Australian and New Zealand Society for Comparative Physiology and Biochemistry

36th Annual Meeting

University of Western Australia

Perth

6-8th December 2019

Australian & New Zealand Society for Comparative Physiology & Biochemistry

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Registration

"Meet the Plenary Speakers" function and registration

17:00-21:00 Thursday 5th December

Bayliss Building (grid H6, building 211)

Paella and beverages

Conference venue

Friday 6th December to Sunday 8th December, finishing lunchtime Sunday

Bayliss Building (grid H6, building 211)

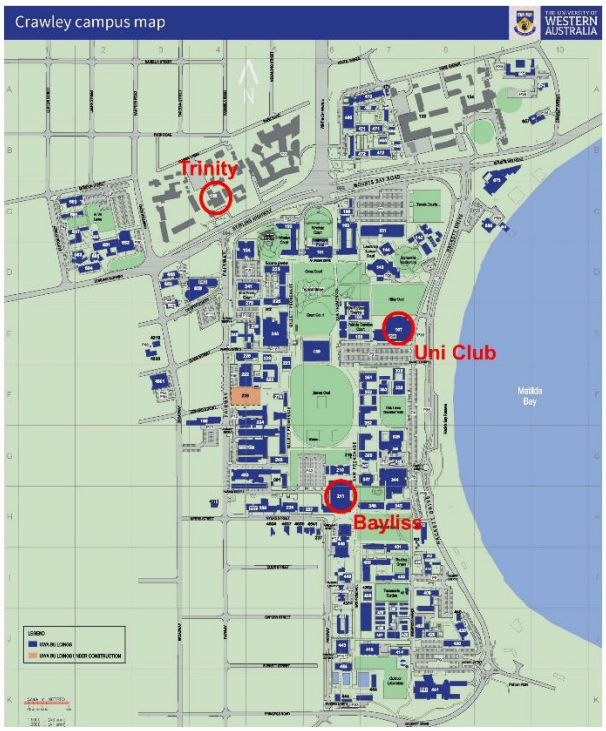
Tea and coffee from 08:30 Friday, Saturday and Sunday.

Conference Dinner

University Club (grid E7, building 107),

Saturday 7th December

Canapé and beverage service 18:00-21:00



Conference Programme

Friday 6th December

		Chair: Philip Withers
09:00		Welcome and opening
09:20	**Taylor Dick**	**Plenary presentation**: Gears, latches, and catapults: the influence of muscle-tendon interactions on animal performance
10:20		**Morning Tea**
		Chair: Christine Cooper
11:00	Shane Maloney	Does heterothermy correlate with fitness outcomes in mammals?
11:20	Christofer Clemente	Using a bio-inspired climbing robot to explore the evolution of optimality in climbing lizards.
11:40	Paul Cooper	Using differential pest resistance in grapevines to control scale insects in relation to climate change effects.
12:00	Bryn Funnekotter	Advancing cryobiotechnology for the conservation of Australia's unique flora.
12:20		**Lunch**
		Chair: Fritz Geiser
13:20	Maartin Strauss	Peripheral vasoconstriction accompanies hypothermia during nutritional stress in African antelope.
13:40	James Wong	Inhibitory nerves dominate airway smooth muscle response to electrical field stimulation.
14:00	Qiaohui Hu	Regional femoral bone blood flow estimation in chickens using fluorescent microspheres and vascular casting.
14:20	Lauren Gilson	Effect of varying the evaporative environment on evaporative water loss and other physiological variables for a small arid habitat parrot.
14:40		**Afternoon Tea**
		Chair: Sean Tomlinson
15:20	Mylene Mariette	Early-life effects on endocrine responses to temperature in the zebra finch.
15:40	Waseem Abbas	Bridging the gap between controlled atmosphere fumigation and respiration physiology for effective management of stored-grain insect pests.
16:00	Luoyang Ding	Associations between temperament related traits and SNPs in the serotonin and oxytocin pathways in Merino sheep.
16:20	Lily Whelehan	Assessing the effect of cryopreservation on oxygen consumption of plant shoot tips.
16:40		**AGM**

Conference Programme

Saturday 7th December

		Chair: Philip Withers
09:00	**Roger Seymour**	**Plenary presentation**: The holes in the fossil record: how foramina in fossil bones gauge blood flow rate and metabolic intensity of archosaurs and human ancestors.
10:00		**Morning Tea**
		Chair: Koa Webster
11:00	Dominique Blache	Can comparative physiology guide the ethical use of animals?
11:20	Fredrik Jutfelt	Reduced physiological plasticity in a fish adapted to stable conditions.
11:40	Tom Nelson	Cerebral blood flow estimation in chickens using fluorescent microspheres, vascular casting, and osteoforamina measurement.
12:00	Subhashi Rajapakshe	Hydrological and thermal responses of seeds from four co-occurring tree species from southwest Western Australia.
12:20		**Lunch**
		Chair: Roger Seymour
13:20	Charlotte Boehm	The influence of limp morphology on spider speed.
13:40	Adian Izwan	Scaling of cardiovascular variables in wild African antelope.
14:00	Mia Kontoolas	Effects of oestrogenic subclover on reproductive function in the ewe.
14:20	Terry Dawson	The metabolic burden of size and growth for juvenile *Osphranter rufus*: How can gut size limitations be countered to process sufficient nutrients?
14:40		**Afternoon Tea**
		Chair: Terry Dawson
15:20	Siobhan Sullivan	Influence of water availability and subsequent drought on plant establishment within the natural and post-mining environments of semi-arid Western Australia.
15:40	Grace Goh	The effect of stable and cycling ambient temperature on lifespan and clock gene expression in *Drosophila melanogaster*.
16:00	Rachael Morgan	Evolution of upper thermal tolerance: an artificial selection experiment in wild-caught zebrafish.
16:20	Matteo Ungaro	Identifying the Devil: a new approach to animal photographic identification.
16:40	Emma Dalziell	The allometric relationship between seed mass and resting metabolic rate.
18:30		**Conference Dinner**

Conference Programme

Sunday 8th December

		Chair: Mylene Mariette
09:00	Christine Cooper	Effect of a summer heatwave on the field metabolic rate and water turnover of a small avian desert granivore.
09:20	Gerhard Körtner	Diurnal versus nocturnal activity patterns in dasyurids.
09:40	Koa Webster	Prevalence of antimicrobial resistance genetic elements in possum faecal samples: preliminary results from the Scoop a Poop citizen science project.
10:00		**Morning Tea**
		Chair: Shane Maloney
11:00	Fritz Gesier	The functional implications of heterothermy during development in altricial mammals.
11:20	Sean Tomlinson	Hydrothermal germination as a distribution-limiting trait: A process oriented approach to understanding short-range endemism in plants.
11:40	Philip Withers	Effects of helox on respiratory exchange via the "diffusion" lung of the aestivating pulmonate snail *Cornu (Helix) aspersa*.
12:00		**Lunch**

Gears, latches, and catapults: the influence of muscle-tendon interactions on animal performance.

Dick, T.J.M.

School of Biomedical Sciences, University of Queensland, Brisbane, Australia.

