64th Australian Mammal Society Meeting 2018

The University of Queensland

Conference Programme & Abstract List

CONFERENCE PROGRAM

Sunday 1st July

1:00 – 5:00 PM	**EARLY CAREER RESEARCH WORKSHOP – BOARDROOM, ST. LEO'S COLLEGE**	
	1:00 – 3:00 PM	RE-THINKING ABSTRACTS
	3:00 – 3:30 PM	*AFTERNOON TEA*
	3:30 – 4:15 PM	ORGANIZE YOUR RESEARCH FROM THE GET-GO
	4:15 – 5:00 PM	WRITING THROUGH BLOCKS (AND OTHER TIPS)
5:00 – 7:00 PM	**REGISTRATION DESK OPEN AND MIXER (LIGHT REFRESHMENTS/DRINKS) THE DECK, ST. LEO'S COLLEGE**	
5:00 – 6:30 PM	PRESENTATION UPLOAD DESK OPEN – ST. LEO'S COLLEGE	

Monday 2nd July

ABEL SMITH LECTURE THEATRE, UQ

9:00 AM	CONFERENCE WELCOME AND WELCOME TO COUNTRY	
	Session 1 Chair: Vera Weisbecker	Speaker
9:30 AM	**PLENARY: MARSUPIAL EARLY DEVELOPMENTAL BIOLOGY: THE ROLE OF TIME AND PLACE**	Lynne Selwood
10:15 AM	HUMANS AND THEIR ROLE IN SHAPING THE ECOLOGICAL FUNCTIONS OF PREDATORS	Thomas Newsome
10:30 AM	URBAN EURASIAN RED SQUIRREL ECOLOGICAL ENERGETICS	James Turner
10:45 AM	*MORNING TEA*	
	Session 2 Chair: Stuart Nichol	
11:15 AM	NOT ALL CITIES ARE THE SAME: CONTRASTING STRESS RESPONSES OF EASTERN GREY KANGAROOS TO DIFFERENT URBAN ENVIRONMENTS	Elizabeth Brunton
11:30 AM	USING WILD MARSUPIALS TO IDENTIFY THE SOURCE OF MANGANESE CONTAMINATION ON GROOTE EYLANDT, NT	Kaylah Del Simone
11:45 AM	LARGE-FOOTED MYOTIS *MYOTIS MACROPUS* ROOST SELECTION IN CULVERTS IN BRISBANE	Vanessa Gorecki*
12:00 PM	ECHIDNAS AT HOBART AIRPORT	Stewart Nichol
12:15 PM	THERMAL NICHE OF THE KOALA (*PHASCOLARCTOS CINEREUS*)	Dalene Adam
12:30 PM	KOALA GUT MICROBIOME INOCULATIONS AND DIET PREFERENCE (SPEED TALK)	Michaela Blyton
12:35 PM	TEACHING AN OLD MACROPOD NEW TRICKS: THE CHALLENGES OF TRAINING A CAPTIVE BRIDLED NAILTAIL WALLABY (SPEED TALK)	Sabrina Muns
12:40 PM	THE NOSE KNOWS: OLFACTORY RECOGNITION BY AN ENDEMIC RODENT, *MELOMYS CERVINIPES* (SPEED TALK)	Tasmin Rymer
12:45 PM	*LUNCH*	

	Session 3 Chair: Skye Cameron	
1:45 PM	**PLENARY: PULLING LEVERS AND PUSHING BOUNDARIES – THE MESSY HANDS-ON BUSINESS OF ECOSYSTEM RECOVERY**	Katherine Tuft
2:30 PM	THE GREAT SYDNEY DIVIDE, EVEN POSSUMS DON'T WANT TO CROSS THE BRIDGE	Greta Frankham
2:45 PM	NEEDING A DRINK: THE COST OF CLIMATE CHANGE ON KOALAS	Valentina Mella
3:00 PM	A PRELIMINARY INVESTIGATION INTO THE USE OF CHAINSAW HOLLOWS FOR THE CONSERVATION OF THE THREATENED BRUSH-TAILED PHASCOGALE	William Terry
3:15 PM	*AFTERNOON TEA*	
	Session 4 Chair: Clare McArthur	
3:45 PM	CREATING PANIC ROOMS FOR WILDLIFE: TRAINING NORTHERN BROWN BANDICOOTS TO ACCESS SAFE REFUGE USING MICROCHIP-AUTOMATION	Megan Edwards
4:00 PM	IDENTIFIYING THE DRIVERS OF LONG-TERM SOCIAL AVOIDANCES IN ANIMALS	Celine Frere
4:15 PM	CAN EASTERN GREY KANGAROO MOTHERS RECOGNISE OFFSPRING DISTRESS CALLS?	Wendy King
4:30 PM	PLANT ODOURS PROVIDE SALIENT FORAGING CUES FOR A MEGA-HERBIVORE, THE AFRICAN ELEPHANT	Clare McArthur
5:00 – 6:45 PM	**POSTER SESSION AT ST LEO'S COLLEGE**	
	REPRODUCTIVE TACTICS IN AN ORNAMENTED MAMMAL: COAT COLOUR AND SOCIABILITY IN MALE GIRAFFES	Madelaine Castles
	HAEMOLYTIC ANAEMIA ASSOCIATED WITH THEILERIOSIS IN AN ORPHANED PLATYPUS (*ORNITHORHYNCHUS ANATINUS*)	Joanne Connolly
	MUCORMYCOSIS IN THE PLATYPUS AND THE ANURAN	Joanne Connolly
	ARCHAEOLOGICAL IMPACTS OF MARSUPIAL CARNIVORES	Lauren Cunningham
	CONSERVATION AND MANAGEMENT OF THE BILBY IN WESTERN AUSTRALIA: PROJECTS IN PARTNERSHIP WITH TRADITIONAL OWNER RANGERS	Martin Dziminski
	THE HIDDEN VALE WILDLIFE CENTRE: COLLABORATIVE NEXT-GENERATION RESEARCH	Julia Hoy
	WHAT'S THAT, SKIP? A PILOT STUDY INVESITIGATING INTERSPECIFIC VARIATION IN SKULL MORPHOLOGY IN THE MACROPODODIFORMES	Jessica Ivory-Church
	INTEGRATING MORPHOLOGICAL AND PERFORMANCE TRAITS TO UNDERSTAND ADAPTATION TO DIFFERENT HABITATS IN THE NORTHERN QUOLL (*DASYURUS HALLUCATUS*)	Ellie Kirke
	INVESTIGATING CRANIODENTAL SEXUAL DIMORPHISM IN BANDICOOTS AND BILBIES USING 3D GEOMETRIC MORPHOMETRICS	Josephine Ménard
	DETERMINING CARRYING CAPACITY USING HABITAT PREFERENCES AND HOME RANGES FOR A REINTRODUCED KOALA (*PHASCOLARCTOS CINEREUS*) POPULATION	Lachlan Miller

	FEEDING BIOMECHANICS INFLUENCES CRANIOFACIAL MORPHOLOGY AMONG EAST AUSTRALIAN PADEMELONS (MACROPODIDAE: *THYLOGALE*)	D. Rex Mitchell
	THE PRESENCE OF COMPLEMENT AND ANTIMICROBIAL ACTIVITY IN RED-TAILED PHASCOGALES (*PHASCOGALE CALURA*)	Oselyne Ong
	AN OBSERVATION OF NEST ROBBING BY THE THREATENED BRUSH-TAILED PHASCOGALE IN CENTRAL VICTORIA	William Terry
	DOES HABITAT CHOICE AFFECT THE DIET OF THE NORTHERN QUOLL (*DASYURUS HALLUCATUS*) ON GROOTE EYLANDT?	Hannah Thomas
	THE CELLULAR STRUCTURE OF MAMMALIAN COGNITION: COMPARATIVE NEURONAL MORPHOLOGY OF THE MARSUPIAL BRAIN	Orlin Todorov
	MAMMALS OF THE WESTERN GREAT VICTORIA DESERT	Jeff Turpin
	SKELETAL ATLAS OF THE THYLACINE	Natalie Warburton
	A 3D SKULL SHAPE STUDY OF MICRO EVOLUTION AND CONSERVATION IN MARSUPIAL TAXA: REPEATABILITY ASSESSMENT OF THE TEMPLATE	Vera Weisbecker
7:15 – 10:00 PM	**STUDENT AND NON-STUDENT DINNERS**	

Tuesday 3rd July

ABEL SMITH LECTURE THEATRE, UQ

	Session 1 Chair: Amy Edwards	Speaker
9:00 AM	FLUCTUATING SELECTION ON TIMING OF PARTURITION IN EASTERN GREY KANGAROOS	Marco Festa-Bianchet
9:15 AM	PREY PRODUCTIVITY AND PREDICTABILITY DRIVE DIFFERENT AXES OF LIFE HISTORY VARIATION IN CARNIVOROUS MARSUPIALS	Rachael Collett*
9:30 AM	TWO-COLOUR FLUORESCENT IN-SITU HYDRIDIZATION SHOWS PRIMARY SEX RATIO BIAS IN THE SPERM OF THE TAMMAR WALLABY, *MACROPUS EUGENII*	Amy Edwards
9:45 AM	CAN JUVENILE RED KANGAROOS STRUCTURALLY SURMOUNT THE METABOLIC BURDENS OF SIZE AND GROWTH	Terence Dawson
10:00 AM	GROWTH AND DEVELOPMENT OF *CONILURUS PENICILLATUS*, A VULNERABLE TREE-RAT FROM NORTHERN AUSTRALIA	Catherine Kemper
10:15 AM	MATERNAL CARE OF PLATYPUS NESTLINGS	Jessica Thomas*
10:30 AM	*MORNING TEA*	
	Session 2 Chair: Matthew Lott	
11:00 AM	HABITAT SUITABILITY ASSESSMENT FOR THE WORLD'S RAREST MARSUPIAL, GILBERT'S POTOROO, BY SHORT-TERM RELEASE OF PIONEERS	Anthony Friend

11:15 AM	FACTORS INFLUENCING THE SUCCESS OF HAND-REARED JUVENILE BRUSHTAIL POSSUMS (*TRICHOSURUS VULPECULA*) RELEASED INTO THE WILD	Callum Gillies
11:30 AM	GENETIC MANAGEMENT OF CAPTIVE AND REINTRODUCED BILBY POPULATIONS	Matthew Lott
11:45 AM	THE SECRET TO A LONG AND SUCCESSFUL LIFE: REPRODUCTION, SURVIVAL AND LONGEVITY OF MAINLAND EASTERN BARRED BANDICOOTS	Marissa Parrott
12:00 PM	REINTRODUCTION TRIALS FOR THE SWAMP ANTECHINUS (*A. MINIMUS MARITIMUS*) IN THE EASTERN OTWAYS; IMPLICATIONS FOR RECOVERY	Barbara Wilson
12:15 PM	REWILDING THE SOUTHERN YORKE PENINSULA: MAMMAL REINTRODUCTIONS TO RESTORE ECOSYSTEM FUNCTION (SPEED TALK)	Clementine Menz
12:20 PM	FERAL CAT CONTROL FOR THREATENED MAMMAL RECOVERY IN CENTRAL QUEENSLAND (SPEED TALK)	Jessica Guidotti
12:30 PM	*LUNCH*	
	Session 3 Chair: Dan Lunney	
1:30 PM	AUSTRALIA'S PROTECTED AREAS ARE INADEQUATE FOR THE LONG-TERM SURVIVAL OF THE SPOTTED-TAILED QUOLL	Scott Burnett
1:45 PM	MECHANISMS OF CLIMATE CHANGE-INDUCED SPECIES DECLINE: SPATIAL, TEMPORAL AND LONG-TERM VARIATION IN THE DIET OF AN ENDANGERED MARSUPIAL CARNIVORE, THE EASTERN QUOLL	Bronwyn Fancourt
2:00 PM	NORTHERN QUOLL DEMOGRAPHY IN THE PILBARA	Lorna Hernandez-Santin
2:15 PM	DISTRIBUTION MODELLING AND POPULATION GENETICS OF WET TROPICS SPOTTED-TAILED QUOLLS	Conrad Hoskin
2:30 PM	THE DISTRIBUTION OF THE ENDANGERED SPOTTED-TAILED QUOLL (*DASYURUS MACULATUS*) IN NEW SOUTH WALES	Dan Lunney
2:45 PM	BEING BIGGER ISN'T BETTER: SMALLER BODY SIZE MOST IMPORTANT TRAIT FOR PREDICITING SURVIVAL OF NORTHERN QUOLLS (*DASYURUS HALLUCATUS*) ON GROOTE EYLANDT	Miranda Rew-Duffy
3:00 PM	HOW DOES NORTHERN QUOLL (*DASYURUS HALLUCATUS*) PERSONALITY AND PERFORMANCE AFFECT VULNERABILITY TO PREDATION? (SPEED TALK)	Natalie Freeman
3:05 PM	METHOD FOR REVEALING POPULATION DEMOGRAPHY OF SPOTTED-TAILED QUOLLS (*DASYURUS MACULATUS GRACILIS*) USING REMOTE CAMERAS (SPEED TALK)	Jesse Rowland
3:10 PM	*AFTERNOON TEA*	

3:40 – 6:15 PM **ANNUAL GENERAL MEETING**

7:00 – 10:00 PM **CONFERENCE DINNER – QUEENSLAND MUSEUM (SOUTHBANK)**

Wednesday 4th July

ABEL SMITH LECTURE THEATRE, UQ

	Session 1 Chair: Tamara Keeley	Speaker
9:00 AM	**PLENARY: WILDLIFE GENOMICS AND CONSERVATION – LESSONS FROM THE KOALA GENOME**	Rebecca Johnson
9:45 AM	HITTING THE GROUND RUNNING: TIMING OF TERRESTRIAL ACTIVITY BY KOALAS IN FRAGMENTED WOODLAND ON THE NEW ENGLAND TABLELAND	Karl Vernes
10:00 AM	WomSAT – WOMBAT SURVEY AND ANALYSIS TOOL	Julie Old
10:15 AM	COMPARING VIDEO AND STILL IMAGERY TO ASSESS THE BURROW OCCUPANCY RATE OF SOUTHERN HAIRY-NOSED WOMBATS (*LASIORHINUS LATIFRONS*): A CAUTIONARY TALE IN THE USE OF MOTION-ACTIVATED CAMERAS	Michael Swinborne
10:30 AM	*MORNING TEA*	
	Session 2 Chair: Kenny Travouillon	
11:00 AM	UNTANGLING THE HISTORY AND NATURAL HISTORY OF EXTINCT BANDICOOTS	Kenny Travouillon
11:15 AM	USING A NEXT-GENERATION SEQUENCING APPROACH TO UNDERSTAND THE POPULATION GENETIC STRUCTURE IN AUSTRALIAN DESERT-DWELLING MARSUPIALS	Linette Umbrello*
11:30 AM	MICROBATS OF THE SOUTH WEST BOTANICAL PROVINCE OF WESTERN AUSTRALIA: PATHOGEN DIVERSITY AND HOST GENETIC CONNECTIVITY	Diana Prada
11:45 AM	SPATIAL MOVEMENTS OF A THREATENED TROPICAL ROCK-WALLABY BEFORE AND AFTER PRESCRIBED BURNING	Catherine Hayes
12:00 PM	A GREY AREA: DELINEATING THE SYMPATRIC ZONE OF EASTERN AND WESTERN GREY KANGAROOS IN SPACE AND TIME	Graeme Coulson
12:15 PM	DOES HABITAT COMPLEXITY AFFECT PREDATION RISK? PREDICTIONS USING A BIOMECHANICAL AGENT-BASED MODEL	Rebecca Wheatley
12:30 PM	*LUNCH*	
	Session 3 Chair: Jemma Cripps	
1:30 PM	CHRONIC PHYSIOLOGICAL STRESS AND HENDRA VIRUS IN BLACK FLYING-FOXES (*PTEROPUS ALECTO*), AUSTRALIA	Lee McMichael
1:45 PM	DISCOVERY, DETECTION AND CONSERVATION OF ENDANGERED ANTECHINUSES	Andrew Baker
2:00 PM	IMPROVING ESTIMATES OF GREATER GLIDER DENSITY - DISTANCE SAMPLING USING TWO OBSERVERS	Jemma Cripps
2:15 PM	THE CALAMITY OF COUNTING KOALAS	Mathew Crowther
2:30 PM	BILBIES WHERE THE DESERT MEETS THE OCEAN: OCCUPANCY, ABUNDANCE AND HABITAT SUITABILITY IN A KEY AREA TOWARDS WHICH THE NATURAL DISTRIBUTION IS CONTRACTING	Martin Dziminski
2:45 PM	MONITORING OF GROUND-DWELLING MAMMALS IN NORTHERN WESTERN PORT, VICTORIA	David G. Nicholls
3:00 PM	*AFTERNOON TEA*	
	Session 4 Chair: Alexander Baynes	

3:30 PM	ECOMORPHOLOGY OF THE FEEDING APPARATUSES OF THE AUSTRALIAN MURIDS *PSEUDOMYS OCCIDENTALIS* AND *PSEUDOMYS DESERTOR*	Alexander Baynes
3:45 PM	FORELIMB BONE SHAPE IN A DIGGING MAMMAL	Meg Martin
4:00 PM	ONLY YESTERDAY: QUATERNARY FOSSIL MAMMALS FROM QUEENSLAND, WITH IMPLICATIONS FOR CONSERVATION	Jonathan Cramb
4:15 PM	TWENTY-FIVE YEARS OF TROPICAL FOSSILS: MINING, MAMMALS AND MEGAFAUNA	Scott Hocknull
4:30 PM	**PRIZE GIVING**	

