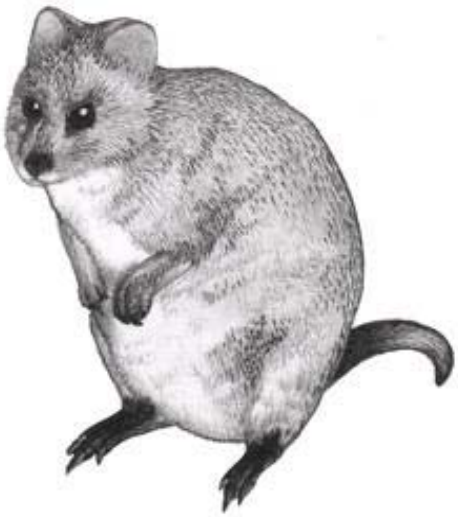
The Australian Mammal Society

# SEMI-CENTENARY and 55TH MEETING in PERTH

## *July 5-9, 2009*

# SCIENTIFIC PROGRAMME



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Roberta Bencini
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Brian Chambers
Tony Friend
Keith Morris
Phil Withers
Christine Cooper
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**Front cover artwork by Claire Stevenson (drawing) and Andrea Le Page (photograph).**

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# Conference Programme

## Spoken Papers (52)

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| 10:00 | Elena Trentin | Sexual Maturity in Male Indo-Pacific Bottlenose Dolphins: Evidence for Non-breeding Adults |
| 10:15 | Kylie Robert | Adaptive Advantage of Sex Allocation in Mammals: An Experimental Test Exploiting a Unique Model System |
| 10:30 | Tamara Keeley | Development of Sperm Cryopreservation Methods for the Tasmanian Devil |
| 10:45 | Felicity Bradshaw | Progestation in Marsupials – A Second Look |
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| 12:00 | Fritz Geiser | Hibernation and Noah's Ark |
| 12:15 | Paul Story | Sensitivity of Australian Native Marsupials to the Organophosphate Pesticide, Fenitrothion, and Physiological Consequences of Sublethal Exposure |
| 12:30 | Sean Tomlinson | Rubidium-86: A Novel Tool for the Measurement of FMR – A Case Study in Western Australian Dunnarts |
| 12:45 | Phil Withers | Diet Drives the Evolution of Marsupial Body Mass. |
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| 9:15 | Kaori Yokochi | Fluctuating Asymmetry Is an Unreliable Indicator of Inbreeding - a Study in Populations of the Tammar Wallaby (*Macropus eugenii*). |
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| 10:00 | Susan Campbell | Pipistrelle in Peril: The Fight for an Australian Endemic on the Verge of Extinction |
| 10:15 | Brian Chambers | Human Disturbance Alters the Population Dynamics of Tammar Wallabies (*Macropus eugenii*) on Garden Island, Western Australia. |
| 10:30 | Roberta Bencini | Road Kills of the Western Ringtail Possum (*Pseudocheirus occidentalis*) Occur at Specific Hotspots |
| 10:45 | Naomi Dwyer | Developing Threatened Species Policy under the EPBC Act |
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| 11:45 | Karlene Bain | Quantitative Determination of the Abundance of Quokka (*Setonix brachyurus)* Populations in the Southern Forests of Western Australia Using Relative Abundance Indices |
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| 14:45 | Leonie Valentine | Impacts of Fire and Climate Change on Honey Possums (*Tarsipes rostratus)* in Banksia Woodlands |
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| 15:45 | Stephen Kolomyjec | Climatic Constraints on the Distribution of the Platypus (*Ornithorhynchus anatinus*) |
| | ***Parasites and Disease*** *(Chair: Fritz Geiser)* | |
| 16:00 | Kath Handasyde | Mycobacterium ulcerans Infection in Marsupials and Their Possible Role as Reservoirs for Human Outbreaks |
| 16:15 | Nick Gust | Platypus Mucormycosis Disease in Tasmania: Distribution, Prevalence and Impacts |
| 16:30 | Adrian Wayne | A Wildlife Pandemic? Are Introduced Predators and Disease the Causes of the Collapse of Woylie (Brush-tailed Bettong) Populations? |
| 16:45 | Natasha Speight | Oxalate Nephrosis in Koalas in the Adelaide Hills |
| 17:00 | ***Poster Session*** *– Poster authors in attendance* | |
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**Posters (19)**

| Author | Title |
|---|---|
| Melissa Danks | Mean Retention Time of Truffle Spores in the Swamp Wallaby Digestive System |
| Greta Frankham | The Phylogeography and Population Genetics of the Long-nosed Potoroo (*Potorous tridactylus*) |
| Tony Friend | Preliminary Assessment of Non-target Risk Associated with Poison Baiting for Introduced House Mice on Boullanger and Whitlock Islands, Western Australia |
| Stephen Kolomyjec | Cross Catchment Gene Flow in the Platypus |
| Daniella Rojas | Locomotion in Torpid Planigales |
| Justine Smith | Fire Ecology of Southern Brown Bandicoots and Long-nosed Potoroos in Southwest Victoria |
| Clare Stawski | Hibernation in a Subtropical Microbat |
| Siyam Subair | Animals to Develop Techniques for Managing Overabundant, Free-ranging Populations Brendan Taylor - Will Squirrel Gliders Use a Land-bridge to Cross a Road-gap? |
| Brendan Taylor | Will Squirrel Gliders Use a Land-bridge to Cross a Road Gap? |
| Kerry Zosky | Variation in the Diet of the Woylie, *Bettongia penicillata* |
| Tim McGrath | Developing Threatened Species Policy – The Water Mouse *Xeromys myoides* |
| Chris Mayberry | Evidence of Toxoplasma and Neospora Infection in Western Grey Kangaroos (*Macropus fuliginosus ocydromus*) but Not Black-flanked Rock Wallabies (*Petrogale lateralis lateralis*) in South-western Western Australia |
| Jennifer Anson | Threatening Processes Influencing Occupancy Rates of Arboreal Mammal in Far East Gippsland |
| Lisa Warnecke | Small-scale Movement Patterns of Three Small Dasyurids in Semi-arid Australia |
| Barbara Jones | An Odd Population of *Trichosurus vulpecula* Is an Interesting Example for Possum Conservation |
| Christine Rafferty | Herbivore Feeding Preferences in Captive and Wild Populations |
| Jo Williams | Monitoring a translocated Population of Black-flanked Rock-wallabies (*Petrogale lateralis lateralis*) at Paruna Sanctuary, Western Australia |
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# SPOKEN PAPERS

## The Australian Mammal Society: The First Fifty Years

**Tyndale-Biscoe, Hugh**
114 Grayson Street, Hackett ACT 2602

The first meeting of the Society was dominated by comparative physiology; no paper was presented on ecology or conservation or rabbits. The Society was one of the first specialist societies founded in Australia and it was held in conjunction with the ANZAAS meeting because that was the premier science meeting of the time. The next 25 years saw the Society grow to its peak in membership and encompass a wide range of disciplines. It was a time of generous funding in CSIRO and the universities. Many of the founder members established their own research groups and their new discoveries were first presented at the AMS annual meetings.

The second half of the Society's life has been different. Specialist societies in all the disciplines that the AMS had fostered sprang up and drew support away from it. Support for research on mammals also changed and research became much more expensive to do as new and powerful techniques became available. This was reflected in a decline in comparative physiology and a rise in field ecology and behaviour and a much greater emphasis on conservation, and research on the control of pest species.

The future for mammalogy in Australia will be dominated by the effects of global warming. The knowledge of the native species that has been gathered in the last 50 years will help to predict their responses to these changes but much effort will probably be directed to rescuing relict populations from extinction.

## *Reproductive Biology*

### Regional Differences in Reproduction Shown by *Sminthopsis macroura* Colony Animals

**Selwood, Lynne**, Angela Nation, Phil Au and Ellen Menkhorst
Department of Zoology, University of Melbourne, Vic 3010

The captive colony of *Sminthopsis macroura* has survived for 25 years, with addition of wild-caught stock at 5-8 year intervals to overcome inbreeding depression. It was based originally on stock from SA, WA and QLD. Wild caught animals have been introduced from Alice Springs and Kings Canyon, NT in 1989 (3), Stony Desert, near Oodnadatta, SA. in 1996 (2) and Lake Eyre Basin, SA in 2004(1). All except the two animals from King's Canyon bred with colony animals, but at each introduction only one animal had offspring that contributed to the colony in the long term. Breeding performance of animals in the colony always improved following incorporation of wild caught stock.

In the first 15 years of the colony, the reproductive parameters of the animals, determined by daily reproductive monitoring of weight, urine samples and pouch changes during July to February, resembled the original stock in that the oestrous cycle length (26 days) and the period of successful sperm storage (1-5 days) resulting in embryos or pouch young were similar. Following introduction of the South Australian stock, however, some descendants had a longer oestrous cycle, the shape of the female weight profile during the follicular phase changed, the follicular phase and the period of oestrus where the females was receptive to a male increased in length and the maximum length of successful sperm storage changed from 5 days to 12 days. These features, especially that of longer sperm storage, would be advantageous to sparsely distributed animals.

### Sexual Maturity in Male Indo-Pacific Bottlenose Dolphins: Evidence for Non-breeding Adults

**Trentin, Elena**[1, 2] and Catherine Kemper[1]
[1] South Australian Museum, North Terrace, Adelaide, South Australia 5000, Australia
[2] Università Politecnica delle Marche, Ancona, Italy

Age and sexual maturity were studied in 50 male *Tursiops aduncus* carcasses collected opportunistically from strandings and by-catch in South Australia. Age was estimated by counting growth layer groups in thin-sectioned teeth. Formalin-fixed testes and epididymides were weighed, measured and assessed histologically for stage of spermatogenesis. Testis size of nine dolphins with autolyzed organs was used to assess maturity after comparison with fresh testes. Immature testes had mean tubule diameters <77 μm and only Sertoli cells and spermatogonia, testis/epididymis weights <44 g and lengths ≤165 mm. Mature dolphins had spermatozoa in the testis and epididymis, mean tubule diameters >84 μm, and testis/epidiymis weights >185 g and lengths ≥165 mm. Sexual maturity was attained between 208–220 cm body length and 90–115 kg body weight. Age at sexual maturity appeared to be at 9–12 years but there was a lack of specimens in this critical period of development. Some males were sexually but not physically mature as judged by fusion of the vertebral epiphyses. All physically mature males were sexually mature except two: 1) a 16-year-old, 212 cm dolphin

with a testis/epididymis weight of 203 g and 2) a 27-year-old, 221 cm animal with a testis/epididymis weight of 209 g. Reasons for these exceptions are not known but may relate to non-breeding cycles in testis activity, heavy metal toxicity and/or reproductive senescence. More males with intermediately-sized testes need to be studied to refine age at sexual maturity and factors that may influence this and the breeding cycle.

## Adaptive Advantage of Sex Allocation in Mammals: An Experimental Test Exploiting a Unique Model System

**Robert, Kylie A.**
School of Animal Biology, The University of Western Australia, Crawley, Australia

Sex allocation is an important topic in evolutionary biology. Despite decades of interest we are still struggling to understand the occurrence and adaptive explanation for the production of biased offspring sex ratios, particularly within mammalian taxa. This is complicated by virtually no direct experimental tests of the adaptive advantage of sex allocation in mammals due to the limitations posed by the biological constraints of viviparity. Many marsupials produce biased sex ratios, and these departures from equality may be more frequent than those recorded in eutherians. The relative ease of offspring sex ratio manipulation and the low cost of facultative adjustment by marsupial mothers lend this group to new avenues of inquiry for the adaptive explanations of sex allocation. In particular, researchers can access marsupial offspring early in development and can manipulate sex ratio in order to test its adaptive value. Here I cross-fostered offspring by sex in a captive population of Tammar wallabies (*Macropus eugenii*) [5 treatments based on the sex born and the sex fostered (born/fostered): 1) daughter/son; 2) daughter/daughter; 3) son/son; 4) son/daughter; and 5) mothers that give birth and foster their own offspring (sham)] to test whether offspring sex has fitness consequences for mothers. A mother that birthed a son had a significantly greater probability of successfully raising a young to weaning than a mother that birthed a daughter irrespective of sex raised. This experimental work is being replicated in a wild population to provide the definitive test of whether offspring sex has fitness consequences for mothers.

