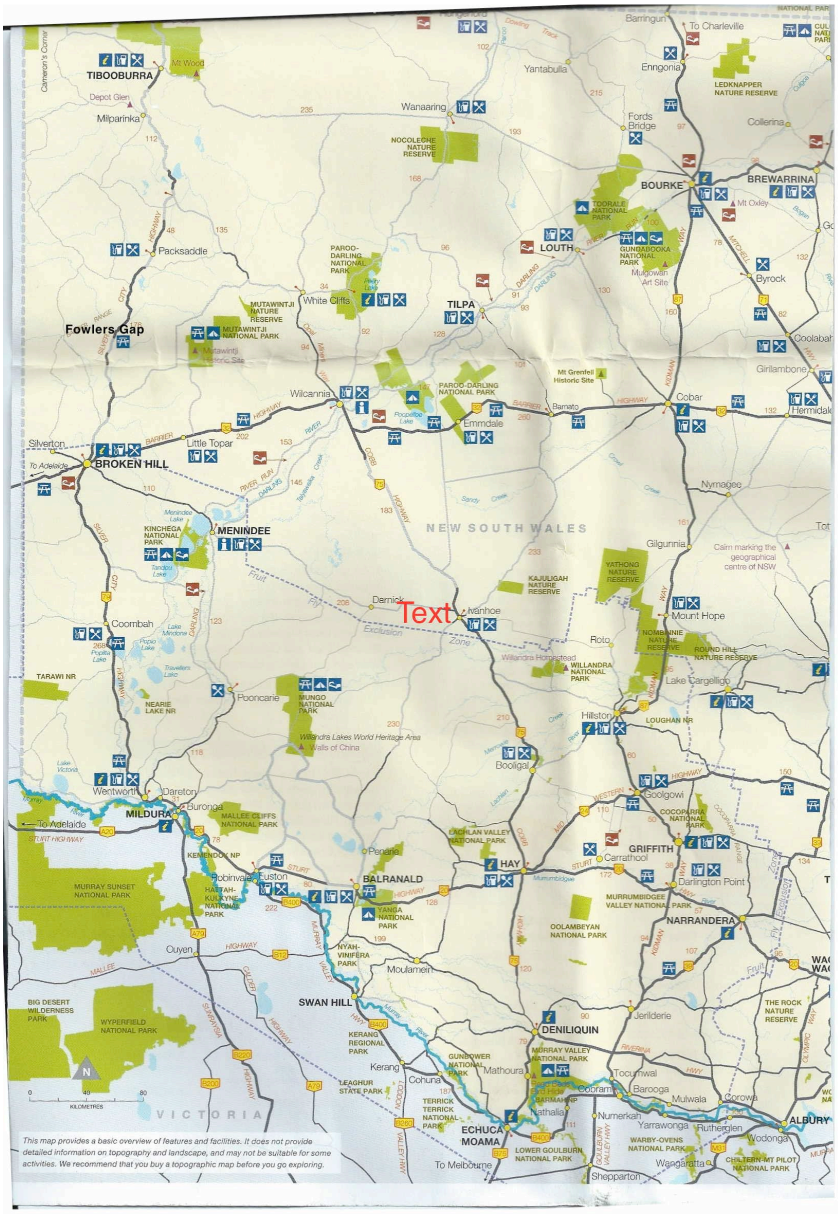
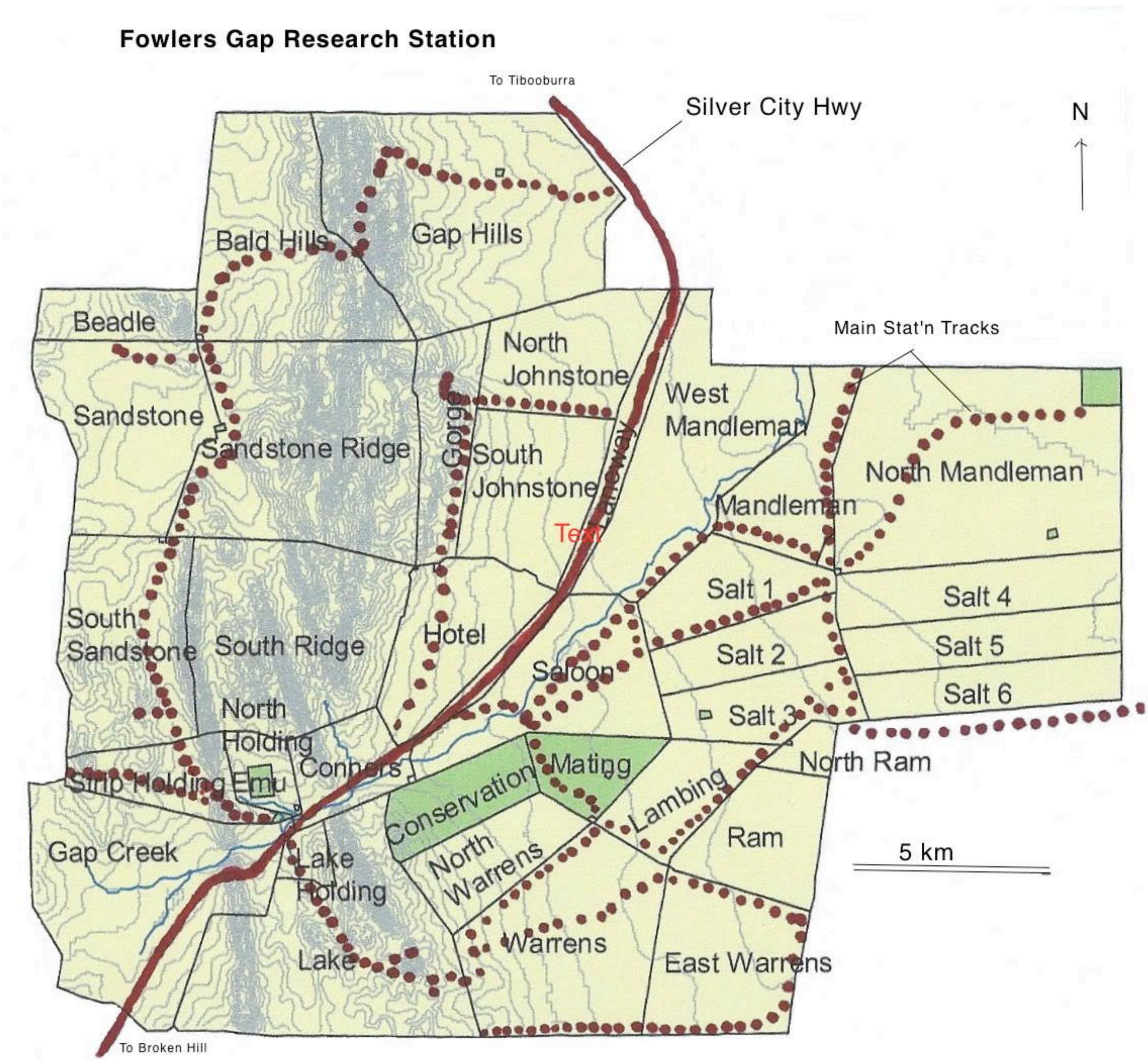
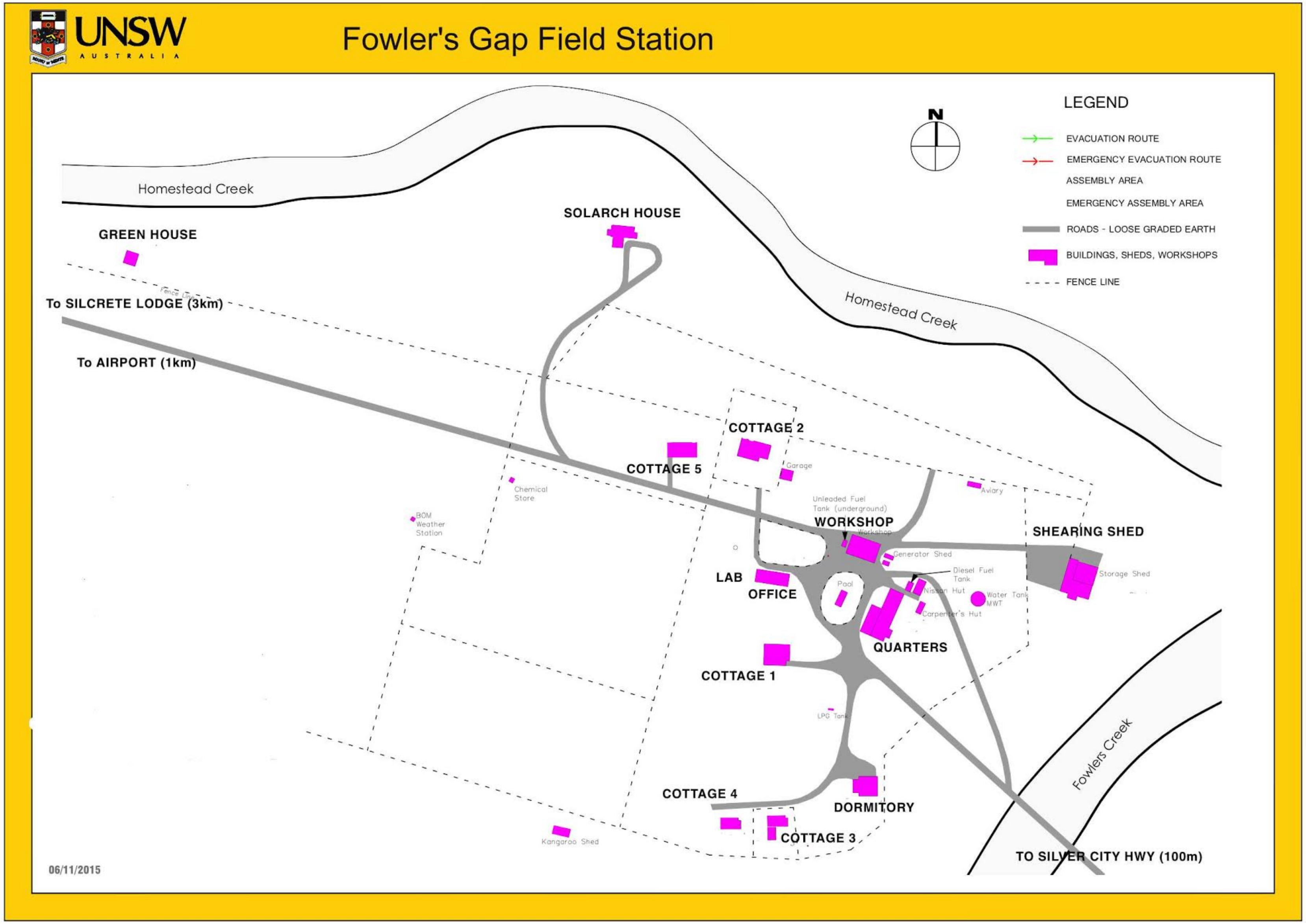
District map