Thursday 5th July

BOARDROOM, ST. LEO'S COLLEGE, UQ

SYMPOSIUM 1: FORM, FUNCTION AND EVOLUTION OF AUSTRALASIAN MAMMALS

8:30 AM	SYMPOSIUM WELCOME	
	Session 1 Chair: Matthew Phillips	Speaker
8:45 AM	ENHANCING MITOGENOMIC PHYLOGENY: RESOLVING THE RELATIONSHIPS OF EXTINCT MEGAFAUNAL PLACENTAL MAMMALS	Matthew Phillips
9:00 AM	DATING THE DIVERSIFICATION OF BATS HIGHLIGHTS THE IMPACT OF POORLY SUPPORTED FOSSILS ON DIVERGENCE ESTIMATES	Adam Stone
9:15 AM	A MAJOR STEP IN A JOURNEY THROUGH (MORPHO)SPACE AND TIME? THE EFFECT OF THE K-PG EXTINCTION ON MAMMALIAN MORPHOLOGICAL EVOLUTION	Thomas Guillerme
9:30 AM	FANGAROOS AND KANGAROOS: PHYLOGENY, PALAEOECOLOGY, DIVERSIFICATION AND EXTINCTION OF EARLY KANGAROOS (MARSUPIALIA: MACROPODIFORMES) FROM THE RIVERSLEIGH WORLD HERITAGE AREA	Kaylene Butler
9:45 AM	MICE IN OZ: GEOMETRIC MORPHOMETRIC ANALYSIS OF 35 RODENT SPECIES SUGGESTS GENERALIST SHAPE AND BODY SIZE VARIATION SUPPORT BIODIVERSITY	Ariel Marcy
10:00 AM	CHEW ON THIS: ARE MASTICATORY BIOMECHANICS MASKING THE ORIGINS OF WOMBAT DIVERSITY?	Vera Weisbecker
10:15 AM	THE ORAL APPARATUS OF MARSUPIALS IS MORE INTEGRATED BUT NOT LESS MORPHOLOGICALLY DIVERSE THAN THAT OF PLACENTAL CARNIVORES	Gabriele Sansalone
10:30 AM	*MORNING TEA*	
	Session 2 Chair: Vera Weisbecker	Speaker
11:00 AM	EVOLUTION OF DIET IN ECHIDNAS	Stewart Nicol
11:15 AM	WHO HAS A LEG UP ON THE COMPETITION? FUNCTIONAL HIND LIMB MYOLOGY IN THE PERAMELEMORPHIA	Natasha Tay
11:30 AM	MAMMALS BORN TO FLY: POSTCRANIAL DEVELOPMENT IN BATS	Camilo Lopez-Aguirre

11:45 AM	WHAT CAN THE MALE REPRODUCTIVE ANATOMY OF AUSTRALIAN HYDROMYINE RODENTS TELL US ABOUT THEIR BREEDING SYSTEM?	William Breed
12:00 PM	DEVELOPMENT OF THE MARSUPIAL IMMUNE TISSUES	Julie Old
12:15 PM	COMPUTER SIMULATIONS SHOW THAT NEANDERTHAL FACIAL MORPHOLOGY REPRESENTS ADAPTATION TO COLD AND HIGH ENERGY DEMANDS, BUT NOT HEAVY BITING	Stephen Wroe
12:30 PM	*LUNCH*	
1:30 PM	*Sponsor demonstration by Materialise Mimics*	
	SYMPOSIUM 2: LAND CLEARING	
2:00 PM	SYMPOSIUM WELCOME	
	Session 1 Chair: April Reside	Speaker
2:15 PM	LAND CLEARING ACROSS AUSTRALIA, THE REGULATED AND UN(DER)-REGULATED	April Reside
2:30 PM	IMPACT OF LAND CLEARING ON KOALAS	Clive McAlpine
2:45 PM	INTERACTIONS AND PERVERSE OUTCOMES: LAND CLEARING AND SMALL MAMMAL COMMUNITIES	Teresa Eyre
3:00 PM	*AFTERNOON TEA*	
	Session 2 Chair: April Reside	Speaker
3:30 PM	AUSTRALIA'S BIODIVERSITY HOUSING CRISIS: A SYNTHESIS OF THE IMPACTS OF LAND CLEARING ON NATIVE MAMMALS (SPEED TALK)	Euan Ritchie
3:35 PM	GREY-HEADED FLYING-FOXES USE ADAPTIVE BEHAVIOURS TO RESPOND TO ONGOING CLEARING OF CRITICAL WINTER HABITAT, WITH ADVERSE CONSEQUENCES	Peggy Eby
4:00 PM	MAMMALS KILLED AND HARMED BY BULLDOZING OF HABITATS IN QUEENSLAND	Martin Taylor
4:15 PM	THE IMPORTANCE OF USING AN ANIMAL-CENTRIC APPROACH TO MANAGING SPECIES RESPONSE TO LAND CLEARANCE	Menna Jones
4:30 PM	HUMAN IMPACTS ON THREATENED MAMMALS SUGGEST ACCELERATING EXTINCTIONS	James Allan
4:45 PM	CHANGES IN CUMULATIVE HUMAN PRESSURE DRIVE CHANGES IN SPECIES EXTINCTION RISK	Moreno Di Marco
	END OF SCHEDULED TALKS	

*Students presenting for the Bolliger award

Alphabetic List of Abstracts

PLENARY ADDRESSES

MARSUPIAL EARLY DEVELOPMENTAL BIOLOGY: THE ROLE OF TIME AND PLACE

Selwood, Lynne

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Marsupial developmental biology was of great interest to early researchers including Selenka, Semon, Hill, Hartman, McCrady and more recently Hughes and Hall and Lyne and Hollis. It is of considerable interest to those looking at the evolution of vertebrates and mammals in particular and to researchers of eutherian conceptuses, who are interested in how the marsupial blastocyst is formed, how early cell lineages are allocated and how the body form is established. In dasyurids, the dorso-ventral axis is established early and is recognisable in the polarity in maturing oocytes, which is tweaked by sperm entry and is maintained in early blastomeres. Cleavage separates blastomere into a ring of pluriblast cells (the future dorsal side) and a ring of trophoblast cells (the ventral side). Time-lapse cinematography in vitro demonstrates a mechanism that creates an axis across both pluriblast and trophoblast of first and last cells to divide at each division. Each new step in early development, is characterised by proliferation on cells at one side of the blastocyst (the future posterior side). In conclusion, a brief outline of invention of a marsupial browsing deterrent spray is given. Thoughts about how embryos develop contributed to invention of the spray

WILDLIFE GENOMICS AND CONSERVATION – LESSONS FROM THE KOALA GENOME

Johnson, Rebecca[1,2]

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[2]Faculty of Science, University of Sydney, Camperdown, NSW 2006, Australia e-mail: rebecca.johnson@austmus.gov.au / Twitter: @DrRebeccaJ

Koalas are both biologically unique and evolutionarily distinct as the only living representative of the marsupial family *Phascolarctidae*. Koalas are increasingly vulnerable to the detrimental effects of population bottlenecks, disease, the loss of genetic diversity and climate change as increased urbanisation reduces habitat. As a result, koala populations are expected to decline across Australia by up to 50% over the next three generations (approx. 20 years) in the regions with the most genetically diverse animals but by contrast culling measures are likely in the southern parts of the distribution due to overcrowding and starvation, thus significant conservation intervention measures will be required.

The Koala Genome Consortium was established in 2013 with the collective aim to determine a way forward and steer their research towards ensuring the long-term survival of this important marsupial while simultaneously increasing Australia's genome sequencing capability (no *de novo* mammal genome had ever been sequenced and assembled by a solely Australian led group before). Rebecca will present an overview of the koala genome, including genomic insights gained into some of the koala's well known biological adaptations. She will also outline how the genome is now being used to inform conservation of koalas and what future outcomes the genome might offer.

PULLING LEVERS AND PUSHING BOUNDARIES – THE MESSY HANDS-ON BUSINESS OF ECOSYSTEM RECOVERY

Tuft, Katherine[1]; Moseby, Katherine[1,2] and Read, John [2]

[1] Arid Recovery, Roxby Downs SA
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Ecosystem restoration and reintroduction is a worthy goal and tremendously exciting in its vision to redress loss and recreate some of the former glory of Australia's currently imperilled mammal fauna. At the same time, the field is complex, fraught with difficulty and littered with failure. In this plenary, I will talk through the journey of one community's mission to restore part of Australia's arid zone. Arid Recovery started with a goal to regenerate vegetation in a patch of desert by capitalising on the success of calivirus to completely remove rabbits from a fenced area. This goal has grown to include exclusion of introduced predators, reintroductions of locally extinct fauna, restoration of ecological processes and the blue sky aim of enabling vulnerable animals to thrive once more in open landscapes. Arid Recovery is now Australia's largest predator-proof fenced reserve and a major research site. Four locally extinct mammals have been reintroduced, with a fifth having reintroduced itself and a sixth reintroduction currently underway (Greater Stick-nest Rat, Burrowing Bettong, Greater Bilby, Western Barred Bandicoot, Plains Mouse and Western Quoll respectively). Pulling levers in an ecosystem can have powerful flow on effects, some of them positive and others unintended. Of the reintroduced mammals, the fossorial species have fundamentally changed soil properties and vegetation communities. At the same time, one species has become so successful within the confines of the fence that it is now having a negative impact on other parts of the ecosystem. Excluding predators has entrenched prey naivety in these populations, so one of our initiatives is to carefully 'reintroduce' feral cats and now quolls into some parts of the reserve to improve prey animals' predator savviness. Arid Recovery does not meddle with this complex system lightly. A long term and detailed monitoring program is critical to understanding and reacting to the ecosystem changes that occur. Documenting tests and trials and making the results publically available is essential to moving forward iteratively, learning as much as possible from each setback. Facing the challenges in restoration and reintroduction requires a bold approach, a collaborative spirit and a fair degree of pig-headedness, but most importantly the passion and diverse talents of individuals who believe in an optimistic future.

GENERAL SESSION & SYMPOSIUM PRESENTATIONS

A

THERMAL NICHE OF THE KOALA (*PHASCOLARCTOS CINEREUS*)

Adam, Dalene[1]; FitzGibbon, Sean[2]; Barth, Ben[2]; Melzer, Alistair[3]; Gillet, Amber[2]; Johnston, Stephen[1] and Ellis, William[2]

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[2]Koala Ecology Group, School of Agriculture & Food Sciences, The University of Queensland, St Lucia, Queensland 4067, Australia
[3]Koala Research Centre of Central Queensland, School of Medical and Applied Sciences, Central Queensland University, Rockhampton, Queensland 4702, Australia
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Koalas (*Phascolarctos cinereus*) have been identified as a species particularly susceptible to climate change. Koalas do not seek any form of shelter such as nests or hollow logs, so are completely exposed to the elements. The aim of this study was to determine whether koalas on St Bees Island exploit the spatial and temporal variability in their home range in order to cope with high environmental temperatures. HOBO® data loggers were deployed in a grid to record light intensity and ambient temperature every 15 min, continuously, between August 2015 and May 2016. GPS units fixed to the koala collars recorded their mid-day and midnight locations. Significant variability was identified across the landscape, both spatially and temporally. Individual koalas experienced as much as 10°C variation at the hottest part of hot days; on the coolest days koalas experienced as much as 4°C variation. During the warmer months, koalas were most likely to be found in an area that was below the range average temperature (0.07°C). During the cooler months koalas still chose cooler areas of their range (0.02°C). The results did not challenge the contention that koalas are susceptible to climate change, but suggests that movement of koalas into new or existing climate refugia is possible.

HUMAN IMPACTS ON THREATENED MAMMALS SUGGEST ACCELERATING EXTINCTIONS

Allan, James R.[1,4]; Watson, James E.M.[1,2,4]; Di Marco, Moreno[1,3]; O'Bryan, Christopher J.[1,4]; Possingham, Hugh P.[4,5]; Atkinson, Scott C.[4] and Venter, Oscar[6]

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[4]Centre for Biodiversity and Conservation Science, The University of Queensland, St Lucia, QLD 4072, Australia
[5]The Nature Conservancy, VA 22203-1606, USA
[6]Natural Resource and Environmental Studies Institute, University of Northern British Columbia, Prince George, V2N4Z9, Canada
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Conserving threatened species requires identifying where across their range they are being impacted by threats. We present the first spatially-explicit analysis of the cumulative human impacts on 1,277 globally threatened terrestrial mammals. We show that impacts to mammals are widespread, occurring across the majority of Earth's surface, and identify hotspots of impacted and unimpacted mammal richness. Over one third of assessed mammals are impacted across > 90% of their distribution, and ~9% are impacted across their entire range. This foreshadows localized extirpations, and potential extinctions, without conservation action. Our framework for analyzing the co-occurrence of threatening process and vulnerable species offers a tool for defining strategies to mitigate the threats driving species declines, providing essential information for future national and global conservation agendas

B

DISCOVERY, DETECTION AND CONSERVATION OF ENDANGERED ANTECHINUSES

Baker, A.M. and Thomas, M.

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Five new antechinus species have been named in as many years. Four of these species may be threatened, with two listed federally as Endangered in May 2018. General ecology is known for the two endangered species, *A. arktos* and *A. argentus*, but we don't know their geographic range. This information is urgently required to understand distribution patterns, population densities, genetic structures and habitat requirements, which together will inform conservation strategies. Rapid determination of a species' geographic range requires effective detection strategies. This presents challenges when dealing with rare mammals. Traditional metal box (Elliott) trapping has been successful but is onerous. Given the species' low densities and extinction risks, faster detection is required. In the last 2 years, our research team has been developing targeted canine-based detection strategies for both endangered antechinus species. We present a brief overview of this research, focusing on processes of species discovery and canine-based detection, exploring the various strengths and limitations, with a view to developing future conservation and research priorities.

Form, function and evolution symposium

ECOMORPHOLOGY OF THE FEEDING APPARATUSES OF THE AUSTRALIAN MURIDS *PSEUDOMYS OCCIDENTALIS* AND *PSEUDOMYS DESERTOR*

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Ecomorphology is the study of the relationship between the morphology of organisms and their ecology (e.g., https://academic.oup.com/icb/issue/56/3). Most Australian native mice have unspecialized skulls, with small, narrow incisors and long, wide foramina in their palates. Two western Australian species, however, are different: having heavily built skulls with very short, narrow anterior palatine foramina. The incisors of *Pseudomys occidentalis* are narrow but very deep (large lip-to-tongue dimension), and the skull has extensive areas for attachment of jaw muscles, yet the molars are relatively

small and narrow. This suggested to me that it feeds on something easy to masticate encased in a tough shell, probably woody fruits, which abound in southwest habitats. But I was astounded to discover from the literature that it can exert enough bite force to chew its way into a quandong nut, the size equivalent of a coconut for a human. In contrast, the incisors of *Pseudomys desertor* are very wide and chisel-like, with flat labial surfaces. Its molars are broad, with low, strongly sloping cusps. It is known to feed on grass plants, seeds and rhizomes, which its incisors are presumably adapted for gathering and its molars for shredding.

Speed talk

KOALA GUT MICROBIOME INOCULATIONS AND DIET PREFERENCES

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An animal's gastrointestinal microbiome plays a crucial role in digestion and nutrition. Further, the GI microbiome may influence diet selection by assisting animals to digest otherwise toxic material. In Cape Otway, Victoria, most koalas feed exclusively on manna gum, while, others feed predominately on messmate. In 2013 koalas became overabundant at the cape and defoliated large areas of manna gum. Sadly, the majority of these koalas did not begin feeding on available messmate and instead starved. Interestingly, animals that feed on messmate had a different microbiome to that of animals that fed on manna gum. In this study, we undertook GI microbiome inoculations on captive koalas to test whether a koala's preference for feeding on manna gum or messmate was influenced by their GI microbiome. We successfully introduced live gut bacteria from messmate animals into animals that fed on manna gum. In combination with the animals feeding partly on messmate this was associated with GI microbiome shifts. However, there was no effect on diet preference. These findings suggest that other factors, such as host physiology, may be responsible for diet preferences rather than the GI microbiome. Additionally, these inoculations offer the potential for probiotic development for treatment of sick koalas.

WHAT CAN THE MALE REPRODUCTIVE ANATOMY OF AUSTRALIAN HYDROMYINE RODENTS TELL US ABOUT THEIR BREEDING SYSTEM?

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There is good evidence that, in various vertebrate groups, postcopulatory sexual selection determines interspecific variation in relative testes mass (RTM), sperm size and sperm quality due to differences in intensity of intermale sperm competition. RTM is thus often used as an indirect proxy of the species' breeding system. Here relevant reproductive data for Australian hydromyine rodents are presented and past ecological and behavioural literature investigated to determine if this hypothesis is supported. Although all female hydromyines have low ovulation rates, the RTM, sperm numbers produced, and sperm size, all vary markedly across species. Many (e.g. *Pseudomys australis, P.desertor, P. nanus*) have large RTM of 1 – 4% and produce abundant sperm. In *P. apodemoides, P. delicatulus,* and *P. shortridgei* however RTM is only ca.
0.5% body mass, whereas in most *Notomys* (e.g. *N. alexis)* RTM is just 0.1 to 0.2%, with far fewer, and more variable, sperm occurring. These observations suggest polyandrous and/or promiscuous mating systems of species in group 1, and monogamy in species of the latter two groups. What do the data suggest? Not all conclusions in the literature are consistent with this prediction. Where discordance occurs further studies should, perhaps, be carried out to test the above hypothesis.

