2020 University Student Grants Scheme winners

The Australian Wildlife Society's University Research Grants are scholarships offered to honours or postgraduate students at Australian universities. Each year, ten grants of $1,500 are awarded. Grants are available for research projects of direct relevance to the conservation of Australian wildlife; plant or animal. Grants may be used for the purchase of equipment and consumables, travel expenses related to field research, or attendance at conferences at which you are presenting your work.

The Australian Wildlife Society is delighted to announce the winners of the ten grants of $1,500 each to honours or postgraduate students conducting research that will contribute to the conservation of Australian wildlife.

The winners for 2020 are:

ANGELA RAÑA - School of Life and Environmental Sciences, University of Sydney
Project Title: Assessing the success of the rewilding of small mammals into North Head

BALI LEE - Faculty of Biology, Medicine and Health, University of Tasmania
Project Title: Are microplastics causing inflammation in seabirds?

BEN STEPKOVITCH - School of Biological, Earth and Environmental Sciences, University of New South Wales
Project Title: Ecosystem effects of western quoll (*Dasyurus geoffroii*) reintroduction on prey species inside a fenced reserve

CAROLYN WHEELER -
ARC Centre of Excellence for Coral Reef Studies, James Cook University
Project Title: A novel approach to investigate reproduction in a model shark species threatened by ocean warming

CHRISTINE MAUGER - School of Biological Sciences, University of Queensland
Project Title: The effect of fire regimes on habitat structure, demography and predator avoidance in northern brown bandicoots (*Isoodon macrourus*) and northern quolls (*Dasyurus hallucatus*)

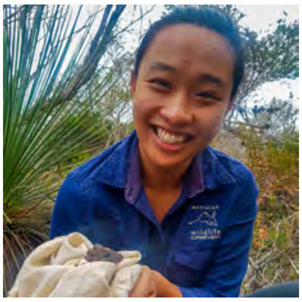
EMILY JARVIS - School of Biological Sciences, Monash University
Project Title: Artificial microhabitat use of the agile antechinus (*Antechinus agilis*) in wet-forest environments

JOSHUA ZIMMERMAN - School of Environmental and Rural Science, University of New England
Project Title: Next-generation sequencing of *Felis catus* in Australia: Helping to elucidate feral cat population dynamics and interaction with domestic cats

JULIANNA SANTOS - School of Ecosystem & Forest Sciences, University of Melbourne
Project Title: Mammals on the move in fire-driven mosaics

KELLY WILLIAMS - School of Life Sciences, La Trobe University
Project Title: Surviving predators: Assessing antipredator behaviours in an endangered wallaby to improve threatened species conservation

MOSES OMOGBEME - School of Veterinary & Life Sciences, Murdoch University
Project Title: Dingoes and trophic interactions in landscape-scale cell fencing










How invasive predators and fire interact and affect the persistence of native mammals

CHRISTINE MAUGER
School of Biological Sciences
University of Queensland

Australia has more mammals listed extinct than any other country in the world, we have lost more than twenty-five species since European colonisation. Smaller mammals weighing between 35g – 5.5kg (known as the critical weight range), such as rodents, bandicoots, and carnivorous marsupials such as quolls, have been the most affected. The impact of habitat loss due to land clearing, invasive species such as foxes and feral cats, and altered fire regimes on Australia's biodiversity is both profound and complex and are all contributing factors to such extinctions.

Predators are advantaged by land clearing and large wildfires. For example, field experiments, in the Kimberley savanna region of northern Western Australia, showed that management with small cool fires reduced the severity of late dry-season fires and promoted the survival of small and medium mammals. Severe late dry-season fires increase the hunting capabilities of feral cats, which travel large distances to hunt vulnerable prey. Such experiments have not yet been replicated in Far North Queensland, particularly in the more heavily wooded but fire-prone tropical open forest of this region.

Without effective fire management, crucial habitats can be rapidly devastated as seen in Australia's catastrophic 2019 – 2020 summer bushfires. Researchers estimate that approximately three billion animals (mammals, aves, amphibians, and reptiles) perished in the recent bushfires, indicating that now is a critical time to understand how fire management practices can be used to better conserve Australia's threatened and declining wildlife species.

In saying this, and since the recent bushfires, interest and attraction in fire practices by Indigenous Australians have greatly increased. Indigenous Australians, and researchers across the country, suggest that traditional fire practices can restore landscapes and are crucial to conserving Australia's wildlife and ecosystems.

This project aims to understand the role of habitat complexity in predator-prey dynamics and how invasive predators and fire interact and affect the persistence of native mammals, focusing on the Endangered northern quoll (*Dasyurus hallucatus*), and the northern brown bandicoot (*Isoodon macrourus*). The northern brown bandicoot is listed as Least Concerned but is declining in savannas and was shown to be sensitive to large fires in an experiment in Kakadu in the 1990s and early 2000s.

The project takes place in Far North Queensland, near Mareeba, on Muluridji country, and draws on Indigenous ecological knowledge and fire practices to explore faunal responses to different types of fires. Mareeba has one of the stronghold populations of northern quolls, and so is an important site to research and understand species' ecology. Because threats such as fire and predators often interact, the project will examine how fire influences predator movement and presence in recently burnt areas. It will also look at how predators affect the presence and abundance of small mammals over time in a fire-affected landscape.

The northern brown bandicoot is a common species and is being included in the project because small digging marsupials are known to be greatly affected by the impact of habitat loss due to land clearing, invasive species such as foxes and feral cats and altered fire regimes. Several bandicoot species are now extinct, and the northern brown bandicoot is locally extinct in some parts of Queensland and New South Wales. Monitoring common species can identify any arising issues that have the potential to worsen in the future, where the conservation listing of a species may need to be updated. Bandicoots are ecosystem engineers, turning soil as they dig for invertebrates, seeds, and roots as well as fungi. This digging creates air and water flow, turns nutrients, spreads fungal spores, and encourages seed germination. Reductions in northern brown bandicoot numbers could have an overall negative effect on the ecosystems they occupy.

Fieldwork for this project will involve undertaking habitat assessments, camera trapping and live animal trapping of northern brown bandicoots and northern quolls and camera trapping of feral cats and foxes. The chosen sites will vary in flora understorey density, number of retreat sites, rock and vegetation density, past fire frequency, and fire intensity.