To succeed in nature, animals must be capable of movements that are slow, precise and delicate but also fast, forceful, and powerful. These movements are driven by skeletal muscle, thus animal locomotor performance requires an incredibly broad range of mechanical outputs. The interactions between the contractile and elastic machinery that comprises muscle-tendon units, enables the mechanical performance of an animal to far exceed the capabilities of muscle contractile elements alone. Although some of the mechanisms that allow for such a broad functional range are well understood, others are far less familiar. Recent advances in imaging and biomechanical experimental techniques allow us to look 'under the skin' and have unveiled a series of phenomena that emerge within the muscle-tendon units of a moving animal. In this talk, I will highlight three of these muscle-based phenomenon - gears, latches, and catapults - and discuss how they influence animal performance. Specifically, I will focus on how muscle bulging or 3 dimensional shape changes influences performance; how robotic elastic exoskeletons alter efficiency during locomotion; and finally how the lower limb behaves during rapid unexpected perturbations, like falling in a hole. These features will illustrate how animals are able to perform the remarkable diversity of locomotor tasks we see in nature today, but also may allow us to make predictions regarding how extinct creatures may have moved.

Notes

Does heterothermy correlate with fitness outcomes in mammals?

Maloney, S.K.[1,2], Blache, D. [3], Daud, D.[1,3], Kamerman, P.R.[2] and Fuller, A.[2]

[1]School of Human Sciences, University of Western Australia, Australia.

[2]School of Physiology, University of the Witwatersrand, Johannesburg, South Africa.

[3]School of Agriculture & Environment, University of Western Australia, Australia.

An increase in the amplitude of the 24-h rhythm of body temperature in mammals can be induced by energy and water deficits. Since performance traits also are impacted by energy and water, we investigated whether variability in the body temperature rhythm provides an indication of investment in growth. We measured the core body temperature of 25 sub-adult alpacas for a year using temperature loggers. Each month, the animals were weighed and a blood sample collected for leptin and insulin measurement. We used cosinor analysis to determine the average daily mean, minimum, and amplitude of core body temperature for each month. Body mass gain per month was lower in months that were cooler, and the average minimum daily core body temperature (a measure of heterothermy) was lower in those same months. The minimum core body temperature was a strong predictor of the average monthly gain in body mass. Insulin and leptin were significantly related to mass gain, but the effect size was small. We propose that the pattern of the 24-h body temperature rhythm could provide an index of animal fitness in a given environment.

Notes

Using a bio-inspired climbing robot to explore the evolution of optimality in climbing lizards.

Schultz, J., Beck, H., Haagensen, T., Proost, T. and **Clemente, C.**

School of Science & Engineering, University of the Sunshine Coast, Sippy Downs, Australia.

Most scientists generally accept that the ability for natural systems to become optimised for any one task is limited by both developmental and functional constraints. Exploring these limitations in nature is often limited by a biased sample of extant species, i.e. only successful species survive. To better understand this idea we developed a climbing robot based on the morphology of climbing lizards. The robot is able to be quickly customized, adjusting wrist angles, limb excursion angles, spine excursion angles, speed of movement, as well as claw morphology. In this way we can understand the extent to which species have been optimized to the task of climbing vertical surfaces, and the extent to which species have prioritized conflicting tasks such as speed and stability. We compare our climbing robot with kinematics recorded from both the Asian house gecko (*Hemidactylus frenatus*), and the Australian water dragon (*Intellagama lesueurii*), with good agreement in limb kinematics optimizing for increased climbing speed, though distance from the optimal solution differed between species. Our robot was also able to reproduce the functional trade-off between speed and stability, with higher climbing speeds resulting in more slips from vertical surfaces.

Notes

Using differential pest resistance in grapevines to control scale insects in relation to climate change effects.

Cooper, P.D.

Research School of Biology, Australian National University, Canberra, Australia.

The effect of potential changes in climate rarely considers how changes may impact the effect of pest insects on the yield of agricultural crops. Crops in temperate regions may be affected to a greater extent than more tropical crops. Grapevines are typical of temperate plants and therefore may be more susceptible to the effects of soft scales (*Parthenolecanium* sp.) as temperature and humidity change in the future. Scale insects produce honeydew that initiates the growth of sooty mould on grapes and leaves and vineyards have suffered yield reduction and economic losses as a result. Honeydew residues remain on leaves and fruit for longer periods with increased absolute humidity, and sooty mould may become more prevalent with climate change. A solution to this problem is using naturally occurring resistance expressed in cultivars of grapevines in relation to scale infestation (*e.g.* Pinot Noir and Sauvignon Blanc) and determining how to use natural compounds to combat this potential change in all grapevines around Australia. Using solid phase microextraction GC-MS to determine how inducible defenses are differentially expressed in grapevines exposed to scales, my work suggests how that might be applied in the future.

Notes

Advancing cryobiotechnology for the conservation of Australia's unique flora.

Funnekotter, B.[1,2], Bunn, E.[2] and Mancera, R.L. [1]

[1]School of Pharmacy & Biomedical Sciences, Curtin University, Perth, Australia.

[2]Kings Park Science, Botanic Gardens and Park Authority, Perth, Australia.

Cryopreservation is a valuable tool for the long-term conservation of recalcitrant and valuable species. However, the process of cryopreserving a species imposes various stresses, including ice formation, oxidative stress, mitochondrial damage, and solute toxicity, all of which can limit survival rates after cryopreservation. Cryobiotechnology aims to understand and mitigate these cryo-stresses, resulting in the continued development of new and improved cryopreservation protocols. Oxidative stress is a major contributor to damage during the cryopreservation process – this presentation will focus on recent work looking at the role of antioxidants in mitigating stress incurred during cryopreservation with Australian species. The major cellular antioxidants show significant declines during the cryopreservation process. Cryo-tolerant species (e.g. *Anigozanthos viridis*) tend to maintain their antioxidant status far better than cryo-sensitive species (e.g. *Loxocarya cinerea*). To mitigate oxidative stress, the addition of exogenous antioxidants during the cryopreservation protocol is commonly used, with the addition of glutathione significantly improving post-cryogenic success of *L. cinerea*. However, exogenous antioxidants were of limited benefit for the cryopreservation of recalcitrant *Syzygium* species, which showed similar reductions in antioxidant capacity and increased lipid peroxidation during cryopreservation. Further work will need to be done to understand the sensitivities of this species to cryopreservation.

Notes

Peripheral vasoconstriction accompanies hypothermia during nutritional stress in African antelope.

Strauss, W.M.[1,2], Hetem, R.S.[2,3], Mitchell, D.[2], Maloney, S.K.[4], Boyers, M.[3] and Fuller, A.[2]

[1]Department of Environmental Science, University of South Africa, Johannesburg, South Africa.

[2]School of Physiology, University of the Witwatersrand, Johannesburg, South Africa.

[3]School of Animal, Plant & Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa.

[4]School of Human Sciences, University of Western Australia, Perth, Australia.