NOT ALL CITIES ARE THE SAME: CONTRASTING STRESS RESPONSES OF EASTERN GREY KANGAROOS TO DIFFERENT URBAN ENVIRONMENTS

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Chronic stress in response to urbanisation can impact on the health and viability of wildlife populations. However, it is not well understood how urban landscapes differ from non-urban landscapes with regard to their impact on wildlife. This study investigated the physiological response of eastern grey kangaroos (*Macropus giganteus*) to urban landscapes by comparing faecal glucocorticoid metabolites (FGM), in urban versus non-urban environments, across two contrasting regions in Australia. We quantified stress responses of 24 populations to land use type (urban or non-urban), environmental and anthropogenic factors using a linear modelling approach. Land-use was a significant predictor of FGM concentration with significant differences in concentrations between

urban and non-urban populations. However, the direction of the response differed between northern and southern regions of Australia. In the northern study sites (South East Queensland), kangaroos in urban areas had higher FGM levels than their non-urban counterparts, whereas the opposite was true in southern sites (Australian Capital Territory). These results are consistent with the contrasting abundance and persistence of kangaroo populations within the urban matrix between regions. This study suggests that it is the characteristics of urban environments, rather than the urban environment per se, which determines the extent of impacts of urbanisation on wildlife.

AUSTRALIA'S PROTECTED AREAS ARE INADEQUATE FOR THE LONG-TERM SURVIVAL OF THE SPOTTED-TAILED QUOLL

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The spotted-tailed quoll has vanished from large areas of its apparently intact historical range. The species is very vulnerable to extinction through elevated extrinsic mortality, individuals are vulnerable to many human threats, and are highly mobile. We therefore aimed to summarise two aspects of the spatial ecology of female *D. maculatus* which are likely to affect their exposure to threats in anthropogenic landscapes, (i) home range size and (ii) lineal dimensions of the home range and use these data to model buffers and the areas of habitat required to support quoll populations of 50, 100 and 250 individual female quolls. A buffer of at least 1900m is suggested, and when this is applied to the spatial extent of each Australian National Park, reveals that very few of these protected areas large enough to support even 100 female spotted-tailed quolls. The only National Parks large enough to support a population of 250 or more female quolls are the Blue Mountains National Park aggregate, the Australian Alps National Park Aggregate and south-west Tasmania. The results of this modelling are in concordance with patterns of regional quoll extinctions, provide a rationale for places that should be the focus of long-term quoll conservation strategies, and highlights the importance of State Forests and private lands for quoll conservation.

FANGAROOS AND KANGAROOS: PHYLOGENY, PALAEOECOLOGY, DIVERSIFICATION AND EXTINCTION OF EARLY KANGAROOS (MARSUPIALIA: MACROPODIFORMES) FROM THE RIVERSLEIGH WORLD HERITAGE AREA

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Riversleigh is a World Heritage listed area located in northwestern Queensland which contains numerous mid to late Cenozoic vertebrate-bearing fossil deposits. These have produced early representatives of three families of the suborder Macropodiformes (kangaroos): Hypsiprymnodontidae (musky rat-kangaroos), Macropodidae (kangaroos and wallabies), and Balbaridae, an extinct family of fanged kangaroos. Previous research suggests that macropodids were more diverse than balbarids throughout most of the Oligo-Miocene with balbarids becoming extinct during the late Miocene. Previous interpretations of diet of Oligo-Miocene macropodiforms (kangaroos and allies) from Riversleigh suggest that, in contrast to modern macropodiform communities in Australia, extinct representatives of Macropodidae and Balbaridae were predominantly folivorous browsers or fungivores. Here, we use 3D geometric morphometric analyses to investigate the probable diet of early macropodiforms by examining the relationship between skull shape and diet in macropodiforms more broadly. Using principal component analysis of shape variation for crania, Riversleigh macropodids and balbarids generally cluster closest to extant folivorous browsers, providing support for previous interpretations of these species as browsers. Further, despite representing taxonomically distinct families, balbarids and early macropodids exhibit similar overall cranial shapes.

C

PREY PRODUCTIVITY AND PREDICTABILITY DRIVE DIFFERENT AXES OF LIFE HISTORY VARIATION IN CARNIVOROUS MARSUPIALS

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Variation in life-history strategies has usually been characterized as a single fast–slow continuum, in which mean lifespan increases with age at maturity, as reproductive output declines. Some analyses of plants and animals suggest an additional independent axis based on the strategy of reproductive timing, with iteroparous species at one extreme, and semelparous species at the other. We test and confirm that reproductive output and life history timing axes are independent in female insectivorous marsupials (family Dasyuridae). Variation in reproductive output per episode is associated with mean annual rainfall, which predicts food availability. Reproductive timing is not associated with annual rainfall, but species in regions of unpredictable rainfall have long maximum lifespans, more potential reproductive events per year, and longer breeding seasons. We suggest that these two axes of life history variation arise because reproductive output is limited by overall food availability, and selection for high offspring survival favours concentrated breeding in seasonal environments and long lifespans in which reproductive opportunities are dispersed over longer periods in environments with less predictable food schedules.

A GREY AREA: DELINEATING THE SYMPATRIC ZONE OF EASTERN AND WESTERN GREY KANGAROOS IN SPACE AND TIME

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Eastern Grey (*Macropus giganteus*) and Western Grey (*M. fuliginosus*) Kangaroos are known to co-occur in a broad zone of overlap in south-eastern South Australia, north-

western Victoria, western New South Wales and southern Queensland. Much less is known about ratios of the two species across sympatric space, or how ratios might change through time. We estimated the spatiotemporal distribution of the two species using a Generalized Additive Model (GAM) incorporating a smoother of space and time dimensions. We based the analysis on data from the Atlas of Living Australia, filtered to remove erroneous and dubious records, and augmented these records with a ground survey of western Victoria in September 2017. Modelling indicates that the overlap zone has been essentially stable over a 50-year period. However, there is some evidence of a shift in north-western Victoria and southern NSW in the last decade. There is also considerable uncertainty about the location and breadth of overlap in northern NSW and southern Queensland due to poor coverage. Our model predictions can be used to direct further surveys to reduce uncertainty and monitor shifts in the zone. We conclude that spatio-temporal GAMs perform well in estimating location and movement of zones of interaction between taxa.

ONLY YESTERDAY: QUATERNARY FOSSIL MAMMALS FROM QUEENSLAND, WITH IMPLICATIONS FOR CONSERVATION

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The ongoing extinction crisis affecting Australian mammals is likely to worsen with numerous impacting factors (e.g., exotic species, habitat destruction, climate change, etc) increasing in intensity. Conservation of species and communities is hampered by a lack of baseline ecological data, and a dearth of long-term understanding of the ecological tolerances of individual species. The fossil record can fill some of these gaps; for example: documentation of unrecorded recent species extinction, and the effects of rapid changes in climate. We present results of a long running research project investigating Quaternary cave sites in eastern tropical Queensland, particularly those at Chillagoe, the Broken River, and Mount Etna. Each area contains multiple deposits, providing a history of change in local faunas. Small mammals, particularly murid rodents, are most abundant and diverse in the majority of study sites. An assemblage interpreted as representing a rainforest palaeoenvironment occurred at Mount Etna and the Broken River during the middle Pleistocene before being replaced by a fauna indicative of dry, even arid conditions. This ‘dry’ fauna also occurred at Chillagoe, although the timing of this climatic phase appears to have varied across the study areas. In the context of the Quaternary fossil record, the current faunas in the study areas are an anomaly, being present for only a fraction of the last 500 thousand years.

IMPROVING ESTIMATES OF GREATER GLIDER DENSITY - DISTANCE SAMPLING USING TWO OBSERVERS

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Determining the population size or density of a species is often fundamental for wildlife conservation. For nocturnal species, estimates are commonly extrapolated from standardised spotlighting indices (e.g. sighting rate per km). Distance sampling is a technique that provides rigorous estimates of the size of wildlife populations, incorporating detection probabilities into the analysis. We used double-observer (mark-recapture) distance sampling to estimate densities of the Greater Glider (*Petauroides volans*) in the Strathbogie Ranges, Victoria. Two observers, 15 minutes apart, surveyed 25 randomly located 500 m off-track transects throughout the survey area, in late 2017. Overall, 121 individuals were observed, with 0–14 gliders seen per transect. The double-observer method of surveying revealed that, on average, only
21% of the total number of gliders detected were seen by both observers. Our results show that the detection probability of gliders on occupied sites is relatively low. Therefore, raw spotlight counts will underestimate the relative abundance of gliders present at a site. The Greater Gilder has undergone substantial declines in recent decades throughout much of its Victorian range. It is therefore vital to have contemporary information about densities to help inform management of this species.

THE CALAMITY OF COUNTING KOALAS

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Estimating the number of organisms in an area is vital for population and epidemiological models, as well as management decisions. However such estimates are difficult for cryptic species where detectability can be low. A species where population estimates is particularly controversial is the koala (*Phascolarctos cinereus*). We attempted to estimate the koala numbers on a number of properties on the Liverpool Plains, northern NSW.

This is an area of fragmented habitat on agricultural and potential mining land. It is also a population that has suffered decline due to disease and heatwaves. We used a combination of distance sampling, mark-recapture models and home range analysis to estimate the koala numbers. We show that accurate estimates of the extent of habitat is essential. By applying multiple methods, we allow cross-validation of results to increase our certainty about population abundance. This information is essential for management of koalas in the area for proposed management actions. It also challenges some koala abundance statements in the media.

D

CAN JUVENILE RED KANGAROOS STRUCTURALLY SURMOUNT THE METABOLIC BURDENS OF SIZE AND GROWTH?

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Juvenile red kangaroos have a large metabolic burden relative to adults. Many don't survive to adulthood, notably when faced with poor pasture conditions. We have studied them just after weaning, when they lose the benefit of maternal milk. Around this time they are about 40% of the mass of adult females but to achieve full growth they need to eat almost as much as the adult females. How can they cope with such an imposition? Can they do this via structural changes in the guts? From our data on gut morphology, and insights into the basic allometry of body size and fermentative digestion, this appears doubtful. It emerges that it is the adults that have the reserve digestive capacity. Thus, at the forefront of juvenile survival is the broad issue of diet selection. However, there are elaborations within the juvenile's harvesting apparatus, i.e. its skull and dentition, that facilitate enhanced feed intakes. Relatively larger skulls and advanced development of the incisors were found to be part of this process.

USING WILD MARSUPIALS TO IDENTIFY THE SOURCE OF MANGANESE CONTAMINATION ON GROOTE EYLANDT, NT.

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Manganese (Mn) is an essential metal that induces neurological degeneration upon

overexposure. On Groote Eylandt, NT, 100 k tonnes of Mn are extracted each day, and though mining releases particulates into the air, it is not yet clear whether this is the only source of contamination for wildlife on the island. In this study, the hair of wild northern brown bandicoots (*Isodon macrourus*) and northern quolls (*Dasyurus hallucatus*) was collected at sites of known proximity to mining activities, on various geomorphology types and used to establish the source and level of Mn contamination. Mn accumulated in the hair of both species was found to be negatively correlated with distance to active mine areas, with individuals living closer to the mine having greater levels of Mn within the hair. Both sex and age also had a significant effect on Mn accumulation for both species, highlighting the importance of accounting for varying behaviour and life history strategies, as well as hair strand morphology. This study demonstrates that Mn accumulation in wild animals on Groote Eylandt was associated with mining processes, rather than the natural undisturbed geomorphologies.

Land clearing symposium

CHANGES IN CUMULATIVE HUMAN PRESSURE DRIVE CHANGES IN SPECIES EXTINCTION RISK

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Predicting how species respond to human pressure is essential to anticipate their decline and identify appropriate conservation strategies. Both human pressure and species extinction risk change over time, but this dynamic is rarely included in extinction risk modelling. Here we measure the relationship between a 16-year trend in terrestrial human footprint (HFP) – a spatial representation of the cumulative human pressure on the environment – and the trend in extinction risk of the world's terrestrial mammals. We found that the degree of HFP, and its change over time, are significantly correlated to global trends in species extinction risk, explaining more variation than other variables. Our results show that averting the conversion of natural and semi- natural areas, those with HFP values <3, is the most effective global strategy to prevent species from undergoing a high-risk transition in their conservation status. However, we also found some

biogeographical variations. In Australia, substantial portions of the distribution of high-risk species were converted from low/moderate HFP values (≤5) to high/very high HFP values (>5); this was much less the case for low- risk species. Our framework, calibrated on past extinction risk trends, allows for projection of extinction risk under scenarios of change in human pressure.

BILBIES WHERE THE DESERT MEETS THE OCEAN: OCCUPANCY, ABUNDANCE AND HABITAT SUITABILITY IN A KEY AREA TOWARDS WHICH THE NATURAL DISTRIBUTION IS CONTRACTING

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The greater bilby (*Macrotis lagotis*) occurred across much of arid Australia, however, since European colonisation, abundance has declined, and the distribution has contracted towards the northwest where bilbies are now only found in 20% of their former range. The La Grange area in the northwest of Australia is where the Great Sandy Desert meets the ocean, and has been identified as an important area for wild bilby populations towards where range contraction is occurring. The Western Australian Department of Biodiversity, Conservation and Attractions and the Karajarri Rangers, Nyangumarta Rangers and Yawuru Country Managers partnered to survey the occupancy, abundance and habitat suitability for bilbies in this key area. 439 standardised 2 ha sign plots were surveyed, with 216 plots revisited. Bilby occupancy was estimated at 0.22 with a per survey detection probability of 0.42. Bilby occupancy across the area coupled with large areas of suitable habitat, as well as the presence of the largest known naturally occurring wild bilby population in Western Australia, confirm the La Grange area as important for the continued persistence of wild bilby populations, particularly with the continued contraction in range and decreases in occupancy across the nation.

E

Land clearing symposium

GREY-HEADED FLYING-FOXES USE ADAPTIVE BEHAVIOURS TO RESPOND TO ONGOING CLEARING OF CRITICAL WINTER HABITAT, WITH ADVERSE CONSEQUENCES

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Periods of resource concentration expose migratory species to disproportionately large impacts from the loss of relatively small areas of habitat. Migratory Grey-headed Flying-foxes (GHFFs) once congregated during winter on rich nectar pulses in coastal lowland forests of southern Queensland and northern New South Wales, areas valued for agriculture and development. During the 1990s, high rates of clearing in these critical habitats were associated with a rapid decline in population. Clearing has continued and GHFFs no longer aggregate during winter in this part of their range. However, a commensurate decline in population size has not been observed. Rather, the species has adjusted its feeding and roosting behaviours to support increased use of introduced food in urban and agricultural landscapes: establishing new roosts near human habitation, increasing roost density to reduce the cost of foraging flights, and expanding their winter range beyond those of native diet plants. These behaviours are consistent with the adaptive responses of GHFFs to temporary, acute winter food shortages and suggest that behaviours that evolved under past conditions have the capacity to increase fitness under current conditions of rapid, persistent change. The behavioural modifications have adverse consequences for both human-wildlife conflict and disease risk.

TWO-COLOUR FLUORESCENT IN-SITU HYDRIDIZATION SHOWS PRIMARY SEX RATIO BIAS IN THE SPERM OF THE TAMMAR WALLABY, *MACROPUS EUGENII*

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Sex allocation research is a whole branch of evolutionary biology devoted to investigations of models which violate one or more assumptions of Fisher's Principle. While these violations explain secondary sex ratio biases, or extraordinary sex ratios, at the theoretical level, the proximate explanation remains unclear. In order to understand these offspring sex ratio biases, we have taken a step back to look at the primary sex ratio within the sperm of the metatherian model, the Tammar wallaby, *Macropus eugenii*. Previously, it was assumed that sperm sex ratios must be at parity, considering meiosis creates an equal number of X- and Y-chromosomes. However, recent technological advances have allowed for faster and more accurate measures of sperm sex ratios. Research has since uncovered many skews at the primary level, though generally these skews exist only on an individual basis. Using two-colour fluorescent *in-situ* hybridization analysis we show not only individual level sperm sex ratio biases, but also a significant bias at the population level. We discuss the ramifications of these biases for population stability and management, as well as investigating the interactions between this potential adaptive paternal sex allocation, and the more often studied maternal sex allocation.

CREATING PANIC ROOMS FOR WILDLIFE: TRAINING NORTHERN BROWN BANDICOOTS TO ACCESS SAFE REFUGE USING MICROCHIP-AUTOMATION

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The incorporation of technology is expanding the limits of traditional conservation programs. RFID technology, in the form of microchip-automation, has great potential for providing supplementary feed and shelter to reintroduced animals. Microchip-automated doors allow the exclusion on non-target competitor and predator species to artificial burrows or feeding stations, and can provide individualised access to supplementary food after release. The aim of this research was to train northern brown

bandicoots, *Isoodon macrourus,* to use microchip-automated doors to access a food reward. Six wild-caught bandicoots brought into captivity at the Hidden Vale Wildlife Centre were trained to use commercially available microchip-automated doors. Behavioural observations were analysed to determine the bandicoots' response to using the door. Training was broken into six stages, with each stage gradually leading to full operation. The bandicoots took a mean total of 12 days to learn to use the doors in their full capacity. Given the feasible training period, this microchip-automated technology has the potential for use with reintroduced, rehabilitated, or captive-bred animals after release back to the wild, to provide individualised access to food whilst providing safe shelter. The doors can also provide an alternative method to post-release monitoring, improving current reintroduction and soft-release programs.