Short-term responses of the northern brown bandicoot and northern quoll to fire will be tested along with their responses to predators, by monitoring their activity in sixteen different sites, four recently burnt, four long-unburnt, four current burning treatment sites and four control sites. Sites will be in areas of woodland to open woodland on basalt plains, metamorphic hills, and rhyolite hills, and they will vary in elevation so there is a large coverage of potential habitat for the two species. The project will assess habitat complexity at each site after wet and dry season conditions, record the density of obstacles, potential den sites, nest sites, and ground and understorey cover at different heights. The project will also monitor insect abundance (prey availability) using close-focus time-lapse cameras and pitfall trapping.

The project will test how capture-mark-recapture survival probabilities in northern brown bandicoots and northern quolls vary with size and performance indicators, habitat structure, and fire history. To monitor survival and population dynamics, the project will trap northern quolls and northern brown bandicoots three times a year, individually microchip and record age, morphological measurements, pouch young measurements (to estimate age and reproductive rate), and take DNA samples (a small piece of skin from the ear) from each newly caught individual. To monitor populations continually throughout the year, an additional method of capture-mark-recapture analysis will be performed, and habitat use of northern quolls will be recorded (which can be individually identified from fur spot patterns). To capture the activity of predators in each treatment, the project will install five camera traps at each of the sixteen sites, each baited with a punctured sardine tin (long-term attractant) above ground level.

The short-term outcomes of this study will allow for a better understanding of the ecology and physiology of northern brown bandicoots and northern quolls in a naturally occurring population in Far North Queensland, and a clearer understanding of the relationship between predators and prey population dynamics within habitats. Understanding how invasive predators and altered fire regimes interact to affect both an Endangered and common marsupial, can help land managers conserve populations to prevent further declines and identify important areas to conserve so threatened species continue to have refuge. Furthermore, understanding how fire and predators influence species' distribution and habitat use, is critical to wildlife conservation. Data and results from this study, will inform conservation and management decisions (particularly fire management) for these selected species, not only in Far North Queensland, but across their range on mainland Australia.

Dingo control and trophic interactions

MOSES OMOGBEME is a PhD candidate in Environmental and Conservation Science at Murdoch University

Livestock production is one of the primary land uses across Australia. Rangelands are desert, grassland, shrubland, wetland and woodland areas, of which fifty-four percent is used for extensive grazing of domestic livestock. Across these landscapes, domestic livestock often co-exists with other wildlife such as native and non-native herbivores, small mammals and reptiles, as well as their natural predators – dingoes (*Canis lupus dingo*).

The dingo is a medium-sized carnivorous mammal native to Australia and an apex predator that contributes to the control of many feral species that threaten Australia's wildlife. In saying this, macropods are an important component of a dingo's diet, however they also prey on feral herbivores and domestic livestock. Research indicates that whilst dingoes play an important role within the environment, keeping natural systems in balance, their impact on lower trophic levels is still uncertain.

The dingo's predatory behaviour on domestic livestock has caused economic and social distress for pastoralists, resulting in a loss of approximately eighty-nine million dollars per annum. Predation by dingoes has also contributed to a shift in domestic livestock enterprise choice. In Western Australia, there has been a decline in sheep and goat production and a significant move to cattle production, as cattle are more resilient to dingo predation, although calves can be susceptible. Consequently, dingoes are considered as pests by many people and are targeted for control across most rangelands in Australia. In addition to dingo-proof cell fencing, targeted trapping, shooting, and broadscale deployment of toxic baits is carried out to control dingo populations.

The combined approach of dingo-proof cell fencing and lethal control of dingoes has the potential to increase the presence of native and non-native herbivores, and consequently the total grazing pressure between these herbivores. Increased grazing results in habitat loss which exposes small native mammals and reptiles to predation by feral cats and foxes. Furthermore, increased grazing pressure reduces overall pasture biomass and alters habitats used by small native wildlife, which can be detrimental to these species. Therefore, dingoes home ranges, and their predation on native and non-native herbivores, can be considered as refuge zones for small native wildlife, however this hypothesis is highly debated as dingoes often prey on the same small wildlife they are presumed to protect. However, research on the direct predation risks of dingoes on small native wildlife is limited.

Previous research suggests that the presence of dingoes plays a key role in enhancing biodiversity. The predation behaviour of dingoes on native and non-native herbivores, lethal and non-lethal (e.g. fear causing aversion and altered space use), is predicted to result in greater vegetation cover and biomass of plant species in areas where dingoes are present. In saying this, the ecological, environmental, and economic benefits of dingoes on rangelands vegetation is limited and yet to be fully explored.

The project takes place in the southern rangelands of Western Australia. The project will examine the abundance and activity patterns of dingoes, and population dynamics and activity patterns of native and non-native herbivores. The community composition of small native mammals and reptiles, within a planned single large dingo exclosure (the Murchison Regional Vermin Council cell fencing), will also be explored. To do this, camera trap and sand plot monitoring will be carried out across thirty-six sampling transects over two years. The thirty-six transects are nested within six study sites, inside and outside the dingo-proof cell fencing. Between July and August 2020, the project deployed over one hundred motion-sensor cameras (Reconyx Hyperfire) across the six study sites. Vegetation composition will also be examined over the two-year period using satellite imagery to evaluate any changes in vegetation.

The project will be the first to investigate and research the top-down trophic cascade impact/control of dingoes on native and non-native herbivores in the southern rangelands of Western Australia. The outcome of this project will help with the management of improved livestock production and conservation of small threatened native mammals and reptiles.

Moses setting up a motion-sensor camera on a vehicle dirt track. Dingoes, macropods, and non-native herbivores are most efficiently surveyed on tracks.

Assessing the success of the reintroduction of small mammals into North Head

ANGELA RAÑA
School of Life and Environmental Sciences
University of Sydney

Australia's mammal species have been subjected to elevated rates of extinction following European settlement and, as a result, wildlife conservation experts have progressively turned to reintroductions in the hopes to protect Australia's declining native mammals. Previously, attempted reintroductions have resulted in some success, where native species have not only been able to persist in the landscape, but the reintroductions have also resulted in positive ecosystem-level effects. However, these successes are not commonplace, as the reintroduced species often face low rates of survival and establishment.

Post-release monitoring is essential to determine the success of a reintroduction program, and to investigate factors that may affect the establishment and persistence of the reintroduced species. Immediate post-release tracking of animal movements is also crucial, as reintroduced animals often disperse extensively throughout the landscape, and may display poor site fidelity. In these cases, reintroduced animals may disperse too far to contribute to the reproductive pool and therefore to population establishment.