## Development of Sperm Cryopreservation Methods for the Tasmanian Devil (*Sarcophilus harrisii*)

**Keeley[1,2], Tamara**, Paul D. McGreevy[1] and Justine K. O'Brien[1,3]
[1]Faculty of Veterinary Science, University of Sydney
[2]Taronga Conservation Society Australia
[3]SeaWorld and Busch Gardens Reproductive Research Center (USA)

Since the emergence of the fatal and contagious Devil Facial Tumour Disease over a decade ago, the Tasmanian devil (*Sarcophilus harrisii*) has undergone an estimated population decline of 50 percent. Artificial insemination of cryopreserved spermatozoa can potentially be used to supplement the gene pool of captive-breeding programs without the introduction of additional animals, and may reduce the risks associated with breeding animals

of unknown disease status. The success of a devil genome resource bank depends on optimised gamete preservation techniques. At present, gamete cryopreservation techniques are not established for any dasyurid species. The aim of this study was to determine appropriate sperm cryopreservation methods using post-mortem epididymal devil spermatozoa and *in vitro* sperm evaluations (motility, plasma membrane integrity and acrosomal status). Pooled cauda and corpus epididymal sperm samples (n=9) were cryopreserved with 4%, 10% and 18% glycerol in an egg yolk diluent (TEST yolk buffer). Sperm samples displayed an initial motility of 47.7 ± 7.5% (range 38-60%). All *in vitro* sperm parameters were reduced ($P < 0.05$) post-thawing. Post-thaw motility was similar ($P > 0.1$) for 4% (3.0 ± 1.9%) and 10% (4.2 ± 5.7%) treatments, but was reduced ($P < 0.05$) for the 18% (0.1 ± 0.3%) glycerol treatment. Samples cryopreserved using 4% and 10% glycerol retained 6.2 ± 1.3% (range 0-12%) and 8.6 ± 3.9% (range 0–35%) of their initial motility, respectively. These results demonstrate that devil spermatozoa are highly susceptible to damage during the cryopreservation and thawing processes. Additional diluent components and freezing rates are under investigation.

## Progestation in Marsupials – A Second Look

**Bradshaw, Felicity**
School of Animal Biology, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009

Progesterone levels were first reported in a marsupial over thirty years ago; since then, profiles have been published throughout the reproductive cycle of a total of twenty-nine species. A feature to emerge from this re-examination is the prevalence of high levels of progesterone around the time of ovulation in seven species of Dasyuridae, two species of Didelphidae and the koala. Clearly not of luteal origin, this progesterone appears to be involved in mate-attraction and the induction of ovulation. Following ovulation, and before the *corpus luteum* is fully formed, it secretes a transient pulse of progesterone, recognised as a common feature of the pregnant and non-pregnant cycles of Macropodidae and Potoroidae. A careful comparison of progesterone levels and the timing of the pulse during these cycles indicate a maternal recognition of the early embryo. Taken together with the effect of the late embryo, the overall result is a shortening of the life-span of the *corpus luteum*, favouring the birth of an embryonic young. This strategy contrasts with that of the eutherian mammal, in which pregnancy prolongs rather than shortens the life span of the *corpus luteum.*

## *Physiology*

### Comparative Physiology of Australian Quolls

**Cooper, Christine**[1,2] and Philip Withers[1,2]

[1]Centre of Ecosystem Diversity and Dynamics in the Department of Environmental and Aquatic Sciences, Curtin University of Technology, Western Australia 6845
[2]Zoology, Animal Biology M092, University of Western Australia, Crawley, Western Australia 6009

We compare the metabolic, ventilatory, thermal and hygric physiology of the four species of Australian quoll. All quoll species showed expected endothermic physiological responses to varying ambient temperature, with basal (standard) states occurring at a thermoneutral temperature of 30°C. Ventilatory parameters closely matched metabolic demand, with increased metabolic rate accommodated by increased minute volume at low ambient temperatures. Eastern quolls had a significantly higher basal metabolic rate (0.62 ± 0.033 ml $O_2$ $g^{-1}$ $h^{-1}$) and evaporative water loss (1.46 ± 0.231 mg $H_2O$ $g^{-1}$ $h^{-1}$) than the other quoll species, while the western quoll had the highest point of relative water economy (22.6°C). Basic physiological variables of quolls statistically conformed to those of other marsupials, although the western quoll had a significantly higher point of relative water economy than predicted by allometry. We interpret the physiological differences between the quoll species as adaptations to habitat aridity; the elevated physiological variables of the eastern quoll are consistent with its very mesic temperate habitat and the high point of relative water economy of the western quoll reflects its historically arid zone distribution.

### Nitrogen Metabolism and Protein Turnover in the Honey Possum, *Tarsipes rostratus*

**Bradshaw, Don** and Felicity

School of Animal Biology and Centre for Native Animal Research, University of WA, 35 Stirling Highway, Crawley, WA 6009

Smith & Lee (1984) in an early allometric study found that the reproductive productivity of Honey possums and other possums feeding on nectar, gum and exudates was low when compared with that of folivorous species, suggesting that their carbohydrate-rich diet may be deficient in protein. Isotopic measurements of the rates of intake of nectar and pollen in free-ranging Honey possums in the SW of WA show that a 9g individual consumes, on average, 7ml of nectar and 1g of pollen per day. This equates to 30mg of nitrogen, which is approximately 10 times their daily minimum requirement for balance (MNR = 89 $mg.kg^{-0.75}.d^{-1}$). Rates of protein turnover have recently been measured and compared in males and in females with and without pouch young using $^{15}$N-glycine with $NH_3$ as the end product. The overall mean rate of protein synthesis was 7.7 ± 0.5 $g.kg^{-0.75}.d^{-1}$. Whole body rates of nitrogen flux and protein synthesis did not vary significantly between males and females when the females' body mass was corrected for that of the young, but rates of protein degradation were significantly reduced in females carrying pouch young. Calculations indicate that less than 5% of the daily fraction of the female's nitrogen synthesis needs to be diverted to the growing young in the form of milk to sustain their growth. The diet of the Honey possums is thus not

deficient in protein and the lower reproductive productivity of the species probably reflects the enhanced maternal care shown by this species.

## Hibernation and Noah's Ark

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

An article published at www.creationontheweb.org discusses the implications of yearlong hibernation by eastern pygmy-possums (*Cercartetus nanus*) for the "Flood Account" and prolonged survival of animals on Noah's Ark. The article correctly points out that prolonged periods of daily torpor and hibernation (multi-day torpor) enable mammals to survive adverse conditions on limited food. As torpor substantially reduces food and thus foraging requirements the question arises whether torpor could have implications for mammalian conservation. This is especially important because recent evidence shows that torpor is much more widespread than previously thought, occurring in mammalian orders that contain approximately 90% of all extant mammals from all climate zones. Interestingly, of the 61 mammals confirmed extinct over the last 500 years, 57 were likely homeothermic (unable to enter torpor) whereas only 4 species were likely heterothermic (capable of torpor). This suggests that torpor use permits mammals to survive not only adverse conditions, but also helps them in dealing with habitat degradation and introduced competitors/predators. Thus, while the significance of torpor use on the Ark may never be resolved, it appears that torpor use in extant mammals is an important factor that has been overlooked but must be considered by conservation biologists.

## Sensitivity of Australian Native Marsupials to the Organophosphate Pesticide, Fenitrothion, and Physiological Consequences of Sublethal Exposure

**Story, Paul G.[1,2],** William A. Buttemer[2], Michael, J. Hooper[3] and Lee B. Asthemier[4]
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[2]Institute for Conservation Biology, University of Wollongong, Northfields Avenue, Wollongong NSW 2522 Australia
[3]United States Geological Survey, Columbia Environmental Research Centre Columbia, MO 65201 USA
[4]Deakin University

Using the Up-and-Down method for determining acute oral toxicity, *Sminthopsis crassicaudata* and *S. macroura* were found to have LD50 values of 129mg/kg and 97mg/kg respectively for the insecticide fenitrothion. These values are 10-14 times lower than reported LD50 values for a similar-sized eutherian mammal, *Mus musculus* (LD50=1100-1400mg/kg) and lower than all other reported mammalian LD50 values.

To examine the sublethal physiological response of *S. macroura* to pesticide exposure, we gave treated dunnarts a single fenitrothion dose of 90 mg/kg by gavage, whereas control animals received the oil vehicle alone. Dosed dunnarts showed up to 80% reductions in locomotor performance (measured as running endurance at 1m/s) with endurance measures

returning to pre-dose levels by 10 days post-dose. There was no effect of treatment on oxygen consumption rates while running.

Body temperatures, before and after running, were significantly lower in treated dunnarts, returning to pre-dose levels by 10 days post-dose. By contrast, peak metabolic rates, cumulative oxygen consumption, and endpoint body temperatures were indistinguishable between pesticide-treated and control animals during a 60 minute exposure to a temperature equivalent to -20$^{o}$C.

The locomotor impairments identified in this study, in otherwise asymptomatic animals, emphasise the importance of incorporating performance-based measures into pesticide evaluations. Additionally, the higher than expected sensitivity of Australian marsupials to fenitrothion highlights the importance of evaluating the effects of pesticides on non-target species that are likely to be exposed, particularly when these species are phylogenetically distinct from those commonly used to establish pesticide sensitivity

## Rubidium-86: A Novel Tool for the Measurement of FMR – A Case Study in Western Australian Dunnarts

**Tomlinson, Sean**[1]; Philip Withers[1], Shane Maloney[2] and Ariovaldo Cruz-Neto[3]

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[2]School of Biomedical and Chemical Science, University of WA, 35 Stirling Highway, Crawley WA 6009
[3]Departamento de Zoologia, UNESP, Campus de Rio Claro, Brazil

The doubly-labelled water method (DLW) is a widespread technique for measuring the field metabolism (FMR) in free-ranging animals. Its application is limited in species with high water efflux relative to metabolism, and the very short optimal turnover periods in small animals (usually less than 36 hours), which may provide very little accurate information concerning their daily requirements free of capture and experimental procedures. Repetitive bleeding may also influence metabolic rates, and the isotopes can be prohibitively expensive to procure and analyse. Here we validate the use of rubidium-86 ($^{86}$Rb), a gamma-emitting radio-isotope, turnovers to infer metabolism in two dunnarts (*Sminthopsis* spp.). There was a strong correlation between $VCO_2$ measured by flow-through respirometry and $^{86}$Rb biological turnovers by linear and RMA regression. Comparing data of previous studies yields a strong relationship ($r^2 = 0.91$) between metabolism and $^{86}$Rb turnover, suggesting this to be a reliable analogue by which to infer FMR. $^{86}$Rb might be useful in correcting FMR overestimates under a range of conditions, such as in nectarivores or diving species, or in groups that have been too small to permit DLW studies (such as insects). Its advantages include lower cost, equipment requirements and technical expertise and obviation of bleeding to make measurements, and the longer time span during which effective measurements can be made. Where the $^{86}$Rb technique is to be used, costs and ethical limitations can be reduced by the use of flow-through respirometry in the laboratory to provide the requisite validation of $^{86}$Rb turnover to $VCO_2$.

## Diet Drives the Evolution of Marsupial Body Mass.

**Withers, Philip**[1,2] and Christine Cooper[1,2]

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Body mass of marsupials ranges from 6.4 g (*Planigale ingrami*) to 43.3 kg (*Macropus giganteus*), and dietary niches include omnivores (the presumed ancestral state), nectarivores, insectivores, vertebrativores, folivores, fungivores, browsers, and grazers. We investigated patterns of body mass for 237 marsupial species based on their dietary niche and phylogeny using conventional and phylogenetic analyses. As expected, body mass was significantly related to dietary niche (11g nectarivores to 9500g grazers). However, there is a highly significant phylogenetic signal in body mass and in dietary niche. The body mass of the putative omnivorous ancestral marsupial is calculated to be 140g (by independent contrasts). The difference between actual and phylogentically-predicted body mass was significantly related to diet. Nectarivores had much smaller-than-expected body masses, at only 1.6% of predicted. Insectivores (74%), browsers (79%) and fungivores (81%) were also smaller than predicted. Actual and phylogentically-predicted body mass was similar for omnivores (114%). Actual body mass was greater than predicted for folivores (222%), grazers (617%) and especially vertebrativores (1537%). These results suggest that the most intense selection for dietary niche on body mass is reduced mass for nectarivores (e.g. honey possum) and increased body mass for vertebrativores (e.g. quolls). Amongst fermenting marsupials, browsers and fungivores are selected for lower body mass whereas grazers are selected for higher body mass. Omnivores, although varying widely in mass, conform most closely to phylogenetic predictions.