Land clearing symposium

INTERACTIONS AND PERVERSE OUTCOMES: LAND CLEARING AND SMALL MAMMAL COMMUNITIES

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Almost 60% of the forest and woodland cover of the Brigalow Bioregion have been lost since European colonisation. Clearing has predominantly been focused in the productive areas for the purposes of grazing, creating a landscape mosaic of numerous small and isolated fragments of remnant vegetation interspersed with native and exotic pastureland. While there is a growing awareness of the importance of these fragments for biodiversity conservation, it is known that small fragments are susceptible to changed ecological processes that facilitate biodiversity homogenisation and decline. However, little is known about the interactive effects of other land management practices upon terrestrial fauna, and particularly small terrestrial mammals, in these fragmented landscapes. In the region, both the establishment of waterpoints – to allow even grazing pressure – and the use of fire – to promote pasture growth and control of woody regrowth – are increasing. Here we examine the interactive effects of artificial water, fire and habitat clearing on small terrestrial mammal assemblages, and provide informed comment on some of the more perverse impacts.

F

MECHANISMS OF CLIMATE CHANGE-INDUCED SPECIES DECLINE: SPATIAL, TEMPORAL AND LONG-TERM VARIATION IN THE DIET OF AN ENDANGERED MARSUPIAL CARNIVORE, THE EASTERN QUOLL

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The endangered eastern quoll has recently undergone rapid and severe population decline, with no sign of recovery. Weather modelling suggests a prolonged period of unfavourable weather between 2001 and 2003 as the proximate cause of decline, but the mechanisms are not understood. We hypothesised that changing weather conditions may have altered the availability of key prey species, contributing to the species' decline. We analysed 229 scats from 125 individual wild quolls across four sites between July 2011 and May 2012. Dietary composition and niche breadth were similar across sites but differed between seasons. Dietary niche contracted during winter and early spring when insect larvae formed the bulk of eastern quoll diet, rendering quolls vulnerable to weather-related fluctuations in food availability at that time. Current and historic dietary composition differed, with a shift from insect larvae to mammals over time, predominantly due to a reduction in corbie and southern armyworm moth larvae. Quoll abundance appears positively related to corbie larva abundance during winter, and both quoll and corbie larva abundance appear negatively related to winter rainfall. We suggest that insects represent an important food item for eastern quolls, and that weather-induced fluctuations in quoll abundance are potentially driven by weather-induced fluctuations in corbie larva abundance.

THE GREAT SYDNEY DIVIDE, EVEN POSSUMS DON'T WANT TO CROSS THE BRIDGE

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The south eastern corner of Australia is one of the topographically most complex regions of Australia and one of the only remnants of Australia's ancestral biome (the mesic biome). Surprisingly, however, even though the mesic biome overlaps with Australia's most heavily populated and modified landscapes, the biogeographic and evolutionary history of this region is still poorly understood for many species. Here we present data on biogeographic structuring in the Eastern Pygmy Possum (EPP) *Cercartetus nanus,* which is widely distributed along the east coast of Australia (Tasmania to south-east Queensland). Ninety-one individuals were investigated using both Mitochondrial DNA (Dloop) and Single Nucleotide Polymorphisms (SNP) data. Significant phylogeographic structuring was identified across the Sydney Basin region. These data add to a growing body of evidence that the Sydney Basin has acted as a significant barrier to gene flow across this region in mammalian species. Divergences and the absence of gene flow between EPP populations, at both mitochondrial and SNP loci, located ~60 km apart suggest long term isolation and potential speciation. If this is the case, *Cercartetus nanus* would represent the species south of Sydney Harbour with *Cercartetus unicolor* (Kreft 1863) available for the putative species distributed north of Sydney Harbour.

Speed talk

HOW DOES NORTHERN QUOLL (*DASYURUS HALLUCATUS)* PERSONALITY AND PERFORMANCE AFFECT VULNERABILITY TO PREDATION?

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With the current extinction and decline rates of Australian mammals, identifying factors that increase an individual's susceptibility to predation are of utmost importance. Once common across northern Australia, northern quolls (*Dasyurus hallucatus*) have undergone severe population declines due in part to feral predators and recent changes

in fire regimes. One of the riskiest activities for quolls is foraging, individuals must make decisions that balance the potential benefits of food against the perceived risk of predation. Therefore, bold or risk-prone individuals may gain greater access to food but increase their chance of detection. Once detected by a predator, survival depends on the prey's speed and agility as it attempts escape. Hence, both personality and performance capability contribute to an individual's fitness. Quantifying foraging behaviour will provide information on whether specific personalities are more prone to predation, and how foraging decisions change over seasons for both sexes. We predict that bolder individuals will be male, spend more time foraging in risky areas, and obtain higher energy gains from these risks. Using mark-recapture, remote video, and experimental manipulations, we will show how sex, size, metabolism and motor performance of quolls affects their willingness to take risks during foraging, and how this contributes to their survival and reproductive success on Groote Eylandt, NT.

IDENTIFIYING THE DRIVERS OF LONG-TERM SOCIAL AVOIDANCES IN ANIMALS

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Animals may form pro-social relationships (also known as preferences or affiliations) to reduce costs associated with social or environmental pressures such as predation, resource competition, or sexual harassment. These relationships are important because they can improve an individual's survival or reproductive success. However, affiliation represents only one side of the coin: individuals also can and do choose to actively and consistently avoid conspecifics over long periods of time, even when they share space or habitat. Though avoidance is generally accepted as an alternative to preference in animal societies, few studies have attempted to characterise the ecological or genetic conditions that drive its evolution. Understanding what drives the dynamics of groups is a vital goal not just for biologists, but researchers in fields including psychology, economics, agricultural science, and political science. Here, I will present a general framework for the study of long-term social avoidance behaviour with specific references to findings across multiple key study systems including koalas, dolphins, kangaroos and reptiles.

HABITAT SUITABILITY ASSESSMENT FOR THE WORLD'S RAREST MARSUPIAL, GILBERT'S POTOROO, BY SHORT-TERM RELEASE OF PIONEERS

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Recovery planning for Gilbert's potoroo gives the highest priority to the establishment of new populations. Prior to any translocations, knowledge of the potoroo's habitat requirements was based entirely on the single site where it survived. Closely- monitored short-term translocations of a few individuals on three offshore islands with no prior record of the species were used to test their ability to support Gilbert's potoroos. Individuals were monitored by radio-tracking daily, GPS logging and trapping. On Bald Island, release of a male and a female in late summer resulted in both animals returning to their release weight within a month. In a similar trial on Michaelmas Island, the male was found dead after two weeks while the female lost weight over a month but her pouch young grew heavier. On Middle Island, where the adjacent mainland is far outside the historic range of the species, four-week trials in summer and winter each involving four animals met the success criterion of body weight loss under 10% after four weeks. Consequently, Bald and Middle Islands were identified as suitable translocation sites. A significant benefit of monitoring movements by radio-tracking and deployment of GPS loggers was the identification of preferred habitat which could be targeted in subsequent releases.

G

FACTORS INFLUENCING THE SUCCESS OF HAND-REARED JUVENILE BRUSHTAIL POSSUMS (*TRICHOSURUS VULPECULA*) RELEASED INTO THE WILD

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Wildlife is ubiquitous in Australian urban environments, resulting in frequent interactions with humans, often negative for wildlife. Wildlife rehabilitation and reintroduction programs are devised to counter these negative interactions. However, the success of current management strategies is rarely assessed. Juvenile hand- reared common brushtail possums (*Trichosurus vulpecula*) were released into the wild to assess if dispersal and survival are a function of (1) intrinsic factors, such as body weight, sex, personality and domestication or (2) extrinsic factors, such as release practice (soft *vs* hard-release), time in care or release location (urban vs rural). Over the 4-week study period 20 juvenile brushtail possums (10 females and 10 males) were radio-tracked and monitored to assess dispersal and survival. 8 possums achieved short-term success (i.e. short-term survival), 9 possums failed in the wild (i.e. died or had to be returned to care) and 3 possums had unknown fates (i.e. VHF signal lost). Personality traits such as boldness and exploration and domestication were found to significantly impact the dispersal and survival of individuals. For example, hand-raised possums that were highly domesticated were more likely to be unsuccessful after release in the wild. Understanding the factors that influence a species success in the wild will help to evaluate current release programs, as well as improve future ones.

LARGE-FOOTED MYOTIS *MYOTIS MACROPUS* ROOST SELECTION IN CULVERTS IN BRISBANE

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The large-footed myotis, *Myotis macropus,* is Australia's only fishing bat. This species has adapted to living and breeding in urban areas and has been recorded roosting in concrete culverts under roads. However, little is known about the roosting ecology of bats which use these unique roosting structures in Australia. This paucity of information makes it difficult for road managers and government departments to make science-based decisions on how to manage such roosts, presenting challenges when works must be carried out on structures containing a roost. We investigated bat roosting preferences in Brisbane City Council (BCC). We developed a stratified sampling design to test which landscape and structure attributes most likely account for the presence of a bat roost in a culvert. Over 300 concrete culverts were inspected for the presence of roosting bats between December 2017 and May 2018. Both day roosts and maternity roost sites of *M. macropus* were located. Preliminary results from the fieldwork suggest that roost sites are associated with semi-permanent to permanent waterways and located in large box or pipe culverts. Understanding the types of culverts that are likely to provide suitable bat habitat will prevent the disturbance to bat roosts during the breeding season.

Speed talk

FERAL CAT CONTROL FOR THREATENED MAMMAL RECOVERY IN CENTRAL QUEENSLAND

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Bridled nailtail wallabies are listed as vulnerable as they were once common throughout eastern Australia but suffered range and population declines following European settlement and the introduction of cats, foxes and dogs. In July 2017, Biosecurity Queensland aerially deployed Eradicat baits across the entirety of Taunton National Park in an effort to reduce the cat population on park. Because cats prey specifically on the young-at-foot, we predicted that the bait knockdown of cats would lead to an increase in juvenile success. We used spotlighting, camera traps and capture-mark-recapture surveys to determine the juvenile survival of the bridled nailtail wallabies before and after the baiting. The preliminary results suggest an increase in juvenile success after the baiting. This supports the existing research showing how feral cat control can assist the recovery of threatened mammals in central Queensland.

A MAJOR STEP IN A JOURNEY THROUGH (MORPHO)SPACE AND TIME? THE EFFECT OF THE K-PG EXTINCTION ON MAMMALIAN MORPHOLOGICAL EVOLUTION

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Popular science accounts state that after the extinction of the non-avian dinosaurs at the Cretaceous-Paleogene (K-Pg) boundary 66 million years ago, mammals rapidly diversified to fill empty ecological niches. However, evidence for this is mixed. Paleontological analyses suggest that mammals radiated in response to the K-Pg extinction event, whereas neontological analyses suggest that the radiation began before K-Pg and was not greatly affected by it. Here we aim to shed light on this debate by looking at living and fossil taxa simultaneously. We tested the effect of the K-Pg extinction event on mammalian morphological diversity (disparity) based on a new Total Evidence tip-dated tree. Using a continuous time-slicing method for measuring changes in disparity-through-time, along with null models of disparity evolution, we found mixed support for a change in disparity after the K-Pg boundary between a gradual and a punctuated model of evolution. This implies that the extinctions at the end of the Creataceous had a much more complex effect on mammalian morphological evolution than previously thought. Our findings contradict the popular theory that the non-avian dinosaurs and other Mesozoic tetrapods were simply restricting mammalian evolution, and that their extinction liberated ecological niches for mammals to fill through evolution.

H

Land clearing symposium

THE IMPORTANCE OF USING AN ANIMAL-CENTRIC APPROACH TO MANAGING SPECIES RESPONSE TO LAND CLEARANCE

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Managing species responses to land clearance requires understanding of how animals perceive and use habitat. Using occupancy analyses of camera data and GPS tracking, we show the importance of using an animal-centric approach to managing fragmented landscapes in the Tasmanian Midlands for invasive (feral cat) and native (spotted-tailed and eastern quolls, Tasmanian devils) mammalian predators and prey (eastern bettong). No one habitat model: island biogeography, habitat amount and continuum, works for all species. At the regional scale, each species responded differently to landscape patterns of habitat depending on contrasting mobility. Bettongs depend on sufficient habitat amount; crossing small but not large gaps to use woodland remnants. Carnivores use the landscape as a continuum; crossing all gap sizes, they are more affected by the type or quality of landscape vegetation. Fine-scale studies (GPS tracking) are necessary to understand *why* animals are present in different habitat types, to establish the relative value of occupied habitats and provide better insight into species response to fragmentation. Density and home range size of bettongs varies with habitat quality. Female spotted-tailed quolls require large woodland patches to breed but small patches are valuable as stepping stones. All patches are valuable to retain for both species.

SPATIAL MOVEMENTS OF A THREATENED TROPICAL ROCK-WALLABY BEFORE AND AFTER PRESCRIBED BURNING

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Fire is a frequent occurrence in the wet-dry tropics, but little is known about the movement patterns of rock-dwelling species following fire events. We examined the

response of the vulnerable Sharman's rock-wallaby, *Petrogale sharmani*, to early dry-season burns at the Australian Wildlife Conservancy's Mount Zero-Taravale nature sanctuary in north Queensland. We deployed 16 GPS/VHF collars on animals at three sites in April 2017. We monitored the rock-wallabies' movement patterns before and after early dry season prescribed burning. Our aims were (1) to determine the dry season home range of *P. sharmani* and (2) to examine the effect of prescribed burning on its movement patterns. This study is the first investigation of the movement patterns of this threatened species and provides important baseline information for future conservation management. We will present our home range and habitat use data, and discuss the implications for fire management of this and other tropical rock-wallaby species.

NORTHERN QUOLL DEMOGRAPHY IN THE PILBARA

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The endangered northern quoll (*Dasyurus hallucatus*) is a carnivorous marsupial that inhabits the northern third of Australia. Thought to be one of its lasts strongholds, the Pilbara region of Western Australia was highlighted in need of baseline data of quoll populations. The overall objective of this study was to assess population characteristics of northern quolls at two rocky sites in the Pilbara, and interpret these in the context of climate, habitat, and latitude. We assessed survival, population sizes of males and females, growth rates, body condition, and reproductive timing. We found that although reproduction occurred later in the year than in populations of more mesic locations where quolls have been previously studied, their life history and demography were similar to other parts of their range. Supporting previous findings, we found that survival, population size, and body condition were higher for females than for males, and higher for quolls in their first year than in their second. Unlike some previous studies of grassland populations, but like other populations in rock outcrops, we did not find complete male mortality after mating, or unequal sex ratios, except during the mating season.

TWENTY-FIVE YEARS OF TROPICAL FOSSILS: MINING, MAMMALS AND MEGAFAUNA

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For the lead author, 2018 marks twenty-five years of discovery, excavation and salvage of Quaternary vertebrate fossils throughout Queensland, especially those threatened by mining. So, what is there to show for it? Focussing on the upper and lower reaches of the Fitzroy River Basin (FRB), two areas of intensive collecting have produced hard fought for but remarkably diverse and complex palaeontological records. The FRB record, thus far, indicates a complex biogeographic story of connectivity and filtering between rainforests of New Guinea and Australia with biased middle-late Pleistocene extinctions of mesic lineages. It does not support the synchronous continent-wide nor the step-wise models for megafauna extinction but does suggest climatically driven faunal turnovers that included species of variable body-size and climatic preference. Unique and diverse Late Pleistocene megafauna were seemingly driven rapidly extinct, and not replaced - happening long after mainland arrival of people. Overall, the FRB seems to have responded differently to similar-sized and larger basins that border it to the coastal north, south and western interior. This suggests that key factors driving Quaternary biogeographic pattern and extinction timings are basin-specific. With so few studies integrating upper and lower regions of any Australian basin, we are probably missing the point.

DISTRIBUTION MODELLING AND POPULATION GENETICS OF WET TROPICS SPOTTED-TAILED QUOLLS

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The northern subspecies of Spotted-tailed Quoll, *Dasyurus maculatus gracilis*, is restricted to upland rainforest of the Wet Tropics. It is listed as Endangered and has suffered range decline since European settlement. However, recent estimates of distribution and population size have been lacking; as has information on population connectivity. We quantified range decline over the last century using species distributional modelling and attempted to identify causes. This revealed a significant decline, especially from peripheral areas of the Wet Tropics and from the Atherton Tableland. The modelling identified core remaining areas of habitat and we estimated population sizes in these by extrapolating density estimates from camera-trap monitoring transects. We performed genomic analyses (using SNPs) on samples from six sites across four key populations to assess genetic structuring. The samples clustered into three genetically highly distinct groups, including high differentiation even between the neighbouring Windsor and Carbine Tablelands. Intriguingly, the genetics also revealed the samples from the individuals of one population (Lamb Range) to be essentially identical to those of a geographically distant population (Carbine Tableland). The likely reason for this is startling. I will also outline directions for research and management.