Fowlers Gap Station map



Fowlers Gap residential compound map



Program Overview

PLEASE NOTE: The station operates on Central Daylight Time (the same as Broken Hill and Adelaide).

Time	Thursday 3rd December	Time	Friday 4th December	Time	Saturday 5th December	Time	Sunday 6th December
		8:45-9:00	Announcements	7:00-11:00	Sturt's Meadow excursion	8:45-9:00	Announcements
		9:00-9:45	Introduction to Fowlers Gap			9:00-9:45	Plenary presentation
		9:45-10:30	Plenary presentation			9:45-10:30	Presentations
		10:30-11:00	**MORNING TEA**	11:00-11:30	**MORNING TEA**	10:30-11	**MORNING TEA**
		11:00-12:40	Presentations	11:30-12:15	Plenary presentation	11:00-13:00	Presentations & awarding of student prizes
				12:15-12:55	Presentations		
		12:40-14:00	**LUNCH**	12:55-14:00	**LUNCH**	13:00-14:00	**LUNCH**
		14:00-15:40	Presentations	14:00-15:30	Presentations	15:00	Optional station excursions
15:00-17:00	**Registration**	15:40-16:00	**AFTERNOON TEA**	15:30-16:00	**AFTERNOON TEA**		
17:30	Welcome drinks @ Silcrete Lodge	16:00	Station tour 'tag along'	16:00-17:00	Presentations		
				17:00-18:00	AGM		
20:00	**Dinner**	**20:00**	**Dinner**	**20:00**	**Conference Dinner**	**20:00**	**Dinner**

Detailed program

Reminder: The station operates on Central Daylight Time.

Thursday 3rd December

15:00	Registration opens
17:30	Welcome drinks at Silcrete Lodge (Freislich Dam)
20:00	**DINNER**

Friday 4th December

*** indicates students eligible for prizes**

Session 1 **Chair:** Bill Buttemer	
8:45	Announcements
9:00	**Terry Dawson** An introduction to Fowlers Gap
9:45	Plenary talk: **Catharina Vendl** Comparative methane production by five non-ruminating foregut fermenting herbivore species
10:30	**MORNING TEA**
Session 2 **Chair:** Christine Cooper	
11:00	**Vanya Bosiocic*** and Roger S. Seymour Evolution of hominin brain perfusion: the holes in the fossil record
11:20	**Nicolas Martin*,** Anthony J. Hulbert, Todd W. Mitchell and Paul Else Long-live the queen: lipidomics of ageing in honey bees (*Apis mellifera*)
11:40	**Peter Derbyshire*** Cholinergic or Somatostatin Innervation: Two ways squamates might beat the heat
12:00	**Paul Else** Is Peroxidation the Key to Endothermy?
12:20	Philipp Comanns, Falk J. Esser, Werner Baumgartner, Jeremy Shaw and **Philip Withers** Skin capillary water transport by the thorny devil (Agamidae: *Moloch horridus*)
12:40	**LUNCH**
Session 3 **Chair:** Philip Withers	
14:00	**Jacinta Kong*,** Jason K. Axford, Ary A. Hoffmann and Michael R. Kearney Novel applications of thermocyclers for high-throughput phenotyping of invertebrate thermal response

14:20	**Tegan Douglas*,** Christine E. Cooper, Philip C. Withers, and Stephen J.J.F. Davies The biophysical properties of plumage for the Western Magpie *Gymnorhina tibicen dorsalis*
14:40	**Thomas Nelson*,** Edward P Snelling and Roger S Seymour Development of brain metabolism in western grey kangaroos
15:00	**W. Maartin Strauss,** Robyn S. Hetem, Duncan Mitchell, Shane K. Maloney and Andrea Fuller Comparison of the body temperature patterns of three large, arid-zone antelope
15:20	Erika E. Eto, Philip C. Withers and **Christine Cooper** Regulation of insensible evaporative water loss: Can birds do it too?
15:40	**AFTERNOON TEA**
16:00	Station Tour ‘tag along’
20:00	**DINNER**

Saturday 5th December

*** indicates students eligible for prizes**

7:00	Station Excursion: Sturt's Meadow
11:00	**MORNING TEA**
Session 4 **Chair:** Terry Dawson	
11:30	Plenary talk: **Bill Buttemer** Challenging the paradigms: lessons from studies of White-plumed Honeyeaters (*Lichenostomus penicillatus*)
12:15	**James H. Jones,** George H. Crocker and Linda S. Barter Measuring pulmonary diffusing capacity with a rebreathing method in awake animals
12:35	**Fritz Geiser,** Artiom Bondarenco and Clare Stawski Is mammalian torpor expression affected by their geographical distribution?
12:55	**LUNCH**
Session 5 **Chair:** Duncan Mitchell	
14:00	**Anna C. Doty*,** Clare Stawski and Fritz Geiser Physiological responses of heterothermic mammals to fire
14:20	**Elia Pirtle*,** Rob Hayes, Michael R. Kearney Behavioural regulation of water loss in two Australian skinks
14:40	**Edward P. Snelling,** Roger S. Seymour, J. E. F. Green, *et al.* Structure–function analysis of the left ventricle performing routine and maximum work
Speed Talks (5 minute talk plus 2 minutes for questions)	
15:00	**Mathew (Stewie) Stewart*** and Adam J. Munn Fibre-induced feed-sorting in King Quail (*Coturnix chinensis*): behavioural plasticity invoked by a physiological challenge
15:07	**Charlotte Payne*,** Bridget Roberts, Alex Leslie, Adam J. Munn A comparison of Infrared thermography to respirometry to determine its accuracy as a method for measuring metabolic rate

15:14	**Bridget Roberts*,** Charlotte Payne, Alex Leslie and Adam J. Munn Comparison of traditional and 3D scanning methods for estimating animal surface area
15:21	**Hamali Ratnayake*,** Justin Welbergen, Rodney van der Ree and Michael R. Kearney Forecasting flying-fox die-offs under extreme heat events
15:30	**AFTERNOON TEA**
Session 6	**Chair:** Shane Maloney
16:00	**Roger S. Seymour** The role of energetics in selection for pollinator body size
16:20	**Terrence J. Dawson** and Shane K. Maloney The thermal properties of kangaroo furs: What happens to solar heat loads when insulation diminishes?
16:40	Melinda Boyers, Francesca Parrini, Norman Owen-Smith, Barend F.N. Erasmus and **Robyn S. Hetem** Water-dependent wildebeest display enhanced heterothermy compared to arid-adapted gemsbok
17:00	**Annual General Meeting of the ANZSCPB**
20:00	**CONFERENCE DINNER**

Sunday 6th December

	Session 7 **Chair:** Koa Webster
8:45	Announcements
9:00	Plenary talk: **Eduardo Bicudo** Energy expenditure during locomotion in the capuchin monkey *Cebus paella*
9:45	**Adam Munn** Grazing the Gap: 50-odd years of rangelands herbivore research
10:30	**MORNING TEA**
	Session 8 **Chair:** Adam Munn
11:00	**Koa Webster** Non-invasive measurement of glucocorticoid hormones: how to do it (and how NOT to do it!)
11:20	**Stuart Linton,** Melissa S. Cameron, Michael Gray, John A. Donald, *et al.* A glycosyl hydrolase family 16 gene is responsible for the endogenous production of β-1,3-glucanases within decapod crustaceans (Part II)
11:40	**Michael Kearney,** James Maino, James D. Woodman and Ted Deveson New methods for predicting climatic constraints on insects, applied to the Australian Plague Locust
12:00	Morgan Armstrong, Anthony J. Bakker and **Shane K. Maloney** Housing temperature and the contractile function of skeletal muscle in laboratory mice and a mouse model of muscular disease
12:20	Ian W. Murray, Andrea Fuller, Hilary M. Lease, Robyn S. Hetem and **Duncan Mitchell** Different foraging behaviour leads to different body temperatures in two insectivorous diurnal lizard species living in the same Namib habitat
12:40	Presentation of student prizes and close of meeting
13:00	**LUNCH**
15:00	Optional station excursions
20:00	**DINNER**

Abstracts

All abstracts are listed alphabetically by **presenting** author.