## Consumption of Milk by Quokka (*Setonix brachyurus*) Young

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We investigated the consumption of milk by the young quokka using the stable isotope deuterium oxide. The volume of milk consumed increased from 1.6 ml $d^{-1}$ at 55 days *post partum* to 32.5 ml $d^{-1}$ at 165 days. The daily energy intake ranged from approximately 22 to 151 kJ $d^{-1}$ during pouch life. The crude growth efficiency (g of growth per ml of milk consumed) increased from an average of 0.35 to 0.46 g $ml^{-1}$ in the early stages of pouch life, and then decreased to 0.24 g $ml^{-1}$ during Phase 2b of lactation. The crude growth efficiency measured in our study indicates that quokkas are equally efficient in converting milk energy to body mass as other marsupials reported in the literature. Measuring milk intake with this method offers a non-toxic, minimally invasive alternative to other techniques for measuring milk consumption in marsupials, when milk is the only source of water intake.

## *Morphology and Taxonomy*

### Skin and Bones – Problems with ID in the Field

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Species are often named and described on the basis of preserved museum specimens and the resultant identifying characteristics may bear little relationship to those observed in the field. The paper describes the author's struggles with identifying closely related species in the field using two species of *Antechinus* as examples. The paper also describes difficulties in using published field guides for identifying closely related species and calls for a scheme where identification characteristics can be gathered and used by field biologists.

### Functional Morphology of the Macropod Temporomandibular Joint

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The temporomandibular joint (TMJ) is a defining feature of the masticatory apparatus of mammals, in which the mandibular condyle articulates with the squamous temporal bone of the skull. Striking differences in TMJ morphology exist between taxa and reflect both phylogeny and the different processing requirements of contrasting diets. The morphological configurations of the articular surfaces reflect varying degrees of mandibular mobility and stability during the masticatory cycle.

This paper describes the TMJ anatomy of kangaroos, wallabies and rat kangaroos, as part of a larger study of macropod masticatory apparatus. Macropods are a diverse group of herbivores that can be characterised into distinct feeding groups; grazers, browsers and mixed feeders. Skulls from 22 species of kangaroos were scanned by a laser scanner to retrieve 3-dimensional data. TMJ morphology, including articular surfaces, principle axes of rotation and shape were extracted. Considerable variation in TMJ morphology was found. Browsers were characterised by small rounded condyles and principle axis that is consistent with a predominately hinging action with a limited rotation about the mental symphysis. Grazers contrasted with the condyles that have a large surface area with a distinctive concavity that had elliptical expansions on the medial and lateral aspects of the articular surface. This enables rotation of hemimandibles about the symphysis. The vector of the principle axis of the joint reflected this rotational component. The observed variation in macropod TMJ form illustrates the complex interaction between the range of motion and stability required for varied feeding patterns within a single phylogenetic lineage.

## *Conservation Genetics*

### Scat DNA Used to Detect Remnant Quokka Population on the Swan Coastal Plain

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There are few recent records of the Quokka, *Setonix brachyurus*, from the Swan Coastal Plain between Bunbury and Busselton, despite anecdotal information indicating they were once common. Several reported sightings, skeletal material, and old scats over the past decade suggest that *S. brachyurus* is present on the Swan Coastal Plain. An extensive on-ground survey of the Muddy Lakes area was carried during March 2008. It was determined that *S. brachyurus* was present based on one adult carcass, one juvenile skull, and fresh scats.

We developed a molecular method to conclusively distinguish fresh scats belonging to *S. brachyurus* from those of three other potentially sympatric macropod species. DNA extraction protocols were refined to successfully extract DNA from fresh macropod scat and we amplified two short mitochondrial DNA regions (12S and Cyt-*b*) via Real-Time-PCR. PCR amplification and DNA-melt temperatures differed between macropod species, which allowed identification of the source species. Use of sex-linked *SRY* markers also allowed the sex of each animal to be determined from the scat DNA. At the time of our survey, at least two females and one male *S. brachyurus* were inhabiting Muddy Lakes. This method can confirm the presence of *S. brachyurus*, particularly when numbers are critically low and animals are difficult to trap, or in areas where other macropods are present and hence scat may be misidentified. Further testing will be required to confirm the method can be applied to scat samples from other field locations in the south-west.

### Oocyte Vitrification as a Tool for Genome Resource Banking in a Dasyurid Marsupial, the Fat Tailed Dunnart

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Dasyurid marsupials are native Australian carnivores or insectivores and include the endangered Tasmanian devil (*Sarcophilus harrisii*) and northern quoll (*Dasyurus hallucatus*) which have both recently undergone large-scale population declines. These species are carefully managed in captivity but another form of *ex situ* conservation is genome resource banking, involving the long-term cryopreservation of reproductive tissues. Ovarian tissue contains several thousand follicles which are present thought the reproductive cycle and are comprised of oocytes and their surrounding granulosa cells. This study examines a model dasyurid, the fat tailed dunnart (*Sminthopsis crassicaudata*), and describes protocols for the collection and preservation of ovarian follicles for the purpose of dasyurid genome resource

banking. Follicles were isolated from the ovary using an enzymatic dissociation method which resulted in the collection of undamaged primordial (100.0 ± 0.0%), early primary (91.2 ± 8.2%) or late primary (84.4 ± 6.3%) follicles. Undamaged primordial and early primary follicles were also collected from tissue transported overnight at 4ºC (primordial: 99.4 ± 0.7%, early primary: 82.0 ± 3.5%), but tissues transported at 22ºC contained lower quality follicles ($P<0.0001$). There was no significant loss of oocyte viability following cold shock, exposure to high concentrations of cryoprotectants or vitrification and storage at -196ºC and 69.4 ± 2.4% of oocytes were viable post-thaw. These protocols allow the transport, collection and preservation of oocytes from a dasyurid marsupial and provide practical tools for genome resource banking which could be implemented into conservation programs to limit the loss of genetic diversity from populations of threatened dasyurids.

## The Short-eared Rock-wallaby (*Petrogale brachyotis*) – One Species?

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Historically, the short-eared rock-wallaby (*Petrogale brachyotis*) was described as multiple species, based on variable morphological characteristics (Van Dyck & Strahan 2008). Currently it is considered as one species that ranges from the Kimberley eastward to the Northern Territory/Queensland border. Molecular genetics research in the Northern Territory questioned the accuracy of current taxonomy, recording high levels of mitochondrial sequence divergence between populations (Telfer 2006). Molecular genetics provides useful guidance in conservation management, using evolutionarily significant units (ESUs) to prioritise units for protection, where existing classifications may not accurately reflect evolutionary history or the distribution of diversity (Moritz 1994). The aims of this study were therefore to (i) assess levels of genetic diversity, (ii) evaluate taxonomic classification/ESUs, (iii) identify biogeographical barriers and (iv) assess impacts of (i), (ii) and (iii) on future conservation. Mitochondrial control region and ND2 sequence data revealed high levels of sequence divergence (up to 15%) between Northern Territory and Kimberley individuals. Nuclear intron sequences and anonymous nuclear markers also support long term isolation between the two regions. The 'Victoria River Drainage' biogeographic barrier apparent for bird species in this region may similarly explain the isolation found in *P. brachyotis*. Smaller biogeographical barriers could also be present within the Kimberley region, where data indicates additional divergence within *P. brachyotis*. Although *P. brachyotis* is currently relatively abundant throughout its range, these data suggest that the conservation status of regional populations needs to be reviewed independently and that future management will be influenced by both long term population isolation and significant intra-species divergence.

## Reproductive Isolation between Adjacent *Antechinus agilis* Populations with Different Teat Numbers

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Teat number sets the upper limit for the number of young antechinus can produce. *Antechinus agilis* show geographic variation in teat number associated with localised environments, putatively via resource availability. This geographic pattern of teat number and therefore litter size generally holds true for most antechinus species and is relatively constant within a given region. Within the Otway Ranges in southwest Victoria, distinct 6- and 10-teat phenotypes of *A. agilis* can be found in adjacent sites at similar latitudes and elevation. Where the two distinct forms co-exist, a small number of individuals with intermediate teat numbers can be found. Substantial nuclear DNA and morphological differentiation between 6- and 10-teat phenotypes of *A. agilis*, suggest limited gene flow despite the absence of obvious barriers to dispersal. However, it remains unclear what mechanisms and evolutionary drivers are responsible.

In the present study, we selected multiple sites where 6- and 10-teat have every opportunity to interbreed. Ecological and genetic data were collected to characterize dispersal, pre- and post-zygotic mating outcomes, and degree of genetic mixing between forms and its phenotypic consequences. Data on reproductive timing, resource availability, trophic and other morphology and environmental variables were acquired to investigate a suite of proposed mechanisms that might underpin and drive partial reproductive isolation among environments. Analysis of the nuclear DNA and morphological divergence between the teat-number forms suggests incipient functional and genetic differentiation through ecological specialization, in the face of gene flow.

## High Levels of Genetic Divergence between Tasmanian and Victorian Platypuses, *Ornithorhynchus anatinus,* as Revealed by Microsatellite Loci

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The platypus, *Ornithorhynchus anatinus* is a unique, iconic mammal endemic to Australia. Despite being listed as 'common' throughout its range, platypus abundance is poorly understood. Dependence on aquatic habitats in drought affected Australia renders this species potentially vulnerable to a variety of processes including climate change and habitat loss. To assist with understanding population processes, 13 microsatellite loci were isolated and optimised for amplification. Characterisation of 180 individuals from Tasmania and Victoria revealed all loci to be polymorphic (3-24 alleles per locus). Observed heterozygosities ranged from 0.445 – 0.610. Large genetic differences were evident between Tasmanian and Victorian

*O. anatinus*. The long-term isolation of Tasmanian individuals from their mainland counterparts is likely to have contributed to the high levels of genetic differentiation observed. Within Tasmania, high levels of allelic diversity were detected with genetic differentiation identified among some populations. Similar levels of allelic diversity were found within Victorian platypuses along with significant genetic differentiation among populations. These microsatellite loci will facilitate research into the population genetics of *O. anatinus* throughout its Australian range and assist with species management and conservation efforts.

## A Phylogeny and Timescale for Evolution in Living Bandicoots

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Relationships both within bandicoots and between them and other marsupials have proven difficult to discern especially when based solely on morphological characters. Using a concatenation of multiple nuclear and mitochondrial genes we have shown that bandicoots are sister group to dasyurids plus *Notoryctes.* Relationships of bilbies and the extinct pig-footed bandicoot as shown by a new morphological data matrix and by DNA sequences will be discussed. Using relaxed molecular clock techniques we show that modern bandicoots probably originated in the late Oligocene or early Miocene, well before the earliest fossils suggest.

## Molecular Systematics of the Extinct? Christmas Island Shrew *Crocidura attenuata trichura*

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The Christmas Island (CI) shrew *Crocidura attenuata trichura* is the only member of the eutherian family Soricidae recorded from Australia. It is currently classified as an endemic island subspecies of the long-tailed shrew *C. attenuata,* although it was originally described as a subspecies of the white-toothed shrew *C. fuliginosa*. In 1899 a series of CI shrew specimens were collected and lodged with the Natural History Museum in London (NHM). Subsequently the species declined dramatically and was considered extinct by 1908. However, in 1985 two shrews were collected on CI and lodged with the West Australian Museum (WAM). It is unclear whether the 1985 specimens represent the same taxon as was collected in 1899 or were a recent introduction from Asia. In this study we examined cytochrome *b* (cyt*b*) sequence from museum specimens of the CI shrew to determine its taxonomic affinities and to resolve the identity of the 1985 specimens. DNA sequences amplified from both the 1899 and 1985 specimens were identical confirming the 1985 specimens were authentic CI shrews. The CI shrew cyt*b* sequence was found to be divergent at the species level from all other available *Crocidura* cyt*b* sequences (>70 species), including *C. attenuata* and *C.*

*fuliginosa*. This suggests that the CI shrew represents a distinct species, *C. trichura*. It is therefore imperative that the conservation status of the CI shrew be definitively established since if it remains extant it represents not only the sole member of the Soricidae in Australia but also a highly endangered endemic species.

**Fluctuating asymmetry is an unreliable indicator of inbreeding - a study in populations of the tammar wallaby (*Macropus eugenii*).**

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The accuracy of fluctuating asymmetry (FA) as an indicator of inbreeding is controversial and studies conducted thus far have not conformed to all the recommendations and conditions for calculating accurate FA. We tested the correlation between heterozygosity and FA in three populations of the tammar wallaby (*Macropus eugenii*) in Western Australia: Garden Island, North Island in the Abrolhos archipelago and Tutanning Nature Reserve on the mainland. Due to the history of the populations we expected that the North Island population would be the most inbred, followed by the Garden Island population, and the Tutanning population would be the least inbred. We collected ear biopsies and data on long pes, short pes and forearm length from 30 individuals in each population. We then conducted a microsatellite analysis using seven tammar wallaby markers to calculate the individual heterozygosity and parameters of genetic diversity. The level of FA was calculated using three different indices. Results showed that the Tutanning population was the least inbred ($H_E$ - Tutanning: 0.86 ± 0.02, Garden Island: 0.45 ± 0.02, North Island: 0.33 ± 0.10); however, its level of FA was the highest among the three populations. This strongly suggests that the level of FA does not correlate to the level of heterozygosity or inbreeding. We concluded that FA is an unreliable indicator of inbreeding, and it should not be used to represent the genetic stress in wild animal populations.