When animals do stay near the release site, their post-release movements are often atypical. Translocated animals often move further than their resident counterparts, presumably taking time to become familiar with their surroundings, which is followed by an establishment phase in which home ranges are determined. Home ranges determine factors such as an animal's foraging and sheltering behaviour and conspecifics interaction, and will therefore influence individual fitness and determine long-term survival at both the individual and population level. Furthermore, individual fitness and the long-term survival of a species results in ecosystem-level effects, such as the restoration of ecological services including pollination, seed dispersal, and soil aeration via digging. Post-release monitoring is therefore critical in determining the success of reintroduction efforts and understanding the impacts of reintroduction efforts on the wider ecological system.

Inflorescence of Banksia marginata, one of the species the reintroduced mammals may be pollinating.

North Head Sanctuary, in New South Wales, is managed by Sydney Harbour Federation Trust and New South Wales National Parks and Wildlife Services, with active wildlife management and monitoring carried out by the Australian Wildlife Conservancy. Collectively, these organisations are reintroducing locally extinct populations of Stuart's antechinus (*Antechinus stuartii*), native bush rat (*Rattus fuscipes*), and the Vulnerable eastern pygmy possum (*Cercartetus nanus*). The return of locally extinct species is achieved through a program that includes feral predator and herbivore control and fire and weed management. North Head Sanctuary is therefore an ideal site to explore how these reintroduced populations are responding and if the wider

Above: Angela Rana in the field, holding a juvenile bush rat (*Rattus fuscipes*).

ecosystem is changing as a result of the reintroductions.

The project will explore the factors affecting the establishment and persistence of reintroduced populations of Stuart's antechinus, native bush rat, and eastern pygmy possum into North Head Sanctuary. The project will radio-track the reintroduced populations for one-month post-release, which will include daylight tracking – to obtain nest locations, and nocturnal tracking – to obtain animal movement and home range data. Triangulation and non-invasive personal observation will also be used to determine the animals' dispersal.

Understanding the dispersal and space utilisation behaviour of these animals will help to provide a baseline understanding of the ecosystem-level effects of these reintroductions. The project will conduct further experiments to determine whether these reintroduced populations contribute to the pollination of the eastern suburbs banksia scrub, an endangered ecological community, and the dominant habitat type at North Head Sanctuary.

In the later stages of the project, dispersal and space utilisation data will be combined with genetic analyses to further investigate the success of the reintroduction program. The project will examine the genetic profiles of the reintroduced populations using deoxyribonucleic acid (DNA) collected from release and captured individuals. The genetic data will be used to determine the diversity of the population and whether the population is likely to be self-sustaining, or if they require further support. The data may also be analysed alongside movement data to determine whether there are genetic drivers to dispersal (interspecific) and space use.

Overall, the project will better inform the continued reintroduction of small native mammals into North Head Sanctuary, and reintroduction practices and methodologies in general. Refinement of these reintroduction practices is essential, as reintroductions are increasingly being used to save native species threatened by a changing climate and habitat loss and fragmentation.


A juvenile eastern pygmy possum (*Cercartetus nanus*).


Inflorescence of Banksia ericifolia, one of the species the reintroduced mammals may be pollinating.


A view from North Head Sanctuary.

Are microplastics causing inflammation in seabirds?

BALI LEE is a PhD student at the University of Manchester and the University of Tasmania, looking at the effects of microplastics on the immune system of flesh-footed shearwaters (*Ardenna carneipes*)

Plastics have existed for a long time. In the 15th century, the Olmecs of Mexico were known to play ballgames with rubber balls, a naturally derived plastic, while medieval craftsmen used keratin from animal horns to fashion lantern windows. However, the first fully synthetic plastic was not invented until the 1900s by a Belgian chemist, Leo Baekeland, who, soon after, wrote in his journal "unless I am very much mistaken, this invention will prove important in the future." Prescient as this statement was, Baekeland probably did not imagine quite how ubiquitous plastic was to become. Now, there are at least eight different types of commonly used synthetic plastics, whose inexpensiveness, strength, and chemical inertness mean that they have been co-opted to produce almost all our daily items – from our toothbrushes to our clothes and to the seats we sit on – synthetic plastics are everywhere.

What deems a material as plastic? Plastics are materials made up of repeating units of the same molecule that are malleable when soft but will retain their shape once hardened. Their name comes from the Greek verb plassein, which means 'to mould or shape' and now their presence, it has been argued, is shaping the very earth we live on. The omnipresence of plastics in our lives, coupled with their exceedingly long lifecycle, has led some scientists to begin calling for the naming of a new epoch termed – the Anthropocene. These scientists argue that the presence of plastic is so great, that in the future, our rock strata will be littered with the physical evidence of plastics. Indeed, since the 1950s, when mass production of synthetic plastic began, more than 8.3 billion tonnes of plastic has been created, with over half of this plastic discarded in landfill and the natural environment. In particular, marine environments have been exceedingly impacted, with forty percent of discarded plastic estimated to have ended up in the ocean.

Jennifer Lavers processes a flesh-footed shearwater (*Ardenna carneipes*) blood sample on Lord Howe Island. Image: Cameron Muir

Microplastics, which are plastics less than five millimetres in length, are the most predominant form of global plastic pollution and can originate from either primary or secondary sources. Primary microplastics are purposefully manufactured to be microscopic (e.g. scrubber beads), whilst secondary microplastics are derived from the fragmentation of larger plastic pieces. Fragmentation of larger plastic pieces generally occurs over time due to exposure to ultraviolet light. However, there is also evidence to suggest that marine animals, such as Antarctic krill (*Euphausia superba*), may also contribute to the fragmentation process via digestive fragmentation. These microplastics, once in the oceans, are often mistaken for food by marine animals and sadly there are numerous accounts of marine animal fatalities due to plastic ingestion. However, our understanding of the sub-lethal effects of these plastics on marine wildlife is limited.

Flesh-footed shearwaters (*Ardenna carneipes*), a type of medium-sized seabird within the petrel family, which has three main breeding areas, the largest of which is on Lord Howe Island, New South Wales, is a marine species that is particularly and severely impacted by plastic waste. Studies by Doctor Jennifer Lavers and her team at the University of Tasmania and Adrift Lab, have shown that roughly ninety percent of flesh-footed shearwater fledgelings have plastic within their stomachs. Plastic in the fledgelings stomachs is thought to be due to their parents unwittingly feeding them plastic, that would have been mistaken for squid or other fish. Alarmingly, studies examining their general health also appeared to show a correlation between high levels of stomach plastics and markers of ill health, such as heightened levels of cholesterol and uric acid, markers that go beyond simple signs of malnutrition. Despite successful conservation efforts, the correlation between high levels of stomach plastics and markers of ill health may explain why many flesh-footed shearwater populations have been in decline for decades. Nevertheless, whether plastics are causing these effects and how, is still unknown at this point.