Plenary talks

Energy expenditure during locomotion in the capuchin monkey *Cebus paella*

José Eduardo P. W. Bicudo[1,2]

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[2]Bioscience Institute, University of São Paulo, São Paulo, SP 05508-900, Brazil

This study aimed to evaluate the energy expenditure and biomechanical variables associated to the locomotion of *Cebus apella* (capuchin monkey). Measurements of metabolic rate (oxygen consumption) and kinematic variables (stride frequency, foot contact time, step length and degree of flexion/extension of the joints and body segments) were obtained with the subjects moving on a motorized treadmill. Our results show that *C. apella* displays a lower stride frequency than quadruped mammals of similar body masses. Notwithstanding, a lower stride frequency is the kinematic parameter preferentially adjusted by *C. apella* to cope with faster treadmill velocities. In addition, oxygen consumption data obtained in this study indicate that significant differences between the energy cost of locomotion of primates and non-primates quadrupeds of similar body masses should not be expected. Based on this, we suggest that another element, besides the rate of generating force (inferred from the stride frequency), could explain the magnitude of the energy cost of locomotion frequently found in primates. We suggest that anatomic characteristics of certain primates, i.e. a relatively larger muscular volume of the hind limbs as it is observed in capuchin monkeys, might be a key element to understanding the cost of locomotion showed by capuchin monkeys, which is similar to non-primate quadrupeds. Additionally, our results indicate that flexion of the spinal column can be an important mechanism for elastic energy storage during locomotion in *C. apella*, particularly at higher treadmill velocities.

Challenging the paradigms: lessons from studies of White-plumed Honeyeaters (*Lichenostomus penicillatus*)

William A. Buttemer[1,2], Bethany J. Hoye[1], Marina B. Buttemer[3] and Lee B. Astheimer[1]

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[2]Wombarra Academy of New Knowledge, [3]School of Biological Sciences, Tas Uni, Hobart.

There is consensus that reproduction and moult are two of the most energetically and nutritionally challenging phases in the life cycle of birds. There is also experimental evidence that elevated plasma corticosterone (CORT) levels during moult leads to production of malformed feathers. These factors are believed to underlie the hormonally regulated temporal partitioning of breeding and moult phases in birds and the rapid transition from elevated CORT levels while breeding to CORT suppression during moult. Long-term studies of White-plumed Honeyeaters (WPHE) at Fowlers Gap have revealed that these birds may breed at any time of year and that moult/breeding overlap occurs often. Another departure from typical avian patterns is a complete absence of annual and sex-related variation in CORT levels. Follow-up captive studies of WPHE and House Sparrows give insight into how honeyeaters are able to 'disobey' the rules.

Comparative methane production by five non-ruminating foregut fermenting herbivore species: Linnè's two-toed sloth (*Choloepus didactylus*), western grey (*Macropus fuliginosus)* and red kangaroo (*Macropus rufus)*, collared peccary (*Pecari tajacu*) and pygmy hippopotamus (*Hexaprotodon liberiensis*)

Catharina Vendl[1], Samuel Frei[2], Marie Dittmann[1,3], Samuel Furrer[4], Jürgen Hummel[5], Bastian Lange[6], Arne Lawrenz[2], Keith Leggett[7], Sylvia Ortmann[8], Christine Osmann[9], Matthew Stewart[10], Michael Kreuzer[3], Adam Munn[10] and Marcus Clauss[1]

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[2]Zoo Wuppertal, Wuppertal, Germany
[3] ETH Zurich, Institute of Agricultural Sciences, Zurich, Switzerland
[4]Zoo Zurich, Zurich, Switzerland
[5] Department of Animal Sciences, Georg-August University Göttingen, Germany
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[7]Fowlers Gap Arid Zone Research Station, School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW, Australia
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[10]School of Biological Sciences, University of Wollongong, Wollongong, NSW, Australia

Methane (CH_4) production varies between herbivore species, but reasons for this variation remain to be elucidated. Here, we report open-circuit chamber respiration measurements of CH_4 production in five species of non-ruminant mammalian herbivores with a complex forestomach but largely differing in body size: Linnè's two-toed sloths (*Choloepus didactylus* mean body mass 10 kg), the western grey (*Macropus fuliginosus,* 22 kg) and red kangaroos (*Macropus rufus,* 18 kg), collared peccary (*Pecari tajacu*, 17 kg) and the pygmy hippopotamus (*Hexaprotodon liberiensis*, 229 kg). Except for sloths, animals were only fed lucerne-based *ad libitum* diets. Exclusively in kangaroos, a second food intake level was fed meeting 75% of maintenance energy requirements. In addition, food intake, digestibility and mean retention times (except for kangaroos) were measured in the same experiments in all species. CH_4 production averaged as follows: Linnè's two-toed sloth: 3 L/d, 33 L/kg dry matter intake, 7.7% of gross energy intake; the western grey and red kangaroo: 3 L/d, 8 L/kg dry matter intake, 1.6% of gross energy intake; collared peccary: 8 L/d, 18 L/kg dry matter intake, 4.0% of gross energy intake; pygmy hippopotamus: 72 L/d, 19 L/kg dry matter intake, 4.2% of gross energy intake. When compared to previously reported data on CH_4 production in ruminant foregut fermenting as well as hindgut fermenting species, it is evident that neither the question whether a species is a foregut fermenter or not, or whether it ruminates or not, is of the relevance previously suggested to explain variation in CH_4 production between species. Rather, differences in CH_4 production between species on similar diets appear related to species-specific differences in food intake and digesta retention kinetics.

Standard talks

Evolution of hominin brain perfusion: the holes in the fossil record

Vanya Bosiocic[1] and Roger S. Seymour[1]

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One of the most distinctive features of the evolution of the modern *Homo sapiens* is the relative and absolute large size of the brain and its high metabolic demand. Studies of hominin brain evolution have revealed that *Australopithecus* to our late *Homo* ancestors experienced an approximate threefold increase in brain size with respect to body mass, with endocast indents showing evidence of cerebral reorganisation associated with cognitive specialisation. Despite considerable paleontological and neurological research into this trajectory, cerebral metabolic rates of ancestral hominins remain unknown. We estimated cerebral perfusion rates ($\dot{Q}_{ICA}$; $cm^3\ s^{-1}$) from the size of the internal carotid foramina of 12 fossil hominin species and use it as a proxy for cerebral metabolic rate and cognitive evolution. Cerebral perfusion scales disproportionately high with brain size (V_{br}; cm^3), according to $\dot{Q}_{ICA} = 1.73 \times 10^{-4}\ V_{br}^{1.44}$. This indicates that the metabolic intensity of cerebral tissue increased in later *Homo* species, rather than remaining constant ($V_{br}^{1.0}$) as expected by a linear increase in neuron number or decreasing in accordance with Kleiber's Law ($V_{br}^{0.75}$). By comparison, the scaling of brain perfusion is proportional to $V_{br}^{0.95}$ in living haplorrhine primates and $V_{br}^{0.73}$ in diprotodont marsupials. Our research suggests a link between the transition towards a cooked, calorically rich diet and the increase of energy investment into cerebral metabolic up-regulation and, potentially, cognitive advancement. In future fossil discoveries, the internal carotid foramen can be used as a gauge of hominin cerebral metabolism and allow better understanding of energy trade-off strategies during human evolution.

Regulation of insensible evaporative water loss: Can birds do it too?