Homeothermy requires energy and water, and appears to be a luxury, maintained in large mammals only when they have access to sufficient resources. A decrease in the minimum 24h body temperature occurs during times of nutritional stress, but it is unknown whether that is a regulated decrease in body temperature or an inevitable consequence of insufficient energy to defend body temperature. Using implanted biologgers, we measured, during the hot-dry and the hot-wet seasons, abdominal and subcutaneous temperature simultaneously in three antelope species with varying water dependencies; gemsbok *Oryx gazella*, red hartebeest *Alcelaphus buselaphus* and blue wildebeest *Connochaetes taurinus*. The animals lived free in the arid north of South Africa. We found no species differences in the 24h rhythm of abdominal or subcutaneous temperature. Irrespective of ambient temperature, minimum abdominal temperature ($z=5.13$, $P<0.0001$), as well as the minimum subcutaneous temperature ($z=8.52$, $P<0.0001$), decreased as vegetation greenness declined. All three species increased peripheral vasoconstriction (measured as an increased abdominal-subcutaneous differential) when vegetation was brown ($z=-8.67$, $P<0.0001$), implying that they attempted to maintain body temperature during nutritional stress. Hypothermia resulted presumably because the energy deficit compromised their ability to maintain the metabolic rate required for homeothermy.

Notes

Inhibitory nerves dominate airway smooth muscle response to electrical field stimulation.

Wong, J.T.H.[1], Arrow, R.[1], Wang, K.C.W.[1,2], Maloney, S.K.[1], Henry, P.J.[3] and Noble, P.B.[1]

[1]School of Human Sciences, University of Western Australia, Crawley, Australia.

[2]Telethon Kids Institute, Nedlands, Australia.

[3]School of Biomedical Sciences, University of Western Australia, Nedlands, Australia.

Species variability offers an opportunity to reveal different mechanisms by which airway smooth muscle (ASM) is activated/deactivated to understand its underlying function. The unique hopping-mediated breathing in kangaroos may expose ASM to different physiological/mechanical environments compared to other species. Our study characterised excitatory and inhibitory neural control of ASM from kangaroos. Kangaroo lungs were acquired after licensed culls and airway rings isolated and mounted in organ bath chambers. Contraction/relaxation to electrical field stimulation (EFS) of nerve endings (30Hz, 5ms, 60V) was normalised to a reference contraction produced by histamine (10^{-5}M). Responses were examined with and without exposure to propranolol (n=7), L-NAME (n=7), or indomethacin (n=7). Contraction to EFS (36±14%) was blocked by atropine (4.5±1%) but unaffected by propranolol or indomethacin. However, in the presence of L-NAME (88±18%), contraction to EFS was increased compared with controls. Rexalation via inhibitory nerves was assessed in the presence of atropine and after pre-contraction to histamine. Relaxation to EFS was two-fold greater than the excitatation (63±5% reversal of histamine-induced contraction) and partially inhibited by propranolol (33±2%). These data demonstrate that neurally-induced ASM contraction is driven by cholinergic nerves, while inhibitory responses involve both β-adrenergic and nitrergic pathways and the latter response dominates.

Notes

Regional femoral bone blood flow estimation in chickens using fluorescent microspheres and vascular casting.

Hu, Q., Nelson, T.J and Seymour, R.S.

School of Biological Sciences, University of Adelaide, Adelaide, Australia.

Regional blood flow rates reflect local tissue oxygen requirements. Femoral bone blood flows estimated from femoral nutrient foramina in vertebrates showed associations with bone metabolism. In this study, fluorescent microspheres were injected into the circulation to investigate regional femoral bone blood flow in young non-laying hens, laying hens and roosters. Laying hens have higher mass-independent blood flow to the femora than the non-laying hens, associated with egg shell production. Sizes of arteries and osteoforamina that contain arteries can also represent the regional blood flow rates. Femoral nutrient artery lumen sizes inside femoral nutrient foramina were measured under physiological pressure using vascular casting and micro-CT scanning. Nutrient arteries mainly supply the femoral femur shaft regions. In all three groups of chickens, absolute nutrient artery blood flow rates estimated from the lumen sizes were not significantly different from the absolute femur shaft bone blood flow collected from the fluorescent microsphere technique. Relationships among chicken absolute femoral bone blood flows, nutrient artery sizes and nutrient foramen sizes can provide insight into dinosaur femoral bone blood flows.

Notes

Effect of varying the evaporative environment on evaporative water loss and other physiological variables for a small arid habitat parrot.

Gilson, L.N.[1], Cooper, C.E.[1,2] and Withers, P.C.[1,2]

[1]School of Molecular & Life Sciences, Curtin University, Perth, Australia.

[2]School of Biological Sciences, University of Western Australia, Perth, Australia.

The ability to regulate "insensible" evaporative water loss (EWL) independent of the water vapour pressure differential (ΔWVP) between the animal and ambient air has been described for several species of mammal and one bird. Here we assess the ability of another small, arid-habitat bird, the mulga parrot (*Psephotus varius*), to regulate insensible EWL using two techniques. We measured EWL and other physiological parameters and manipulated the evaporative environment by adjusting the relative humidity (RH), and by exposing the birds to helox (21% oxygen in helium), at a range of ambient temperatures. A significant relationship between EWL/ΔWVP and RH, indicating regulation of insensible EWL, occurred at 25° and 30°C, but not at 20°C. Body temperature, metabolic rate, and thermal conductance did not vary with humidity, suggesting that EWL regulation allowed these thermoregulatory variables to remain constant under different evaporative conditions. Helox increased thermal conductance such that metabolic rate also increased, and EWL in helox was significantly higher at 15 and 20°C but did not differ significantly to that in air at 25° or 30°C. Modifying the evaporative environment by two different methods confirms regulation of "insensible" evaporative water loss at some ambient temperatures in another arid-adapted bird, the mulga parrot.

Notes

Early-life effects on endocrine responses to temperature in the zebra finch.

Mariette, M.M, Udino, E., Crino, O.L. and Buchanan, K.L.

School of Life & Environmental Sciences, Deakin University, Geelong, Australia.

As climate change intensifies and global temperatures increase, understanding species physiological adaptations to elevated air temperatures is becoming increasingly urgent. In particular, little is known about the sources of variation giving rise to inter-individual differences in thermal preferences and susceptibility to heat. Recently, we demonstrated that zebra finch parents emit a peculiar vocalization at high air temperature, particularly during late incubation. In a large playback experiment in incubators, we showed that exposure of embryos to this call alone adaptively alters subsequent nestling growth in response to nest temperature, and influences individuals' thermal preferences as adults. Here, we investigate the possible physiological mechanisms underlying such developmental programming by prenatal acoustic signals. Specifically, we hypothesized that changes in baseline corticosterone levels, the principal stress hormone in birds, which also regulates metabolism, may contribute to the differential growth patterns observed. We therefore tested the effects of prenatal acoustic experience on baseline corticosterone on zebra finch nestlings raised in different thermal environments. We found that early-life experience had subtle effects on nestling endocrine profile, which warrants further investigation. Overall, our study highlights the importance of considering physiological responses to thermal challenges to better predict the impact of climate change on biodiversity loss.