As an immunologist by training, much of Bali's research has focused on how the immune system becomes activated and what processes mediate the activation. During her Master's degree, she investigated the effects of microplastics on immune cells and found that plastics were capable of activating immune cells inflammatory pathways. Interestingly, different types of plastics were found to have different effects, with some plastics being more inflammatory than others. Nevertheless, how these inflammatory effects translate when looking at plastics ingested by living animals remains unclear.

Because inflammation is a vital part of the immune system and is the process by which we respond to infection and injury, the project predicts that the high plastic diet being fed to shearwater fledgelings is resulting in unwarranted inflammation and is the source of their well-documented sub-lethal health defects.

The project will take place on Lord Howe Island, New South Wales, at the end of April 2021, just before many of the shearwater fledgelings will be departing on their first flight out to sea. The project will collect blood samples and the stomach contents of multiple shearwater fledgelings, which will be achieved without harming the fledgelings, and should allow us to determine if there is a correlation between a high plastic load and increased markers of inflammation. Shearwater fledgelings will also be scored on their general health and wellbeing by looking at and recording statistics such as body mass and general behaviour. The fledgelings that appear the most unwell will be treated with an anti-inflammatory drug. Recapture of the fledgelings will then be attempted forty-eight hours later, and a subsequent blood sample will be taken. Blood samples and any plastics retrieved from the fledgelings stomach contents will be sent to the University of Tasmania, where the project will carry out blood sample analysis as well as identification of the ingested plastic-type.

Microplastic pollution is a growing problem and one that is not going to subside on its own. In recent years, the issue has received increasing attention, but studies investigating the sub-lethal effects of microplastics on large vertebrates are few and far between. Flesh-footed shearwaters are one of the most impacted seabirds when it comes to plastic ingestion, and they have already been shown to directly suffer as a result. However, without knowing how plastics are inducing inflammatory effects it is very difficult to mitigate against them. Furthermore, as plastic ingestion is something that has been shown to occur across species, including the human species, we hope that this research may also have a knock-on effect on the conservation of many other animals, as well as human health. If we can show that some plastics are more inflammatory than others, we could potentially push for the cessation of the use of some types of plastic altogether.

Plastic is removed from a juvenile shearwater (*Ardenna carneipes*) on Lord Howe Island. Image: Cameron Muir.

Can predation on endangered species be a good thing?

Using native predators to smarten up endangered mammals for life outside fences

BEN STEPKOVITCH is a PhD Candidate with the Centre for Ecosystem Science at the University of New South Wales.

For many of Australia's endangered mammal species, fenced predator-proof reserves provide a safe-haven from predation by introduced predators such as foxes and feral cats, often the major cause of native mammal decline and sometimes extinction on the mainland. Native marsupials, like the burrowing bettong (*Bettongia lesueur*) and western barred bandicoot (*Perameles bougainville)*, now only occur on offshore islands or are introduced into fenced predator-proof reserves which are exempt from introduced predators. In the absence of predation, these threatened species can explode beyond the capacity of the reserves. Furthermore, these animals can lose their 'smarts', or anti-predator behavioural responses. Given that the long-term goal of most fenced predator-proof wildlife reserves is to reintroduce species back into the wild, outside fenced safe-havens, wildlife managers face significant challenges to ensure the survival of native endangered species.

What if we could teach native endangered species to be warier of predators in general, while also conserving native predators? Western quolls (*Dasyurus geoffroii*), a native marsupial predator, has disappeared from most of its former range due to land clearing and predation by introduced foxes and feral cats. In 2018, western quolls were reintroduced to Arid Recovery, a large 123 km² fenced wildlife reserve in outback South Australia. Prior to 2018, Arid Recovery reintroduced the greater bilby (*Macrotis lagotis*), greater stick-nest rat (*Leporillus conditor*), burrowing bettong and western barred bandicoot to the fenced wildlife reserve. Western quolls are now breeding, expanding outside the reserve, and feeding on the native reintroduced mammals.

Ben Stepkovitch releasing a burrowing bettong (*Bettongia lesueur*) that has been fitted with a radio collar. Image: Janniko Kelk

The project will investigate the differences in behaviour between bettongs that have been exposed to western quolls in the reserve, compared to bettongs in the quoll-free area of the reserve. Previous research at Arid Recovery has shown that bettongs can coexist with low densities of feral cats and increase their wariness after two years of exposure. The project will test the multi-predator hypothesis – species' response to one predator is generalised to other predators. If the multi-predator hypothesis holds, exposing bettongs to native predators may improve their awareness of introduced foxes and feral cats.

During the initial field trip this winter, radio collars were fitted to fifteen bettongs in exclosures, with and without quolls, to monitor their survival and behaviour. The project will examine how bettongs respond to different predator scents and replicas of native and introduced feral animals, including quolls and feral cats, to see if they alter their behaviour and increase their awareness. Furthermore, to determine if the reintroduction of quolls trigger anti-predator responses in naive prey, behavioural experiments will be conducted to examine the flight initiation distance, foraging behaviour, and trap docility of prey species. To identify whether reintroduced quolls are preying on and suppressing overabundant populations of bettongs, leading to a positive impact on native vegetation, the density of bettongs in areas where quolls are absent and present will be compared over time using trapping and track counts. Plant species known to be impacted by bettongs will also be monitored in each area to measure browsing damage and recruitment. To identify whether reintroduced quolls are negatively impacting reintroduced prey species, the survival of the greater stick-nest rat, greater bilby, burrowing bettong, and western-barred bandicoot will be compared by radio-tracking individuals where quolls are present and absent. Any carcasses found will be swabbed for quoll deoxyribonucleic acid (DNA) and sent to Helix Molecular Solutions at the University of Western Australia to confirm if the animal had been predated by a quoll. Population trajectories of prey species will be compared between areas with and without quolls, using track counts and annual cage trapping.

The results of the project will help to understand the role of native predators inside fenced wildlife reserves and if native predators significantly impact resident prey species and their ecosystems. The project will also assist in planning for other groups aiming to reintroduce native predators, such as the western quoll, into wildlife reserves. There may be lessons learnt for endangered wildlife conservation elsewhere.

The project is part of a larger ARC Linkage Grant led by the University of New South Wales Sydney focussing on addressing prey naivety and subsequent vulnerability of endangered species. The project is supported by Arid Recovery, a joint conservation initiative between BHP, the University of Adelaide, South Australia Department for Environment and Water, Bush Heritage Australia, and the local community.