Erika E. Eto[1], Philip C. Withers[1,2] and Christine E. Cooper[1,2]

[1]School of Animal Biology, University of Western Australia, Perth, Western Australia 6009, Australia
[2]Department of Environment and Agriculture, Curtin University, Perth, Western Australia 6147, Australia

Determination of insensible evaporative water loss (EWL) has been traditionally considered to be physical, where water vapour pressure deficit (Δwvp) between the animal and the ambient air is the major driver of EWL. However, recent studies have demonstrated that small mammals can maintain EWL constant over a range of environmental conditions predicted to perturb EWL, suggesting acute physiological control of insensible water loss. Birds, the other major endothermic group of vertebrates, are physiologically convergent with mammals in many ways, and therefore we examined if a small, arid-habitat bird (the budgerigar, *Melopsittacus undulatus*) was able to physiologically regulate its insensible evaporative water loss. We measured EWL (and other physiological variables) of wild-type budgerigars at four relative humidities (RH) and three ambient temperatures (T_a). EWL increased with increasing T_a as expected. However, there was no influence of RH on EWL at T_a = 20 or 30°C, but there was a linear effect of RH on EWL near the lower limit of thermoneutrality (T_a = 25°C). If we express EWL as a function of Δwvp, then the physical model predicts no relationship between EWL/Δwvp and RH (i.e. a slope of 0); we found significant linear relationships at T_a = 20°C and 30°C, but not T_a = 25°C. Physiological control of EWL could be interpreted as a water-saving adaptation for an arid-habitat species, but we propose here that it may have thermoregulatory significance. If EWL was influenced by Δwvp, then changes in EWL and therefore heat loss would impact on either body temperature (T_b) or metabolic rate (MR); however, we found no influence of RH on either. Our observation that EWL is not regulated near the lower limit of thermoneutrality but is maintained constant at higher and lower T_a supports a thermoregulatory role for EWL regulation and may indicate a possible control system.

The thermal properties of kangaroo furs: What happens to solar heat loads when insulation diminishes?

Terence J. Dawson[1] and Shane K. Maloney[2]

[1]School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, NSW 2052, Australia
[2]School of Anatomy, Physiology, and Human Biology, University of Western Australia, Crawley, WA 6009, Australia

Fur fibre has many roles ranging from uses in sensory inputs to the diverse applications of colouration. However, it is its functions in thermoregulation that are fundamental. It provides insulation to restrict heat outflows in the cold and heat inflows in hot conditions. Fur also is involved in the modulation of heat flows associated with radiation exchanges between a mammal and its environment. In this regard solar radiation, because of its intensity, presents a special challenge to diurnally active mammals. All solar radiation is not absorbed and converted into heat at the coat surface. Complex reflection patterns occur because of changing reflectivities of furs across the solar wavelength profile, with visible wavelengths accounting for only half of solar radiation. a variable portion of incident radiation is reflected to the environment. A portion is also reflected deeper into the coat, some of which reaches the skin as heat. How much depends on the interaction between overall coat reflectance and coat structure, together with environmental features such as wind. If insulation is substantial heat inflow is restricted, irrespective of levels of reflectance, e.g. koalas and polar bears. At an uninsulated surface, however, the absorbance – reflectance balance determines heat load. To establish the levels of insulation at which coat spectral characteristics play a major role in governing effective solar heat loads on mammals we have studied the summer coats of diverse kangaroos. The species are from a range of climatic zones but at times all face marked solar heat loads. Their coats differ between species and across body regions in colour, depth, and structural features. While our data show interactions between reflectance and insulation to limit the potential heat load from solar radiation, complex structural features of the coats also come into play.

Cholinergic or Somatostatin Innervation: Two ways squamates might beat the heat.

Peter Derbyshire[1]

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Cardiac output is determined by the trade-off between the rate of cardiac contraction and the force of each contraction. Control of these factors is maintained either by hormonal regulatory systems, fine nervous innervation or various combinations of these mechanisms. Fine nervous control is considered to increase in complexity from teleost fish to mammals with previous work suggesting cardiac innervation of reptiles is comparable to amphibian innervation. A pilot study on the dragon *Ctenophorus ornatus* however has shown cholinergic nerve activity in the ventricular chamber, something only demonstrated in heterothermic mammals. A broader study using several species of squamate reptiles was undertaken to demonstrate whether this is a common cardiac innervation pattern in squamates or unique to this species. The hearts of several different species of squamate were dissected into atrial and ventricular chambers, suspended from a force transducer and placed in an organ bath containing reptile saline solution. Nerves in the preparations were characterised by electrical stimulation, mimicking the response using exogenously applied neurotransmitters such as adrenaline and acetylcholine before finally stimulating the chambers again in the presence of known neurotransmitter blockers. Reptiles belonging to the Family Gekkonidae, Agamidae, and Scincidae all presented similar cardiac innervation patterns to that shown in *C. ornatus*. Of the three species of snake examined however, there was no indication of the cholinergic nerve activity in the ventricle. Snakes did however show a response to exogenously applied somatostatin in the atrial chambers that was not found in the lizard species. Although Somatostatin has previously been found in snake cardiac muscle there has not been any success in activating the nerves resulting in a release of this neurotransmitter. The use of co-localised somatostatin could be an alternate method for fine cardiac control.

Physiological responses of heterothermic mammals to fire

Anna C. Doty[1], Clare Stawski[1] and Fritz Geiser[1]

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

Historical patterns of wildfires are changing as a result of climate change and therefore are becoming an increasingly pressing global issue. However, how small mammals deal physiologically with changes in landscape and food availability due to fire remains largely unknown, although recent studies on antechinus, small terrestrial marsupials, have shown a post-fire increase in torpor for energy conservation. To fully understand the impact of large-scale environmental changes on small mammals and the role of torpor in enhancing survival, it is essential to also investigate the response of flying animals. Therefore, we determined the post-fire thermal biology of Lesser Long-eared Bats (*Nyctophilus geoffroyi*) using temperature-telemetry in Warrumbungle National Park, NSW, which experienced a devastating wildfire in 2013 that destroyed about 80% of the park. We also obtained data from Gould's Long-eared Bats (*Nyctophilus gouldi*) prior to and after a low-level prescribed fire at Guy Fawkes National Park, NSW. Data on these small, insectivorous and aerial mammals were compared with those collected for the terrestrial antechinus. Post-fire survival strategies differed between *Nyctophilus* spp. and *Antechinus* spp. Bats demonstrated a decrease in torpor use in response to wildfire when insect abundance increased and no change in torpor use following prescribed fire. This is in contrast to *Antechinus* spp., which used significantly more torpor both after the wildfire and prescribed fire. Although heterothermic mammals can reduce energy via a decrease in metabolic rate and body temperature, torpor use after a disaster may not always be the ideal response. It is likely that these differences in heterothermy in terrestrial and volant mammals are due to a suite of factors, such as an increase in aerial resource abundance and easier foraging for bats resulting from a decrease in vegetative clutter.

The biophysical properties of plumage for the Western Magpie *Gymnorhina tibicen dorsalis*

Tegan K. Douglas[1], Christine E. Cooper[1,2], Philip C. Withers[1,2] and Stephen J.J.F. Davies[1]

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[2] School of Animal Biology, University of Western Australia, 35 Stirling Highway, Crawley Western Australia 6009

The Australian Magpie (*Gymnorhina tibicen*) is a large sedentary passerine (300g), frequenting open habitats. How non-migratory species balance their energy budgets at low ambient temperatures (T_a) is of particular interest. We measured standard physiological variables for magpies using open-flow respirometry at T_a = 5 – 32.5 °C. Magpies had a typical endothermic response to low T_a, maintaining T_b at T_a = 5 °C only 0.6 °C below T_b at thermoneutrality (T_a = 25 °C). They achieved this with a 38% increase in metabolic rate and a 40 % decrease in conductance. There was no evidence of torpor. Observations of basking by wild magpies suggests they may use solar heat gain to reduce thermoregulatory costs. In southwest Australia the magpie is sexually dimorphic; males have white dorsal plumage and females and sub-adults black. Magpies of different age and sex may subsequently experience different radiant heat loads. We measured plumage characteristics at wind speeds of 1 to 6 m sec^{-1} and quantified solar heat gain at the level of the skin. Plumage of males, females and sub-adults showed similar patterns in resistance, decreasing with increasing wind speed from 536 s m^{-1} at 1 m sec^{-1} to 190 s m^{-1} at 6 m sec^{-1}. As expected, the reflectivity of the male's white dorsal plumage was greater than that of the dark females and sub-adults. There was substantially less variation in solar heat gain with increasing wind speed for males (6.63% at 1 m sec^{-1} to 5.33% at 6 m sec^{-1}), compared with females and sub-adults from (8.13% to 2.20%). The high thermal resistance and low solar heat gain of magpies means that their plumage may play a considerable role in balancing their energy budget and allowing the maintenance of homothermia in winter.