I

J

K

GROWTH AND DEVELOPMENT OF *CONILURUS PENICILLATUS*, A VULNERABLE TREE-RAT FROM NORTHERN AUSTRALIA

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Understanding life history contributes to management of threatened species. This study documents growth and development of Brush-tailed Tree-rats and compares results with other rodents. A laboratory colony yielded 34 litters (87 individuals) studied during 1982–1985, under ambient conditions in southern Australia. Weight, measurements (pes, head, head/body, tail) and developmental features were recorded daily and at other intervals. Sex ratio at birth was 1.2:1, not statistically different from parity. Ears opened at 7–9 days and eyes at 11–13 days. Weaning was from 34 days. Females matured at 7–9 weeks when 88% of adult weight. Natal pelage disappeared by 4 days and juvenile pelage was complete by 7 days. A post-juvenile moult commenced at 36 days (range 32–40) and was completed in 36 days. Males (11.5 g) were significantly heavier than females (10.3 g) at birth (6.5 % adult) but not as adults (171.0 vs 166.9 g). Head, but not pes, head-body or tail length, was significantly greater in males at birth and as adults. Growth models showed pes and head grew the most rapidly. Compared with Australian and other rodents, *C. penicillatus* is altricial but is quite precocial relative to other Australian tree-rats.

CAN EASTERN GREY KANGAROO MOTHERS RECOGNISE OFFSPRING DISTRESS CALLS?

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Mother-young communication is important to maintain the maternal bond in mammals. Young eastern grey kangaroos (*Macropus giganteus*) often give “distress calls” when they become separated from their mothers. To test whether mothers recognise the distress calls of their offspring, we conducted 92 playbacks of pouch young calls to 32 different mothers at Wilsons Promontory National Park, Victoria. Responses of kangaroos were coded on a scale from 0 to 7, depending on time spent alert and latency to approach the speaker. Mothers reacted more to their offspring’s call than to that of another young, but only when carrying a pouch young. They also reacted more strongly to the first call played. Individual mothers varied greatly in the strength of their reaction, but their body condition, location and boldness appeared not to influence their response. Our results suggest that mothers can recognise offspring by their distress calls, but this was only revealed when there had not been another recent distress call and was more conspicuous when the mother had a pouch young.

L

Form, function and evolution symposium

MAMMALS BORN TO FLY: POSTCRANIAL DEVELOPMENT IN BATS

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Flight is one of the most energy-demanding types of locomotion found in vertebrates. It is also associated with a range of extreme morpho-physiological adaptations that evolved convergently in three different vertebrate groups. Considering that development acts as a bridge between the genotype and phenotype on which selection acts, studying the development of the postcranium can potentially illuminate our understanding of bat flight evolution. To trace how the evolution of flight may have resulted in differences in the extent and mode of development in bats, we quantitatively compared the prenatal development of the postcranium (24 bones) between bats (14 species), non-volant mammals (11 species) and birds (14 species). Also, by combining for the first time prenatal sequence heterochrony and developmental growth data, we assessed differences in modularity between groups, as well as how integration and morphological diversity shape postcranial ontogeny. Sequence heterochrony was found across groups, showing that postcranial development in bats shows patterns found in other flying vertebrates but also those in non-volant mammals. Modularity was evident in the form of an axial-appendicular partition, suggesting postcranial covariance patterns are shaped by development at prenatal stages. Our results support the hypothesis that integration facilitates phenotypic diversification in bones forming developmental modules.

GENETIC MANAGEMENT OF CAPTIVE AND REINTRODUCED BILBY POPULATIONS

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Captive breeding programs, and the associated translocation of wildlife, represent a powerful tool for conservation management. However, small, intensively managed populations are highly susceptible to inbreeding depression and genetic drift, and often face strong directional selection for survival in artificial environments that may bear little similarity to natural habitats. Consequently, stakeholders are increasingly employing active genetic monitoring to guide and evaluate the management of genetic diversity in captive systems. In this study, we used hypervariable genetic markers (SNPs) to conduct a comprehensive survey of population structure and genetic diversity in captive and reintroduced bilby populations across Australia. Our goal was to define management units that can be used to inform future breeding strategies and translocations, and to use molecular data to comment on the efficacy of the current bilby National Recovery Plan. Our results indicate that while there was partitioning of genetic diversity between independently managed populations, the majority of variation occurred within samples. We also found evidence for the ongoing loss of genetic diversity in some semi–free range bilby populations. Maintaining the genetic health of bilbies in captivity will therefore require stakeholders to focus on reducing individual mortality, and maintaining connectivity across all populations.

THE DISTRIBUTION OF THE ENDANGERED SPOTTED-TAILED QUOLL (*DASYURUS MACULATUS*) IN NEW SOUTH WALES

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We employed both citizen science (community) and camera trapping surveys to address actions in the 2016 “National Recovery Plan for the Spotted-tailed Quoll” related to determining their distribution and status. The initial dataset was our 2006 state-wide

citizen science survey of 10 iconic species. We received 16 694 replies, yielding 48 841 animal sightings, of which 1246 were quolls, allowing us to produce a distribution map of quoll likelihood of occurrence. To investigate possible causes ofthe distribution (particularly the impact of foxes), we compared the locations of quolls, foxes, dogs and cats over four years (2012-15) within the NSW OEH WildCount project, where 208 camera sites are situated in national parks. The results revealed higher numbers of sites where only quolls were recorded than would be expected if the distribution of quolls and predators were independent of each other. With a more refined distribution map, identifying locations where quolls occur in, and better understanding of the influence of foxes on quolls, we are closer to being more effective in managing quolls, but still very a long way from delisting them as an endangered species.

M

FLUCTUATING SELECTION ON TIMING OF PARTURITION IN EASTERN GREY KANGAROOS

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In unpredictable environments, temporally fluctuating selection may limit directional micro-evolutionary responses. Identifying ecological or climatic drivers of selection is critical for predicting long-term changes in phenological traits like timing of parturition, which may directly affect fitness. Kangaroos evolved with intense environmental variability, including drought and variable timing of rainfall. We recorded annually fluctuating selection on timing of parturition in eastern grey kangaroos in southern Victoria over 8 years. Very few births were recorded from June to October. Low rainfall and high temperatures during lactation reduced survival to weaning, but high rainfall during colder years also reduced juvenile survival, likely through a trade-off between thermoregulation and lactation. Overall, increased survival of young born before the birth peak in early January suggested net directional selection for early parturition. That selection, however, was weakened by 4 years, including 3 when nearly all juveniles died, when survival was independent of birthdate. Hence, female fitness likely depends mostly on ability to survive and reproduce in favorable years. Weak selection and strong year effects on juvenile survival lead to a rather long breeding season, as fitness returns of late parturition appear greater than those of skipping a breeding opportunity.

MICE IN OZ: GEOMETRIC MORPHOMETRIC ANALYSIS OF 35 RODENT SPECIES SUGGESTS GENERALIST SHAPE AND BODY SIZE VARIATION SUPPORT BIODIVERSITY

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Rodents are Australia's only native terrestrial placental mammal. Despite relatively recent arrivals (~5MYA, 2-3MYA, modern era), rodents are also Australia's most specious mammal family. We used geometric morphometrics to investigate rodent skull variation using species from every major environment. The skull is a useful proxy for overall shape and it reflects diet, locomotion, body size, and traits like nocturnality. Due to rapid rodent diversification, we expected to find cases of convergent evolution, distinct clusters of species by habitat, and differentiation between species from each radiation. Principal Component Analysis on a preliminary dataset (n=111) shows that most species, regardless of habitat and arrival time, maintain a similar skull shape with the vast majority of variation captured by body size (PC1=41%). The only distinct clusters along PC2 (9.5%) are the carnivorous semiaquatic species, *Hydromys chrysogaster* and *Xeromys myoides*, as well as, the highly herbivorous species, *Mastacomys fuscus* and *Pseudomys oralis*. All of these species have significant modifications to their teeth. Australian rodents cover almost three orders of magnitude in size (12g to 720g). We suggest that highly variable body size coupled with a generalist skull shape underlies Australian rodent biodiversity.

FORELIMB BONE SHAPE IN A DIGGING MAMMAL

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Digging mammals such as Quenda (*Isoodon fusciventer*) have adaptations of their forelimbs to generate the force required to move soil as they forage for their subterranean food sources. We sought to quantify the relationship between forelimb bone shape and muscle anatomy in Quenda to test if forelimb musculature drives the shape changes of bones, and if sex influences the development of bones. Linear

measurements of n=34 Quenda bones were carried out to determine indices and micro-CT scanned (scapula, humerus, ulna, and third-metacarpal) using landmark analysis to determine shape change. Three of these bones showed no significant sex effect on shape ($p>0.05$ for each, metacarpal $p=0.014$). All bones showed a significant shape change with body mass ($p<0.05$). The index of fossoriality (IFA) was positively correlated with the shape change of both the humerus and third-metacarpal, while the pectorals and latissimus dorsi were negatively correlated with the scapula shape change. Ulna shape change score was negatively correlated with brachial index and the digital/carpal flexors. Results indicate that Quenda ontogenetic bone shape changes are primarily due to body size but are also influenced by muscles that are primary movers in the power stroke of digging and the ratios of forelimb bone lengths.

Land clearing symposium

IMPACT OF LAND CLEARING ON KOALAS

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Koalas are widely distributed across eastern Australia, where they selectively use of a small number of eucalypt species. Land clearing directly impacts on koala populations by destroying, fragmenting and degrading their habitat. Habitat destruction is the major driver of koala population declines. In this presentation, we provide observational evidence of declines in koala populations in Queensland, and the links to land clearing. Prominent in these declines is the urban and peri-urban “Koala Coast” population, which has declined by 80% since 1996. In southwest Queensland, there has been a 80% decline in koala populations over the past 20 years, mainly due to land clearing pressures, combined with extended drought and heatwaves. Where populations are declining, there needs to be concerted effort to protect and restore remnant and regrowth habitat, and to address other causes of decline, especially the incidence of dog attack and road-related mortality, the prevalence of Chlamydia disease. These policies must also take into account the predicted impacts of climate change.

PLANT ODOURS PROVIDE SALIENT FORAGING CUES FOR A MEGA-HERBIVORE, THE AFRICAN ELEPHANT

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For animals to forage non-randomly, they must discriminate amongst food items. Foods differ in look, smell and taste, providing cues for foragers with appropriate senses. It is unclear how or even which food cues mammalian herbivores use. This matters because, with little pressure from apex predators, foraging mammalian herbivores often cause trophic cascades. We tested whether plant odour provides a salient cue for mammalian herbivores, using an ecologically significant mega- herbivore, the African elephant *Loxodonta africana*. Choice tests with semi-tame elephants established their plant species preference and capacity to choose plants using odour. GC-MS analysis demonstrated that volatile organic compound profiles differed among plant species. Elephants detected, discriminated and selected preferred plants based on odour alone. They succeeded even with complex background odours from non-preferred plants, and despite attempting to mask distinguishing odours. Our findings provide clear evidence that natural plant odours impart salient information that elephants can exploit, providing an efficient mechanism for selective foraging. We predict that plant odour cues play a key role enabling selective foraging by other ecologically-influential mammalian herbivores. Our results call for the merging of sensory and foraging ecology to yield new insights into food selection, foraging, and their individual- to ecosystem-level consequences.

CHRONIC PHYSIOLOGICAL STRESS AND HENDRA VIRUS IN BLACK FLYING-FOXES (*PTEROPUS ALECTO*), AUSTRALIA

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Release of adrenal glucocorticoids, such as cortisol, is crucial for an animal's survival when facing a stressor. However, it has been suggested that chronically high levels of

circulating cortisol may have a negative impact on immunological function and subsequently predisposition to disease. Pteropus species, known as flying-foxes in Australia, are reservoir hosts to many viral pathogens of zoonotic significance, and the effect of physiological stress has been hypothesised to lead to increased incidence of spill-over of viral infections from flying-fox reservoir hosts to other species. Seasonal fluctuations in urinary cortisol and correlations with Hendra virus excretion prevalence at the flying-fox colony level have been examined. This subsequent study is the first of its kind to examine longer term measurements of cortisol laid down in the hair of individual *Pteropus alecto* (Black flying-fox), a known reservoir host of Hendra virus in Australia. The seasonal fluctuations of cortisol in hair of individual *P. alecto* captured bimonthly over a year, are compared with individual animal health blood biomarkers and Hendra virus infection and excretion status. This work contributes to the understanding of virus epidemiology in the flying-fox reservoir host, and more broadly, informs investigation of emerging disease infection dynamics across the wildlife/livestock/human interface.

NEEDING A DRINK: THE COST OF CLIMATE CHANGE ON KOALAS

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Koalas are vulnerable to the impacts of extreme climate change-driven heatwaves and droughts as they rely on leaf moisture to maintain hydration. During these increasingly common and intense weather events, leaf water content may not be enough to meet koalas' moisture requirements, leading to large-scale koala mortality due to dehydration. No study to date has looked at the importance of free (drinking) water for koalas and the general belief is that koalas seldom drink in the wild. However, during hot and dry conditions free water availability could be of vital significance for the conservation of koala populations Australia-wide. We have tested artificial water stations for koalas in the Liverpool Plains, in New South Wales, as a potential mitigation measure against water deficient conditions. Koalas used supplemented water stations extensively throughout the year, even during cooler months. The use of water stations increased as weather became hotter and drier, and as leaf moisture decreased, suggesting that leaf water content in certain circumstances might not be sufficient to meet koalas' water requirements. Rainfall and temperature were the main drivers of koala drinking behaviour, indicating the severe cost of climate change on this threatened species.

Speed talk

REWILDING THE SOUTHERN YORKE PENINSULA: MAMMAL REINTRODUCTIONS TO RESTORE ECOSYSTEM FUNCTION

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The southern Yorke Peninsula supports some of the few remaining large areas of native vegetation in the South Australian agricultural zone. Despite the region's significance for biodiversity, the majority of native mammal species were locally extinct by the beginning of last century, and the health of the remnant bushland is deteriorating due to the absence of supporting ecological processes. This isolated mainland 'island' provides a rare opportunity for reintroducing mammals back into the wild, many of which have also become extinct in other parts of mainland Australia, and to assess their ability to restore ecosystem function. Following a long-term and widespread feral predator control program, and combined with a planned coast-to- coast predator diversion fence across the peninsula, the reintroductions of several mammal species are planned over a 20-year timeline. The project focuses on reintroducing species with potential to play a vital role in maintaining the health and function of the region's natural systems: ecological engineers that redistribute nutrients through the soil profile, and predators that regulate that abundance of introduced species. Extensive baseline monitoring of the region's environment will enable an evaluation of ecosystem responses to species reintroductions, and will form the basis of numerous research opportunities in coming years.

Speed talk

TEACHING AN OLD MACROPOD NEW TRICKS: THE CHALLENGES OF TRAINING A CAPTIVE BRIDLED NAILTAIL WALLABY

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Training of wildlife has been carried out in captive animal settings to improve welfare and husbandry with great success. However, the training of macropods has received limited research attention and methodologies are scarcely described. In this study, we developed a training methodology and conducted a detailed evaluation of a captive bridled nailtail wallaby's (*Onychogalea fraenata*) interactions with a SureFlap Microchip Pet Door. Throughout the 62-day study the wallaby's interactions with the door increased in frequency and intensity, culminating in the repeated use of the microchip-

automated door. The data collected showed that each training stage provided a novel experience that the study animal required varied periods of time to habituate to. It was found that a gradual training process improved learning outcomes. This was the first record of any captive macropod being trained to use a microchip- automated device indicating that captive macropods can be trained successfully. Furthermore, this study provides a base methodology for macropod training. Further research is recommended to refine the methodology while also exploring intra- and inter-species variations in responses.

N

HUMANS AND THEIR ROLE IN SHAPING THE ECOLOGICAL FUNCTIONS OF PREDATORS

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As the human population continues to expand its footprint there will be increasing contact between humans and other animals, especially wildlife that take advantage of anthropogenic foods such as garbage and livestock. As a result of this interaction, the evolution and function of many species may be altered through time via processes including hybridisation and domestication. In this talk, I will discuss the ecological and management importance of such possibilities using dingoes and other large carnivoresas case studies. I will outline how the ecological function of predators might be altered in human dominated landscapes through changes to social structures, behaviour and movement patterns, changes in survivorship, evolutionary divergence and potential speciation events. The results have important implications for understanding how to conserve and protect the ecological functions of predators and for mitigating human-wildlife conflicts.

MONITORING OF GROUND-DWELLING MAMMALS IN NORTHERN WESTERN PORT, VICTORIA

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Melbourne is located in a region of relatively high biodiversity and the region continues to play an important role in the conservation of local, state and national biodiversity including some nationally threatened taxa. In this study we attempted the first

systematic, broad scale survey of mammals over 795 km^2 in the region north of Western Port, including Melbourne's rapidly urbanising South-east growth corridor, adjacent agricultural areas and nature conservation reserves. We deployed unbaited covert "trail" cameras at 404 sites for 20 to ~100 days or continuously over multiple years. Eleven native and eight introduced mammalian taxa were detected a total of
403184 times. The majority of sites (~80%) recorded between one and twelve mammal species including up to eight native taxa. There was a distinct difference in the mammal communities found in areas of predominantly cleared agricultural land and areas that retained some indigenous vegetation. Our survey confirms that the region continues to support a rich mammal fauna, including a suite of iconic Australian species. The new records refine distribution patterns and emphasise that the complex rural and peri-urban nature of this study area is particularly challenging for mammalian conservation.