If you would like further information on the work being conducted at Arid Recovery, please visit their website https://www.aridrecovery.org.au/

Ben Stepkovitch releasing a burrowing bettong (*Bettongia lesueur*) that has been fitted with a radio collar. Image: Janniko Kelk

A western quoll (*Dasyurus geoffroii*) at Arid Recovery. Image: Janniko Kelk

Shark obstetrics:

Assessing reproduction of ocean predators to climate change

CAROLYN WHEELER is a co-tutelle PhD candidate between the School for the Environment at the University of Massachusetts, Boston and the ARC Centre of Excellence for Coral Reef Studies at James Cook University. Carolyn spent the first half of her PhD working with the Anderson Cabot Center for Ocean Life at the New England Aquarium in Boston studying the effects of temperature on development and physiological performance of epaulette shark embryos and hatchlings. Now she is continuing her research at James Cook University assessing the impacts of thermal stress on reproduction in adult epaulette sharks.

Did you know that scientists use some of the same tools as medical doctors to track reproduction in sharks? Methods using ultrasound technology and blood analyses are allowing us to assess reproduction patterns in the epaulette shark (*Hemiscyllium ocellatum*), a species that is likely to experience significant changes in its environment from ocean warming caused by climate change.

Epaulette sharks reproduce by laying thick egg capsules – sometimes called mermaid's purses – that develop for three to four months on the ocean floor. During this incubation period, warm water temperatures can reduce the number of embryos that survive long enough to hatch. We have been studying how warming waters will impact the offspring of epaulette sharks. The consequences of climate change will be direr if the capacity for the parents to reproduce, in the first place, is also compromised. The project, based at the ARC Centre of Excellence for Coral Reef Studies at James Cook University under the supervision of Doctor Jodie Rummer, will aim to fill this knowledge gap. The project will be conducted on wild epaulette sharks around the Heron Island reef flats on the southern Great Barrier Reef, a known hotspot for this species. The project will use a combination of minimally invasive methods, including ultrasound and blood sampling, to determine the real-time reproductive status of sharks and how their hormone levels change over time. The project will also tag each shark with a small transponder – similar to a microchip used in cats and dogs – so they can be identified if recaptured, which will allow the project to track their reproductive status over time.

A newly hatched epaulette shark raised under current-day Great Barrier Reef temperatures. Image: Emily Moothart

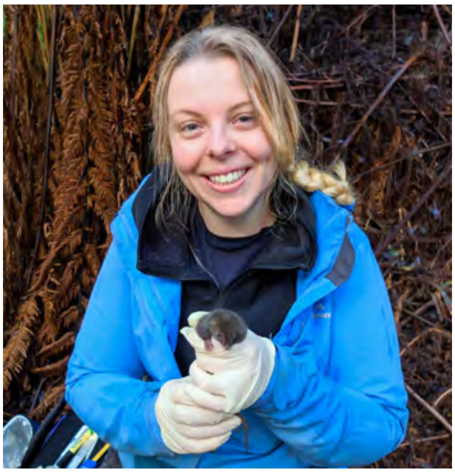
There are approximately 150 species of sharks, and their relatives (rays and skates), within the Great Barrier Reef ecosystem, ranging from the largest shark in the world – the whale shark (*Rhincodon typus*) – to sharks and rays that are smaller than one metre long and unknown to most. One of these small species of shark is the epaulette shark. Named for the prominent dark black spots flanking its sides, that resemble military epaulettes, these little sharks rarely grow larger than eighty to ninety centimetres but can be found throughout the shallows of the Great Barrier Reef. Because this species is considered Least Concerned by the International Union for Conservation of Nature, it thrives in captivity and is quite docile, they have been the subject of many ground-breaking studies over the last few decades. Indeed, this species is hearty; these sharks can survive for hours in water with nearly no oxygen in it without any damage. They can even use their modified fins to 'walk' from reef flat to reef flat, even if it means getting out of the water to do so. These attributes are some of the unique adaptations that allow epaulette sharks to hunt and feed in isolated tidal pools that may be too small and potentially too challenging for other species to endure. Moreover, these are some of the reasons our team has focused on this species to investigate the effects of climate change. However, from our research thus far, warming waters seem to be problematic for this species.

Many marine ecosystems are under threat from climate change, over the next century, where warming temperatures, ocean acidification, and deoxygenation are rapidly changing the environment. In Australia, these impacts are already evident. The Great Barrier Reef experienced large-scale bleaching events from warmer than usual water temperatures in the summers of 2016, 2017, and 2020. The effects of these events are complex, and scientists are still unsure as to how many species of coral, invertebrates, and fishes respond to these short-term seasonal heat-wave events as well as the long-term predicted warming. Furthermore, globally, shark populations are in a state of decline, mostly due to overfishing and their slow generation times and low reproductive output. Understanding how climate change will impact epaulette shark reproduction is an important step in predicting how sharks and their relatives will fair under future ocean conditions. The project's findings will aid in developing conservation plans for these species and others, both now and into the future.

An adult epaulette shark (*Hemiscyllium ocellatum*) resting on the reef flat. Image: John Gaskel

An adult epaulette shark (*Hemiscyllium ocellatum*) camouflaged on the reef. Image: Connor Gervais

A three-week-old epaulette shark embryo developing inside an egg case. Image: Martijn Johnson

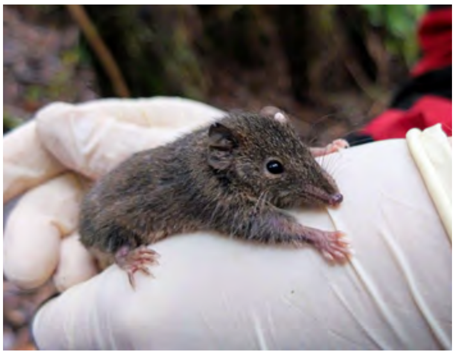


Making microhabitats:

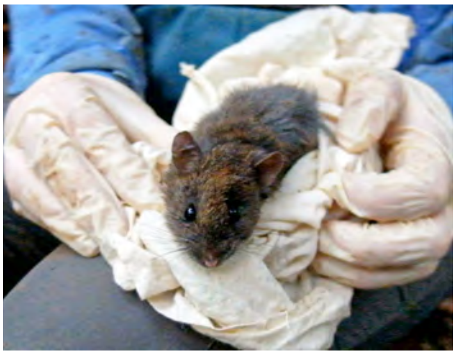
Can artificial cover enhance habitat for small mammals?

EMILY JARVIS is an honours student from Monash University, Melbourne. She completed her Bachelor of Science Degree in 2019, majoring in ecology and conservation biology. She works as a wildlife educator at Animals of Oz, an interactive and educational company, and hopes to continue researching wildlife conservation and ecology in the future.