Is Peroxidation the Key to Endothermy

Paul L Else[1]

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Endothermy is associated with high rates of metabolism and growth. It is acquired during early development, and evolved in mammals and birds from ectothermic reptiles. No current theory of endothermy explains; i) why membranes of endotherms tend to be more unsaturated than those of ectotherms, ii) how increased metabolic rate and growth are linked, and iii) how the evolution of endothermy relates to its ontogenetic development in mammals and birds. To address these points it is proposed that the evolution of endothermy involved an increase in the unsaturation of membrane polyunsaturated fatty acids (PUFA). Since PUFAs are far more prone to oxidation (peroxidation) than other fatty acids this change increased the basal level of peroxidation, and level of peroxidation product (e.g. lipid hydroperoxides and aldehydes) in cells. In turn this acted to increase the ionic permeability, mitochondrial biogenesis and intracellular organelle density of cells. These changes resulted in increases in the rate of metabolism and growth associated with endothermy. These same processes are also proposed to produce the same changes during ontogeny in mammals and birds that allows for the development of endothermy and are likely to be involved in similar changes associated with body mass. This theoretical framework will be examined using currently available research.

Is mammalian torpor expression affected by their geographical distribution?

Fritz Geiser[1], Artiom Bondarenco[1] and Clare Stawski[1]

[1]Centre for Behavioural and Physiological Ecology, Zoology, University of New England, Armidale, Australia

Expression of mammalian torpor, a controlled reduction in metabolic rate and body temperature for energy and water conservation, differs among species and variables of torpor often are correlated with the thermal conditions of the mammal's habitat. As some species have large geographical ranges that experience different thermal challenges, we examined whether and how individuals from the same or closely related species differ in their expression of torpor. We also tested whether variables of torpor measured for one population can be extrapolated to another by using regressions of temperature-dependent physiological variables. Patterns of torpor differed among populations for several species of marsupials and bats with generally deeper (lower minimum body temperature) and longer torpor bouts in colder habitats suggesting that ambient temperature has a strong influence on selection of these variables. Especially pronounced differences were observed in species with large geographic ranges or species living along altitudinal gradients, but even small-scale sexual segregations can result in different torpor patterns. Surprisingly, and in contrast to the observations on torpor expression by populations from different habitats in general, predictions of torpor variables from cold habitats to warmer habitats, even for strongly temperature-dependent variables like torpor bout duration that profoundly affect energy expenditure, substantially underestimated values measured in the wild. These data suggest that other specific requirements, in addition to coping with different temperatures, are reflected in the expression of torpor patterns of populations.

Water-dependent wildebeest display enhanced heterothermy compared to arid-adapted gemsbok

Melinda Boyers[1,2], Francesca Parrini[2], Norman Owen-Smith[2], Barend F.N. Erasmus[2] and Robyn S. Hetem[1,2]

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Heterothermy, a variability in body temperature beyond the limits of homeothermy, is widely viewed as a key adaptation of large mammals to their arid-zone life. If heterothermy is indeed adaptive, we would hypothesise that an arid-adapted species would display enhanced heterothermy compared to a water-dependent species when exposed to the same hot and dry conditions. We measured body temperature and activity patterns, using implanted data loggers, for a 20 month period, in five arid-adapted gemsbok *Oryx gazella* and six water-dependent blue wildebeest *Connochaetes taurinus*, free-living in the Kalahari, Botswana. We compared the interannual variability in response of these two species during hot-dry periods in which ambient temperatures were similar (maximum air temperature 34.9±5.1ºC vs. 35.2±4.5ºC) but rainfall differed (10mm vs. 20mm). Both species showed significantly higher maximum 24h body temperatures when conditions were drier (39.7±0.2ºC vs. 40.0±0.2 ºC, $F_{1,9}$=30.8 P=0.0004). Wildebeest displayed lower minimum 24h body temperatures than gemsbok (36.5±0.6 ºC vs. 37.5±0.4ºC, $F_{1.9}$=11.1 P=0.009), which resulted in larger amplitudes of 24h body temperature rhythm (3.5±0.4ºC vs. 2.4±0.5 ºC, $F_{1,9}$=10.1 P=0.01), when conditions were drier. Overall, wildebeest displayed a higher proportion of nocturnal activity than gemsbok (55±5% vs. 45±6% $F_{1,4}$=15.4 P=0.02). We propose that the enhanced heterothermy displayed by the water-dependent wildebeest may reflect a species compromised by energy and water limitations.

Measuring pulmonary diffusing capacity with a rebreathing method in awake animals

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We developed a rebreathing method to measure pulmonary diffusing capacity for CO (D_LCO) in awake, spontaneously breathing animals at rest. We continuously measured the rate of CO uptake as goats rebreathed from a bag containing a mixture of 21% O_2, 10% He, 0.3% CO and balance N_2 and used He dilution to calculate the lung volume (functional residual capacity) at which the measurements were made. We compared D_LCO values measured in four awake goats with those in the same goats while they were anaesthetized and manually ventilated to mimic standardized human single-breath and rebreathing D_LCO techniques that require patient cooperation. The D_LCO calculated with the awake, rebreathing method did not differ from D_LCO calculated in anaesthetized, manually ventilated goats (P = 0.782), although manually ventilated goats had smaller coefficients of variation (5 ± 4%) than awake, spontaneously breathing goats (15 ± 3%, P = 0.029). Awake, rebreathing D_LCO values were lower than those measured using the single-breath technique (P = 0.040) presumably due to the larger lung volume (total lung capacity) utilized in the single-breath method. We have adapted the technique for use in horses.

New methods for predicting climatic constraints on insects, applied to the Australian Plague Locust

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The dynamics of insect populations are often strongly tied to climate and weather, especially via soil temperature and moisture conditions and their influence on development and food availability. We developed and tested a mechanistic model for predicting hourly soil temperature and moisture as a function of gridded environmental data. The model builds on the NicheMapR microclimate modelling package to include a Newton-Raphson solution to the soil water balance developed by Campbell. It handles variable soil properties with depth, and includes transpiration processes. We show how the model performs in tests against the detailed OzNet soil moisture observations across south-eastern Australia. We then apply the model in conjunction with a detailed model of egg development and growth of the Australian Plague Locust and its food plants, and test it against 20 years of observations made by the Australian Plague Locust Commission. We discuss the success of the model in predicting observed locust and food plant dynamics, and its potential role in guiding future ecophysiological research on this important pest species.

Novel applications of thermocyclers for high-throughput phenotyping of invertebrate thermal response

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Advances in high-throughput genetic techniques in the past decade have greatly increased the amount of genetic information available. The need for phenomic data to complement such genomic data has driven recent developments of high-throughput phenomics for human, mice and plant models. However, there have been fewer advances in high-throughput methods for characterising invertebrate phenotypes. To develop a new method of high-throughput characterisation of invertebrate thermal response, we propose a novel use of thermocyclers as temperature-controlled incubators. We tested the performance of thermocyclers as incubators and demonstrated the application of this method for high-throughput characterisation of thermal responses for model and non-model invertebrates. The thermocyclers successfully performed as incubators with high precision, accuracy and resolution under various and fluctuating ambient conditions. This work describes a general means to explore variation in phenotypes and to understand the relationship between genotype, phenotype and the environment on a greater scale than current methods. Our methods are applicable to investigate key problems in the evolution and ecology of invertebrates, including biological adaptation and responses to variable and changing environments.

A glycosyl hydrolase family 16 gene is responsible for the endogenous production of β-1,3-glucanases within decapod crustaceans (Part II)

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β-1,3-glucanase (laminarinase) is an enzyme which is present within the digestive fluid of decapod crustaceans. It hydrolyses β-1,3-glycosidic bonds to digest hemicelluloses such as laminarin and callose. The enzyme has been previously purified and characterised from the yabby, *Cherax destructor* and the Christmas Island red crab, *Gecarcoidea natalis*. In *Cherax destructor* it is encoded by glycosyl hydrolase 16 (GHF16) gene. To complete the characterisation, this gene was also sequenced from cDNA derived from the midgut gland of *G. natalis.* The β-1,3-glucanase gene of *G. natalis* had an open reading frame of 1098bp; this encoded a putative protein of 365 amino acid residues with an estimated molecular mass of 41.4 kDa. The putative protein contained both catalytic and binding domains that are characteristic of a GHF16 β-1,3-glucanase. The amino acid sequence (8-9 residues) of two short peptides, derived from a β-1,3-glucanase protein matched that of the putative amino acid sequence. This plus the putative molecular mass matching that of the purified protein strongly suggests that the sequence presented encodes the enzyme. The GHF16 gene is expressed widely amongst the crustacea since it is also expressed within the midgut glands of other amphibious (*Myctris platycheles* and *Paragrapsus laevis*) and terrestrial (*Coenobita rugosus*, *C. perlatus, C. brevimanus* and *Birgus latro*) species. All sequences aligned with other crustacean GHF16 proteins which are primarily expressed within the haemocytes and have been previously identified as lipopolysaccharide and β-glucan binding proteins (immune protein). Indeed an identical GHF16 protein was also expressed within the haemocytes of *Cherax destructor*. There are three possible hypothesised functions and thus evolutionary routes for the GHF16 β-1,3-glucanase: 1) a digestive enzyme which hydrolyses β-1,3-glucanase, 2) an enzyme which helps to break open the cell walls to release cell contents or 3) an immune protein which can hydrolyse the cell walls of potentially pathogenic micro-organisms.