Notes

Bridging the gap between controlled atmosphere fumigation and respiration physiology for effective management of stored-grain insect pests.

Abbas, W., Withers, P.C. and Evans, T.A.

School of Biological Sciences, University of Western Australia, Perth, Australia.

Insect pests of stored grains are developing tolerance to controlled atmospheres fumigation, which is one of the very few eco-friendly management tools. Empirical approaches of controlled atmospheres research have largely focused on the issue of tolerance, whereas the respiration physiology of these insect pests has not been given enough attention. Insects can modify their respiratory exchange by using at least three different breathing patterns in response to changing temperature, humidity, or sub-lethal gaseous conditions. The persistence of insect pests in relatively dry storage environments and their tolerance of controlled atmospheres may reflect the use of one of these patterns, discontinuous gas exchange cycles (DGC), which can enable insects to survive dry or sub-lethal gaseous conditions. The red flour beetle, *Tribolium castaneum*, which is a cosmopolitan pest of stored grains, was investigated for its gas exchange patterns for consecutive three days using flow through respirometry. Beetles initially showed continuous breathing but switched to DGC after 24 hours. The small body size of flour beetles resulted in a high cycle frequency of DGC, approaching the continuous breathing pattern. Knowledge of these gas exchange patterns of insect pests could provide a sound theoretical base to the efficacy of controlled atmospheres.

Notes

Associations between temperament related traits and SNPs in the serotonin and oxytocin pathways in Merino sheep

Ding, L.[1], Maloney, S. K.[2], Rodger, J.[2], Chen, L.[3], Wang, M.[4] and Blache, D.[1]

[1]School of Agriculture & Environment, University of Western Australia, Perth, Australia.

[2]School of Human Sciences, University of Western Australia, Perth, Australia.

[3]Department of Genetics & Pediatrics, University of Groningen, Groningen, Netherlands.

[4]College of Animal Science & Technology, Yangzhou University, Yangzhou, China.

In humans, single nucleotide polymorphisms (SNPs) in genes that code for tryptophan hydroxylase (TPH2), the serotonin transporter (SLC6A4), the serotonin receptor (HTR2A), and the oxytocin receptor (OXTR) are associated with differences in personality traits. In other species, the response to common stressors differs between individuals with nervous and calm temperaments. The objective of this study was to identify if there are associations between SNPs in *TPH2, SLC6A4, HTR2A,* and *OXTR* and temperament traits in Merino sheep. We used sixty sheep from a flock at UWA that has been bred for more than 20 generations for "calm" or "nervous" temperament. A total of 12 SNPs were tested, and the genotypes of 8 SNPs (rs107856757, rs107856818, rs107856856 and rs107857156 in *TPH2*, rs20917091 in *SLC6A4*, rs17196799 and rs17193181 in *HTR2A*, and rs17664565 in *OXTR*) distributed differently between the calm and nervous sheep. Those 8 SNPs were then genotyped in 260 sheep that had never been selected on temperament traits. We then determined the behaviour of those sheep to calculate the capacity of using these SNPs to predict the temperament phenotypes. Two SNPs (rs107856856 and rs17196799) were associated with the temperament phenotype, suggesting that the serotonin pathway is involved in the expression of temperament in sheep.

Notes

Assessing the effect of cryopreservation on oxygen consumption of plant shoot tips.

Whelehan L.M.[1,2,], Dalziell, E.L.[2,3], Bunn, E.[2], Mancera, R.M.[1] and Funnekotter, B.[1,2]

[1] School of Pharmacy & Biomedical Sciences, Curtin University, Perth, Australia.

[2] Kings Park Science, Department of Biodiversity, Conservation & Attractions, Perth, Australia.

[3] School of Molecular & Life Sciences, Curtin University, Perth, Australia.

Cryopreservation is a method of *ex situ* conservation for threatened plant species. Although this method allows long-term storage, it also causes damage to plant tissues, which must be repaired for survival. This repair process is fuelled by the metabolic function of mitochondria; however, little is known about how metabolic function is affected by cryopreservation in plants. While metabolic rates and mitochondrial function have been examined in animal cryopreservation, this is the first study to characterise metabolic function during cryopreservation in plants. In this study we describe a new approach that utilises fluorometric respirometry to characterise metabolism and mitochondrial function in plant tissues subject to cryopreservation. The metabolic rates of shoot tips of *Androcalva perlaria* and *Anigozanthos viridis* were determined before and after cryopreservation, with cryopreservation causing the average metabolic rate to be significantly reduced in both species ($p < 0.01$). The average post-cryopreservation metabolic rate differed significantly between dead, surviving and regenerating shoot tips in both species ($p < 0.01$). The findings of this study can inform the direction of further research into mitochondrial function during plant cryopreservation and how fluorometric respirometry can best be applied to this type of research.

Notes

The holes in the fossil record: how foramina in fossil bones gauge blood flow rate and metabolic intensity of archosaurs and human ancestors.

Seymour, R.S.

School of Biological Sciences, University of Adelaide, Adelaide, Australia.

The Metabolic Theory of Ecology is based on the erroneous proposition that the structure of the circulatory system determines the metabolic rates of animals. Quite the opposite, the structure of the vertebrate circulatory system is determined by the metabolic intensity of the tissues that it services. The sizes of the arteries are dynamically regulated by the flow regimes imposed by the demands of the tissues for oxygen. Thus vascular size can be used to infer metabolic rate, and where blood vessels pass through bones, the size of the bone foramen provides a gauge of the metabolic intensity of the serviced tissue. This presentation includes the theoretical and empirical bases for evaluating vascular foramina in recent and fossil bones. Then it uses fossil bones to show the antiquity of endothermy in archosaurs and the trajectory of brain perfusion in human ancestors.

The shaft of the femur is perfused by vessels that pass through the principal nutrient foramen. The size of the foramen indicates an index of blood flow rate (Qi) that can be compared between species. We have found principal nutrient foramina on well-preserved femora in about 200 fossils from the two archosaur lineages: the dinosaur-avian lineage and the crocodylian lineage. To determine how far back in the archosaur lineages high bone perfusion existed, here we focus on the basal archosaurs with 13 Triassic genera. The Qi values for these animals are not significantly different from extant endothermic mammals and birds, but are significantly above extant ectothermic non-avian reptiles. These results support the hypothesis that the basal archosaurs were originally highly active animals, relying on aerobic metabolism for sustained locomotion as adults. Some exceptionally large foramina may be associated with rapid bone growth. High activity and growth rates are characteristic of endotherms. Interestingly, large foramina among crocodylian lineage persisted past the extinction event at the end of the Mesozoic.