What if the secret to protecting some of our most vulnerable native species has been hiding in the undergrowth all along? Complex microhabitats, such as rugged rocky outcrops and dense understory vegetation, reduce the hunting efficiency of feral predators by providing small animals with more places to hide. Unfortunately, rugged outcrops and dense vegetation are among the first things lost from a damaged ecosystem and are often difficult to restore. Dense ground cover and fallen timber may take decades to accumulate and some elements, such as large hollow-bearing trees, are virtually irreplaceable in our lifetime. Whilst established conservation strategies continue to lessen the impact of feral predators, their limitations mean that many species remain unprotected. With future conservation work demanding a longer-term landscape-scale approach, there is a genuine need for the development of additional budget-friendly conservation strategies.



An agile antechinus (*Antechinus agilis*).



A patient bush rat (*Rattus fuscipes*) ready for release.

A large mountain ash (*Eucalyptus regnans*) makes a prime spot for catching agile antechinus.

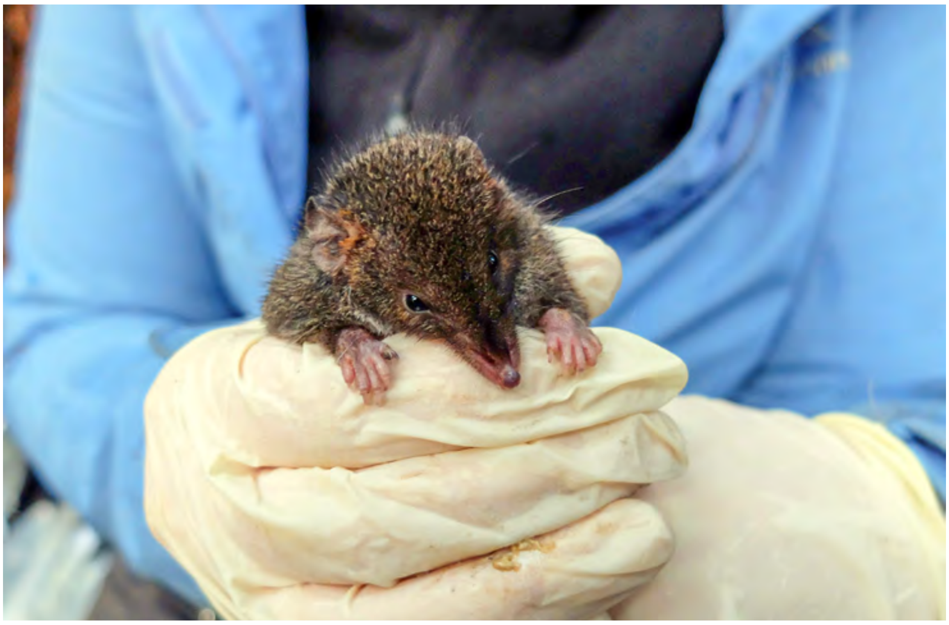
Creating complexity through artificial microhabitats

One possible conservation strategy is to use artificial microhabitats to compliment natural refuges remaining in a degraded and damaged ecosystem. Artificial tree hollows (e.g. nest boxes) are currently used as an effective conservation tool for native birds and arboreal mammals. In addition, the success of artificial 'rocks' (e.g. pavers and concrete tiles) as a viable habitat for reptiles has been widely demonstrated. Artificial microhabitats appear cost-effective at large scales and the potential for rapid deployment could offer immediate shelter for a range of native species. Importantly, it may also offer an additional management option where other conservation strategies, such as predator-proof reserves, are not viable. Nonetheless, many questions must be answered before artificial microhabitats can be readily deployed as a reliable conservation strategy.

Despite their greater vulnerability to fox and cat predation, far fewer studies have examined the potential benefits of artificial refuges for ground-dwelling mammals compared to their arboreal counterparts. Research has focused on extreme low-cover environments (e.g. deserts and post-fire) such that the effectiveness of artificial cover in more closed environments is less certain.

Artificial ground cover in wet-forest environments

The project aims to assess the effectiveness of an artificial material, hessian fabric, as a suitable refuge for small mammals in the wet-forests of southern Victoria. The project aims to contrast the effects between degraded low-cover habitat along the forest edge and denser vegetation towards the interior. The project focuses on three ground-foraging species that, despite



A dusky antechinus (*Antechinus swainsonii*) has a nibble on Emily's hand, after being weighed and measured.

being relatively common in the area, are likely already in decline. These species are the agile antechinus (*Antechinus agilis*), dusky antechinus (*Antechinus swainsonii*), and native bush rat (*Rattus fuscipes*). The project predicts that the animals will respond more strongly to the hessian microhabitat along the degraded forest edge, opposed to the denser vegetation towards the interior, given the greater benefit of additional cover on the overall habitat complexity. By using camera traps to observe how the animals interact with the fabric and comparing the live-capture rates between low and high-cover environments, we can begin to understand how small mammals respond to artificial habitats in various contexts. The results from a preliminary field trial conducted in July 2020 suggests that these species will readily utilise the hessian cover and experience it as a safe microhabitat refuge, moving through and even foraging underneath the fabric. The project hopes to confirm these results with a more expansive field experiment in late September 2020.

Why hessian fabric? Previous studies indicate that small mammals respond to artificial cover such as shade cloth and plastic tarp, however there is an overall preference among land managers for more natural refuge characteristics. Hessian fabric is a relatively inexpensive natural material that is lightweight, biodegradable and presents minimal risks to small animals (e.g. entanglement). We hope that hessian fabric may be used to enhance habitat complexity in degraded and damaged environments and will provide transitional cover and protection for ground-foraging species whilst the forest regenerates.

Two examples of artificial cover, where hessian microhabitat was used to build habitat complexity around existing natural refuges in the forest interior.

Camera trap footage showing an agile antechinus (*Antechinus agilis*) exploring the hessian microhabitat.

Camera trap footage showing bush rat (*Rattus fuscipes*) foraging underneath the hessian fabric.

Next-generation sequencing of *Felis catus* in Australia:

Helping to elucidate feral cat population dynamics and interaction with domestic cats

JOSHUA ZIMMERMAN is undertaking feral cat genetic research at the University of New England, New South Wales

Feral cats have become ubiquitous across the Australian continent since their introduction in the nineteenth century, occurring over 99.8 percent of the mainland, and Tasmania. Cats are recognised as one of the major threats to small vertebrates across the continent, with an estimated 1,140 million animals killed by cats each year. Of these, an estimated 450 million individuals are native animals. Since European settlement, thirty native mammal species have gone extinct, with feral cats being implicated as a causal factor in most of these extinctions. As such, the management of feral cats in the landscape is one of the most important facets of small animal conservation in Australia. Though studies on cat diet and ecology have given us valuable insight into how cats interact with native animals, there is much more we need to understand about feral cats to effectively manage them in an economical, and sustainable manner.