## *Wildlife Conservation*

### What Makes Brush-tailed Rock-wallaby *Petrogale penicillata* Habitat for a Large Population Considered to Be Secure?

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Curracabundi National Park in the New England region of New South Wales hosts a large population of the endangered Brush-tailed Rock-wallaby *Petrogale penicillata*. This species has declined and gone extinct over much of its former range south to Victoria and west to central New South Wales. I investigated habitat use patterns of Curracabundi National Park's comparatively intact population. To achieve this, 1100 transects each 100 meters long were walked in what was deemed potentially rocky habitat throughout the park (i.e. gullies, ridges, exposed outcrops). In each transect, abundance of Brush-tailed Rock-wallaby scat, rock structure and complexity, vegetation variables, slope, aspect, elevation, time since fire, and distance to water were measured. Scats of goats, predators and sympatric macropods were also recorded. Brush-tailed Rock-wallaby scat was found in 56% of transects, occupying a diverse array of habitats: rainforest gullies and dry ridges, riverbanks and outcrops far from water sources, refuges adjacent to and far from cleared pasture. Brush-tailed Rock-wallabies in Curracabundi National Park were more abundant in larger and more complex refuges. However, they also occupied less complex habitat down to the most marginal refuges consisting of scattered boulders, with a few notable exceptions. These patterns are in stark contrast to populations to the south and west, where Brush-tailed Rock-wallabies have declined and are now restricted to only complex and remote rocky refuges.

### Western Ringtail Possums in Remnant Habitats – Implications for Management

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This presentation will describe the results of a two-year monthly monitoring program of Western Ringtail Possums (WRP) in a remnant habitat near Busselton, WA. The WRP is listed as 'Vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999* and as a 'Schedule 1' species (fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection) under the WA *Wildlife Conservation Act 1950*. The WRP is under threat in the south-west due to pressures from residential development, agriculture and subsequent habitat fragmentation.

We provide data on seasonal changes in the population and examine variations in possum observations at various times in the night. These data will then be used to provide comment on current monitoring strategies for WRP in the Busselton area, in particular the optimal time of night for surveying WRP, expected seasonal variations, consecutive vs non-consecutive nights surveys and quadrant vs transect surveys.

This information can be used to optimise the data that are being collected for WRPs in the south-west, improve management strategies and assist with both State and Commonwealth policy development for the protection of WRPs in the future.

**Pipistrelle in Peril: The Fight for an Australian Endemic on the Verge of Extinction**

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Australia is facing its first mammal extinction in 50 years and our first native microbat extinction in historical time. The Critically Endangered Christmas Island Pipistrelle *Pipistrellus murrayi* has declined in abundance by 99% since 1994, despite a number of ecological studies, ongoing monitoring and management actions. Predation by introduced species and disease have been implicated in the species' decline. In January 2009, as few as 20 individuals remained. An emergency rescue of these animals was recommended by March 2009, to form the basis of a long-term captive breeding program.

The Australasian Bat Society (ABS) consists of 300 members throughout Australasia and comprises a wealth of knowledge on bat ecology and care. The ABS (and the AMS) first alerted the federal government of their concern in 2005. As the decline continued, the ABS increased its lobbying for urgent action. In 2008/09, letters were sent to Government Ministers and information was also circulated amongst ABS members and their contacts. This generated a huge response world-wide and attracted significant media interest. This pressure led to the government establishing an expert working group and initiating a captive trial in NT. When by May 2009 there was still no government decision on the emergency rescue, the ABS generated further media interest, resulting in a meeting with the Minister Peter Garrett. We provide an update on the pipistrelle's current status and describe the lessons learnt by the ABS throughout this tragic event so that they can be applied to the conservation of other threatened Australian fauna.

**Human Disturbance Alters the Population Dynamics of Tammar Wallabies (*Macropus eugenii*) on Garden Island, Western Australia.**

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Modifications of habitat that change the availability of resources can alter the dynamics of populations of animals that rely on those resources. We tested the hypothesis that human disturbance in the form of a large naval base would alter the population dynamics of a population of tammar wallabies (*Macropus eugenii*). Increased food availability from the presence of large areas of irrigated lawns on the naval base was expected to increase the

tammars' rate of population growth (λ) by increasing rates of weaning and survival of young-adult and adult animals. We also expected that road-kills, which occur in large numbers on the naval base, would reduce the population growth rate in this area. We conducted a mark and recapture program, in disturbed and undisturbed areas, over three years in order to estimate rates of survival and reproduction and to determine population growth rates. The population on the naval base had a mean λ of 1.02±0.083 (s.e.) per year which was higher than the population in an area of adjacent bushland at 0.92±0.065 per year and the undisturbed bushland at 0.93±0.100 per year. When the impact of road-kills was removed, λ increased to 1.15±0.101 per year on the naval base and 0.96±0.076 per year in the bushland adjacent to the naval base. These results demonstrate how habitat modification can significantly alter the underlying vital rates that determine the rate of change in the size of populations. They also demonstrate the significant role that sources of additional mortality can pay in reducing population growth rates.

## Road Kills of the Western Ringtail Possum (*Pseudocheirus occidentalis*) Occur at Specific Hotspots

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We identified road kill hotspots of the western ringtail possum (*Pseudocheirus occidentalis*) in southwest Western Australia, where the species persists in urban environments and often falls victim to collisions with vehicles.

Using a Geographical Information Systems (GIS), we identified four hotspots where over nine road kills occurred in the last 21 years. We analysed temporal and spatial factors (monthly rainfall, day length, roadside vegetation, land uses and speed limit) that potentially influence rates of road mortality. Temporal variables were analysed using a 1-factor analysis of covariance.

Although we expected that more road kills would occur in winter, when rainfall is greater and days are shorter, the correlation between road kills and monthly rainfall using day length as a covariate was not significant ($p=0.0736$). We used a generalised linear model assuming a Poisson distribution and a log identity link function to analyse the spatial variables. This model was a significant predictor of road kills ($p=0.0068$), with land use and vegetation type as the significant explanatory variables.

More road kills occurred on stretches of road with forest on one side and rural land on the other ($p=0.0044$) while fewer possums were killed where vegetation was present on both sides of the road ($p=0.0063$). Significantly fewer road kills occurred where the vegetation was classified as medium forest ($p=0.0168$), but speed limit was not a significant predictor of the number of road kills.

The identification of hotspots should assist in the placement of mitigation measures to decrease the road toll of western ringtail possums.

## Developing Threatened Species Policy under the EPBC Act

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The Department of the Environment, Water, Heritage and the Arts (DEWHA) are currently developing policy statements for a variety of threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act protects 'matters of national environmental significance', including listed threatened species, through the assessment of actions that are likely to have a significant negative impact on a listed matter. Policy statements aim to assist the community to design developments and other proposed actions so as not to have a significant impact on listed threatened species.

The threatened species policy statements expand on the Australian Government's existing EPBC Act Policy Statement 1.1– Significant impact guidelines for matters of national environmental significance by defining populations and important habitat, identifying threats, and defining significant impact thresholds and appropriate mitigation strategies for a particular species or species group. This information is developed through discussions and conclusions drawn from an expert workshop. The expert workshops focus on sharing important knowledge on threatened species whilst building relationships between state and Commonwealth governments, researchers and conservation organisations.

EPBC Act policy statements are currently being prepared for a number of Australia's threatened mammals including the western ringtail possum (*Pseudocheirus occidentalis*), water mouse (*Xeromys myoides*), and the quokka (*Setonix brachyurus*).

## *Translocation*

### Effect of Changing Monitoring Design on Cryptic and Readily Trappable Species of Faure Island, Western Australia

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Since 2002, 5 mammal species have been reintroduced to Faure Island (5,300ha) in Shark Bay (WA), subsequent to the eradication of feral cats and goats. The challenge lies in designing an ongoing monitoring program that is effective for all species. In particular, the boodie (*Bettongia lesueur*) has shown a dramatic increase in abundance and a willingness to enter or disturb traps, compromising the monitoring of other species.

In an attempt to effectively monitor all five reintroduced species, and to reduce the influence of boodies, we changed our monitoring design from linear transects of traps along track networks to intensive trapping grids, stratified by habitat type. Furthermore, we employed a novel device designed to protect Elliott traps from boodie disturbance whilst still allowing smaller mammals to enter. This resulted in a reduction in the number of boodies trapped and reduced trap rates, but the number of re-trapped individuals increased. There was also a reduction in the number of Elliot traps disturbed by boodies which resulted in a higher trap rate for Shark Bay Mice.

This suggests that different sampling designs may affect the results and this should be considered when interpreting data. It is important that the aim of the trapping session be clear and drive the design process. In this situation, the change in design did not allow for more effective monitoring of all species. It was determined that trapping be used in combination with other methods (e.g. track counts, spotlighting, remote cameras), particularly for highly cryptic species.

### Establishment of an Island Population of the World's Rarest Marsupial, Gilbert's Potoroo *Potorous gilbertii*

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Prior to 2005, Gilbert's potoroo (*Potorous gilbertii*) was only known to exist in a tiny population at Two Peoples Bay Nature Reserve. A trial release of two potoroos onto Bald Island, 25 kilometres east of Two Peoples Bay, for five weeks in February 2005 showed that there was sufficient food available for the potoroos to survive and maintain body mass.

Between August 2005 and December 2007, 10 wild potoroos from Two Peoples Bay were transferred to Bald Island. The new population was monitored by radio-tracking and trapping during 6-8 trips each year and scats were collected at all trapping sessions. 22 new animals have been recorded during trapping sessions, to January 2009. In July 2008, a total of 22 independent animals were known to be alive on the island. As on the mainland, pouch young are present in all months of the year.

The released potoroos rapidly accessed the fungi available. Four potoroos released onto the island only 4 to 8 days previously consumed 23 species of fungi. Three potoroos released between one and two years previously and one island-born individual consumed 27 species of fungi during a two-day sampling period. Thirteen of the 27 fungi species were the same as those that had been consumed by the potoroos within days after their release onto the island.

## Fauna Reconstruction in the WA Rangelands

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The arid areas of Australia, which include most of the West Australian rangelands, have suffered a high rate of loss of mammal fauna in the past 200 years. Of the 85 species of native mammals (excluding bats) known to have once occurred in the arid zone, 11 are now extinct, another six are found only on offshore islands, and 16 are now severely restricted.

Fauna reconstruction is one of the ecologically-integrated components of the Rangelands Restoration project, which aims to restore natural ecosystem function and biodiversity at a landscape scale. The project is being carried out on two adjoining ex-pastoral leases – Lorna Glen and Earaheedy, straddling the Gascoyne and Murchison IBRA regions, north-east of Wiluna.

Since acquisition of the properties by the WA Government in 2000 there has been control of introduced herbivores (camels, cattle and goats), carnivores (cats and foxes) and implementation of ecologically-appropriate fire regimes to maintain a heterogenous landscape. We now aim to reintroduce 11 species of mammals that were formerly present in this area, over an 11-year period. In 2007 and 2008 bilbies (*Macrotis lagotis)* and brushtail possums (*Trichosurus vulpecula)* were reintroduced and have successfully established. Mala (*Lagorchestes hirsutus*) were released in 2008 but proved to be unsuccessful in a "hard release" situation. Several strategies are being implemented to improve survivorship, including better cat control, timing of releases and a soft release pen for Mala and other cat-sensitive species. The populations within the fenced area will also allow more intensive studies of population health and factors affecting translocation success.

## Animal Health Surveillance in Preparation of a Reintroduction of a Critically Endangered Macropod in the Grampians National Park

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In preparation for a reintroduction of *Petrogale penicillata* disease and pathogen studies had two distinct objectives. Firstly the health of the individuals chosen for release had to be ascertained to maximise their survival potential and secondly to minimise the risk of novel parasites and pathogens being introduced to other species in the intended reintroduction area.

Serologically, macropod herpesvirus (MaHV) was of particular interest as positive antibody titres for this disease had been detected in 70% of the *P. penicillata* selected for reintroduction, although there were no overt signs. Because of this, it became essential that the MaHV status of extant species of macropods in the Grampians became known. Parasites implicated in morbidity and mortality in *Petrogale* species from other studies, (hydatids and toxoplasmosis), were also investigated.

