AUSTRALIAN Wildlife

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Celebrating a new century of wildlife preservation in Australia

Journal of the Wildlife Preservation Society of Australia Limited
(Founded 1909)

The Queen's Platinum Jubilee Australia 2022

Patrick Medway AM signing the guest book at the Platinum Jubilee Ball, Government House, Canberra.

Dr Julie Old signing the guest book at the Platinum Jubilee Ball, Government House, Canberra.

A portrait of Her Majesty The Queen on display at Government House.

The beautiful heart-shaped jubilee dessert in royal purple – a salted caramel mousse with blueberry gel, meringue, and gold leaf.

Guests on table twelve at the Platinum Jubilee Ball, Government House, Canberra.

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Editor, *Australian Wildlife*

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Australian Wildlife Society

Conserving Australia's Wildlife since 1909

Australian Wildlife

is the official journal of the Australian Wildlife Society
(Wildlife Preservation Society of Australia Limited).

Founded in 1909, the Society is dedicated to the conservation of our unique Australian wildlife in all its forms.

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Member Notice

The Australian Wildlife Society (Wildlife Preservation Society of Australia Limited) is managed and controlled by an elected Board of ten volunteer Directors. The Society is a tax-deductible gift recipient and registered with the Australian Charities and Not-for-profit Commission. Its public fund is listed on the Register of Environmental Organisations under item 6.1.1 of subsection 30-55(1) of the Income Tax Assessment Act 1997.

Any member who might like to consider serving as a Director of the Society is invited to contact the national office for more details. The most important qualification to serving as a Director is 'a commitment to and love of Australian wildlife'.

The Society holds regular monthly meetings on the first Wednesday of each month in Sydney.

The Editor would like to feature a member's profile in the fortnightly email newsletter and occasionally in our quarterly magazine. Members are invited to consider submitting a short article with a photograph for possible publication.

Our Mission

The Australian Wildlife Society (Wildlife Preservation Society of Australia Limited) is a national not-for-profit wildlife conservation organisation, formed in 1909, and is committed to the preservation of Australia's precious flora and fauna. We act as a watchdog and provide advice to government agencies and institutions regarding environmental and conservation issues concerning all aspects of wildlife preservation.

Our mission is to conserve Australia's fauna and flora through education and involvement of the community. We are dedicated to the conservation of our unique Australian wildlife in all its forms through national environmental education, advocacy, public awareness, community involvement, and hands-on conservation work.

Our Society has always known that a conservation battle is never really won until the victory is enshrined in legislation. We have always attempted to convince politicians of the necessity to include the preservation of Australia's precious wildlife and its vital habitat in all their planning, environmental issues, and discussions.

From the President's Desk

Dr Julie Old – President

The Society has again been extremely busy campaigning to protect and preserve Australia's flora and fauna. We have had significant conservation wins with all our lobbying resulting in banning plastic bags in New South Wales and the koala (*Phascolarctos cinereus*) being listed as Endangered.

Welcome to the Winter 2022 Edition of *Australian Wildlife*

The Society has again been extremely busy campaigning to protect and preserve Australia's flora and fauna. We have had significant conservation wins with all our lobbying resulting in banning plastic bags in New South Wales and the koala (*Phascolarctos cinereus*) being listed as Endangered.

The Society inaugurated Dr Richard Mason into the Australian Wildlife Society Roll of Honour. Dr Mason joined the Society in 1976 and served on the Board of Directors for over forty years, mainly as a Vice President of the Society. As a keen ornithologist, he was instrumental in supporting the work of the Society, particularly advocating against the plume trade and traffic in wild birds. Since his retirement from the Board, he has remained passionate about conservation and enjoys watching the birds in his backyard. When our Vice President, Brian Scarsbrick AM, and I recently met with Dr Mason to present his award, I asked him if he has a favourite bird. He thought that was a difficult question but that it would likely be one of our parrots. I too, have trouble deciding which Australian bird would be my favourite and will struggle when I submit my vote for the Director's choice for the 2022 Australian Wildlife Society's Threatened Wildlife Photographic Competition. The public voting period for People's Choice closes on 30 July 2022.

Our CEO, Mr Patrick Medway AM, recently attended the 2nd Australian Biosecurity Symposium on the Gold Coast and spoke with Mr Costa Georgiadis, a great supporter of the environment, particularly sustainability. The Symposium featured a range of speakers discussing the many threats posed to Australia's native flora and fauna, including yellow crazy ants (*Anoplolepis gracilipes*). These ants, first reported on Christmas Island in 1934, are now found in the Northern Territory, New South Wales, and are currently threatening our World Heritage Listed Wet Tropics in Queensland. We hope to feature an article on yellow crazy ants in an upcoming article in *Australian Wildlife*.

The CEO and I were also invited by our patron, His Excellency General the Honourable David Hurley AC DSC (Retd) Governor-General of the Commonwealth of Australia, to the Government House Platinum Jubilee Ball in Canberra. The Society is very proud to have had the Australian Governor-General as our patron for well over one hundred years. As our patron, the Governor-General has always supported our efforts and commitment to conserving Australia's native flora and fauna.