Genomic analyses has the potential to be a powerful tool that can be used to inform the management of feral cats, and feral animals in general. They enable estimation of individual numbers in the environment, quantification of feral population interactions within and around controlled sites, and elucidation of interactions between feral and domestic cats. Previous genetic studies on cats in Australia were carried out with microsatellite markers. In these studies, they were able to determine feral cat population structures across the continent and identify two subpopulations of feral cats – a coastal western Australian population centered around Shark Bay, and a pan-Australian population encompassing the rest of the continent. Additionally, they modelled the spread of cats across the continent, identifying human-mediated dispersal as the most likely culprit for their rapid colonisation of the Australian landscape. These studies also gave some insight into the limited interactions between feral and domestic/stray cats around the Shark Bay area in Western Australia. Although these studies provided valuable information, microsatellite markers were unable to resolve population differences at sufficiently small scales to be useful for management purposes.

The project implements a newer next-generation sequencing-based genetic marker technology – 3RAD, a reduced-representation technique allowing for high-throughput and cost-effective sequencing of multiple deoxyribonucleic acid (DNA) molecules in parallel, which will provide improved resolution in downstream analysis through the generation of thousands of sequence-based markers. This new technology allows for a powerful analysis of feral cat populations at a finer scale than was previously possible with older technologies.

A feral cat with a recently killed grey shrike-thrush (*Colluricincla harmonica*). Feral cats are known to impact many small vertebrate species in Australia. Image: Daryl Panther

For this project, roughly 280 cat tissue and blood samples will be sequenced and analysed. These samples were provided by collaborators and have been taken from cats across continental Australia and Tasmania, allowing for comparison of many individuals from domestic, feral, and stray populations across numerous sites. The sampling sites in this study will include coastal Western Australia, the Kimberley region, Central Australia, multiple populations from across New South Wales, as well as populations from Tasmania, and Macquarie Island.

The aims of the project are to:

1. Elucidate genetic relationships of cats at fine-scales;
2. Test for gene flow between domestic and feral cats (whether domestic/stray cats reproduce with feral cats in areas where they may be in close contact); and
3. Quantify the levels of overall differentiation between feral and domestic populations across Australia.

In addition to these central aims, the project seeks to re-analyse continent-wide structure in feral cats, with the inclusion of more sites from eastern Australia, as well as sampled cats from the previously understudied Tasmanian mainland. Re-sequencing of roughly fifty samples, previously run using a different method, will enable comparison of the newer 3RAD technique with the older next-generation method, thereby providing a practical example of 3RAD sequencing application for wildlife studies.

Results for the project are still to come, lab work is underway, and DNA is being extracted from the tissue samples in preparation for further sequencing and subsequent analysis. The project will provide a real-world example of the efficacy of genomic analyses as an important facet in the application, appraisal, and modification of feral animal control programs in an Australian context. The ability to differentiate populations genetically at small scales could facilitate the classification of subpopulations into appropriate management units, as well as identification of subpopulations responsible for site reinvasion. Furthermore, the project could provide management officers with the ability to identify areas where control resources would be most effectively implemented, thereby improving resource use efficiency and control outcomes.

A subset of the tissue, blood, and DNA samples of domestic and feral cats held at the University of New England, New South Wales.

Mammals on the move in fire-driven mosaics

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Fire is a key part of Australian ecosystems, and many plants and animals have adaptations that help them thrive in fire-prone areas. However, substantial changes to fire-regime characteristics – including modification of fire season, intensity, frequency, and size – can cause negative impacts on wildlife. In fact, many animals and plants are currently threatened by altered fire regimes.

In fire-prone ecosystems, different fire events, that vary in intensity, frequency, size, and patchiness, create heterogeneous areas of different fire histories, that we call 'fire mosaics' (e.g. long unburnt and recently burnt areas). Because fire mosaics are composed of patches of vegetation at different successional stages, they play an important role in shaping habitat suitability and the distribution of resources for different species of animals.

An individual common dunnart (*Sminthopsis murina*) with a luminescent tag attached. The Image was taken during project trials in the Murray-Mallee region of south-eastern Australia.

The research project will be conducted in a range of fire mosaics in the Murray-Mallee region of south-eastern Australia. These semi-arid ecosystems are home to several small mammals of conservation concern, including the Mallee ningaui (*Ningaui yvonneae*), Bolam's mouse (*Pseudomys bolami*), western pygmy-possum (*Cercartetus concinnus*) and common dunnart (*Sminthopsis murina*). Based on previous studies, of species occurrence and abundance in the area, we know that some of these species prefer fire mosaics dominated by long-unburnt patches with dense vegetation, such as the Mallee ningaui. Whereas other species, such as the Bolam's mouse, can occupy a greater range of post-fire environments including more recently burnt vegetation. However, we still know little about the traits that describe the movement and foraging behaviour of small mammal species in fire mosaics. Examining animal movement patterns and habitat use can help us to better understand the mechanisms that drive species' responses to fire and adaptations that help small mammals persist in fire-prone areas.

Another important knowledge gap is how the properties of fire mosaics – such as the size, diversity, and configuration of habitats of different fire history – shape the abundance and spatial distribution of critical resources for small mammals (e.g. habitat refuges). Patches of vegetation that remain unburnt, logs, and burrows are examples of habitat components that can be used as refuges for small mammals living in flammable areas. Refuges, a crucial habitat element, can increase the chances of an animal's survival during a fire and help them to persist in a post-fire habitat, by protecting animals from harsh weather conditions and predators.

The overarching aim of the project is to understand how animal movement is influenced by different types of fire mosaics. The project will identify critical habitat refuges within fire mosaics that enable multiple species to persist in post-fire environments. To determine how different fire mosaics shape the availability of resources and habitat refuges used by small mammals in Mallee landscapes, the project will use live trapping and direct observation to monitor the movement and habitat use of the Mallee ningaui, Bolam's mouse, western pygmy-possum and common dunnart, during periods of activity.