Amongst the animals targeted for release, results of repeated physical examinations indicated all animals were normal, especially in regard to oral cavity health. Haematological and biochemical parameters were within normal limits. Faecal floats showed low numbers of strongyles and coccidia or were negative.

Necropsies (n=46) of four species of macropods culled in the vicinity of the Grampians National Park were conducted and blood and tissue samples collected. Of the extant macropods surveyed 91% had positive antibody titres for MaHV, no hydatidosis was observed and all tests for toxoplasmosis were negative. Post release monitoring has detected exchanges of parasites between released animals and wild macropods within the release site.

## An Overview of Mammal Translocations Conducted by the Australian Wildlife Conservancy, 1994 – 2008

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The Australian Wildlife Conservancy (AWC) is a non-profit organisation dedicated to the conservation of Australia's threatened wildlife and their habitats. AWC manages 20 sanctuaries spanning over 25 million hectares for conservation with translocation of mammals representing an important tool in the conservation and restoration of ecosystems. Historically, translocations within AWC have been associated with sanctuaries in southern Australia but there is potential for past translocations to guide future efforts both in southern and northern Australia.

Between 1994 and 2008, over 40 translocations have been conducted for 18 different mammal species. Over 2000 individuals have been translocated in and out of AWC

sanctuaries, with more than 800 of these being for a single species; *Bettongia penicillata*. Translocations have ranged from the movement of single animals from wildlife carers to operations involving relocation of substantial numbers of animals over long distances.

We will review the success of AWC's translocations based on a number of criteria, including post-release survival, evidence of recruitment, and population size over the longer term. Reasons for the success or otherwise of translocation events will be discussed, as will issues relating to overabundance in reintroduced populations. Analysis of AWC's translocation history will be used to inform AWC's translocation strategy and prioritise which species to translocate, and where.

## *Ecology*

### Dietary Overlap between Native and Introduced Carnivores in Eastern Australia

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Dietary overlap between carnivores can indicate the likelihood and potential severity of competition. Invasive predators have had devastating impacts in Australia, but few studies have investigated their interactions with endangered native predators such as the spotted-tailed quoll (*Dasyurus maculatus*). We aimed to quantify dietary overlap between quolls, foxes (*Vulpes vulpes*), feral cats (*Felis catus*) and wild dogs (*Canis lupus* ssp.) in the Barrington Tops, eastern New South Wales, and to detect any differences that may facilitate coexistence. We also sought evidence of intraguild predation.

We investigated the diet of each predator by analysing scats collected from targeted searches and from trapped animals. Mammals dominated the diets of all four predators. Pairwise comparisons between species indicated moderate to high dietary overlap, with the greatest similarities occurring between foxes and cats, and foxes and wild dogs. The endangered quoll showed moderate dietary overlap with foxes and cats, but low overlap with wild dogs. Wild dogs consumed more large mammals than the other predators. Feral cats consumed more small mammals and birds, whereas foxes and quolls mainly consumed small to medium-sized mammals, which they took in similar proportions. There was some evidence of intraguild predation, with fox remains detected in two of 68 dog scats (3%).
Our results show considerable dietary overlap within the carnivore assemblage. However, differences in the size distribution of prey may help to facilitate coexistence. Based on dietary overlap, foxes and cats are likely to present a greater threat to the endangered quoll than do wild dogs.

### The Effect of Time since Fire and Season on Small Mammal Diet

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To aid effective conservation and management of fire-prone ecosystems there is a need to better understand the impact of fire on resource use by fauna. In this study we investigated the diet of Silky Mouse (*Pseudomys apodemoides*), Heath Mouse (*P. shortridgei*) and Yellow-footed Antechinus (*Antechinus flavipes*) at sites with differing fire histories. Due to reports of *Pseudomys* as generalist feeders with the capacity to exploit resources in recently burnt habitats, we expected the diet of both species to change with time since fire. Faecal samples were collected for the three species during winter and spring from 20 sites

representing four time-since-last-fire categories (ranging from 2 to 55 years post-fire) and a microhistological technique was used to classify diet on the basis of broad plant and invertebrate groups. There was a substantial difference in diet between the three species with Yellow-footed Antechinus being the most insectivorous and the Heath Mouse the most herbivorous. Both *Pseudomys* species consumed leaf material from forbs in winter while Silky Mouse consumed more seed in spring. Silky Mouse diet differed between time-since-last-fire categories, with more seed consumed in very recently burnt areas and more flower eaten at older sites. In contrast, there was little evidence that Heath Mouse diet varied with time-since-last-fire category. The results for Silky Mouse were consistent with our original expectation, but this was not the case for Heath Mouse. The different responses to habitat changes due to fire may reduce competition for these two closely related and co-existing species.

## What the *H*…! Selection of the Smoothing Parameter in Kernel Home Range Estimation

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Kernel density estimation is a sophisticated and useful probabilistic method for home range analysis. Selection of the method used to calculate the smoothing parameter, *h*, is the most important choice when undertaking kernel analysis. The strengths and weaknesses of each of the three methods prominent in the literature – the reference method, least squares cross validation (LSCV) and likelihood cross validation (LCV) – will be discussed. In the course of analysing radio tracking data I investigated and applied software that implements the LCV method to calculate *h*.

I calculated $h_{CV}$ using the program Animal Space Use 1.2 (www.cnr.uidaho.edu/population_ecology/animal_space_use.htm) and used the resulting value to manually stipulate *h* in the ArcMAP extension software Home Range Tools (HRT, http://flash.lakeheadu.ca/~arodgers/hre/). It is also possible to complete the home range analysis using Animal Space Use 1.2 for more detailed weighting options. I compared the results of kernel estimation using both the reference and LCV methods on my radio tracking data of western ringtail and common brushtail possums. It was not possible to use LSCV due to small sample sizes and repeated use of diurnal rest sites. The results produced by the LCV method relative to the reference method depended on the distribution pattern of fixes.

Researchers undertaking kernel home range analysis should consider using the LCV method. The software Animal Space Use 1.2 and the HRT Extension are freely available and relatively user friendly. Use of the HRT Extension enables home range analysis to be carried out in a familiar GIS setting.

## Testing the Suitability of Simple Habitat Models: Is Forest Age Class a Good Predictor of Habitat Selection, Abundance and Occupancy?

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Habitat is often defined using statistical models relating response variables such as abundance or occupancy to particular habitat attributes. Past work has shown that fauna respond to attributes representing important resources (breeding sites, shelter, food) and that responses may change with spatial scale. Nevertheless, habitat management is often based on simple models that use broad landscape-scale classifications such as forest age class to define habitat. An implicit assumption of such models is that the simple classification schemes upon which they are based are suitable surrogates for abundance, or other indicators of habitat use. I tested this assumption for two species (the swamp wallaby *Wallabia bicolor* and the heath rat *Pseudomys shortridgei*) at two spatial scales by developing statistical models of habitat selection, abundance and occupancy. I built simple models including a categorical variable representing vegetation age which were then compared to more complex models including variables representing important resources. I expected vegetation age to be identified as an important predictor if the response variables were well represented by a simple habitat model. In all but one case, variables representing important resources were better predictors of habitat selection, abundance and occupancy than vegetation age. The exception was a model predicting diurnal habitat selection by female swamp wallabies, a result that can be explained by a close association between vegetation age and lateral cover, an important diurnal resource. I argue that simple habitat models are unlikely to represent the complexity of fauna-habitat relationships, and may often be inappropriate management tools

## Ecological Determinants of Foraging Behaviour in Rock-wallabies (*Petrogale lateralis lateralis*): Refuge Importance in a Variable Environment

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The black-flanked rock-wallaby (*petrogale lateralis lateralis*) has suffered a large decline in its distribution in Western Australia. This has been attributed to introduced predators and herbivores, fire, and habitat destruction due to clearing. Since 2001 the Department Of Environment And Conservation (DEC) has begun to reintroduce this species back into its former range. However there is little information on the behavioural, foraging and feeding patterns, and the population dynamics of this species. There is a long-standing premise in behavioural ecology that highly variable environments can significantly affect the behaviour and demography of animal populations. Although this has been well documented in birds, primates, and some macropod groups, it has rarely been clearly documented in rock-wallabies. For the success of any current and future reintroductions of rock- wallaby populations into new areas, we need to understand the relationships between the landscape and climatic elements and that of the behavioural patterns and population dynamics of the species in habitat use. In addition although a long term fox baiting program has resulted in

population increases for this species in the Central Wheatbelt, fox presence has been regularly observed throughout the study. Little is known of the impact that this presence may have on the behavioural patterns of rock-wallabies. This study set out to identify the key ecological determinants of the foraging and feeding behaviour *of P. l. lateralis* in a highly variable environment and how the use of a permanent central rock refuge both contributes to their continued survival and may restrict its future distribution.

## Behaviour of the Swamp Antechinus in Contrasting Habitats

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Comparative analyses of the biology of insular and mainland populations of mammals have demonstrated a number of behavioral differences within insular populations, including reduced home range size, increased territory overlap and reduced aggressiveness. We tested the hypothesis that island and mainland populations of the swamp antechinus (*Antechinus minimus maritimus*), an insectivorous marsupial, would differ in their use of space potentially causing disparity in energy expenditure. Island individuals occupied significantly smaller home ranges and were mainly nocturnal, whereas mainland individuals were diurnal and had large home ranges. The small home ranges of island individuals may have been in response to increased food resources, resulting from large allocthonous inputs from seabirds. The nocturnality of island animals was likely to be a predator avoidance mechanism to evade diurnal raptors in the open tussock grassland. These large behavioural differences, however, were not found to influence daily energy expenditure.

## Quantitative Determination of the Abundance of Quokka (*Setonix brachyurus*) Populations in the Southern Forests of Western Australia Using Relative Abundance Indices

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A cost-effective but reliable measure of abundance of quokka (*Setonix brachyurus*) populations is fundamental to understanding the ecology of this species in the southern forests of Western Australia and for the implementation of effective conservation and management actions.

Transect counts of faecal pellet groups have been used to estimate population densities of quokkas in the fragmented swampy habitat of the northern Jarrah forest. Landscape structure and greater habitat connectivity in the southern forest makes the estimation of population abundance more challenging as quokkas are more likely to be moving between habitat patches. If this is the case, then the southern forest population of quokkas is likely to

be important in terms of genetic diversity and resilience to disturbance and demographic fluctuation.

A rapid survey technique has been devised to provide a qualitative measure of relative abundance (i.e. high, medium, low) using indicators of activity including scats and runnels. This subjective and intuitive categorisation of quokka abundance is evaluated and quantified using established methodologies for the estimation of populations.

**Not All Remnants Began Equal – The Relative Influence of Remnant Shape and Environmental Conditions on Agile Antechinus (*Antechinus agilis*) Populations in North East Victoria.**

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Humans have drastically modified natural landscapes, 'fragmenting' continuous vegetation into smaller, more isolated patches surrounded by a matrix of different land cover-types. Fragmentation is a serious threat to biodiversity. Linear vegetation remnants are generally thought to provide lower quality habitat for wildlife than larger patches. There is increasing recognition, however, that parameters other than remnant shape and size also affect the value of remnants for wildlife. I investigated the influence of natural variation in environmental conditions on Agile Antechinus (*Antechinus agilis*) populations in Forest Patches (FPs) and Linear Roadside Remnants (LRRs) at five sites in the Strathbogie Ranges, north-east Victoria, Australia. My study contrasted with an earlier study in the same area which deliberately minimised inter-site environmental heterogeneity. I also radio-tracked male antechinus in both remnant shapes. Tick loads were higher, and females were smaller, in LRRs than FPs. Remnant shape, however, did not affect antechinus abundance, body mass, condition or male pes length. In contrast, site location affected abundance and sex ratios. Antechinus abundance was positively correlated with a PCA factor which described cut stump density and dense cover availability. Radio-telemetry suggested that remnant shape influenced the ranging behaviour of individuals. This potentially biases comparisons of FP and LRR population densities toward FPs (if trapping success along single transects is used to estimate densities). This issue aside, remnant shape was not a good indicator of remnant habitat quality for antechinus. My study highlights the need to consider other environmental variables when assessing the value of remnants for forest-dependent species.

## *Introduced Predators*

### Mammalian and Reptilian Predators: Niche Overlap and Competitive Interactions

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The introduction and spread of the red fox (*Vulpes vulpes*) and feral cat (*Felis catus*) has dramatically altered faunal composition in Australia. Consequently these carnivores are actively managed for native fauna conservation. Native predators may compete with foxes and cats, either for resources, through agonistic interactions or both, and such competition may have profound impacts on faunal community composition. However, the impact of fox and cat control on competing native predators, and hence the faunal community, is unclear.