Housing temperature and the contractile function of skeletal muscle in laboratory mice and a mouse model of muscular disease

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Cold stress can alter the physiology of mice, and influence disease progression in murine models of human disease. Given that the temperature in most animal houses is well below the thermoneutral zone for mice, we assessed the effect of housing temperature on skeletal muscle function and the progression of muscular dystrophy in a mouse model of the disease.

Duchenne Muscular Dystrophy (DMD) is a recessive X-linked form of muscular dystrophy that mainly affects young boys, caused by a missense mutation in the gene for dystrophin. It is commonly investigated using the *mdx* mouse that has a similar genetic defect.

C57BL/10 and C57BL/10ScSn-Dmdmdx/A (mdx) mice were housed at either room temperature (RT, 23°C) or within their TNZ (30°C) from 3 until 7 weeks of age. Body mass, food intake, and grip strength were measured regularly. At 7 weeks of age, the extensor digitorum longus (EDL) and soleus muscles were dissected and contractile measurements made. The diaphragm was preserved for histology.

Mice housed at RT were bigger and ate more than mice housed at TNZ, but their grip strength did not differ. There was no difference in contraction and relaxation times between RT and TNZ, but the muscles from mdx mice generated less specific force (N/cm^2) than the muscles from the wild types. The EDL muscles from mice housed at TNZ took 25% longer to fatigue to 60% of initial force than the muscles from those housed at RT. Housing temperature had no significant effect on necrosis or regeneration in the diaphragm.

We conclude that disease progression in the mdx mouse is not amplified by the cold stress imposed by normal housing conditions, but that cold housing induces changes that affect fatigue resistance, possibly due to changes in fibre type proportion or increases in the capacity for oxidative metabolism.

Long-live the queen: lipidomics of ageing in honey bees (*Apis mellifera*)

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The 'Oxidative Stress Theory of Ageing' forms the basis of the most accepted mechanistic explanation of ageing. It involves interplay between membrane lipid composition and metabolic rate, where the accumulation of oxidative damage is proposed as the main cause of ageing, and lifespan is determined by the rate at which this damage occurs. Free radicals are highly reactive molecules that can react with oxygen and damage DNA, proteins and lipids. Lipid-radical reactions are particular damaging as they propagate the process (peroxidation) with polyunsaturated fatty acids more prone to peroxidation compare to monounsaturated and saturated fatty acids. This suggests that fatty acid composition is actively involved in ageing and it has been proposed that fatty acid composition provides a mechanistic explanation for variation in lifespan among animal species.
In honey bees, the same egg can develop into a queen or a worker adult bee. The queen lays eggs and apart from a mating flight, remains inside the hive throughout her lifetime. Workers perform the tasks to maintain the colony and are characterized by different life-history stages. This division in labor is associated with a 100-fold difference in lifespan: queen lives for years, workers live for weeks. This study looked at the lipid profile of queens and workers at different ages. Queens and workers share a similar phospholipid fatty acid composition at larval stages, which is associated with a lower potential to propagate oxidative damage through lipid peroxidation. Phospholipid fatty acids composition changes after emergence with workers increasing the proportion of polyunsaturated fatty acids within the first week. In contrast, queens maintain low abundance of polyunsaturated fatty acid with ageing. These differences are shared among the different phospholipid classes. These results suggest that the maintenance of a low abundance of polyunsaturated fatty acids in long-live queens may have evolved to facilitate an extraordinary long lifespan.

Different foraging behaviour leads to different body temperatures in two insectivorous diurnal lizard species living in the same Namib habitat

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Rhoptropus bradfieldi and *Pedioplanis husabensis* are insectivorous lizards of similar size (snout-vent length ~50mm) and similar colour that live in the same rocky habitat in the Namib Desert. They emerge from rock crevices to forage, for overlapping diurnal activity periods. When on the surface, they are exposed to the same air temperature, radiant heat load, wind speed and water vapour pressure. We noosed stationary lizards from both species (minimum 31, maximum 62 in a cohort) in their natural habitat in December/January (summer) and May (autumn), and measured cloacal temperature with a calibrated thermocouple thermometer. We used the same thermometer to measure air temperature and substrate temperature at each lizard's capture site. Lizard sex did not affect cloacal temperature significantly. Mean cloacal temperature of a cohort of lizards differed from air temperature at the capture site by 10°C and from substrate temperature by 20°C. At lower air and substrate temperatures, *R. bradfieldi* was significantly cooler than was *P. husabensis*. Its body temperature was more strongly dependent on air temperature and on substrate temperature than was that of *P. husabensis*. The differences in field body temperatures between the species resulted mainly from differences in behaviour and consequently microhabitat. *R. bradfieldi* mainly eats ants and is a sit-and-wait forager on the rocks, while *P. husabensis* mainly eats termites and is an active forager, venturing off the rock on to nearby sandy substrates. Modelling of the body temperature of these two lizard species would require incorporation of foraging behaviour, which, for *P. husabensis*, has a stochastic component. Failure to incorporate behaviour, and therefore microclimate, as input variables will induce serious errors in model prediction of body temperature and consequently survival under thermal stress.

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Grazing the Gap: 50-odd years of rangelands herbivore research.

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Australia's rangelands, the classic 'outback' Australia, has been embedded in our cultural and economic identify since the earliest days of European settlement. Since that time water point and grazing management/mismanagement have dramatically transformed these landscapes, yet they remain central to Australia's economic productivity and food security. Following the 'glory years' of rangelands grazing, when infiltration by sheep and cattle burgeoned, major reductions in domestic stock numbers have occurred, principally due to overgrazing lowering herbivore carrying capacities, coupled with wildly fluctuating rainfall patterns and frequent intense drought. Nonetheless, numerous domestic, introduced feral and native herbivores persist in these regions, and have been the focus of much 'bush research' at Fowlers Gap since it was established in 1966. Here, I will review the history and trajectory of herbivore research at Fowlers Gap. What have we learned from this research? How can we use this to best prepare for and manage future changes? Specifically, can we use individual-specific, whole life-cycle studies of herbivore physiology to satisfy the broad-scale needs of industry while preserving the long-term sustainable management of these iconic landscapes?

Development of brain metabolism in western grey kangaroos

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There is a direct relationship between the metabolic rate of the brain and cerebral blood perfusion. Recently, a technique of estimating cerebral perfusion from the size of the internal carotid foramina of the skull has been developed. Total cerebral perfusion scales with brain volume with the exponents of 0.95 for haplorrhine primates and 0.73 for diprotodont marsupials. This study uses the same method to examine the scaling of brain metabolism intraspecifically for the first time. We used X-ray computed tomography to take cranial measurements of brain volume and carotid foramina radius from an ontological sequence in a large diprotodont marsupial, the western grey kangaroo, *Macropus fuliginosus*. Allometric analysis across a 1300-fold body mass range (0.052 – 70.5 kg) established a biphasic relationship for cerebral blood perfusion ($\dot{Q}_{ICA}$) with a breakpoint occurring at ca. 1.5-2.0 kg body mass (M_b). In the pouch, brain volumes (V_{br}) of joeys scale according to $V_{br} = 0.22M_{b(in\text{-}pouch)}^{0.71\pm0.39}$, whereas a statistically significant decrease in scaling exponent is seen in post-pouch juveniles and adult individuals; $V_{br} = 5.5M_{b(post\text{-}pouch)}^{0.23\pm0.060}$. For in-pouch joeys, cerebral perfusion through the internal carotid arteries scales to body mass with an exponent ($\dot{Q}_{ICA} = 0.0017M_{b(in\text{-}pouch)}^{0.85\pm0.22}$) which is significantly higher than the exponent for both post-pouch individuals ($\dot{Q}_{ICA} = 0.20M_{b(post\text{-}pouch)}^{0.17\pm0.21}$) or diprotodonts interspecifically (0.51). Cerebral perfusion through the internal carotids scales to brain volume according to $\dot{Q}_{ICA} = 0.0114V_{br(in\text{-}pouch)}^{1.161\pm0.752}$, $\dot{Q}_{ICA} = 0.0762V_{br(post\text{-}pouch)}^{0.514\pm0.837}$. The relatively steep initial allometric scaling exponent of cerebral blood perfusion in regards to body mass in pouch young is consistent with the requirements for brain growth and development in altricial marsupial juveniles.