Individual mammals captured in pitfall traps will be fitted with small luminescent tags and tracked at night. The luminescent tags are attached to the fur on the animal's rump, using a small amount of glue. Luminescent tracking has been previously trialled with success and without harming the animal or changing its natural behaviour. Furthermore, the small luminescent tag does not impede animal movement through vegetation. After the tags are attached, individuals will be released close to their capture site and observed using a red-lensed spotlight, from approximately three metres away. The project will record data on individual activity (e.g. feeding, walking, and sheltering) and habitat complexity (e.g. leaf litter, spinifex cover, and bare ground). To determine if the small mammals prefer a specific habitat type, data on animal movement, foraging activity, and use of habitat will be compared with habitat availability and complexity at each site. These results will then be compared amongst different fire mosaics.

Fieldwork has not yet started, however is predicted to begin shortly. The project will contribute to current knowledge and understanding of the relationship between fine-scale patchiness of fires (e.g. the proportion of burnt and unburnt habitats), and the spatial arrangement and abundance of critical refuges for small native mammals. The results will inform fire management strategies in Mallee ecosystems, including how to refine the spatial arrangement of prescribed burns to protect and enhance critical habitats and refuges for small mammals. Additionally, the outcomes of the project will be critical for the development of recovery plans and conservation strategies for threatened wildlife in South Australia.

A study site, in Murray Sunset National Park, Victoria, a few months after a prescribed burn.

Are antipredator behaviours taught or inherited?

A novel approach to improve threatened species conservation

KELLY WILLIAMS is a first-year PhD candidate in the Reproductive Ecology and Conservation Biology Group at La Trobe University. She completed her Bachelor of Animal and Veterinary Biosciences with Honours in 2019, where she investigated female mate choice in the spinifex hopping mouse (*Notomys alexis*). She is now furthering her interests in animal behaviour and reproduction to conduct research that contributes towards the conservation of threatened species, a lifelong aspiration of hers.

Australia has a wonderfully unique and diverse array of fish, reptile, bird and mammal species not found anywhere else in the world. Despite this privilege, Australia is the leading country with the highest rate of mammal extinctions, with thirty-four species lost forever in the last two hundred years. Macropods are among Australia's most recognised pouched mammals, comprising the iconic kangaroos and wallabies. Of our country's fifty living macropod species, forty-two percent have a conservation status of Near Threatened or worse, while another seven species have become extinct since European settlement.

The bridled nailtail wallaby (*Onychogalea fraenata*) was once widespread throughout eastern Australia and initially thought to be extinct until a chance rediscovery in 1973. Today, the species is nationally classified as Endangered, surviving in small wild populations in Queensland and translocated populations within fenced reserves in New South Wales. However, the translocated populations comprise less than one percent of its former range. Fortunately, conservation measures are being implemented in efforts to help the species recover.

Recovery programs often aim to return species to their former range, yet to date, reintroductions of animals into wild habitats with non-native predators have been largely unsuccessful. Predation by feral cats and introduced foxes is the primary cause of reintroduction failure in threatened Australian mammals. Prey animals need to be able to recognise and respond appropriately to predators if they are to survive. However, many small mammals, like the bridled nailtail wallaby, have not evolved alongside cats and foxes and therefore have ill-equipped defences. Furthermore, when populations are isolated from predators, such as on islands, within fenced reserves and in captivity, antipredator behaviours can diminish as a result of relaxed predation pressures. These predator-naïve populations are often the source of individuals used for reintroductions, which begs the question: how are they going to cope with predators in their new, wild home?

The bridled nailtail wallaby (*Onychogalea fraenata*) is a small and Endangered mammal unique to Australia. Image: Kylie Robert

Antipredator behaviours include those used to avoid and recognise predators and respond to their attacks. A typical wallaby response to a predator involves fleeing, hiding or freezing. Many macropod species also use an alarm signalling foot-thump, in which the ground is thumped with one or both hind feet. The behaviour is thought to have one of two functions, firstly as an audible alarm signal to warn other nearby wallabies of the present danger, and the other to alert the predator that they have been detected to hopefully deter their attack. Foot-thumping has been recorded in some populations of bridled nailtail wallabies but not in others. The project aims to understand how juvenile wallabies acquire their antipredator behaviours, focusing on foot-thumping. Is it learnt or inherited?

A wallaby joey develops in the pouch over many months, offering an ideal opportunity to examine how the mother influences the behaviour of her offspring. To investigate this, the project aims to exchange pouch young between mothers that do not foot-thump and mothers that do foot-thump. The project will utilise bridled nailtail wallabies from a population not known to foot-thump and tammar wallabies (*Notamacropus eugenii derbianus*) that readily exhibit the behaviour. Both wallaby species are small, nocturnal and predominantly solitary. After cross-fostering has occurred, the joeys will be raised in three separate groups. Once they have reached weaning age, they will have their antipredator behaviours assessed. The first group will comprise the nailtail joeys with tammar mothers to determine if the joeys acquire foot-thumping from their mothers non-genetically (hence, behaviourally). The second group will be tammar joeys with nailtail mothers to see if foot-thumping is retained, indicating a genetic basis for the behaviour. The third enclosure will be a mixed group of nailtail joeys with nailtail mothers and tammar joeys with tammar mothers to determine if the nailtails can socially learn foot-thumping by observing the tammars. To assess antipredator behaviours, mothers and joeys will be safely exposed to a live dog, with dingo-like features, on several occasions. The live dog will be located on the external side of the fenced enclosures and the wallaby's responses will be recorded via video. The project is also interested in determining if the strength of responses displayed by an individual wallaby matches that of its biological or foster mother, for example, if more vigilant mothers produce similarly vigilant offspring. The findings of this project will be invaluable, as understanding antipredator behaviours has implications for future reintroductions of threatened species.


Joeys will be swapped between bridled nailtail wallaby (*Onychogalea fraenata*) mothers (left) and tammar wallaby (*Notamacropus eugenii derbianus*) mothers (right) and then have their predator responses evaluated at weaning age. Images: Kylie Robert

If critical survival behaviours are being lost as a result of reduced selection pressures in environments uninhibited by predators (such as in captive breeding colonies and predator-free reserves), this will have dire long-term effects on a species' survival in any post-release environment. Reintroduced animals need to be able to recognise and respond to predators present in their new habitat if the population is to become sustainable – the overarching aim of reintroduction projects. Therefore, we must continue to improve our understanding of essential behaviours through research, so we can make informed management choices. Findings from this research can then be used to develop behavioural criteria to assist in choosing individuals most suitable for breeding or release projects. Furthermore, the continued development of novel techniques to help animals maintain, and even improve, their antipredator behaviours, is desperately needed to ensure that Australia's unique species persist for future generations.

As it grows, a bridled nailtail wallaby (*Onychogalea fraenata*) joey will periodically leave its mother's pouch to explore the outside world. Image: Kylie Robert