One group of high-order predators that are rarely considered by managers and researchers in this context are varanid lizards. Varanids are a conspicuous feature of the Australian landscape and are the top native terrestrial predator over much of the continent, but being reptiles their response to carnivore management and impact on shared prey is largely ignored. Using mechanistic niche modelling, we investigate the potential for competition between foxes, feral cats, two large varanid lizard species (*Varanus rosenbergi* and *V. gouldii*) and a large dasyurid, the chuditch (*Dasyurus geoffroii*). We model the energetic requirements of each predator and its potential impact on prey communities. All of these active predators occur in the northern jarrah forest of Western Australia, where a large scale fox management program has been under way for over 10 years. We illustrate the relative impact that reptilian, marsupial and eutherian predators may have on prey communities and contend that reptilian predators warrant serious consideration in Australian predator guild interactions.

### The Influence of Predation Risk on the Behaviour of the Western Grey Kangaroo

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Predation risk influences foraging decisions and time allocation of prey species. Habitat shifts from potentially dangerous to safe areas have previously been reported. We tested the efficacy of predator scents to influence time allocated to different behaviours, to dissuade feeding from habitual areas and to induce changes in habitat use of a wild population of western grey kangaroos (*Macropus fuliginosus*) . Kangaroos were exposed to the odour of an historical predator, the dingo (*Canis lupus dingo*), an introduced predator, the red fox (*Vulpes vulpes*) and two control treatments, an unscented and an herbivorous odour. We

hypothesised that predator scents would provoke an increase in vigilance and a change in the kangaroos' distribution. Kangaroos did not increase their anti-predator scanning behaviour in predator scented areas (mean number of scanning events was 7.3±1.05 in unscented areas, 7.3±0.82 for horse, 4.3±1.58 for fox and 5.9±1.04 for dingo; mean time spent vigilant was 100.7±18.7 sec in unscented areas, 85.9±11.2 sec for horse, 48.6±18.5 sec for fox and 60.2±15.8 sec for dingo). However, kangaroos showed strong investigative behaviour by approaching and sniffing the odour sources. They exhibited clear avoidance responses to both predator scents, modifying their space use by moving away or escaping from these odours (mean time spent moving away was 18.3±5.3 sec for fox and 16.1±5.3 sec for dingo; mean time spent escaping was 41.4±17.5 sec for fox and 33.8±13 sec for dingo). Kangaroos were deterred from predator scented areas and shifted to control sites, although preferred feeding patches were not completely abandoned.

## *Climate Change*

### Climate Change Impacts on Mammals: the Gnangara Sustainability Strategy, Western Australia.

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Declining rainfall and increased aquifer abstraction have heavily impacted water availability and ecosystems on the Gnangara Groundwater System (GGS), which supplies 60% of Perth's water. The Gnangara Sustainability Strategy (GSS) was established to develop a sustainable water management regime under future predicted climate changes, the impacts of which are likely to be severe for mammals. This study investigated the previous and current distribution of mammals on the GGS, and predicted impacts of climate change. Forty sites surveyed using pit-fall, Elliot and cage traps (2007-08) represented the range of landforms, vegetation and fuel ages. Targeted trapping surveys were also undertaken for *Isoodon obesulus* (Brown Bandicoot, Quenda) and *Hydromys chrysogaster* (Water rat, Rakali) focusing on wetlands. Nine native and seven introduced mammal species were recorded during the general survey and capture rates were very low. *Tarsipes rostratus* (Honey Possum) was the most common native species and was trapped at sites widely distributed across the area. Quenda were recorded at 5 of the 9 targeted sites, the highest abundance being at the only site fenced and baited against predators. *H. chrysogaster* was present at a number of lakes indicating that currently they provide suitable habitat and food resources. Evaluation of the current extinction risk of mammals identified that more than 60% are likely to suffer further declines under conditions of reduced rainfall. These studies have provided information necessary for management and recovery actions that will be required under predicted future climatic changes.

### Impacts of Fire and Climate Change on Honey Possums (*Tarsipes rostratus*) in *Banksia* Woodlands

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Natural ecosystems are subjected to human-mediated disturbances that substantially modify ecosystem process and patterns. Understanding the influences of human-mediated disturbances is important for setting appropriate management and conservation priorities. The honey possum *Tarsipes rostratus* is a south-west Western Australian endemic marsupial species that is potentially threatened by a number of human-mediated disturbances. Our study investigated the influence of fire and the potential impacts of climate change on honey possums on the Gnangara Sustainability Strategy study area, northern Swan Coastal Plain. Over 30 sites of varying fire ages were trapped for honey possums during 2007 and 2008.

Fire age was significantly associated with honey possum abundance, with peak abundance occurring in sites that were 22 – 26 years since last burnt. In contrast, lower abundances of honey possums were observed in very young or very old fire age sites. The potential impacts of climate change in south-west Western Australia include climate change induced declines in rainfall. We modelled possible changes in honey possum abundance under different climate change scenarios, with the worst case rainfall scenarios predicting a 57 % decline in honey possum densities. Our results provide substantial information for conservation managers regarding the impact of disturbances on honey possums and will be incorporated into regional management strategies.

**Modelling Biotic Interactions under Climate Change Scenarios: Predicting Northern Bettong (*Bettongia tropica*) Distribution**

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The northern bettong (*Bettongia tropica*) is an endangered rat-kangaroo restricted to Queensland's Wet Tropics Bioregion; an area that previous research indicates many species will be sensitive to climate change. There is a need to understand what constitutes suitable habitat of the northern bettong, in particular the role that climate and biotic interactions have on its current distribution to allow for future predictions under climate change scenarios. Correlative species distribution models are commonly used in an attempt to predict the future distribution of a species. Integrating biotic interactions into such models, particularly those that are directly tied to the abiotic environment and drive current species distributions, allow for a more reliable prediction under a varying climate scenario. Current potential distribution models for the species, modeled using the abiotic correlates of occurrences and including biotic interactions reveal a small realized distribution where the species coexists with cockatoo grass (*Alloteropsis semialata*) and truffle species. We used several modeling algorithms under varying climate change scenarios to integrate predicted distribution models of the northern bettong and these species. With rainfall predicted to become more seasonal in the Wet Tropics, it is anticipated that truffle species distributions will contract towards the rainforest, tracking rainfall, and potentially prevent its co-occurrence with cockatoo grass. As it is essential that habitat contain both truffles and cockatoo grass to maintain *B. tropica* populations throughout the year, modeling will allow us to predict which areas will remain suitable under future climate scenarios.

## Climatic Constraints on the Distribution of the Platypus (*Ornithorhynchus anatinus*)

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Understanding the factors influencing the distribution of a species is necessary for informed management and conservation planning. Current distribution estimates of the platypus are based solely on sightings and capture data from researchers; little is known about the environmental determinants of that distribution. It is our goal to fill this gap in knowledge and provide a better understanding of platypus distribution.

Using a large data set of sighting records (n=4,315) we have generated a predictive climatic model to examine range limiting environmental factors. In doing so, we have also produced a new distribution map for the platypus.

We found that the factors contributing most to the locations of suitable platypus habitat were the amount of precipitation in the driest quarter and the temperature during the hottest quarter. That an amphibious mammal requires a certain amount of water in its habitat comes as no surprise, particularly when many fluvial systems in Australia are seasonally ephemeral. It is also vindicating to see that temperature is an important factor as it has been one the primary factors hypothesized in regards to the northern limit of the platypus distribution by researchers for decades.

Our predictive models also support the observations of regions lacking in platypuses, which create distribution gaps in north Queensland. The gaps are on a scale that may warrant the future resurrection of regional sub-species nomenclature, particularly when combined with other empirical data on northern Queensland platypuses.

## *Parasites and Disease*

### *Mycobacterium ulcerans* Infection in Marsupials and Their Possible Role as Reservoirs for Human Outbreaks

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*Mycobacterium ulcerans* is the causative agent of Bairnsdale/Buruli ulcer (BU), an infection of humans, which can lead to extensive destruction of the skin and subcutis. BU has been reported in over 30 countries, mainly from tropical and sub-tropical regions**,** especially West Africa. In Australia, BU occurs in coastal Victoria and Queensland, and occasionally the Northern Territory. Early Victorian cases were described from the Bairnsdale region, with subsequent outbreaks further to the west (e.g. Phillip Island). In the current outbreak, at Point Lonsdale, over 100 cases have been diagnosed since 2002. BU has also been reported in domestic animals and wildlife, including koalas, brushtail and ringtail possums and potoroos. We are investigating the ecology of *M.ulcerans* in ringtail and brushtail possums, and their possible role as wildlife reservoirs. We surveyed the distribution of *M.ulcerans* in possums via PCR of faecal samples collected at Point Lonsdale, Phillip Island, and two "control" sites, (i.e. no reports of disease in possums or humans). At Point Lonsdale we examined ringtails and brushtails for clinical signs and infection status. We also conducted spotlight surveys of possum population density. PCR analyses of faeces indicated that *M. ulcerans* is widespread in possums in Point Lonsdale, and absent from control sites. A higher proportion of ringtails were infected than brushtails and lesions were only observed in ringtails. Ringtails were at much higher population density (19 fold) than brushtails. We propose that possums may act as a reservoir for this bacterium, and that mosquitoes could play a role in transmission.

### Platypus Mucormycosis Disease in Tasmania: Distribution, Prevalence and Impacts

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While the fungal disease mucormycosis has affected Tasmanian platypuses for nearly three decades, its impacts remain largely unknown. Though a number of mechanisms are suggested, it is currently unclear what the route of individual infection is, or how mucormycosis is spread within or between catchments. To begin assessment of mucormycosis impacts we documented the spatial and temporal distribution of the disease. Over 1700 historic platypus capture and observation records were collated and mapped. They indicate that

between 1982 and 2009 mucormycosis affected platypuses in at least 11, and potentially 22 of Tasmania's 48 river catchments. In 2008-09, live-trapping surveys were undertaken across Tasmania to determine the spread, prevalence and persistence of the disease. Sixty seven rivers and streams were sampled across 16 catchments. Only six of the 160 individuals captured were ulcerated with mucormycosis. Affected individuals were captured from three catchments, including one where mucormycosis has infected platypuses for at least 20 years. Detection probabilities were calculated to estimate the probability that the other surveyed catchments are disease free. Detection probabilities were generally high (>0.9) per catchment, indicating sampling effort was adequate to reliably detect the disease if it was present at historically reported prevalence (around 35% of individuals were ulcerated in infected populations studied in the mid 1990's). However in 2008-09 disease prevalence dropped to only 3.7%. An order of magnitude decline in prevalence from 1994 to 2008-09, makes disease detection more challenging; increased sample sizes are required to confidently assert that some catchments are currently disease free.

## A Wildlife Pandemic? Are Introduced Predators and Disease the Causes of the Collapse of Woylie (Brush-tailed Bettong) Populations?

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The woylie (*Bettongia penicillata*) has declined by about 80% since 2001. The declines in Western Australia and South Australia have been rapid (<95% per annum), substantial (>90% lost) and apparently biased toward the largest and most important populations. The declines are continuing in some areas and as yet there have been no clear signs of a sustained post decline recovery. Most of the remaining unaffected populations are small (<300 individuals), isolated and inherently vulnerable.

The species collapse was unexpected. It followed a successful recovery of the species during the previous 25 years, due principally to the successes achieved by fox control and more than 50 translocations. Research into the cause(s) of the current declines began in 2006 and remains critically important to the conservation of the species. Using Caughley's 'Declining Population Paradigm' as the principal research framework the project has involved a large, collaborative, multidisciplinary, interagency research team. An update is provided on work in progress investigating woylie demographics, survival and mortality and the key putative agents of decline – predators, food resources and disease.

While different factors appear to be involved in at least some of the declines, based on current evidence from the focal populations in the Upper Warren region, the leading hypothesis remains that the observed rates of increased mortality are principally associated with predation/scavenging of individuals made more vulnerable by some other factor, principally disease.

## Oxalate Nephrosis in Koalas in the Adelaide Hills

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Kidney disease is a leading cause of death in the koala population of the Adelaide Hills and appears associated with oxalate nephrosis, a disease in which oxalate is deposited in the kidneys. The current study investigates the possible cause(s) of oxalate nephrosis in these koalas and whether it is due to a deficiency of the liver enzyme alanine: glyoxylate aminotransferase (AGT). In humans this condition is called Primary Hyperoxaluria type 1 (PH1) and has an autosomal recessive pattern of inheritance. Diagnostic testing includes urine oxalate and liver AGT activity and treatment includes vitamin B6, a coenzyme for AGT.