Behavioural regulation of water loss in two Australian skinks

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As global climates warm, temperature induced activity constraints may not be the primary stressor facing ectotherms. An upward trend in air temperature will be accompanied by dramatic changes in spatial and temporal variability of precipitation. However, observational data are confounded by the correlation between high temperatures and high aridity, making it difficult to distinguish thermoregulatory from hydroregulatory behaviour in the field. Here we use experimental manipulation to decouple temperature- and water-based constraints on activity, isolating the hydroregulatory behaviours of two arid-habitat burrowing species of *Egernia* skink. The behaviour of fully hydrated and dehydrated lizards were observed within a finely-controlled weather room during periods of high and low temperatures crossed with high and low humidities. We found little consistent evidence of a behavioural response to humidity and hydration state. *E. striata* reduced time spent exploring in response to dehydration, but showed no responses to humidity. *E. inornata* reduced time spent basking under low humidities, but showed no responses to dehydration. A likely explanation for the minimal activity responses is found within the results of a simultaneous experiment. A hydrated subset of both *Egernia* species were remotely photographed every 1.5 seconds over a 2 hour basking period, under high and low humidities. We found that the amount of time lizards spent basking with their eyes closed increased from 3% at high humidities to 24% at low humidities. Ocular water loss alone can account for a significant proportion of total evaporative water loss. As such, closing the eyes in response to dry conditions may reduce water loss rates considerably, minimizing trade-offs between thermal and hydric concerns. It is possible that both species of *Egernia* were regulating their water loss sufficiently through ocular manipulations, making it unnecessary to compromise basking times.

The role of energetics in selection for pollinator body size

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The requirements of pollinators for floral resources depend on many factors, including the costs of living, locomotion, thermoregulation and behaviour, all of which are influenced by body size. These requirements are modified by the availability of energy offered by plants and environmental conditions. Endothermic insects, birds and bats are very effective pollinators, because they move faster and are more independent of environmental temperatures than are ectothermic insects, but they are energetically costly for the plant. The body size of endothermic pollinators appears to be influenced by opposing requirements of the animals and plants. Large body size is advantageous for endotherms to retain heat. However, plants select for small body size of endotherms, as energy costs of larger size are not matched by increases in flight speed. If high energy costs of endothermy cannot be met, birds and mammals employ daily torpor, and large insects reduce the frequency of facultative endothermy.

Structure–function analysis of the left ventricle performing routine and maximum work

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The mechanical work of the sheep and goat left ventricle was calculated under routine (mild sedation) and maximum conditions (strenuous running exercise) from measurements of cardiac output, arterial blood pressure and kinetic energy, while its structural organisation was obtained by quantification of gross chamber dimensions, capillary network, and cardiomyocyte ultrastructure. Left ventricular work averaged 0.0173 J s^{-1} cm^{-3} of tissue under routine conditions, and was estimated to increase three-fold to 0.0572 J s^{-1} cm^{-3} during strenuous exercise, which corresponds to a maximum oxygen demand of 636 nmol O_2 s^{-1} cm^{-3} (assuming 20% efficiency). According to an oxygen transport model we applied to the left ventricle tissue, maximum oxygen consumption reached 585 nmol O_2 s^{-1} cm^{-3} of tissue, which is 92% of maximum oxygen demand, suggesting that the maximum oxygen requirements of cardiac tissue are nearly, or only just, satisfied under such conditions. The oxygen is consumed by mitochondria, which represents 21 – 22% of cardiomyocyte volume, and has an estimated functional capacity of 3523 nmol O_2 s^{-1} cm^{-3} of mitochondria, which is within 80% of maximum *in vitro* estimates. Thus, at maximum work, oxygen supply by the cardiac capillaries, and oxygen consumption by the cardiac mitochondria, both appear to be operating very close to their functional capacities. The resulting ATP is used by the myofibril contractile machinery, which represents 65 – 66% of cardiomyocyte volume, in order to generate wall tension and pressurise the blood. According to the principle of Laplace, mean arterial pressure exerts a mean fibre stress across the left ventricle wall of 17 – 20 kPa, which is significantly less than maximum tensions up to 110 kPa recorded from isolated cardiac tissue preparations. The discrepancy is partly explained by an apparent safety factor for tension development, which could function to maintain cardiac output during periods of acute volume or pressure overload, or during cardiac disease.

Comparison of the body temperature patterns of three large, arid-zone antelope

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Maintaining homeothermy requires a mammal to use energy and water. Nutritional or water stress therefore may be reflected by an increased amplitude of the 24h rhythm of body temperature. Using implanted data loggers, we measured body temperature simultaneously in three ungulate species with varying water dependencies, gemsbok *Oryx gazella*, red hartebeest *Alcelaphus buselaphus* and blue wildebeest *Connochaetes taurinus*. The animals were free-living in the Northern Cape Province of South Africa during the hot dry season (mean maximum $T_{globe} = 50.5 \pm 4.5^0$C; 35mm of rain) and the hot wet season (mean maximum $T_{globe} = 41.5 \pm 4.5^0$C; 162 mm of rain). The maximum body temperature of individuals of our three study species differed between the seasons ($F_{1,15} = 50.6$, $P<0.0001$), but there was an interaction between season and species ($F_{1,15} = 4.2$, $P = 0.03$), with the gemsbok and blue wildebeest having higher maximum body temperature during the hot dry season. Both minimum body temperature ($F_{1,15} = 56.2$, $P <0.0001$) and the amplitude of body temperature ($F_{1,15} = 124.2$, $P<0.0001$) changed with season, with lower minimum body temperatures during the hot dry season resulting in a greater amplitude of body temperature rhythm in all three species. The observed patterns of body temperature may reveal reduced water availability in dry periods, and reduced food availability in all three ungulate species.

Non-invasive measurement of glucocorticoid hormones: how to do it (and how NOT to do it!)

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The glucocorticoid (GC) hormones cortisol and corticosterone are involved in the regulation of numerous metabolic pathways but are chiefly known for their role in the physiological stress response. When an animal experiences a threat (a 'stressor'), the hypothalamic-pituitary-adrenal (HPA) axis is activated, leading to an elevation of GC hormones circulating in the blood. Because measuring GC hormones directly from blood samples may be confounded by the 'stressful' nature of taking blood, it is now common to measure GC hormones or their metabolites non-invasively in saliva, urine or faeces (and more recently, hair). Using examples from my own studies on numerous Australian mammals, I will illustrate some of the common problems that may arise when measuring GC hormones indirectly, particularly through faecal metabolite assays. I will detail how study design, sampling protocol, sample storage, hormone extraction methods and indeed the choice of enzymatic immunoassay (EIA) itself can all have implications for the reliability and interpretation of results. Finally, I will present guidelines for researchers intending to embark on this type of study for the first time.

Skin capillary water transport by the thorny devil (Agamidae: *Moloch horridus*)

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Some lizards that inhabit arid regions, such as the Australian thorny devil (*Moloch horridus*), have remarkable skin adaptations for moisture-harvesting. Their micro-structured skin surface, with capillary channels in between overlapping scales, enables them to collect water by capillarity and passively transport it to the mouth for ingestion. We characterised this capillary water transport system for live thorny devils using high-speed video analyses. Comparison of data for live and preserved specimens demonstrated that live lizards are required for detailed and quantitative studies of skin water transport (e.g. velocity of spread). There was no directionality in cutaneous water transport (unlike the horned lizard, *Phrynosoma*), as water droplets applied to the skin were transported radially over more than 9.2 mm. Velocity of spread was highest initially, at about 12-14 mm sec^{-1}. We calculated the total capillary volume to be 4.45 µL cm^{-2} (ventral skin) to 5.76 µL cm^{-2} (dorsal skin). Capillary transport ceases when the capillary volume is reduced to 50% by the spread of the water droplet. We found, using µCT and SEM of shed skin, that capillary channel morphology is hierarchically structured, as the large channel between the scales is sub-divided by protrusions into a smaller sub-capillary. We suggest that the large channel quickly absorbs water and the sub-capillary extends the transport distance by about 39%, potentially reducing the volume of water required for imbibition. Hence, we conclude that the sub-capillary structure has an important functional and ecological role for moisture-harvesting by the thorny devil.

Speed talks

A comparison of Infrared thermography to respirometry to determine its accuracy as a method for measuring metabolic rate

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All animals require energy for metabolism and the amount of energy required or expended can be quantified as metabolic rate. A number of methods can be used to measure an animal's metabolic rate through direct and indirect calorimetry. This study aims to estimate metabolic rate as measured by two methods, respirometry and infrared thermography, to determine the accuracy of infrared thermography as a method for measuring metabolic rate. The study species of focus was the fat tailed dunnart (*Sminthopsis crassicaudata*), an Australian arid zone marsupial. Respirometry and Infrared thermography methods were conducted simultaneously. Flow through respirometry was used to measure fractional concentrations of oxygen, carbon dioxide and water vapour gas and subsequently calculate metabolic rate. For infrared thermography, a forward looking infrared radiometer was used to measure surface the temperature of the animals to calculate metabolic rate from sensible and evaporative heat loss. The values for metabolic rate as calculated for sensible heat loss were lower than those from respirometry, but the two methods were significantly correlated. The addition of evaporative heat loss metabolic values to sensible heat loss values generated a value for metabolic rate closer to that calculated by respirometry, however a non-significant correlation between the two methods was seen. The study demonstrated that infrared thermography produces more accurate metabolic values with the addition of evaporative heat loss but the results can be less precise. Overall, this study demonstrates the accuracy of infrared thermography as a non-invasive method for measuring metabolic rate in small mammals.