Of course, one of our other long-standing commitments is to promote and educate the importance of conserving our flora and fauna through *Australian Wildlife*. This year marks the eighty-eighth year of this publication, and whilst there have been changes in our publishing format, it has always remained true to the Society's values. In this edition we have an article on the importance of fungi in the environment (pages 7-9), an update on the Queen's Jubilee celebrations (pages 19-20), and our University Research Grant Winners for 2022 (page 24). We hope you enjoy this edition of *Australian Wildlife*.

L to R: Costa Georgiadis and Patrick Medway AM at the 2022 Australian Biosecurity Symposium.

Dr Julie Old presenting Dr Richard Mason with his Roll of Honour certificate.

Australian Wildlife Week
Video Competition

Australian Wildlife Society
Conserving Australia's Wildlife since 1909

The Australian Wildlife Society's Australian Wildlife Week Video Competition is a national competition celebrated during the first week of October to encourage a positive relationship between humanity and nature by awarding and promoting the plight of threatened Australian wildlife through the medium of videography.

The Australian Wildlife Society invites videographers to raise the plight of threatened wildlife in Australia and encourages the production of videos taken in Australia by Australians that reflect the diversity and uniqueness of Australia's threatened wildlife.

An annual judge's prize of $1,000 will be awarded.

Rules of entry:

1. The subject of each entry must be a threatened Australian species - fauna or flora - and officially listed as either Vulnerable, Endangered, or Critically Endangered.
2. The entry must be the work of the entrant.
3. All videos must have been made specifically for Australian Wildlife Week 2022, the Australian Wildlife Society's website and YouTube channel.
4. By submitting an entry, entrants grant the Australian Wildlife Society rights to the video. Entrants retain the copyright to their entries but accord the Australian Wildlife Society the right to use the video in any of its marketing or promotional material arising therefrom.
5. All videos must include a message on how to conserve the threatened species featured in the video, be no longer than 5 minutes (including titles and credits) and include the Australian Wildlife Society either as an end frame or in the closing credits.
6. There shall be no charge for entry, and entrants may submit more than one entry.
7. The name of the threatened species, videographer, and date the video was created must be in the 'file name' of each video submitted, e.g., Koala_John Smith_6.6.22.
8. Entries will be submitted in mp4 format via a compressed file to video@aws.org.au
9. All entries must be accompanied by a short paragraph (maximum 100 words) describing the status of the threatened species, the location the video was taken, and the reason for choosing the threatened species featured in the video.
10. Directors of the Australian Wildlife Society or their families are ineligible to submit entries.
11. The final result is at the Directors' discretion.

The closing date for entries is 31 August.

The winner will be announced towards the end of September.

REGISTERED CHARITY
acnc.gov.au/charityregister

Australian Wildlife Week
Held during the first week of October every year

Fungi: Often an Underestimated Group of Organisms

Dr Julie Old and Dr Hayley Stannard

Fungi are widespread, and as anyone knows, with so much wet weather in the east of Australia, mould is forming on walls and all manner of things. However, fungi are so much more than mould on the ceiling, the mushrooms you have on toast, or the fairy gardens in your lawn. They are eukaryotes, defined by their membrane-bound nucleus and organelles. In terms of their formal classification, they have their very own kingdom. Unlike animals and plants, fungi have chitin and cellulose in their cell walls. Perhaps surprisingly to many of us, they are more closely related to members of the animal kingdom, including us, than plants. Fungi can be unicellular, such as yeasts we use in the production of wine, cheese, and bread, or more complex multicellular organisms.

Based on recent DNA evidence, there are seven major phyla of fungi, however this level of their classification remains somewhat debatable. The Chytridomycota are believed to be most like the first fungal ancestor. This phylum of fungi includes *Batrachochytrium dendrobatidis*, more commonly known as chytrid fungus, which causes the skin disease chytridiomycosis in amphibians. Death occurs in affected amphibians, most likely due to the reduced capacity of their skin to maintain adequate water and electrolyte balance.

Chytridiomycosis has significantly impacted amphibian species worldwide, with population declines in over 500 species, including ninety of which are presumed extinct. In Australia, it has led to the decline of at least forty-three species and the presumed extinction of at least four native frogs. All four frog species presumed extinct were from Queensland and included the northern and southern gastric-brooding frogs (*Rheobatrachus silus* and *R. vitellinus*) and the sharp-snouted and southern day frogs (*Taudactylus acutirostris* and *T. diurnus*). In some good news, the fungus appears not to have led to a decline in frog species in Western Australia or semi-arid and arid zones, presumably because it cannot survive in temperatures above 28°C.

Generally, we probably think about the importance of fungi in the environment as decomposers. In forests, we might often see a mass of connected hyphae (mycelium) covering fallen logs and branches. In this scenario, the fungi obtain their nutrition by secreting digestive enzymes that break down substrates such as cellulose and lignin in wood, absorb the nutrients they need through their hyphae, and release elements back into the environment.