Previous studies have shown that the koala population of the Adelaide Hills has low genetic variability, increasing the likelihood of a condition such as PH 1. Also, Adelaide Hills captive koalas diagnosed with kidney disease respond to vitamin B6 treatment. If a PH 1 - like disease is affecting these koalas, then: a) mainly young koalas would be affected, b) similar numbers of males and females would be affected and c) the koalas would have increased urine oxalate and decreased AGT activity. Initial epidemiological data shows that 64% of koalas with gross evidence of kidney disease were in the youngest age class (up to approximately two years old) and that more females (9♀:5♂) were affected. These initial results suggest that a disease similar to PH 1 is the cause of oxalate nephrosis in the koala population of the Adelaide Hills, although further studies on urine oxalate and AGT activity are required.

# POSTERS

### Mean Retention Time of Truffle Spores in the Swamp Wallaby Digestive System

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The dispersal of 'truffles' (sequestrate mycorrhizal fungi, symbionts with forest trees) by mammals is an important ecosystem process that contributes to the health of forested ecosystems. Most truffle-eating (mycophagous) mammals are gone from the New England Tableland region of north-eastern NSW. However the swamp wallaby, a preferential mycophagist, is resilient in these landscapes and may be playing a key role in maintaining the vital mammal-truffle-plant relationship. We are investigating the importance of swamp wallabies as truffle spore dispersal agents in modified landscapes. We are examining foraging patterns, defecation patterns and truffle spore content of faecal pellets in free-ranging swamp wallabies and retention time of truffle spores in captive swamp wallabies. Here we assess the mean retention time of truffle spores in the swamp wallaby digestive system.

A digesta passage experiment was conducted with captive swamp wallabies. Wallabies were fed a dose of fresh truffle sporocarps of known identity and their faecal pellets collected at regular intervals over the following 96 hours. Faecal pellets were dried and examined for the presence of truffle spores. The mean retention time of truffle spores was calculated and a plot of fungal spore passage over time was produced.

Other studies have calculated digesta passage rates for macropods, but this is the first study to examine fungal spore digesta passage in the swamp wallaby. The use of this information in modelling the spore dispersal potential of swamp wallabies in modified landscapes will be discussed.

### The Phylogeography and Population Genetics of the Long-nosed Potoroo (*Potorous tridactylus*)

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The long-nosed potoroo (*Potorous tridactylus*) is restricted to patchy and disjunct populations throughout coastal south eastern Australia, from southern Queensland to western Victoria and Tasmania. It is listed as 'vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999,* and 'endangered' in Victoria. Understanding the genetic structure of such populations is important for effective conservation management, especially to protect their future evolutionary potential. The long-nosed potoroo's elusive nature has limited genetic investigation of the species to date. Out study will be the first to look at broad phylogeographic patterning across the species range (using mitochondrial DNA (mtDNA) analysis) as well as fine scale population genetics (*via* microsatellite analysis) within and

between neighbouring populations, including mating systems, dispersal patterns, and relatedness. Tissue samples are being collected (to date: n= 173 from 12 sites) from throughout the species range either via trapping or from museum or government collections. DNA sequence analysis of a section of the mtDNA d-loop has commenced with highly significant divergence detected between southern Queensland/northern New South Wales potoroo populations and southern NSW/eastern Victorian potoroo populations. Population genetics studies have also commenced, initially aiming to identify microsatellite loci that will cross amplify in the long-nosed potoroo. 52 microsatellite loci developed from *Potorous longipes, Bettongia tropica Petrogale xanthopus, Petrogale assimilis, Onychogalea fraenata, Macropus eugenii* and *Macropus giganteus* have been found to amplify in the long-nosed potoroo, however the level of polymorphisms at these loci are yet to be determined.

**Preliminary Assessment of Non-target Risk Associated with Poison Baiting for Introduced House Mice on Boullanger and Whitlock Islands, Western Australia**

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Boullanger and Whitlock Islands, off Jurien Bay, support a diverse terrestrial vertebrate fauna, including two marsupials (the endangered dibbler *Parantechinus apicalis* and the grey-bellied dunnart *Sminthopsis griseoventer*), a gecko and five skinks. House mice were recorded on Boullanger in 1961 and are now found on both islands. In 2007 a workshop recommended a study of the feasibility of eradicating house mice from the islands by poison baiting and the risk posed to non-target species.

We monitored the uptake of non-toxic rodent baits containing rhodamine-B by mammals on Boullanger Island through whisker sampling, and by reptiles through observation of the dye in faeces. The response of dibblers to mouse carcasses on Boullanger Island was observed with motion-activated cameras, while on Whitlock Island, uptake of rhodamine-B in mouse carcases by dibblers was monitored by whisker sampling. We also compared bait uptake using alternative methods of delivery: scattering in the open versus delivery in PVC tubes.

Bait consumption was high for mice (92% of individuals) and moderate for dibblers (48%): no dunnarts consumed baits. Delivery in tubes did not reduce bait consumption by dibblers. The trials with mouse carcases showed that dibblers eat them. In cafeteria trials, 9 of 10 captive dibblers consumed baits. Insufficient collection of scats prevented testing the effect of delivery method on bait consumption by King's skinks (*Egernia kingii*). We conclude that poison baiting on the islands is likely to cause a significant decline in dibbler numbers, although this might be reduced by using more sophisticated bait stations.

## Cross Catchment Gene Flow in the Platypus

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In a changing world where biodiversity management has become of vital importance, the study of population genetics is playing an increasingly important role. As a tool, population genetics gives researchers and wildlife management planners insight into the nature and dynamics of animal populations that may be unachievable with conventional field techniques. Using microsatellite markers to investigate platypuses from two adjacent river systems (the Shoalhaven and Hawkesbury-Nepean) in southeast New South Wales we were able to identify movement of platypuses between neighbouring systems and to discern genetic structuring at the river system level.

A detailed examination of the population structuring suggests that catchments represent the basic level of population structuring while movement of individuals between populations maintains gene flow within a region.

We found evidence of greater than expected gene flow between river systems, 13 individuals out of 120 available samples were determined to be first generation migrants. This helps explain the genetically contiguous nature of platypus distribution across most of eastern Australia. Of the 13 migrants animals, five were male and eight were female. The observed difference in the sex ratio of migrant animals was not significant ($\chi^2 = 0.405$, $p > 0.05$).

An improved understanding of population structure will be a valuable contribution to designing accurate management plans for the long-term conservation of this unique Australian animal.

## Locomotion in Torpid Planigales

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Recent work has shown that some mammals can become mobile when torpid, either to move to a basking site or for other purposes. As almost nothing is known about coordination and movement at low body temperature ($T_b$) in mammals, we investigated locomotion as a function of $T_b$ in Giles' Planigale, *Planigale gilesi*. These small dasyurid marsupials are known to employ daily torpor and basking to passively rewarm from torpor. Running speed of six *P. gilesi* was measured using a video camera; $T_b$ was measured remotely via temperature-sensitive transmitters. Planigales were able to move at all $T_b$s measured. Running speed increased with increasing $T_b$ and was 0.22 ± 0.05m/s ($T_b$ 17.6°C), 1.00 ± 0.11m/s ($T_b$ 27.5°C) and 1.89 ± 0.14m/s ($T_b$ 37.5°C). Thus, running speed increased by more than eight times over a 20°C $T_b$-range (sigmoidal regression model, $r^2 = 0.995$), demonstrating the significant influence of $T_b$ on locomotion. Our study is the first to examine the effect of low $T_b$ on locomotion in mammals. It confirms that these small marsupials are still capable of coordinated movement at extremely low $T_b$. This ability to move at low $T_b$ has important implications for their survival in the wild, as it not only permits basking to reduce energy expenditure during rewarming from torpor, but, even though movement is slowed, also will allow escape from predators.

## Fire Ecology of Southern Brown Bandicoots and Long-nosed Potoroos in Southwest Victoria

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South-eastern Australia is considered one of the most severe fire environments on earth, with the climate, topography and vegetation of this region resulting in many devastating wildfires. As a result, prescribed burning is undertaken to reduce fuel loads. Fire is also increasingly being used as a tool for management to aid in the conservation of biodiversity. The southern brown bandicoot, *Isoodon obesulus,* and long-nosed potoroo, *Potorous tridactylus*, are considered near threatened and endangered in Victoria respectively. Their geographic range includes the fire-prone southwest region of the state, where fire is also frequently used as a management tool.

My study aims to determine how southern brown bandicoots and long-nosed potoroos in southwest Victoria are affected fire, both prescribed burning and wildfire, to assist in establishing suitable fire management practices with respect to the two species. I will investigate the distribution and habitat preferences of the two species in this region, taking into account fire history. Changes in bandicoot and potoroo populations will also be assessed before and after prescribed burns. Remote camera trapping will be undertaken to overcome the low detectability of both species, which are known to be trap shy and generally occur at low densities. This research will strengthen knowledge on the distribution and habitat

preferences of the two species, and provide insight into the consequences of fire to inform effective conservation and fire management.

### Hibernation in a Subtropical Microbat

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Hibernation or multi-day torpor is commonly employed by bat species that reside in temperate regions. In contrast, information on hibernation in bats from tropical or subtropical regions is entirely lacking. We quantified torpor use and patterns in eight northern long-eared bats, *Nyctophilus bifax* (~10g), during winter in a subtropical region on the NSW north coast by temperature telemetry. Bats used torpor on 100% of observation days, with the duration of torpor bouts ranging from 0.8 to 128.5 h (5.4 days). All bats entered at least one torpor bout lasting >48 h during the study period. Torpor patterns were affected by ambient temperature ($T_a$); during cooler periods bats remained torpid throughout the whole day, whereas on warmer days they aroused around sunset to likely feed for several hours before becoming torpid again. Torpor bout duration was negatively correlated with mean $T_a$ over the bout ($P < 0.001$, $R^2 = 0.5$). The lowest skin temperature recorded during winter was 9.4°C and minimum skin temperature was positively correlated with $T_a$ ($P < 0.001$, $R^2 = 0.3$), and was also influenced by the ambient conditions of the roosts in which the bats were residing. Our study provides the first evidence of hibernation in a subtropical free-ranging bat. Duration of torpor bouts measured here was similar to that in some temperate zone hibernators, such as hamsters and chipmunks. Thus, even in subtropical climates, small bats can employ prolonged torpor for energy conservation, balancing energy supply and demand to suit prevailing climatic conditions.

### Animals to Develop Techniques for Managing Overabundant, Free-ranging Populations

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The Common Brushtail Possum (*Trichosurus vulpecula*) is a serious ecological and agricultural pest in New Zealand, and very abundant in many Australian cities. Management of overabundant native species is contentious, with wildlife managers increasingly using fertility control as a humane option. Recent research on possum reproductive biology has identified vital embryonic proteins, embryonic shell coat protein 4 (CP4) and vesicle associated protein 1 (VAP1), which we used to produce immunocontraceptive vaccines. DNA vaccines have advantages over conventional vaccines, including a wider range of immune response types, long-lasting effects, and the purity of antigens (e.g., delivery of the

vaccine as a mammalian protein). This study investigates the immonocontraceptive potential of 3 vaccines for management of possum populations.

DNA vaccines were produced by cloning the genes for marsupial specific proteins (CP4, VAP1 and a combination of both) into a mammalian vector. *In vitro* expression was performed in Chinese hamster ovary (CHO) cells in order to confirm the expression of respective proteins in mammalian cells. The vaccines were delivered intramuscularly to mature captive female possums (initial pilot study: n = 3 for each vaccine & 3 controls) commencing in the 2008 breeding season.

The vaccines were found to be effective, reducing fertility by over 70% without impacting negatively on animal health or reproductive cycling. Significant changes, with respect to social hierarchy, activity pattern and denning behaviour, were observed for a short period, possibly induced by elevated immune responses. Following the success of captive trials, we have now commenced testing vaccines in free-ranging populations.

## Will Squirrel Gliders Use a Land-bridge to Cross a Road-gap?

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Gliding mammals are potentially sensitive to impacts from roads, particularly where they may form barriers to dispersal. However, mitigating road impacts on gliding mammals is a relatively new endeavour. In 2005, Brisbane City Council completed the expansion of Compton Road from a 2-lane to a 4-lane arterial road. This development included the installation of a land-bridge with wooden poles for gliding mammals. Our study aimed to investigate whether these wooden poles were used by squirrel gliders to cross the road. Trapping was conducted on a grid that straddled the road on 14 occasions between June 2005 and March 2008, for 892 trap-nights. No gliders were captured on both sides of the road. Ten gliders from the grid were radio-tracked for 2-6 months each. Gliders were recorded across the road from their home remnant on only 3 of the 398 occasions they were located at night. Surveys with hair-tubes of the 8 poles that span the land-bridge revealed glider hair on 7 of the poles in 3 of 16 sessions across a 2-year period. This suggests that wooden poles have the potential to reconnect habitat severed by roads for gliding mammals. Studies are now required of poles installed at other road locations, including directly on the roadside, to determine the generality of this finding.