Another recent study focuses on brain blood flow rate through the carotid canals of primate skulls. In this case, the internal carotid arteries fill the canal without accompanying veins or nerves, so we can calculate blood flow rate ($\dot{Q}_{ICA}$) in real units ($cm^3\ s^{-1}$), rather than the index Qi. Because the internal carotid arteries supply most of the primate cerebrum, and brain metabolic rate is linked mainly to the cost of cerebral synaptic activity,

the size of the carotid canals should provide a better correlate of cognitive ability than brain size alone. The scaling relationship between $\dot{Q}_{ICA}$ and brain volume (V_{br}) shows an exponent of 1.03 across 44 species of living haplorhine primates; thus ICA perfusion rate is directly proportional to brain size. It is also proportional to the volumes of the cognitive parts of the primate brain, the telencephalon and neocortical gray matter. Humans fall on this primate scaling line with the largest brains. However, humans did not evolve to this state by following the same scaling path. Among 12 species of human ancestors (hominins), $\dot{Q}_{ICA}$ scales with V_{br} with an exponent of 1.41, revealing a much steeper trajectory from early ancestors to humans. Between 4.4-million-year-old *Ardipithecus* and *Homo sapiens*, V_{br} increased 4.7-fold, but $\dot{Q}_{ICA}$ increased 9.3-fold, indicating an approximate doubling of metabolic intensity of brain tissue. The implication of these different scaling relationships is that $\dot{Q}_{ICA}$ is up to two times higher in recent gorillas, chimpanzees and orangutans compared to 3-million-year-old australopithecine human relatives, which had equal or larger brains. Therefore, a recent gorilla (e.g. Koko, who learned to communicate with over 1000 signs) may have been more intelligent than *Australopithecus* species (e.g. Lucy), despite having the same brain size.

Notes

Can comparative physiology guide the ethical use of animals?

Blache, D. [1] and Maloney S.K. [2]

[1] School of Agriculture & Environment, University of Western Australia, Perth, Australia.

[2] School of Human Sciences, University of Western Australia, Perth, Australia.

The ethical use of non-human animals for research is a subject for societal debate and concern. The number and categories of species that are protected by Animal Welfare Law in Australia and New Zealand has increased recently, partly because the definition of "animal" has proved controversial. Knowledge of comparative physiology has been central to the selection of species that are considered worth protecting under animal welfare acts. Over the last two decades, the concept of sentience and, indirectly, that of consciousness, has been introduced incrementally into laws and regulations around the world, from Europe, to New Zealand, and gradually in each Australian jurisdiction. The objectives of this paper are to briefly review and question the past and current role of comparative physiology in informing legislation on the use of animals in research and other human-animal interactions. Then, we will discuss human perceptions of different species and how those perceptions affect our attitude towards the use of animals. As a means of conclusion, we will reflect on possible alternatives that might serve future legislations.

Notes

Reduced physiological plasticity in a fish adapted to stable conditions.

Morgan, R.,[1], Andreassen, A.H.[1], Åsheim, E.R.[1], Finnøen, M.H.[1], Dresler, G.[1], Brembu, T.[2], Loh, A.[3], Miest, J.J.[3] and **Jutfelt, F.**[1]

[1]Department of Biology, Norwegian University of Science & Technology, Trondheim, Norway.
[2]Department of Biotechnology & Food Science, Norwegian University of Science & Technology, Trondheim, Norway.
[3]School of Science, University of Greenwich, Chatham Maritime, Kent, UK.

Environmental temperature controls body temperature in ectotherms. To counter direct thermal effects on biological rates, fish encountering fluctuating temperatures adjust their physiology using physiological plasticity, or acclimation. Zebrafish (*Danio rerio*) in the wild encounter large daily and seasonal temperature changes, suggesting they should display high physiological plasticity. Conversely, laboratory zebrafish lines have been reared for 150 generations at optimal temperature. We treated this zebrafish domestication as an evolution experiment where fish have been adapted to low thermal fluctuations and asked the question if this has reduced the physiological plasticity of lab fish compared to their wild counterparts. We measured a range of traits in wild and lab zebrafish fully acclimated to 15 temperatures from 10°C to 38°C. By comparing a wide range of traits, we show that domestication has had major effects on many levels of their biology. Lab fish show reduced plasticity and are thus less able to counter the direct effects of temperature on e.g. metabolism and thermal tolerance, and this difference is detectable down to gene expression level. Higher growth in the less plastic lab zebrafish suggests there are trade-offs involved in being plastic. These results suggest that stable environments can rapidly cause loss of physiological plasticity.

Notes

Cerebral blood flow estimation in chickens using fluorescent microspheres, vascular casting, and osteoforamina measurement.

Nelson, T.J, Hu, Q. and Seymour, R.S.

School of Biological Sciences, University of Adelaide, Adelaide, Australia.

Measurement of cerebral metabolism relies upon calculation or estimation of cerebral perfusion rate. We utilized three approaches to determine cerebral metabolism via cerebral perfusion in three groups of chickens. Vascular casting techniques are often used for analysis of blood flow patterns while microsphere perfusion techniques are used in quantification of blood flow rates for targeted tissues. We investigated the use of pressurized perfusion of contrast media into arteries for quantification of arterial lumen dimensions. Arteries perfused with contrast media exhibit lumen sizes smaller than predicted lumen sizes. Cerebral blood flow values obtained via the use of fluorescent microspheres correlate with and validate the use of osteoforamina measurements as a method of estimation of cerebral metabolism. Adolescent hens present cerebral perfusion rates and volume specific perfusion rates significantly lower than laying hens. Roosters present cerebral perfusion rates which are not significantly different from either adolescent or laying hens, but volume specific rates of perfusion in the telencephalons which are significantly lower than in laying hens. Roosters had significantly larger telencephalons than adolescent hens. Otherwise, regional brain masses were not significantly different from one another across the three groups.

Notes

Hydrological and thermal responses of seeds from four co-occurring tree species from southwest Western Australia.

Rajapakshe, S.[1,2], Tomlinson, S. [1,2], Cross, A.T.[1] and Turner, S.R.[2,3]

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Seed germination is a critical stage in the life cycle of plants defined by specific tolerance thresholds. Widespread plant species commonly germinate over a broad range of temperatures and water stress levels, whereas range-restricted species often exhibit a narrower germination window in terms of temperature and moisture. We investigated the relationship between maximum germination (G_{max}), and time to 50% germination (t_{50}) in response to temperature and water stress in four co-occurring Western Australian native *Eucalyptus* species. *Eucalyptus caesia* subsp. *caesia* and *E. ornata* exhibit a highly localised distribution and a narrow geographical range. These species were compared with the widespread and dominant congenerics *E. salmonophloia* and *E. salubris*. There was a distinctive hump-shaped response of t_{50} to temperature and an exponential response to water stress characteristic of rate- and threshold-limited processes, but no consistent pattern in the response of G_{max}. The two range-restricted taxa had narrower thermal tolerance ranges than their widespread, eurythermic congenerics. Short range-endemics exhibited higher lability to temperature and drought stress compared to the widespread species in terms of final germination percentage. The insights gained in this study may be beneficial for identifying thresholds for temperature and water stress tolerance in seeds of rare flora.

Notes

The influence of limp morphology on spider speed.

Boehm, C.