ECHIDNAS AT HOBART AIRPORT

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In spring 2015, operational staff were finding a significant number of echidnas on or near the runway at Hobart Airport. They were also concerned that inappropriate relocation of animals could lead to road kills. We undertook a study to seek answers to the following questions: How many echidnas are there at the airport? How do they use the area? How do they get in? Where should they be relocated? We fitted all echidnas found inside the perimeter fence (airside) with tracking transmitters and coloured coded straws. Some animals were also fitted with GPS loggers. Camera traps were deployed at the fence. Between December 2015 and July 2017 12 echidnas were tagged: 5 adult females, 2 subadult females and 3 adult males. As demonstrated previously female home ranges were much smaller than male. An old tip site was within the core home range of 5 echidnas. One female spent a considerable amount of time foraging near the runway. Echidnas could dig under the boundary fence quite easily, but more frequently squeezed under one of the emergency gates. During the study 3 echidnas were killed on adjacent roads.

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EVOLUTION OF DIET IN ECHIDNAS

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Short-beaked echidnas (SBE) are often cited as examples of convergence as they share anatomical and physiological adaptations for myremecophagy (ant- and termite- eating) with placental ant-eaters. These adaptions include a slender, elongated tongue, absence of teeth and low metabolic rate. The closely related long-beaked echidnas (LBE) have similar adaptations in their feeding anatomy and physiology but do not eat ants or termites, and are more specialized for eating worms. We summarise information on diet and feeding behaviour of both extant echidna genera and relate that to the evolutionary history of Tachyglossids, and the beak structure. Extant tachylossids appear to have evolved from a more generalist LBE close to *Megalibgwilia*, which does not appear to have been specialised to eat either worms or ants, but was also edentate. Although the feeding apparatus of the SBE is highly adapted for myrmecophagy, and the LBE for vermivory, the absence of teeth in Tachyglossids is unlikely to be due to selection for either of these diets.

O

Form, function and evolution symposium

DEVELOPMENT OF THE MARSUPIAL IMMUNE TISSUES

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Newborn marsupials have been described as similar in developmental appearance to an eight week old human foetus. They have no histologically mature immune tissues, and unlike those of their eutherian counterparts, the immune tissues must mature in an external pathogen-rich environment. Neonatal marsupials are therefore unable to mount a specific immune response, yet unlike a human foetus of eight weeks of age, are able to successfully survive. The newborn marsupial liver is actively haematopoietic, unlike in eutherian mammals, where liver haematopoiesis has ceased and its role in haematopoiesis replaced by the bone marrow. The thymus, a key immunological tissue essential for T-cell development, is the first primary immune tissue to develop and mature in marsupials. Along with the bone marrow, the secondary immune tissues, including the spleen, lymph nodes and mucosal- associated lymphoid tissues, appear next and mature shortly thereafter. A correlation between marsupial immune tissue development and overall developmental milestones will be assessed, and the timing when marsupial young first become immunocompetent will be suggested. The role of marsupials as key immunological models, and their importance in providing phylogenetic insights into the development of the immune system will be discussed.

WomSAT – WOMBAT SURVEY AND ANALYSIS TOOL

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WomSAT is a citizen science-based website, with associated iPhone and Android apps. It allows anyone to log their wombat (dead or alive, and their level of mange), and wombat burrow sightings online, in real-time, and attach a photograph. The information

gathered is being used to investigate the nation-wide distribution of wombats, and threats to their survival including sarcoptic mange incidence and severity, and the number of wombat deaths due to vehicle collisions. Facebook, Twitter and a dedicated website have been used to recruit citizen-science participants, and to provide education to the wider community about the threats posed to wombats. In the longer term is it hoped that WomSAT will aid in reducing the number of road killed wombats, through improved mitigation strategies, and the development of a nation-wide strategy to manage sarcoptic mange in wombat populations, by identifying factors implicated in increased sarcoptic mange incidence and severity. A summary of the data collected to date will be presented, and management implication discussed.

P

THE SECRET TO A LONG AND SUCCESSFUL LIFE: REPRODUCTION, SURVIVAL AND LONGEVITY OF MAINLAND EASTERN BARRED BANDICOOTS

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The Mainland Eastern Barred Bandicoot (*Perameles gunnii*) has been the focus of a 28-year captive-breeding and recovery program, producing 902 offspring, with 573 released to free-ranging sites. Bandicoots are brought into captivity from free-ranging sites for inclusion in the breeding program, quarantine prior to translocation to new sites, and emergency veterinary treatment for injuries. We examined survival, longevity and breeding success of 119 adults and 16 orphaned young brought into captivity from 1990-2016, and compared it with data from three free-ranging locations.
91% of adults collected for breeding/translocation, and 81% requiring veterinary treatment, survived past their initial 3-month adjustment period. Hairless orphaned young did not survive (n=6). However, 8/10 furred young were hand-raised and integrated into the captive program. Animals brought in for breeding/transfer, hand-raising and veterinary treatment had greater maximum longevity than free-ranging bandicoots (5.8, 5.6, 5.5, 3.4 years respectively). Breeding and hand-raised bandicoots had a greater mean longevity than animals requiring veterinary treatment (3.8, 3.4, 2.6 years respectively). There was no difference in captive-breeding success based on the reason for collection, with >80% of animals successfully producing young. The high survival and breeding success of bandicoots brought into captivity has contributed to the ongoing recovery of the species.

Speed talk

THE NOSE KNOWS: OLFACTORY RECOGNITION BY AN ENDEMIC RODENT, *MELOMYS CERVINIPES*

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Olfaction is used extensively by small mammals to detect predators. However, the anti-predator response, such as avoidance, relies on recognition of the stimulus as threatening, and potentially on discrimination if two or more stimuli are present. We investigated the olfactory ability of the endemic fawn-footed mosaic-tailed rat *Melomys cervinipes* to recognize and discriminate between two native snakes using snake sheds. 20 individuals (12 males, 8 females) were each exposed to three olfactory tests using a Y-maze. Test 1: exposure to a randomly allocated snake shed against a paper control. Test 2: exposure to the other snake shed against the paper control. Test 3: exposure to both sheds simultaneously. In contrast to expectations, *M. cervinipes* did not avoid the snake sheds in both Tests 1 and 2, but spent longer investigating them compared to the paper control, possibly because they were novel cues, or because they did not represent a direct threat. Interestingly, investigation of the snake sheds decreased by more than 6 x from Test 1 to Test 3, potentially suggesting recognition and avoidance, but *M. cervinipes* did not discriminate between snake sheds. Recognition without discrimination may represent a generalised adaptive response to multiple predator types in unpredictable environments.

ENHANCING MITOGENOMIC PHYLOGENY: RESOLVING THE RELATIONSHIPS OF EXTINCT MEGAFAUNAL PLACENTAL MAMMALS

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Mitochondrial genomes provided the first widely-used sequences that were sufficiently informative to resolve relationships among animals from within species to between phyla. However, mitogenome studies supported several highly anomalous relationships, and fell out of favour as sequencing multiple, independent nuclear loci proved to be highly effective. A tendency to blame mitochondrial data (mtDNA) has overshadowed efforts to ameliorate underlying model misspecification. Here we find that the combination of RY-coding the mtDNA, excluding 3rd protein codon sites, and improved taxon sampling are remarkably efficacious for improving the accuracy of mitogenomic phylogeny for placental mammals; almost to the level of large multi-gene nuclear

datasets. Moreover, combined analysis of mtDNA with 3-fold longer nuclear data either maintained or improved upon the nuclear support for all accepted clades, even those that mtDNA alone did not favour, thus indicating “hidden support”. Confident mtDNA phylogeny reconstruction is important for merging ancient DNA (aDNA) into the tree of life, because aDNA is often only accessible as mtDNA. Our aDNA analyses lend confidence to the relationships of three extinct megafaunal taxa: glyptodonts are nested within armadillos, the South American ungulate, *Macrauchenia* is sister to horses and rhinoceroses, and sabre-toothed cats are the monophyletic sister-group of modern cats.

MICROBATS OF THE SOUTH WEST BOTANICAL PROVINCE OF WESTERN AUSTRALIA: PATHOGEN DIVERSITY AND HOST GENETIC CONNECTIVITY

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Microbats in Western Australia are an important component of local biodiversity. However, baseline data necessary for species management is lacking, including information on genetic diversity, population connectivity, and potential infectious disease risks. This project aims to combine epidemiological and ecological approaches to address these knowledge gaps on microchiroptera of the South West Botanical Province of WA. We are screening local bat communities for the presence of known viral pathogens using targeted methodologies (PCR, qPCR, serology) and employing next-generation sequencing for the characterisation of unknown viral agents. Genetic diversity and connectivity of four species (*Chalinolobus gouldii, C. morio, Nyctophilus gouldi*, *Vespadelus regulus*) will be assessed from mitochondrial and nuclear markers, using traditional molecular approaches and gene reduction techniques. Preliminary results from 340 individuals show low prevalence of coronaviruses, adenoviruses, and astroviruses. Additionally, we have not detected exposure to nor oral shedding of lyssavirus in any of the sampled individuals. This project will describe disease agents that may constitute a conservation or public health threat, and combine it with molecular data to infer the genetic diversity and connectivity of microbat populations, to increase our understanding of how pathogens are currently distributed within bat populations, as well as inform management strategies for these species.

R

Land clearing symposium

LAND CLEARING ACROSS AUSTRALIA, THE REGULATED AND UN(DER)-REGULATED

Reside, April E.[1,2] and Taylor, M.[3]

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Land clearing has accelerated across Australia over the past five years, reaching globally significant levels. Land clearing threatens biodiversity, impairs the functioning of ecosystems, and contributes to global climate change. Australian states have a history of major shifts in vegetation policies, cycling through concern about salinity and soil, broad concern for the environment, to relaxation of regulation seen in Queensland, New South Wales, Western Australia and Victoria. Land clearing is emerging as a substantial issue for areas of intact savanna ecosystems across the tropical north. Despite the decline in status of many threatened mammal species, habitat is being cleared through under-regulated state-level vegetation management. Much of this habitat clearing does not receive oversight from federal laws that are purported to protect nationally threatened species. In this talk I will give an overview of the history of land clearing across Australia, the current status of relevant policies, and the consequences of the current land clearing practices for threatened mammals. This talk will set the scene for the symposium “Land clearing across Australia and consequences for mammals”, to provide context to the following talks which will delve deeper into the impacts on mammal species.

BEING BIGGER ISN’T BETTER: SMALLER BODY SIZE MOST IMPORTANT TRAIT FOR PREDICITING SURVIVAL OF NORTHERN QUOLLS (*DASYURUS HALLUCATUS*) ON GROOTE EYLANDT

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Critical weight range (CWR) mammals are declining across northern Australia as feral cats and hot fires increase in number. Fires reduce the vegetative understory, making it easier for predators to find and capture their prey. While relatively large predators like cats will easily outsprint smaller prey, they are constrained to wider turning angles and smaller prey may use sharp turns to escape. Therefore, more-agile CWR mammals may be better able to survive predation attempts. Our study was conducted on Groote Eylandt, Northern Territory. We aimed to predict the survival of juvenile northern quolls (*Dasyurus hallucatus*) over their first breeding season, using phenotypic traits related to escape performance, including body size and shape, sprint speed, acceleration, and agility. We found that female survival was significantly related to body size, with smaller quolls being more likely to survive. Smaller females were faster sprinters and more agile in a 135° turn. We also quantified consistency of the same traits and found quolls that were relatively larger as youngsters were still relatively larger post-breeding, and vice versa. Our findings suggest that a smaller body size could be advantageous for survival, due to an increase in both agility and sprint speed.

Land clearing symposium/ Speed talk

AUSTRALIA'S *BIODIVERSITY* HOUSING CRISIS: A SYNTHESIS OF THE IMPACTS OF LAND CLEARING ON NATIVE MAMMALS

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Habitat loss and modification is still the greatest threat to biodiversity globally, and land clearing is a major driver of this. The Australian landscape has suffered extensive clearing since European arrival, especially in eastern and southern Australia, and of great conservation concern is that accelerating and further proposals for clearing across multiple states and territories, will compound the losses. Such environmental degradation places further pressure on Australia's mammals, which have already suffered an extraordinary rate of extinction (~30 species in 230 years). I will present a synthesis of our current understanding regarding the impacts of land clearing on Australian mammals, including discussing how this threat may interact with and compound other threats such as invasive predators and climate change, and finish with management recommendations aimed at ameliorating current and preventing further impacts.

Speed talk

METHOD FOR REVEALING POPULATION DEMOGRAPHY OF SPOTTED-TAILED QUOLLS (*DASYURUS MACULATUS GRACILIS*) USING REMOTE CAMERAS

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We have developed a technique to determine the sex and identify individual Spotted-tailed quolls (*Dasyurus maculatus gracilis*) using images taken by remote cameras. The key to this method involves bait presentation which entices quolls to stand on their hind legs while presenting their ventral surface to the horizontally-mounted trail camera. Using this method, individual identification was possible in 203 out of 207 detection events and the gender of 80% of quolls was able to be confidently assigned over four survey periods. This study indicates that using this bait station design, remote cameras can be used to successfully identify individual northern spotted-tailed quolls and their gender, therefore providing data to aid in the identification of core quoll habitats and the demographic effects of land use and other ecological processes.

S

Form, function and evolution symposium

THE ORAL APPARATUS OF MARSUPIALS IS MORE INTEGRATED BUT NOT LESS MORPHOLOGICALLY DIVERSE THAN THAT OF PLACENTAL CARNIVORES

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Different clades can display different levels of morphological, taxonomical and ecological variability. Understanding the factors promoting or decreasing organismal variability is a central question for paleobiologists. To answer this question researchers have focused on identifying the key innovations that determined the patterns of radiation in specific clades. In this context developmental constraints can have a major impact on the evolution of morphological variability (e.g. disparity). Phenotypic integration, or covariation among traits, has been shown to play an important role in shaping organismal disparity at macro-evolutionary scale. A longstanding proposition about mammalian evolution has been that morphological variability among marsupials was limited by developmental constraints, in particular, constraints on the marsupial oral apparatus linked to the need for the embryo to access the mother's teat early in its ontogeny. In this study we apply a recently proposed Geometric morphometric approach, i.e., Global Integration, to investigate integration intrinsic to a particular structure to compare the degree of oral apparatus morphological disparity between marsupial and placental carnivores. Our results show that marsupial oral apparatus is significantly more integrated than that of placentals, however, at least when fossil specimens are included, morphological disparity among marsupials was not significantly different to that found in placentals.

Form, function and evolution symposium

DATING THE DIVERSIFICATION OF BATS HIGHLIGHTS THE IMPACT OF POORLY SUPPORTED FOSSILS ON DIVERGENCE ESTIMATES

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Bats include 20% of all described mammals, however their origins remain uncertain.

Shortcomings of the molecular clock and a contentious fossil record have compounded uncertainty regarding the clade's age. The need to adequately vet the fossils that inform calibration priors for molecular dating is often underemphasized, often leading to spurious divergence estimates. Modern bats are believed to have originated between 54 and 75Ma, with some of the highest-cited estimates placing the divergence close to the 66Ma Cretaceous-Paleogene boundary, some 10Ma earlier than even the oldest stem bat fossils. This study assesses the effect of fossil selection criteria on divergence estimates by reanalysing the timescale of bat evolution under various calibration scenarios ranging from appropriately conservative to unjustifiably lenient. Bayesian molecular clock analyses were conducted using MCMCtree, and show that asymmetric treatment of confidence between very liberal minimum bounds and overly conservative maximum bounds can explain large temporal discrepancies between previous molecular dates and fossil evidence for the timing of bat divergence events. Applying our vetted calibration priors, we estimate divergences of 52-56Ma for the chiropteran crown origin, and 48-52Ma and 43-47Ma for Yinpterochiroptera and Yangochiroptera, respectively.

COMPARING VIDEO AND STILL IMAGERY TO ASSESS THE BURROW OCCUPANCY RATE OF SOUTHERN HAIRY-NOSED WOMBATS (*LASIORHINUS LATIFRONS*): A CAUTIONARY TALE IN THE USE OF MOTION-ACTIVATED CAMERAS

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Broad-scale abundance estimates of the southern hairy-nosed wombat population are based on counting the number of active burrows, which is then multiplied by an index of the number of wombats per active burrow. However, the indices in use today were calculated in the 1980s, prior to the use of RHDV to control rabbits, and used invasive methods which could have affected the results. We hypothesise that the use of imagery data would provide a logistically simple, non-invasive means, of calculating updated indices. Motion-activated, infra-red, still and video cameras were mounted on poles at various distances outside active wombat burrows in the South Australian Murraylands and Eyre Peninsula regions. The captured imagery was inspected to determine when the burrow was occupied by one or more wombats. The video cameras provided significantly better results than the still cameras, with more than twice the number of burrow occupancies being positively identified. The calculated index of wombats / active burrow was 0.43. However, there were significant issues with the use of cameras that warrant further research. In particular, the high false alarm rate and failure of some cameras to capture animal activity occurring within their field- of-view are concerns that needs to be addressed.