## Variation in the Diet of the Woylie, *Bettongia penicillata*

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The Woylie *Bettongia penicillata*, endemic to the south-west of Australia, has recently suffered severe population declines. This has prompted investigations to better understand its ecology, and help identify the causes of decline. Previously, little work has been undertaken on the diet of the Woylie, and this study was conducted to investigate temporal and spatial variation in the diet, and assess food resource availability, in order to identify whether food resources are a contributing factor in the recent declines. The diet of the species was examined at five locations (Upper Warren, Karakamia Sanctuary, Tutanning and Batalling Nature Reserves and Dryandra Woodland) in south-west Australia using scat samples collected during Woylie population monitoring. Preliminary findings indicate that fungi (mostly sporocarps of hypogeous fungi), is the major dietary component of the Woylie at all locations, but they were also found to consume plant material, invertebrates and seed. Significantly less fungi and more plant material was recorded in the diet of Woylies at Karakamia Sanctuary. Differences in the minor dietary components (<25%) were recorded between localities. More seed was recorded in the diet at the Upper Warren, and more invertebrates were recorded at Tutanning and Batalling. The dietary differences are likely to be related to different habitat factors at each of the localities. Data obtained from these studies will be interpreted in relation to recent Woylie population declines and the ecological role of Woylies in ecosystem health and diversity.

## Developing Threatened Species Policy – The Water Mouse *Xeromys myoides*

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The Department of the Environment, Water, Heritage and the Arts (DEWHA) is currently developing policy statements for a variety of threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act protects 'matters of national environmental significance', including listed threatened species, through the assessment of actions that are likely to have a significant negative impact on a listed matter. The policy statements aim to assist the community to design developments and other proposed actions so as not to have a significant impact on listed threatened species.

The threatened species policy statements expand on the Australian Government's existing EPBC Act Policy Statement 1.1– Significant impact guidelines for matters of national environmental significance by defining populations and important habitat, identifying threats, and defining significant impact thresholds and appropriate mitigation strategies for a particular species or species group. This information is developed through discussions and

conclusions drawn from an expert workshop. The expert workshops focus on sharing important knowledge on threatened species whilst building relationships between state and Commonwealth governments, researchers and conservation organisations.

EPBC Act policy statements are currently being prepared for a number of Australia's threatened mammals including the western ringtail possum (*Pseudocheirus occidentalis*), water mouse (*Xeromys myoides*) and quokka (*Setonix brachyurus*). This poster provides an insight to developing policy on threatened species using the water mouse *Xeromys myoides* as an example.

## Evidence of Toxoplasma and Neospora Infection in Western Grey Kangaroos (*Macropus fuliginosus ocydromus*) but Not Black-flanked Rock Wallabies (*Petrogale lateralis lateralis*) in South-western Western Australia

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*Toxoplasma gondii* and *Neospora caninum* are coccidian parasites of cats and dogs. Infection of adult cats and dogs respectively, is usually asymptomatic, but infection of juveniles may cause encephalitis, systemic disease and death. Many other species can also be infected as end or intermediate hosts, resulting variously in no symptoms, encephalitis, systemic disease, abortion, or death. *Toxoplasma gondii* has been implicated in the decline of some native marsupials, including the Woylie (*Bettongia penicillata*).

We tested 102 western grey kangaroos (*Macropus fuliginosus ocydromus*) from two nature reserves and two golf courses in Perth, Western Australia, and 68 black-flanked rock wallabies (*Petrogale lateralis lateralis*) from Mt. Caroline, 170 km east of Perth, for serological evidence of infection by either organism. We used indirect fluorescent-antibody tests where test plasma is added to specific antigens followed by rabbit anti-marsupial IgG and then by fluorescein-isothiocyanate conjugated to porcine anti-rabbit IgG. Overall, 12 % of the kangaroo samples tested positive for *Toxoplasma gondii* and 25 % tested positive for *Neospora caninum*. All the rock wallaby samples tested negative for both parasites. On one of the nature reserves where there are neither dogs nor foxes, 12 out of 24 kangaroos tested positive for *Neospora caninum*, with six of these sero-converting, negative to positive, between February and May, 2007.

These results indicate that in Perth, infection of *Macropus fuliginosus ocydromus* by both *Toxoplasma gondii* and *Neospora caninum* is common and further investigation of the significance of these findings is warranted.

## Threatening Processes Influencing Occupancy Rates of Arboreal Mammal in Far East Gippsland

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Key ecological factors regulating individual and population levels of arboreal mammals include the abundance and structure of habitat resources, predation pressure, competition, and disturbance processes.

The common ringtail possum (*Pseudocheirus peregrinus*) is heavily predated upon in far East Gippsland, Victoria by both native and introduced predators. The affects of predation can be influenced or compounded by environmental disturbances and threatening processes. Land management practices, wildfires and control burning can alter habitat characteristics including food availability, refuge access and nesting sites. This research looks at how these interacting influences impact upon the occupancy rates of this species and other arboreal mammals in the area.

Spotlight surveys were conducted throughout the Cape Conran Coastal park, and surrounding state forest, over a 12 month period to ascertain proportional abundances of arboreal mammals. For each transects used throughout this survey habitat characteristics, fire regime and logging history was collected. Combined with predator presence and fox baiting regimes this information can provide a comprehensive picture of disturbance processes on the populations surveyed.

The conservation benefits to 'critical weight range mammals' of fox management strategies can be informed by highlighting these disturbances processes. The influences exerted can compound the problems of predation pressure to have a limiting effect on population levels of arboreal mammals.

## Small-scale Movement Patterns of Three Small Dasyurids in Semi-arid Australia

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Almost no information is available on detailed daily movements of small dasyurids from Australia's arid and semi-arid centre. We therefore aimed to investigate small-scale movement patterns of three species (*Planigale gilesi*, *Sminthopsis crassicaudata* and *S. macroura*) from semi-arid regions. Animals were equipped with internal radio-transmitters to monitor daily movement patterns and burrow use over 4 to 25 days in autumn and winter. Home range size was 0.12 ± 0.02 ha for *P. gilesi* (*Pg*, 6.8 g), 1.70 ± 0.05 ha for *S. crassicaudata* (*Sc*, 10.8 g) and 5.17 ± 2.52 ha for *S. macroura* (*Sm*, 16.3 g). The minimum distance between consecutively used burrows was 41 ± 33 m (*Pg*), 25 ± 8 m (*Sc*) and 103 ± 61 m (*Sm*), and all three species re-used burrows. The maximum distance covered by individuals over the study period was 104 ± 16 m (*Pg*), 268 ± 64 m (*Sc*) and 444 ± 121 m (*Sm*), and hence significantly increased with body mass ($p<0.05$). Our data provide the first information on small-scale movements based on telemetry of any of the three species in a

semi-arid habitat. The data suggests that over the period measured all three species have small and defined home ranges.

## An Odd Population of *Trichosurus vulpecula* Is an Interesting Example for Possum Conservation

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In November 2004, a preliminary assessment of possum habitat values in a remnant riparian strip in the agricultural area near Geraldton, Western Australian, confirmed the brush-tail possum *Trichosurus vulpecula* used habitat along approximately 18 km of the Chapman River. Diurnal behaviour was observed to be unusual - possums were visible, resting in tree forks or on branches. Even though the population is disjunct (200 km) from a large regional population further south, 1990s conservation rankings assigned it to the south-western subspecies, *T. v. hypoleucus.* However, behaviour, habitat usage and body size (*via* a north-south cline) differentiate it from the main regional population. In the context of the broader decline of *T. vulpecula* in Western Australia, the Geraldton population appears to be the only example of *T. vulpecula* recently confirmed extant within a modern *T. vulpecula* extinction zone covering an area about the size of Victoria. The Chapman Valley's riparian habitat strip is limited and owned under numerous land titles. The nearby ports of Geraldton and Oakajee, with mid-western mining, associated industries and services will result in increased human impacts around Geraldton over coming decades that are likely affect the Chapman Valley. When the 2004 habitat inspection was repeated in October 2008, possums were less common: only two possums sighted compared with ten in 2004, despite increased search effort in 2008. Rankings of 'lower risk' of 'near-threatened' for the species or subspecies seem unable to provide this distinctive possum population with the recognition required to secure an optimistic future.

## Herbivore Feeding Preferences in Captive and Wild Populations

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Investigations into the mechanisms underpinning plant selection by herbivores have often yielded conflicting results. Such inconsistency might stem from whether selection experiments are conducted with captive or wild populations, and upon the different measures of plant selection used to determine herbivore preference. Here we compared the feeding preferences of captive and wild kangaroos (*Macropus fuliginosus*) using a standard set of plant species (14 *Hakea* spp, Proteaceae) and several different measures of herbivore selection to examine how environment influenced relative consumption. Three indices of

herbivore consumption were measured: number of plants [NP], total shoot volume per plant [TV] and percentage available shoot volume [PV] consumed. NP and TV were closely correlated in the wild and captive populations and consistently correlated with six morphological and chemical plant attributes; the most notable being a strong negative correlation with shoot phenolic content. This consistency suggests that plant selection by captive kangaroos is broadly consistent with that observed in field trials, and consequently that for macropods at least, captive trials offer a valid way to determine the relative acceptability of different plant species. However, the fact that our third measure of herbivore selection PV was weakly correlated in captive and wild populations and showed no relationship with shoot phenolic content, highlights the importance of which measure of plant selection is applied. We suggest that while NP and TV are potentially confounded by plant size and availability, they offer the clearest insight into plant selection while PV is more suitable for plant-centered studies.

## Monitoring a translocated Population of Black-flanked Rock-wallabies (*Petrogale lateralis lateralis*) at Paruna Sanctuary, Western Australia

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Between 2001 and 2007 sixty five (65) Black-flanked Rock-wallabies (*Petrogale lateralis lateralis*) were translocated to Paruna Sanctuary in the Avon Valley, Western Australia. Paruna, owned and managed by the Australian Wildlife Conservancy, is 2000ha of private conservation estate that connects Avon Valley National Park to Walyunga National Park. Rock-wallabies have also been translocated to both of these National Parks in an attempt to re-establish the species in the region after over 70 years of localised extinction. Monitoring the Paruna Rock-wallaby population has been conducted using several methods including radio-tracking, scat counts and searches, direct observation and motion-sensor camera surveillance. The advantages and limitations of these various monitoring techniques are discussed. Results from this monitoring program provide insights into the population establishment and dispersal of the species at Paruna. Analysis of monitoring techniques will direct future monitoring to guide future sanctuary management by addressing specific questions such as;

- Is Paruna a source or sink for the species for the wider Avon Valley region?
- What is the rate of recruitment and founder survival at the sanctuary?
- Can this translocation be considered a successful?

These future directions for monitoring will be presented.

## Threatened Mammal Recovery in Australia

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Under the *Environment Protection and Biodiversity Conservation Act 1999* listed threatened species and ecological communities may be protected, conserved and managed by recovery plans. The aim of a recovery plan is to maximise long term survival in the wild by setting out the research and management actions necessary to stop decline and support recovery.

This poster will give an overview of the role that recovery plans play in ensuring the long term survival of Australia's threatened mammal species. We will explore common threats facing mammals across Australia and outline the actions that have been developed to combat these threats and support recovery.

## Ectoparasites and the Woylie (*Bettongia penicillata ogilbyi*): Biodiversity and Ectoparasite Burden

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Ectoparasites were collected across a three year period as part of a larger collaborative study, the Woylie Conservation Research Programme, undertaken by the Department of Environment and Conservation and Murdoch University targeting the causes of the precipitous decline of wild woylie populations.

Samples were collected from woylies in both fenced and unfenced sanctuaries and in wild populations in southwestern Australia. Ectoparasite burden was recorded, biometric measurements taken and samples of fleas, ticks, mites and lice taken.

Ectoparasites are being identified to species level. A putative new species of tick is being described using molecular tools and morphological characteristics are described with light and scanning electron microscopy. The variation in ectoparasite biodiversity between wild and sanctuary populations is compared and the relationship between ectoparasite burden and body condition examined. The impact of ectoparasites on the woylie will be discussed.

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