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Spiders locomote with a hydraulic mechanism that changes the internal volume of the haemolymph in their limbs, resulting in leg-extension. This study examined if the locomotory specialisation could limit speed. 67 spiders were collected and data for another 61 spiders from a previous study were analysed, consisting of Lycosidae and Sparassidae. This study assessed running speed, how spiders modulate speed and how this is related to leg morphology and the hydraulic pressure system. As previous research established, maximum running speed is still changing with body mass$^{0.35}$, while speed for a subset of the data scaled with mass$^{0.30}$. Looking at stride distance, it scaled with mass$^{0.30}$ while stride duration scaled with mass$^{0.16}$. Stride distance scaled with mass$^{0.05}$ for Lycosidae and mass$^{0.13}$ for Sparassidae. Linear mixed-effect models for the morphological analyses established that mass, species and leg were the most important variables. Segment lengths increased with body mass to an exponent greater than 0.33. Segment widths for the Lycosidae increased less than expected, while all segment widths for Sparassidaes increased with mass to an exponent greater than 0.33 (as expected). Volume increased much higher than expected for both. As segment length and volume increases more than expected (greater than 0.33), while segment width is not increasing with the same rate, suggests that the locomotory specialisation can increase the resistance of the haemolymph flow and possibly affect spider speed.

Notes

Scaling of cardiovascular variables in wild African antelope.

Izwan, A.[1], Snelling, E.P.[2], Seymour, R.S.[3], Meyer, L.C.R.[4,5], Fuller, A.[4,5], Haw, A.[4], Mitchell, D.[1,4], Farrell, A.P.[6,7], Costello, M.A.[8] and Maloney, S.K.[1,4]

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[2] Department of Anatomy & Physiology, University of Pretoria, South Africa.

[3]School of Biological Sciences, University of Adelaide, Adelaide, Australia.

[4]School of Physiology, University of the Witwatersrand, South Africa.

[5]Department of Paraclinical Sciences, University of Pretoria, South Africa.

[6]Department of Zoology, University of British Columbia, British Columbia, Canada.

[7]Faculty of Land & Food Systems, University of British Columbia, British Columbia, Canada.

[8]Central Animal Service, University of the Witwatersrand, South Africa.

Antelope hearts scale allometrically with body mass, according to a power equation with an exponent of 0.88±0.07 (±95% confidence interval). This differs from the isometric scaling of heart mass in other mammals. Consequently, smaller antelope have relatively larger hearts and stroke volumes than their larger counterparts, and thus a relatively slower heart rate than other comparably sized mammals. By maximally stimulating heart rate with exogenous adrenaline, we found that smaller antelope potentially have the same aerobic scope as larger antelope, which is not the case in other mammals. By having a relatively larger stroke volume at rest, smaller antelope have a larger heart rate reserve by which to increase cardiac output, which would represent a survival advantage due to the higher predation pressures on smaller antelope. Additionally, it was found that the cardiac work rate is not a constant proportion of the total metabolic rate in the antelope. Cardiac work rate scaled as 0.86±0.22, while total metabolic rate scaled as 0.75±0.19. Consequently, the ratio of cardiac work rate to total metabolic rate scaled with an exponent of 0.12±0.10. Therefore, the relative cost of the circulation increases from 10% in a 12 kg duiker to 15% in a 230 kg eland.

Notes

Effects of oestrogenic subclover on reproductive function in the ewe.

Kontoolas, M.,[1,] Blache, D.[2], Wyrwoll.C.S.,[1] Durmic, Z., .[2] Ryan, M.H.[2] and Foster, K.[2]

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One of the primary pasture legumes that is consumed by Merino sheep in Western Australia is the highly nutritive subterranean clover (*Trifolium subterraneum L*), or subclover. Some older cultivars of subclover contain phytoestrogens, naturally occurring phytochemicals, that mimic the structure and function of mammalian oestrogens, especially oestradiol. While dramatic impacts of phytooestrogens on the reproductive system, such as prolapse, have been previoulsy described, more subtle effects have not. The present study investigated the impact of exposure to phytoestrogen (PHY) compared to non-exposure (CON) in ewes. The external genitalia and macroscopic cervical morphology were simlar between PHY and CON. The was no significant difference in the cervical crypt depth, cervical folds, number or muscularis width between PHY and CON ewes. The number of cervical glands was higher in the PHY than in the CON ewes, and there was abnormal pathology observed in animals treated with high doses of oestradiol. This study is the first evidence that permanent histological change to the reproductive tract of ewes fed oestrogenic subclover, that could result in infertility, can occur without the external physical symptoms.

Notes

The metabolic burden of size and growth for juvenile *Osphranter rufus*: How can gut size limitations be countered to process sufficient nutrients?

Dawson, T.J.[1], Norton, M.A.[1], Rodoreda, S.[1] and McLeod, S.[2]

[1]School of Biological, Earth & Environmental Sciences, University of New South Wales, Sydney, Australia.

[2]NSW Department of Primary Industries, Vertebrate Pest Research Unit, Orange, NSW, Australia.

High juvenile mortalities in large mammalian herbivores feature in poor seasons. *O. rufus* inhabits arid lands and its juveniles have fluctuating survivorship, yet, they can grow relatively rapidly. But, at weaning, when only ~40 % of adult female mass, juveniles require nutrient intakes near to those of the females. Investigations of full gut masses showed them to be only directly proportional to body mass across the age classes. So, how do juveniles achieve their nutrient needs for optimal growth? During lactation *O. rufus* increase gut size to cope with the extra nutrient needs but this is not available to juveniles under nutritional stress because they are generally at full capacity. So, two options are open: a) selection of more digestible feed than the adults, or b) process the feed more to make it more digestible – ruminants do this by extra chewing. We determined rates of passage of digesta when the two age classes foraged on natural pasture. Rates of passage for both fluid and particulate digesta components were fastest in juveniles. Differences in digesta particle size patterns also indicate additional mastication by the juveniles. Young grass appeared to be the best option for the juveniles.

Notes

Influence of water availability and subsequent drought on plant establishment within the natural and post-mining environments of semi-arid Western Australia.

Sullivan, S.T.M.[1,2], Veneklaas, E.J.[1], Stevens, J.C.[1,2] and Poot, P. [1]

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Rainfall in the semi-arid regions of Western Australia is highly variable and therefore opportunities for plant establishment are limited in most years. Rainfall patterns in this climatic transition zone are also likely to shift significantly with climate change. While pertinent to conservation and restoration success, little is known about the influence of drought on the assembly of new plant communities. A field trial in the Mid-West of Western Australia was established to provide a greater understanding of the influence of water pulses and drought on plant recruitment in natural and novel semi-arid environments. A small area of native vegetation was cleared to mimic a natural disturbance event and allow for comparison with a bare waste rock dump. Endemic species from the *Acacia* and *Eucalyptus* genera were introduced as seed and tubestock. Three watering treatments were applied to the two sites and seedling emergence, growth, survival and physiology were observed. It is hoped that at the completion of this trial the results will provide a greater understanding of how the interplay between drought, substrate and plant physiology influence establishment success.