T

Form, function and evolution symposium

WHO HAS A LEG UP ON THE COMPETITION? FUNCTIONAL HIND LIMB MYOLOGY IN THE PERAMELEMORPHIA

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Locomotor adaptations reflect a compromise between speed and agility, often tied with constraints of habitat and species-specific behaviours such as digging. The order Peramelemorphia represent a distinct marsupial lineage that possesses an unusual combination of hind limb features. While bilbies and bandicoots typically exhibit half-bounding gaits, differences in the relative development of muscles may reveal aspects of their locomotor performance. We present a comparative analysis of hind limb muscle structure in three species of the extant genera – the western barred bandicoot (*Perameles bougainville*), quenda (*Isoodon fusciventer*), and greater bilby (*Macrotis lagotis*). We analysed muscle-tendon architecture of the hind limb using physiological cross-sectional areas (PCSA) and relative proportions of functional muscle groups. Muscle arrangements in the bandicoots were comparable, though quenda had a larger proportion of hip extensors suggesting adaptation for strong forward propulsion. Bilbies had a more gracile build, with longer tendons in the distal limb and more highly differentiated muscles, potentially allowing for a larger range of movement and greater degree of agility. These interspecific differences provide some insight into their different locomotor abilities, such as how each species escapes from predators. This work provides a view into the functional morphology in this interesting but little-studied group of mammals.

Land clearing symposium

MAMMALS KILLED AND HARMED BY BULLDOZING OF HABITATS IN QUEENSLAND

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Bulldozing or destruction of forest and woodland habitats has severe consequences for native mammal conservation and welfare. We have estimated that at least 1 million native mammals killed by bulldozing of habitats in 2015-16 alone in Queensland. Within this, we estimate about 1,300 koalas lost. Most koala loss occurred outside of the southeast corner, where most bulldozing of habitats currently takes place. Estimates are based on extrapolated mammal densities in the footprint of the areas bulldozed or destroyed and assumes that even animals escaping from the area destroyed, will also die as they generally face a "full house" in remaining habitats. This assumption may not however, fit well with koalas for which densities in intact forests may be depressed below capacity as a result of Chlamydia. These estimates do not include the additional effects on mammalian mortality due to fragmentation of habitat left behind, or other indirect or consequential effects of clearing on for example, water quality or greenhouse pollution. We also consider the animal welfare implications of destruction of mammal habitat. In the absence of laws compelling salvage of native fauna during clearing operations, many animals doubtless suffer severe trauma and illness. Estimates are subject to considerable uncertainty. A great deal more effort should go toward estimation of densities and losses and the fates of native animals during and following clearing events.

A PRELIMINARY INVESTIGATION INTO THE USE OF CHAINSAW HOLLOWS FOR THE CONSERVATION OF THE THREATENED BRUSH-TAILED PHASCOGALE

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This study provides an overview of the initial observations into the usefulness of chainsaw hollows for conserving the Brush-tailed Phascogale in the modified forests of central Victoria. In early 2018, fifty six chainsaw cavities were installed across eight study sites in central Victoria. Nest boxes constructed to the same internal dimensions were installed on nearby trees over the following eight weeks. All artificial cavities were monitored at monthly intervals with the use of a ground operated inspection camera.

Camera traps were also rotated around to the different sites to monitor visitations by wildlife. At two months after installation, 30% of chainsaw hollows were occupied by Sugar Gliders. A large Phascogale scat was also found inside one chainsaw hollow. A species of bracket fungi was recorded within the chainsaw hollows at two sites. While termites completely filled two chainsaw hollows with sawdust within weeks of installation.

MATERNAL CARE OF PLATYPUS NESTLINGS

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Maternal care in essential for the survival of offspring in mammals. However, maternal care in platypuses has never been studied due to the difficulty in locating the burrows. Our aims were to describe the maternal behaviour of a captive platypus and the development of her nestlings. We located and inserted a camera in a nesting burrow to view their activity and behaviour. We also monitored the food consumption of the female. Ages were assigned to the developmental stages of platypus nestlings. The female initially spent most of her time in the burrow, which decreased over lactation. Less time was spent with twins than a single young. The energy intake of the female was more than double that of the non-lactating females in the last month of lactation indicating the large energy requirements for milk production. The mean age of young at emergence was 128 ± 1 days and occurred after weaning in 60% of nestlings. This suggests that weaning occurs as an instantaneous transition from a milk diet to a macroinvertebrate diet. Developing a technique to study maternal care in platypuses has allowed us to understand nestling development and rearing, an aspect of their biology that was poorly understood.

UNTANGLING THE HISTORY AND NATURAL HISTORY OF EXTINCT BANDICOOTS

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The recent discovery of a second unnamed species of Pig-footed Bandicoot (*Chaeropus*) and the split of the Western Barred Bandicoot (*Perameles bougainville*) complex has highlighted how little we know about these species. Since the Western Barred Bandicoot has been translocated outside of its known range, into the range of an extinct species, it would be beneficial to know more about the biology of the extinct species in order to apply best conservation practises. The aim of this study is to recover as much information as possible about these extinct species. Using museumarchives, historical accounts, palaeontology and new taxonomic knowledge, the natural history of these species has been untangled, despite some areas of their biology remaining a mystery. The biological information is compared for each species to identify how similar or different they are from one another. This species comparison has the potential to help with conservation decisions.

URBAN EURASIAN RED SQUIRREL ECOLOGICAL ENERGETICS

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Despite its destructive nature, urbanisation can potentially help wildlife manage energy expenditure by dampening seasonal fluctuations in resource availability and ambient temperature. Some animal species thrive in cities but we have little understanding of the mechanisms underlying their persistence. To address this knowledge gap, we investigated the effect of season on the home range, activity and metabolic rate of the Eurasian red squirrel (*Sciurus vulgaris*) in a large German city. Squirrels' food preference changed seasonally and home range core area location and size were related to the amount and type of available food. Compared to semi-natural habitat, urban home range size tended to be smaller and overall activity decreased. We observed only minor changes in resting metabolism and thermal conductance and energetic modelling suggested that the scope of change was unlikely to be of ecological consequence. Body mass was reasonably constant year-round. We conclude that the scope of physiological seasonal adaptation is minimal when food is abundant and squirrels instead rely on adjustments in activity in response to prevailing ambient temperature and foraging success. Such behavioural plasticity, as well as the ability to exploit anthropogenic food sources and tolerate reduced habitat connectivity, are likely important factors contributing to squirrels' success in cities and may indicate the capacity of other small mammal species to cope with environmental disturbance.

U

USING A NEXT-GENERATION SEQUENCING APPROACH TO UNDERSTAND THE POPULATION GENETIC STRUCTURE IN AUSTRALIAN DESERT- DWELLING MARSUPIALS

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Australian dasyurid marsupials are an arid-zone success story. Rapid radiation during Miocene aridification led to a cohort of highly diverse arid specialists. The unique adaptations that allow dasyurids to persist in arid habitats are quite well known, but we still know little about their population genetic structure. In the past, obtaining enough samples from remote regions for population genetic studies has been difficult, but the rise in high-throughput sequencing technologies means less individual samples are required and can produce 10,000s of loci. We aimed to investigate the population-genetic structure of four dasyurid species, *Sminthopsis ooldea*, *S. youngsoni* and two endemic Pilbara *Planigale* species using ddRADseq. Tissues from
190 individuals held in Museum collections were chosen to give uniform sampling across the large distributions of each species. The ddRADseq SNP results were compared with a previous mtDNA study of each species. Patterns of population structure were different between species, showing examples of isolation-by-distance, landscape driven population differentiation, and Pleistocene-driven population expansion. The results reflect the importance of species ecological requirements in determining small dasyurid presence and dispersal in arid habitats and that ddRADseq is a useful tool in marsupial population genetic studies.

V

HITTING THE GROUND RUNNING: TIMING OF TERRESTRIAL ACTIVITY BY KOALAS IN FRAGMENTED WOODLAND ON THE NEW ENGLAND TABLELAND

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100 years of farming on the New England Tableland has created a landscape modified largely for domestic stock that has a high density of European foxes (*Vulpes vulpes*). Nevertheless, scattered trees and small fragments of native vegetation remain, and these support a seemingly robust population of koalas (*Phascolarctos cinereus*). Using camera trapping, we studied occurrence of koalas and their timing of terrestrial activity, especially relative to the temporal and spatial activity of foxes. In fragmented habitat, koalas and foxes shared a 71% overlap in temporal activity; however, koalas were most active after midnight during a period that coincided with declining fox activity. At a finer scale, spatiotemporal occurrence of koalas with respect to fox occurrence was strongly non-random; of 768 occurrences of one or more foxes at a particular site on a particular night, 13 of these coincided with the occurrence of koala, whereas for the other 24 night x site combinations when koalas were recorded, foxes were not recorded. A checkerboard (*C*-score) approach further revealed that koalas occurred significantly more often on date x camera combinations for which foxes were absent.

W

Form, function and evolution symposium

CHEW ON THIS: ARE MASTICATORY BIOMECHANICS MASKING THE ORIGINS OF WOMBAT DIVERSITY?

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Investigations of mammalian morphological micro- and macroevolution can help us understand the origins of mammalian diversity. In this context, marsupials are of particular interest because their ability to adapt is considered developmentally constrained to size-related change (allometry). In this study, we test this hypothesis using 3D geometric morphometrics on a total of 71 crania and 59 mandibles of the three living wombat species. Using two new approaches for visualizing and comparing cranio-mandibular shape, we show that the use of Principal Components Analysis exaggerates impressions of shape variation that do not consistently translate into individual shape differences. Intra-and inter-specific shape variation is mostly size-independent and concentrated in areas involved in mastication. The details of intra- and interspecific shape variation do not correspond to one another, however. We conclude that the origins of wombat cranio-mandibular shape variation are not constrained by allometry. However, the *intra*specific origins of *inter*specific shape variation are difficult to ascertain. This is because macroevolutionary patterns appear to be masked either by individual genetic variation or individual masticatory biomechanics. It is possible that marsupials with less biomechanically demanding mastication modes will display less cranio-mandibular diversity and conform more to previous finds of strong allometry in marsupial cranial shape variation.

DOES HABITAT COMPLEXITY AFFECT PREDATION RISK? PREDICTIONS USING A BIOMECHANICAL AGENT-BASED MODEL

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Two major causes for decline in Australian mammalian populations are habitat loss and predation by cats and foxes. However, precisely how habitat affects the vulnerability of specific species to predation is poorly understood. Most Australian mammals are smaller and slower than invasive predators, so escaping using speed alone is unlikely to work. Instead, prey can exploit the biomechanical trade-off between speed and agility to *outmaneuver* predators. Habitat structures such as trees or rocks could assist with this escape strategy by constraining the pursuit path of faster but less agile predators. To investigate this idea, we built an agent-based model that predicts prey survival based on habitat complexity and the predator and prey's relative top speeds, agilities and accelerations. In simple, open habitats, prey had the worst chance of escape against faster predators with relatively low agility. However, in complex habitats containing many obstacles, prey had the *best* chance of escape against these predators. This supports our hypothesis that structurally complex habitats reduce predation risk not only by increasing cover and refuges, but also by constraining predators' pursuit paths. We aim to use our model to predict how likely specific mammals are to escape from cats and foxes in different habitats.

REINTRODUCTION TRIALS FOR THE SWAMP ANTECHINUS (*A. MINIMUS MARITIMUS*) IN THE EASTERN OTWAYS; IMPLICATIONS FOR RECOVERY

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Reintroductions of Australian marsupials in the critical weight range have been frequent, but limited for smaller species. The swamp antechinus (*Antechinus minimus maritimus*) is a small dasyurid with a restricted, fragmented distribution. All known heathland populations in the eastern Otways were extirpated following wildfire and recovery was considered unlikely without reintroductions. The aims of this work were to; investigate methods for translocation of the species, assess establishment, body condition, survival, recruitment, movement, habitat use and impacts on the resident mammal community.

Three trial reintroductions utilised radiotelemetry and trapping to determine outcomes for individuals and resident mammals. Although release of juveniles was unsuccessful, adults were effectively trapped and radio tracked. Individuals were recorded up to 6 months post release. They established home ranges (0.04 – 8.4 ha) bred successfully and assembled nests in grasstrees, (*X. australis*). No impacts on resident mammals were evident. The trials resulted in successful methods for future reintroductions of the species, with recommendations to release adults, increase founder numbers and source founders from different populations. Recent evidence of severe decline of the swamp antechinus indicates that reintroductions are a viable conservation option. Small scale, inexpensive trials yield valuable information on protocols and tactics prior to management scale reintroductions.

Form, function and evolution symposium

COMPUTER SIMULATIONS SHOW THAT NEANDERTHAL FACIAL MORPHOLOGY REPRESENTS ADAPTATION TO COLD AND HIGH ENERGY DEMANDS, BUT NOT HEAVY BITING

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Three adaptive hypotheses have been forwarded to explain the distinctive Neanderthal face: 1) an improved ability to accommodate high anterior bite forces, 2) more effective conditioning of cold and/or dry air, and, 3) adaptation to facilitate greater ventilatory demands. We test these hypotheses using three-dimensional models of Neanderthals, modern humans, and a close outgroup (*H. heidelbergensis*), applying finite element analysis (FEA) and computational fluid dynamics (CFD). This is the most comprehensive application of either approach applied to date and the first to include both. FEA reveals few differences between *H. heidelbergensis*, modern humans and Neanderthals in their capacities to sustain high anterior tooth loadings. CFD shows that the nasal cavities of Neanderthals and especially modern humans condition air more efficiently than does that of *H. heidelbergensis*, suggesting that both evolved to better withstand cold and/or dry climates than less derived *Homo*. We further find that Neanderthals could move considerably more air through the nasal pathway than could *H. heidelbergensis* or modern humans, consistent with the propositions that, relative to our outgroup *Homo*, Neanderthal facial morphology evolved to reflect improved capacities to better condition cold, dry air, and, to move greater air volumes in response to higher energetic requirements.

X

Y

Z

POSTERS

A B

C

REPRODUCTIVE TACTICS IN AN ORNAMENTED MAMMAL: COAT COLOUR AND SOCIABILITY IN MALE GIRAFFES

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In species in which males signal physical condition through visible traits, males with different levels of trait expression may adopt alternative tactics to maximise reproductive success. These tactics may be reflected in males' sociability patterns. In giraffes, colour is hypothesised to function as a signal of males' physical condition. We examined the coat colours and sociability patterns of 66 male giraffes over twelve- years to investigate variation in colour expression and its influence on sociability. We demonstrate that not all males reach the same degree of darkness, suggesting that colour is not solely an age-based trait, but likely relates at least somewhat to condition. We then show a distinct difference in the gregariousness of young or pale males compared to darker males. Young or pale males tend to be gregarious while darker males spend more time alone. This is consistent with a system where darker males in good condition roam looking for females in oestrus. Young or pale males may delay roaming or use an alternate tactic, remaining with females to gain copulations when more dominant males are not present. Our results are consistent with the hypothesis that giraffes' colour functions as a signal of condition, but deeper study is required.

HAEMOLYTIC ANAEMIA ASSOCIATED WITH THEILERIOSIS IN AN ORPHANED PLATYPUS (*ORNITHORHYNCHUS ANATINUS*).

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Haemoparasites such as *Theileria* are relatively common in many native Australian mammals; however, their role in disease and their influence on wildlife ecology is not well understood. A tick-infested, juvenile female platypus was seen on the bank of the Murrumbidgee River near Oura during daytime following a flood and was brought into care. Haematology of dorsal bill sinus blood revealed yellow plasma, a PCV of 0.17 and red cell count of 4.4 x 10^{12}/l (normally 0.49 - 0.51 l/l & 9.9 - 10.3 x10^{12}/l respectively) and a marked regenerative anaemia. Numerous erythrocytes contained parasites morphologically consistent with *Theileria ornithorhynchi* were present in Diff- Quik stained smears and some parasitised erythrocytes were phagocytosed. A semi- nested PCR using extracted DNA from blood produced an 18S rDNA gene that aligned with *Theileria* and *Babesia* genotypes. Despite tick removal and PCV improvement; the platypus' condition deteriorated, it died and was necropsied 5 days later. Histopathology revealed a moderate erythroid hyperplasia of the bone marrow and spleen. The animal's death was attributed to a severe immune mediated haemolytic anaemia secondary to *T. ornithorhynchi* infection. *Theileria* is thought to cause little harm under normal circumstances, but in an immunosuppressed platypus may become a significant pathogen.

MUCORMYCOSIS IN THE PLATYPUS AND THE ANURAN

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Mucormycosis in platypuses & anurans is a major fungal disease caused by *Mucor amphibiorum*. Mucormycosis was first reported in an Australian green tree frog imported to Germany in 1972. Since 1994, natural infections in wild anurans from QLD & NT, and frogs from Melbourne & Perth Zoos have been recorded. A severe ulcerative skin condition was first reported in platypuses from the Elizabeth River in Tasmania in 1982, however *M. amphibiorum* was not confirmed until a decade later. The sudden emergence of mucormycosis in TAS platypuses may have been accidental with 'banana

box frogs' from QLD or by a mutated endemic TAS strain becoming pathogenic for platypuses. The ecologic niche of *M. amphibiorum* on the mainland is soil and anurans, whereas in Tasmania its environmental niche is currently unknown. Differentiating species of *Mucor* was traditionally based on phenotypic characters. More recently genotypic analysis has been shown to be reliable and discriminating. We investigated a PCR targeting ITS regions of rDNA genes and HRM analysis for subsequent *Mucor* species identification. The use of evolving molecular tools to detect *M. amphibiorum* in the environment, tissue lesions, and aquatic vectors, would improve our understanding of mucormycosis epidemiology, leading to better surveillance and control.