Forecasting flying-fox die-offs under extreme heat events

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Heatwaves are becoming hotter, longer and more frequent, posing an unprecedented threat to humans and biodiversity alike. Australian flying-foxes (*Pteropus* spp.) are ideal bio-indicators to assess the impacts of extreme heat events on other arboreal or cryptic animals. Recent heatwaves have led to flying-fox die-off events, leaving thousands dead in a single day. There is an urgent need for accurate forecasts of such events to allocate the limited resources of government agencies and bat carers that act to prevent mortalities and resultant consequences.

We developed a predictive model for forecasting when and where die-off events may occur based on an empirically determined air temperature threshold of ≥42°C and the 3 hourly updated ~12km resolution continent-wide forecast product of the Australian Bureau of Meteorology's ACCESS-R Numerical Weather Prediction System.
We evaluated this model using data of a heat stress event that occurred in Southeast Queensland on the 4th January, 2014, where more than 45,500 flying-foxes died. Both the 24 and 48 hour forecasts had accuracies of 77% and 73%, respectively. The relatively large unexplained variance in our forecasts suggests that, in addition to the air temperature, other environmental factors and animal characteristics play a crucial role in determining the heat stress of an animal. We discuss work in progress to generate more accurate spatially-explicit predictions of die-off events as a function of habitat, microclimate, thermophysiology, and behaviour.

Comparison of traditional and 3D scanning methods for estimating animal surface area

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The estimation of body surface area is crucial to measuring aspects of temperature regulation and metabolic rate in small mammals. Presently, methods require the death and skinning of the animal to achieve adequate estimations of body surface area. With technology ever expanding, it may be possible to achieve body surface area measurements using techniques that do not require such difficult and delicate methods. We employed two novel methods of measuring body surface area of the fat-tailed dunnart, *Sminthopsis crassicaudata*, and compared their estimates of the Meeh factor with that of a previously determined Meeh factor estimated via skinning. Our methods included measurements of body surface area using a 3D scanner, which may allow for the animals to be alive during data collection, and a recently described method in which surface area was measured by placing the deceased animal in a small plastic sleeve. We propose to use traditional and modern 3D scanning to estimate surface area. Our data is expected to determine whether 3D scanning is undoubtedly on its way to becoming an essential tool for biologists.

Fibre-induced feed-sorting in King Quail (*Coturnix chinensis*): behavioural plasticity invoked by a physiological challenge

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We examined the effect of an abrupt change in diet fibre content on the feed intake, gastrointestinal morphology and utilisation of gastroliths by a small (ca. 40g body mass) herbivorous bird, the King Quail (*Cortunix chinensis*). King Quail were acclimated for 14 days on a low-fibre (LF) pullet starter diet. Following acclimation, half the quail population was immediately switched to a 23-percent wood-shaving diluted high-fibre (HF) diet for a further 14 days. Contrary to expectations, we found no differences in feed intake, gut morphology or gastrolith mass between the LF- and HF-fed quail. However, when switched from the LF- to HF-diet, the quail commenced feed-sorting behaviours that permitted HF-fed animals to maintain body condition (mass, abdominal fat mass) without adjustments to intestinal organ sizes or gastrolith mass. Feed-sorting was initiated only after exposure to the HF-diet, which corresponded with an immediate reduction in food intake, suggesting that the sorting behaviour was cued by a physiological challenge associated with the HF diet. This challenge apparently induced preferential sorting behaviour and was possibly due to abrupt changes in the rate of food passage, impacting satiation or other internal cues.

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Fowlers Gap Arid Zone Research Station.

A Historical Background.

The Research Station at Fowlers Gap, established by the University of New South Wales in 1966, has its origins in the disordered and unruly nature of the of the settlement of the remote West Darling region. The Fowlers Gap district covers the arid rangelands around the northern Barrier Ranges to the north of Broken Hill. It is distant from major permanent water; the Darling River is far to the east. Charles Sturt explored this region and further north in 1844-5 and his expedition camped on a waterhole at Floods Creek in December 1844. From there he reconnoitered the nearby area of the current Research Station to the east. He noted good grass across the plains near the ranges but his party was impeded by forests of pine (*Callitris columellaris*) on the sandy country further to the east. Such 'pine forests' are no longer present. Sturt's expedition led to the rapid establishment of pastoral stations along the Darling River frontage. By 1859 paddle steamers were operating on the Darling River and tributaries, moving wool to market.

Remote pastoral activity could profitably focus on wool because it was highly compressible for transport and it did not degrade during belated storage and transport overseas but settlement in the Fowlers Gap district was initially restricted by water availability. With rain sheep were moved into the district from the Darling River but in a nomadic, shepherded manner. The first settlement in the area in 1864 started in this manner when Abraham and Matilda Wallace brought 1400 sheep across the Barrier Range from South Australia and established on Sturts Meadows. Water supplies were stabilized by a successful well and 18,000 sheep were utilizing this when the first homestead was built in 1871. Adjoining lands were settled as Corona Station by the 1870s and these included those of Fowlers Gap, which largely operated as one of Corona's outstations until 1947. Who Fowler was is uncertain but the name was in use in 1892 when the Fowlers Gap Hotel was built on the road that serviced the goldfields of the Milparinka and Tibooburra region and the pastoral stations further north.

The pastoral history of the district until the turn of the century was largely one of increasing land degradation and ecological and financial disaster. Both settlers and governments grossly over estimated the long term stocking capacity. By the 1890s conditions were critical and this led to the Royal Commission of 1901 by New South Wales "to enquire into the position of Crown tenants in the Western Division". The Commission recognised that the region was unsuited for close settlement and made changes to land tenure. The assessed carrying capacity was halved to about a sheep per 10 ha and rents were also lowered. In 1903 a new lease until 1943 was issued for Corona of 376,250 ha, which went to the pastoral company Goldsbrough Mort and Co. A map of the Fowlers Gap 'Block' shows 4 paddocks, Gap Creek, Fowlers Gap, North Mandleman and Mandleman. It also gives descriptions of the vegetation, with overall carrying capacity being assessed at a sheep to ~7 ha.

After 1903 the district recovered somewhat as better lease security led to improvements in fencing and water supplies. However, the pastoral industry beyond the Darling River was a marginal enterprise (as it is today). Pastoral conditions improved in good seasons but long-term productivity still declined, though at slower rate. Corona Station, including the Fowlers Gap Block, passed to the pastoral empire of Sir Sydney Kidman in 1917. Leases were again adjusted in the early 1930s to give more financial certainty to

leaseholders but at a cost of surrendering part of their holdings. However, the Kidman group of companies kept their lands intact by not exercising this option. In 1932 the lease for Corona was gazetted until 1947, when it was to be subdivided.

The parlous state of the arid rangelands finally evoked conservation responses from the mid 1930s. The State Soil Conservation Service started in 1938 and Dr. N. C. W. (Noel) Beadle commenced surveys of the Western Division. Beadle's extensive work emphasized the need for field studies for successful vegetation regeneration and soil stabilization. As a result the Department of Conservation acquired Fowlers Gap, the smallest block (~42,000 ha) of the Corona Station subdivision and in 1952 a Special Western Lands Lease No. 7318 was gazetted for 20 years "for conservation purposes". Dr. Beadle and his students continued important studies at the new Fowlers Gap Rural Investigation Station although he had move to Sydney University in 1950 and then to the University of New England in 1955. Conservation Service researchers also examined the reclamation of severely eroded areas and the regeneration of major forage plants. Much of this work was undertaken in Conservation Paddock, from which stock was excluded but not rabbits, kangaroos or feral animals.

A sub lease of Fowlers Gap Station (other than experimental areas) was granted in 1953 to O. J. (Owen) Hayes. The lease was for 5 years but it was extended until 1965. The short-term nature of the lease and meager seasons led to poor conditions on the Station. Since Conservation Service activity on the Station had also lessened, the State Government canvased universities about maintaining conservation studies on the site. The University of New South Wales acquired the lease at the beginning of 1966 and undertook the development of Fowlers Gap as an arid zone research facility. The University was in a major phase of expansion at the time and studies of land use, the biology of native animals and wool and pastoral sciences were part of extended interests that were focused on Fowlers Gap.

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This brief history was mostly based on an article by Professor Jack Mabbutt who was Foundation Professor of Geography at UNSW and a major contributor to the successful establishment of Fowlers Gap Arid Research Station.

Mabbutt, J. A. Historical background of Fowlers Gap Station. Chapter 1. Exploration and early settlement. (1973) In *Lands of Fowlers Gap Station New South Wales.* Edited J. A. Mabbutt and M. E. Sullivan. Research Series No. 3. Fowlers Gap Arid Zone Research Station, University of New South Wales, Sydney. (See link in Fowlers Gap web site.)