Notes

The effect of stable and cycling ambient temperature on lifespan and clock gene expression in *Drosophila melanogaster.*

Goh, G.H.Y.[1], Blache D.[2], Mark, P.J.[1], Kennington J.[3] and Maloney, S.K.[1]

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Circadian rhythms are generated by a transcriptional molecular clock that is sensitive to entrainment by cycling temperatures. In previous experiments in rats, we found that energy intake altered the circadian rhythm of core body temperature (T_c), and that the amplitude of clock gene expression in key metabolic tissues was correlated with T_c amplitude, suggesting that T_c might entrain those clocks. However, an altered diet may also directly entrain clock gene expression. To disentangle the effects of diet and T_c, we manipulated T_c in *Drosophila melanogaster* by adjusting ambient housing temperature (T_a). Male and female *Drosophila* housed at cycling T_a (28:22°C) had increased median lifespan (47 days for both sexes) compared to those housed at constant T_a (25°C) (34 and 38 days, respectively). The amplitude of the expression of the clock genes *per* and *vri* was increased in the bodies of male *Drosophila* housed at cycling compared to constant T_a, whereas gene expression in the heads of males or females was not affected by T_a. These preliminary results contribute to the growing evidence that links a robust circadian amplitude with health and longevity, and further implicate temperature rhythms as a relevant entraining signal for peripheral circadian rhythms *in vivo*.

Notes

Evolution of upper thermal tolerance: an artificial selection experiment in wild-caught zebrafish.

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How organisms will cope with climate change will partly depend on their thermal tolerance and particularly on their ability to adapt to thermal stress during extreme weather events, such as heat waves. However, evolvability of thermal tolerance in vertebrates is largely unknown. To address this question, we artificially selected for upper thermal tolerance in zebrafish. Starting with the offspring from wild-caught individuals (n=1800), we performed seven generations of selection to increase or decrease upper thermal tolerance. We also conducted selection to increase tolerance after warm acclimation. All lines, including a control line (random selection), were duplicated. Upper thermal tolerance diverged between the up- and down-selected lines, but the response was asymmetrical and stronger in the direction of reduced upper thermal tolerance (heritability: up-selected, h^2=0.10; down-selected, h^2=0.24). Warm acclimation prior to selection increased upper thermal tolerance, however, the acclimated lines did not respond to selection (h^2=0). Our results suggest that evolution towards higher thermal tolerance is slow. Considering the rate at which global temperatures are increasing, these results further suggest that fish populations may struggle to adapt rapidly enough to future thermal conditions.

Notes

Identifying the Devil:
a new approach to animal photographic identification.

Ungaro, M.T., Withers P.C. and Hemmi J.

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Numerous methods have been developed to re-identify animals previously captured, with a growing importance of non-invasive approaches. The complex and variable ventral pigmentation patterns of thorny devils (*Moloch horridus*), an agamid lizard endemic to Australia, provide a suitable basis for individual identification in the field. We have developed a custom software package in MATLAB to analyse digital images of ventral pigmentation patterns for individual identification of thorny devils from a database of digital images; we used images of 142 preserved specimens from the WA Museum collection to evaluate the efficacy of the software. A modified SURF algorithm was used to calculate three parameters that reflect the correctness of identification of thorny devil images, a correlation coefficient (R), the number (N) of matching points and the root mean square (RMS) of distances between matching points. ROC (receiver-operating-characteristic) curves produced for differing cut-off values for these parameters showed that N was better than R and RMS in producing more true positive matches (142) and fewer (0) false positive matches. Our approach was considerably better than two commonly used software packages for individual recognition (I^3S and Wild-ID). We can use SURF parameters to examine possible patterns in ventral pigmentation e.g. geographic or climatic.

Notes

The allometric relationship between seed mass and resting metabolic rate.

Dalziell, E.L.[1,2,3], Tomlinson, S.[1,2], Merritt, D.J.[2,3], Lewandrowski, W.[2,3], Turner, S.T.[2,3] and Withers, P.C.[3,1]

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The scaling of metabolic rate with mass is one of the ubiquitous relationships found across biological systems. In animals, the understanding of this relationship has offered important insights into animal form and function. However, the relationship between mass and metabolic rate in the seeds of flowering plants, has largely been overlooked. Using repeated-measures fluorescence-based closed-system respirometry, we measured the resting metabolic rate (RMR) of seeds from 108 wild and domesticated species (24 families, 19 orders). Within these species, seed mass varied by four orders of magnitude, RMR was positively related with seed mass and there was a strong phylogenetic signal. After correcting for phylogeny, metabolic rate scaled as mass$^{0.81}$. Further investigation of the RMR residuals revealed that: (1) Crops had higher RMRs compared with wild species and (2) within the wild species, seeds collected from hotter, more arid environments tended to have higher RMRs than similarly sized seeds collected from more mesic environments. Measures of RMR should therefore provide fundamental insights into seed physiology and ecological function. Seeds may also prove to be useful model organisms for wider investigations into dormancy/metabolic depression, given the ability to manipulate dormancy in many species.

Notes

Effect of a summer heatwave on the field metabolic rate and water turnover of a small avian desert granivore.

Cooper, C.E.[1,2,3], Withers P.C.[3], Hurley, L.L.[2] and Griffith, S.C.[2,4]

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Global environmental change is leading to not just higher mean temperatures but also an increase in the frequency, intensity and duration of extreme weather events, which may have a considerable impact on biodiversity. Effective environmental management therefore requires an understanding of the physiological response of organisms to extreme environmental conditions. Arid-adapted zebra finches can accommodate consecutive days of maximum T_a of 40-45°C, without major impacts on energy or water balance, so long as drinking water is available. In fact, cooler periods during a summer drought pose a greater energetic challenge than a heat wave due to the increased thermoregulatory cost of maintaining T_b against a thermal gradient. Zebra finches limited or avoided activity during the most thermally challenging periods of the day. Their pre-emptive feeding and drinking in preparation for hours of relative inactivity at high T_a, together with a high body water content that provided a buffer against dehydration, enabled zebra finches to survive and maintain body mass during a heatwave. The predictability of upcoming periods of high T_a, together with a high body water content, may be essential for survival of heatwaves by small desert birds.

Notes

Diurnal versus nocturnal activity patterns in dasyurids.

Körtner, G.[1], Claridge, A.[2] and Geiser, F.[1]

[1] Zoology, University of New England, Armidale, Australia.

[2] Office of Environment & Heritage, National Parks and Wildlife Service, Queanbeyan, Australia.

Most small mammals exhibit nocturnal activity to reduce predation risk and high temperatures. While most dasyurids comply with these patterns, activity is curtailed by low ambient temperatures during cold nights, and smaller species use torpor. Animals arouse around mid-morning, often assisted by warming by the sun. Under such conditions dasyurids commence activity as early as possible even before sunset with sufficient vegetation cover. For the brush-tail mulgara, onset of activity correlates with vegetation cover. Several species have managed to shift activity in winter to the energetically more favourable daytime. The kaluta in a spinifex habitat is one example, but it still resorts to torpor at night. Despite reversed activity patterns, torpor in diurnal and nocturnal dasyurids occurs mainly at night. In mesic spotted tailed quolls activity in adults is mainly nocturnal, but lactating females are almost crepuscular, with two activity bouts in the early night and around dawn. Daytime activity also becomes more prevalent. In contrast, juveniles are diurnal during their first weeks of playing outside the maternal den. Consequently, there is very little activity overlap between mother and offspring. However, as they grow and temperatures rise, activity in juveniles gradually extends into the night. When quolls become independent and disperse they show normal nocturnal activity. Evidently, diurnal activity can have some thermoregulatory advantages and dasyurids will shift activity into the daytime if predation risk can be mitigated.