ARCHAEOLOGICAL IMPACTS OF MARSUPIAL CARNIVORES

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Faunal assemblages found in archaeological sites have frequently been modified or produced by the natural behaviours of carnivores. Within an Australian context, humans have shared prey with marsupial carnivores such as *Sarcophilus harrisii* (Tasmanian devil) and *Dasyurus maculatus* (spotted-tailed quoll) since their arrival on the continent. To date, there have been very limited efforts to differentiate prey modification from marsupial carnivores from human prey processing, making it difficult to interpret Australian archaeological sites accurately. In particular, osteophages can produce bone fragments in their scat that do frequently do not have characteristic tooth marks, further complicating identification. This poster considers the few studies that have been conducted examining the impacts of Australian carnivore feeding and digestion on bone, focussing in part on Tasmanian devils, quolls, and dingoes. These data are compared to examine overlaps or unique features in the signatures identified to date, and the poster then proposes future work to strengthen this understanding. The ability to confidently identify the impact of different species in the archaeological and paleontological record would allow archaeologists to better understand past human subsistence practices, and allow analyses of paleontological assemblages to expand our knowledge of temporal, environmental and regional dietary variations in these mammals.

D

CONSERVATION AND MANAGEMENT OF THE BILBY IN WESTERN AUSTRALIA: PROJECTS IN PARTNERSHIP WITH TRADITIONAL OWNER RANGERS.

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The greater bilby is a burrowing marsupial that was once widespread across most of mainland Australia. Since European colonisation, the introduction of the cat and fox, changed fire regimes, the degradation of bilby habitat through pastoralism, introduced herbivores, and clearing of habitat, the range and abundance of greater bilbies have contracted and decreased severely, and bilbies have disappeared from at least 80% of their former range. The bilby is listed as Vulnerable in Western Australia, nationally and internationally under the IUCN Red List. The bilby has high culturally and iconic significance to Australians, and has an important ecological role in arid environments as an ecosystem engineer through the beneficial digging and soil turn-over that bilbies create. The Department of Biodiversity, Conservation and Attractions have initiated a number of research and management projects in which partnerships with Traditional Owner Rangers are a key component.

E F G

H

THE HIDDEN VALE WILDLIFE CENTRE: COLLABORATIVE NEXT-GENERATION RESEARCH

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The Hidden Vale Wildlife Centre is a partnership between the University of Queensland and the Turner Family Foundation. The overarching goal of the Hidden Vale Project is to develop innovative and globally significant solutions for wildlife management and conservation, using the Wildlife Centre and surrounding ecosystems as a model. Neither partner had the capacity alone to develop the Centre, and the overall potential of the project is growing as a result of collaborations with a wide range of other groups. One of the primary objectives of the Hidden Vale Wildlife Centre is research into next-generation solutions for wildlife conservation, such as evaluation of new technologies for captive wildlife management and monitoring post-release wildlife. Wildlife Scientists are unlikely to have the skill-set, knowledge or resources of engineers and commercial manufacturers of such technologies, so this research is only possible by partnering with those that do. For wildlife conservation to be most effective, there is an increasing need to embrace technological advances from wide- ranging sources. Solutions to the global issues related to wildlife conservation demand innovative thinking to maximise impact. This is only achievable by forming strong partnerships, and no one group can achieve this alone.

I

WHAT'S THAT, SKIP? A PILOT STUDY INVESITIGATING INTERSPECIFIC VARIATION IN SKULL MORPHOLOGY IN THE MACROPODODIFORMES

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There is perhaps no other animal more iconic to Australia's cultural identity as the kangaroo. However, despite their international prominence and intensive study acrossmany biological disciplines, the evolutionary and biogeographical history of Macropodiformes (kangaroos and their kin) still engenders contention. Furthermore, despite the almost mandatory associations with kangaroos and Australia, many lesser-known species within the superfamily Macropodoidea are found in New Guinea and surrounding islands. In this pilot study we utilised Three-dimensional (3D) geometric morphometrics (GMM) to investigate interspecific variation in shape using 3D surface scans of crania within Macropodoidea. Geometric morphometrics is emerging as a powerful tool to measure 3D changes in evolutionary shape and can be used to support well-resolved phylogenies and elucidate harder-to-define branches of phylogenetic trees. Our results support the correlation between diet and cranial shape within Macropodoidea and quantify some curious variation in shape of the occipital region within the tree kangaroo genus *Dendrolagus*. Moving forward, the methods piloted here may help resolve questions about Macropodiforme evolution and how these Australasian marsupials have responded to dispersal, geographic isolation, and environmental changes.

J

K

INTEGRATING MORPHOLOGICAL AND PERFORMANCE TRAITS TO UNDERSTAND ADAPTATION TO DIFFERENT HABITATS IN THE NORTHERN QUOLL (*DASYURUS HALLUCATUS*)

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Australian mammal populations have suffered severe declines since early European settlement. Environmental changes, driven by the alteration of fire regimes and the introduction of invasive species, have increased the vulnerability of critical weight range mammals to predation. The ability to escape from predators relies heavily on both the prey's performance capabilities and their underlying morphological traits, which may vary depending on habitat structure. We aim to determine how specific morphologies and performance capabilities of individual northern quolls (*Dasyurus hallucatus*) differ between two habitats on Groote Eylandt, Northern Territory. Wild quolls were trapped in two contrasting habitat types: open sclerophyll forest and rocky escarpment. Several morphological traits were measured for each quoll, including body length and limb length, along with performance traits such as maximum cornering speed, climbing speed and jump acceleration. The two habitats were characterised by measuring tree density, den and shelter abundance, and the proportion of obstacles. We predict that quolls from open sclerophyll will have longer limbs, a faster sprint speed and climbing speed than those from rocky escarpments. Alternatively, quolls from rocky escarpments will be smaller and more agile than those in open habitats. We hope to parameterise northern quoll performance in contrasting habitats to understand how they use their environment during predator escape.

L

M

INVESTIGATING CRANIODENTAL SEXUAL DIMORPHISM IN BANDICOOTS AND BILBIES USING 3D GEOMETRIC MORPHOMETRICS

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Evolution through natural selection acts on traits that promote survival and successful reproduction. Sexual selection, on the other hand, reflects modifications to improve reproductive fitness of individuals within species. Animal morphology, therefore, often represents a compromise between these two selective pressures. We sought to quantify craniodental variation in 25 bandicoot and bilby species/subspecies (Marsupialia; Peramelemorphia) to investigate sexual dimorphism in this clade of animals. Micro-CT and laser scanning techniques were employed to obtain 3D landmark data on the cranium and upper dentition (n=124) to pinpoint areas of variation within and between the genera, species and sexes. Interspecific variation in cranial morphology between genera and species reflects divergence between taxonomic groups and thus likely adaptation by natural selection for different ecologies. Within family Peramelidae, genera formed discrete clusters, reflecting diagnostic differences in cranial shape between the two genera, separating the short- nosed bandicoots (*Isoodon*) from the long-nosed or barred bandicoots (*Perameles*). Intraspecific variation in skull shape showed strong sexual dimorphism in *Macrotis lagotis* and *Isoodon fusciventer*, which also have male biased dimorphism in body mass. *Perameles* spp. do not exhibit sexual dimorphism in skull shape, with the possible exception of *P. papillon.*

DETERMINING CARRYING CAPACITY USING HABITAT PREFERENCES AND HOME RANGES FOR A REINTRODUCED KOALA (*PHASCOLARCTOS CINEREUS*) POPULATION

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Koala reintroduction has been an important conservation tool in Southern Australia. In Queensland, declining populations and a need for methods to conserve koalas is highlighting different translocation measures as means of conservation for koalas in Queensland. I am investigating habitat preferences, home ranges structuring, and site carrying capacity of reintroduced koalas (Phascolarctos cinereus) in a rural environment. The aims of my research are to quantify the available habitat size and habitat quality, calculate home range sizes and home range overlaps of reintroduced individuals, determine different habitat use and preferences, and determine the carrying capacity of the site in relation to home ranges. Habitat quality and quantity is being measured using ground truthed regional ecosystem descriptions. GPS tracking data collected from 7 collared koalas is being analysed to determine home ranges, and habitat preferences will be determined by overlaying home range data onto habitat maps. I plan to use a novel approach to calculate carrying capacity of the site by using average home range sizes multiplied by the area of primary and secondary vegetation types. This poster will present preliminary results on home range sizes, home range over laps, and habitat preferences and provide details of the methods being used.

FEEDING BIOMECHANICS INFLUENCES CRANIOFACIAL MORPHOLOGY AMONG EAST AUSTRALIAN PADEMELONS (MACROPODIDAE: *THYLOGALE*)

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Interspecific variation in the craniofacial morphology of extant macropods is associated with the mechanical properties of preferred vegetation types and the cropping behaviours used to access them. We employed a combination of established

morphometric analyses and novel finite element approaches to examine whether these associations also persist at finer taxonomic scales. Three closely-related pademelon taxa were examined, all of which have distinct proportions of graze and browse in their diets: the red-necked pademelon (*Thylogale thetis*), and two sub- species of the red-legged pademelon (*Thylogale stigmatica stigmatica* and *Thylogale stigmatica wilcoxi*). We identified clear morphological differences in cranial shape and biomechanical performance that are consistent with the respective feeding regimes of each taxon. We also identified significant influences of geography and climate on cranial shape that correspond with the latitudinal differences in the properties of vegetation. Together, our findings suggest that feeding ecology plays an important role in determining craniofacial morphology down to the sub-species scale among macropods. This lends further support to a clear relationship between feeding biomechanics and cranial morphology across the Macropodidae, and to the predictive power of inferring ecology from morphology for species conservation and management.

O

THE PRESENCE OF COMPLEMENT AND ANTIMICROBIAL ACTIVITY IN RED- TAILED PHASCOGALES (*PHASCOGALE CALURA*)

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Marsupials are born immunologically premature and pouch young are thought to rely on cells and maternal milk for immunity. While the development of immune tissues have been explored in developing pouch young, the expression of complement proteins during the development of a marsupial is mainly unknown. In this study, we explored the expression of four complement proteins in developing red-tailed phascogales (*Phascogale calura*); C3, C1r, MASP2 and CFP. The selected complement proteins were chosen for their active role in three main complement pathways. Whole body tissues from day 1-18 day old individuals and liver tissues of adult phascogales from 31-day to 14-month old were tested. Results from this study revealed that the average complement expressions in whole body tissues had relatively low expression of complement proteins in pouch young, but this expression significantly increased as individuals develop into juveniles. Surprisingly, the average expressions of all complement proteins decreased as juveniles develop into adults. Additional research has also shown the expression of an additional complement protein, CRP, in red-tailed phascogales as young as 7-days. The results from this study show the use of complement system as an immune strategy in developing marsupials.

P Q R S

T

AN OBSERVATION OF NEST ROBBING BY THE THREATENED BRUSH-TAILED PHASCOGALE IN CENTRAL VICTORIA

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The use of camera traps as tools for learning about animal natural behaviours has huge potential to increase our knowledge of elusive species. The Brush-tailed Phascogale, *Phascogale tapoatafa*, is an elusive marsupial carnivore that has declined significantly following European settlement. In September 2017, a Grey Shrike-thrush, *Colluricincla harmonica*, was found nesting with three eggs in the garage of a property in Lauriston, west of the central Victorian township of Kyneton. A check of the nest on the following day revealed that the eggs were missing and loose feathers were found suggesting a struggle had taken place. A fake nest using coconut husk was placed in a low tree near the garage entrance. Three Japanese Quail eggs were then placed into the nest. A Reconyx Ultrafire XR6 camera was installed a short distance away and set to record video for thirty seconds. On the first night, a Brush- tailed Phascogale was recorded consuming all three eggs. This is the first observation of a Brush-tailed Phascogale consuming eggs and may be representative of a widespread behaviour.

DOES HABITAT CHOICE AFFECT THE DIET OF THE NORTHERN QUOLL (*DASYURUS HALLUCATUS*) ON GROOTE EYLANDT?

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Australia's unique mammal fauna has experienced severe population declines and extinctions since European settlement. Knowledge of a species' dietary requirements and how this varies among and between individuals and populations is critical for effective management of these threatened species. The endangered northern quoll (*Dasyurus hallucatus*) is one of many native mammals currently experiencing population decline. On the mainland, northern quolls have contracted mainly to rocky habitats, however on the island refuge of Groote Eylandt they are still present in a range of habitats. We aim to investigate how northern quoll diet varies between the sexes, body sizes and

habitat types on Groote Eylandt. We have trapped northern quolls from two distinct habitat types, open sclerophyll woodland and rocky escarpment. From these animals, scats and blood, hair and tissue samples were collected. Short-term diet will be investigated with scat analysis and long-term diet assessed using stable isotope analysis of blood and tissue and compared to isotopic ratios of potential dietary items. We will be presenting initial results from our recent data collection, including variation in body size and sex ratios in the two habitat types. This knowledge will allow us to inform conservation plans for a keystone predator across northern Australia.

THE CELLULAR STRUCTURE OF MAMMALIAN COGNITION: COMPARATIVE NEURONAL MORPHOLOGY OF THE MARSUPIAL BRAIN

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Understanding the constraints and evolutionary pressures acting upon the mammalian brain, its parts, and its architectonics is one of the central aims of evolutionary comparative neuroanatomy. Data on neuronal numbers and neuronal morphology are currently lacking for most mammals, but they are crucial in order to understand, and compare the shaping forces acting upon the evolution of the nervous system. In my study I take a three-pronged approach by quantifying the neuronal composition of the brains of various marsupials, complemented with qualitative and quantitative comparative neuronal morphology survey in several brain areas. I also conduct a phylogenetically informed comparative analysis on a range of data (dendritic length, arborisation, some size, dendritic spines, among others), including ecological and life- history variables. In this presentation, I present a protocol for quantification of neuronal morphology in *Macropus eugenii*, and reveal novel characterizations of superficial and deep pyramidal neuron morphology in the motor and sensorimotor cortex. Additionally, I provide a broad overview on several other neuronal types, quantified for the first time in marsupial species - hippocampal CA basket cells, occipital and frontal pyramidal neurons, interneurons, giganto-pyramidal neurons.

MAMMALS OF THE WESTERN GREAT VICTORIA DESERT

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The western fringe of the Great Victoria Desert supports a diverse assemblage of plants and animals, containing a unique mix of species from the temperate south-west and arid interior. The mammalian assemblage is dominated by widespread arid zone- specialists, however also includes a small number of restricted species, reflecting the area's location on a biogeographic interzone. Since 2007, seventeen small (<200g) and four large (>200g), ground-dwelling mammal species were recorded (via trapping, motion-activated cameras, the identification of trace evidence and the material present in predator scats). Evidence of a further four mammals (now considered regionally extinct) were located by trace evidence and highlight the recent changes to the region's fauna. Introduced mammals dominated the assemblage recorded. From the analysis of prey remains we found both the feral cat and fox predate a wide range of small mammals. In contrast, the dingo's diet was dominated by larger mammals and invertebrates. The widespread influence of fire was also apparent throughout the region, with the vast majority of the landscape burnt multiple times within the last 20 years. The combined influences of introduced mammals and the far-reaching effects of wildfire are likely to influence the range and survival of the region's fauna.

V

A 3D SKULL SHAPE STUDY OF MICRO EVOLUTION AND CONSERVATION IN MARSUPIAL TAXA: REPEATABILITY ASSESSMENT OF THE TEMPLATE

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Both the study of marsupial evolution and conservation efforts are heavily biased on molecular data and traditional linear measurements. However, these approaches do not necessarily cover the whole morphology. Particularly in conservation biology, genetic-centred conservation tools for decision-making may not capture phenotypic adaptive traits relevant for the survival of marsupial populations. This project aims to quantify the whole 3D shape of two threatened but ecologically diverse marsupial taxa at different evolutionary timescales: the population fragmentation of northern quolls and the recent speciation of antechinuses. By using a state-of-the-art methodology, 3D geometric morphometrics, I will be able to capture detailed anatomical variability in cranial shape. The configuration of landmarks (template) in this study will be assessed by repeatability tests. This template will then have the potential to be used in several marsupial taxa, allowing investigations on the way that different parts of the skull adapt to different environments and how these processes occur at the macroevolutionary level. I also aim to integrate the detailed shape information obtained to genetic data in order to provide a novel conservation approach for decision-making on the protection of adaptive morphologies.

W

SKELETAL ATLAS OF THE THYLACINE

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Extinct marsupial wolf or Tasmanian Tiger *Thylacinus cynocephalus* is an iconic part of Australia's natural history. The latest surviving member of the diverse family Thylacinidae, the thylacine was widespread across mainland Australia during the Pleistocene but, by 3200 ybp, it was restricted to Tasmania. Persecuted by farmers, thylacines are thought to have gone extinct in the wild by the 1930s, and the last surviving captive animal died in 1936. Despite much public interest and numerous popular accounts, the ecology of this iconic Australian species is not well-known. Though huge numbers of animals were killed during the extermination of thylacines from Tasmania, very few useful specimens exist in collections. For palaeontologists, access to comparative material is important but not always practicable. The purpose of this atlas is to provide a comprehensive record of the skeletal elements of the Thylacine to enable researchers (without access to skeletal material) a useful reference for comparative studies.