Notes

Prevalence of antimicrobial resistance genetic elements in possum faecal samples: preliminary results from the Scoop a Poop citizen science project.

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[2]School of Veterinary Science, University of Sydney, Sydney, Australia.

Bacterial resistance to antimicrobial medicines is a growing global problem that threatens our ability to treat common infectious diseases. A common genetic mechanism underlying resistance is the Class 1 integron (*intI1* gene), a mobile genetic element that can be shared between bacteria via horizontal gene transfer. Class 1 integrons originated in a clinical setting, but are frequently detected in the wider environment, in both environmental samples (soil and water) and faecal samples from diverse wildlife species. To survey the prevalence and geographical spread of Class 1 integrons in the microbiome of Australian wildlife species, we established the Scoop a Poop citizen science project, which harnesses the sampling power of the general population. To date, over 700 faecal samples from brushtail and ringtail possums have been collected by citizens and screened in our laboratory. Using PCR, we amplified the *intI1* gene and screened for positive bands using gel electrophoresis and visualization under UV light. On average, ~50% of possum faecal samples contained the *intI1* gene. However, prevalence varied by location, with the lowest prevalence of the *intI1* gene (14% of samples) occurring in a National Park, and higher prevalence in city locations (e.g. 52% in central Melbourne, 60% across greater Sydney).

Notes

The functional implications of heterothermy during development in altricial mammals.

Geiser, F.[1,2], Renninger, M.[2,3], Sprau, L.[2,3], Wacker, C.B.[2], Körtner, G.[2], McAllan, B.M.[2,4], Wen, J.[1], Sukhchuluun, G.[1], Wang, D-H.[1,5] and Chi, Q-S.[1]

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[2]Zoology, University of New England, Armidale, Australia.

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[4]Physiology, University of Sydney, Sydney, Australia.

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Most mammals and birds are altricial, small and naked at birth/hatching. They attain endothermic thermoregulation at a fraction of adult size when heat loss is high and using torpor for energy conservation could aid survival. As detailed data on torpor expression during development are currently restricted to <0.1% of extant endotherms, we investigated at what age and body mass (BM) diverse similar-sized small mammals (Australian marsupial dunnarts, Chinese hamsters, cosmopolitan mice) are able to defend their body temperature (T_b) at an ambient temperature (T_a) of ~20°C and whether at that stage they could express torpor. Endothermy was reached at an age of ~2 months in marsupial dunnarts, but already after ~2 weeks in the rodents. All species investigated could enter and arouse from torpor soon after endothermy was established at a BM of ~10 g (~60% adult BM) in dunnarts and ~6g (~20% adult BM) in hamster and mouse pups. Over the next weeks, torpor depth and duration decreased together with a reduction in resting metabolic rate. Our data show that torpor is pronounced in juveniles of these highly diverse small mammals and suggest that torpor during development is an important survival tool for small mammals worldwide.

Notes

Hydrothermal germination as a distribution-limiting trait: A process oriented approach to understanding short-range endemism in plants.

Lewandrowski, W.[1,2], **Tomlinson, S.**[3,1], Anderson, N.[4,1], Whitely, S.[1,2] and Turner, S.[1,2]

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3School of Molecular & Life Sciences, Curtin University, Perth, Australia.

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Short-range endemism (SRE) is a form of rarity that involves the localisation of a species to a relatively small distribution, often specialised to a set of edaphic conditions, and often constrained by reproductive biology. We integrated the theoretical constraints of thermal biology with the hydrological effects on germination to define a mathematical model of hydrothermal germination. We focussed on the SRE plant species: *Ricinocarpos brevis*, *Banskia arboria* and *Androcalva perlaria*, where seeds were germinated at an array of eight water potentials ranging from 0.00 to -1.50 MPa at 5°C intervals between 5 and 25°C. We fitted a logistic decline in maximum germination (G_{max}) over temperature, and an asymmetrical, unimodal thermal performance model to the time to 50% germination (t_{50}) over temperature. Using the resulting model, we estimated the proportion of seeds that were likely to germinate at a landscape scale of 1 arcsec resolution. The known distribution of these SRE species was highly congruent with areas estimated to support their germination. By characterising models of seed germination with interacting effects of temperate and water stress we have gained insight into germination dynamics, and using these potentially identified a distributional-limiting trait associated with patterns of short-range endemism.

Notes

Effects of helox on respiratory exchange via the "diffusion" lung of the aestivating pulmonate snail *Cornu* (*Helix*) *aspersa*.

Dasgoopta, D. and **Withers, P.C.**

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Pulmonate land snails breathe primarily through a single lung, developed from the mantle cavity, via a closeable pneumostome. There is also an, albeit small, cutaneous exchange component. Krogh (1941) described the pulmonate lung as a "diffusion" rather than a "convection" lung, and his description has persisted in the literature despite him, and others, describing associated pulmonary musculature and the role of lung collapse in body retraction that could produce convective flow. We examined whether pulmonate gas exchange was purely diffusive, purely convective or a mix of both, for aestivating garden snails (*Cornu aspersa*) by measuring exchange of CO_2 and H_2O using flow-through respirometry in normal air and helox (79% He, 21% O_2; 2.33 times higher diffusion rate), at two ambient temperatures. Metabolic rate (CO_2 exchange) was not altered in helox, but the duration of pneumostome open-phase decreased and peak exchange rate increased in helox, consistent with but not accounted entirely for by augmented diffusion, so there was presumably a convective component as well. Higher temperature increased the frequency of respiration cycles, consistent with a higher metabolic rate, but did not affect the pneumostome open-phase duration or peak exchange rate, reflecting no effect of temperature on pulmonary diffusion/convection balance.

Notes

List of Registrants

Family Name	Given Name	Institution	Email Address
Abbas	Waseem	University of Western Australia	waseem.abbas@research.uwa.edu.au
Blache	Dominique	University of Western Australia	dominique.blache@uwa.edu.au
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Clemente	Christofer	University of the Sunshine Coast	cclement@usc.edu.au
Cooper	Christine	Curtin University	c.cooper@curtin.edu.au
Cooper	Paul	Australian National University	paul.cooper@anu.edu.au
Dalziell	Emma	Kings Park Science	emma.dalziell@dbca.wa.gov.au
Dawson	Terence	University of New South Wales	t.dawson@unsw.edu.au
Dick	Taylor	University of Queensland	t.dick@uq.edu.au
Ding	Luoyang	University of Western Australia	22284247@student.uwa.edu.au
Funnekotter	Bryn	Curtin University	b.funnekotter@curtin.edu.au
Geiser	Fritz	University of New England	fgeiser@une.edu.au
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