Amazingly, nematophagus fungi are carnivorous and actively prey on nematodes (roundworms)! Some of these fungi infest nematode eggs or enter their host via their hyphae. Other species attract their prey using scents to find food and trap them using rings, nets, or glue. Some species even use toxins to paralyse their prey prior to digestion.

Many fungi also form symbiotic relationships with animals or plants. Some of these relationships are essential for the survival of the fungus, whilst others are not. Endophytic fungi live inside plants. These fungi can be parasitic or form commensal

Top Left: Coral fungi (*Ramaria lorithamnus*) at Newnes Plateau in the upper Blue Mountains, New South Wales. This species grows in tufts on the ground in association with Eucalyptus trees. It is entirely yellow, without any red or pink tints, and does not have a cauliflower-like appearance. Image: Megan Fabian.

Top Middle: Genus *Phylloporus* is a member of Boletes in the Family Boletaceae found growing on the side of a termite nest at Newnes Plateau in the upper Blue Mountains, New South Wales. Image: Megan Fabian.

Top Right: *Pycnoporus coccineus* is a saprophytic, white-rot decomposer fungus in the family Polyporaceae. A widely distributed species, the fungus was first described scientifically by Elias Magnus Fries in 1851. Image: Megan Fabian.

Class Agaricomycetes, a member of Higher Basidiomycetes Subphylum Agaricomycotina. Image: Megan Fabian.

A ruby bonnet (*Cruentomycena viscidocruenta*) at Newnes Plateau in the upper Blue Mountains, New South Wales. The ruby bonnet is a species of agaric fungus in the family Mycenaceae. It is found in moist forested areas of Australia and New Zealand, often in small groups on rotting wood. Image: Megan Fabian.

Class Agaricomycetes, a member of Higher Basidiomycetes Subphylum Agaricomycotina. Image: Megan Fabian.

or mutualistic relationships with their plant host. In some cases, the fungus may even protect the host plant from herbivores by producing toxins. Several native grasses have been found to harbour endophytic fungi in Australia, including hedgehog grass (*Echinopogon* spp.).

Around ninety percent of our native plant species have a mutualistic relationship with fungi. Generally, these fungi support plant growth by enhancing nutrient absorbance and obtaining nutrients from the plant in return. There are several types of 'root fungus' or mycorrhizal fungi. The most common types of mycorrhizal fungi reside solely underground and are referred to as arbuscular mycorrhizae. The second most common type is ectomycorrhizal fungi from the Basidiomycetes phylum, which produce above-ground reproductive structures (e.g., mushrooms and toadstools) and are associated with most Australian forest trees. Many epacrids (heaths and similar plants) have mycorrhizal associations, including *Epacris, Leucopogon*, and *Woollsia* spp., however these are referred to as ericoid mycorrhizae. Terrestrial orchids, such as *Thelymitra ixioides*, form mycorrhizal associations with fungi, as do the potato orchid (*Gastrodia sesamoides*) and spotted hyacinth orchid (*Dipodium punctatum*), both underground orchids lacking chlorophyll and thus unable to photosynthesise. In contrast, many of our *Banksia*, *Grevillea*, and *Hakea* spp. do not form mycorrhizal associations.

Lichens are regarded as biomonitors because they are particularly sensitive to pollutants and absorb water and nutrients through their surfaces. For this reason, we are more unlikely to see lichens in city landscapes, despite them being distributed across a wide variety of habitats, including aquatic environments. They are made up of two types of organisms, a fungus, and a partner organism (or two) that can photosynthesise, such as a cyanobacteria or algae. The fungi portion of the lichen protects the partner portion from intense sunlight and desiccation and, in return, is supplied with nutrition in the form of organic molecules. Hence, neither the fungi nor the partner organism can live without the other.

There are different types of lichens based on the internal structure of their thallus, the main portion of the structure containing the fungus and its partner. These three major forms are crustose, foliose, and fruticose.

Lichens are sometimes incorporated into bird's nests and often utilised by Australian case moths (*Metura elongatus*) as camouflage. Other lichens are used as food by slugs, snails, springtails, grasshoppers, termites, butterflies, moths, and even web-spinner spiders (*Notoligotoma* spp.).

Still, other mutualistic relationships occur between fungi and animals. While many ruminant animals (cattle, sheep, and their relatives) have large stomachs containing bacteria, they also contain fungi. These microbes are required to breakdown complex plant material, like cellulose and lignin, into molecules the host animals can then utilise. Likewise, some invertebrates have gut fungi to breakdown plant material and allow absorption of nutrients.

Fungi are also essential to many animals as a direct source of food. Fungus-feeding is known as mycophagy and is widespread in invertebrates. Some notable examples include the South American leafcutter ants (subfamily Myrmicinae) and some African termites, which propagate and tend fungi in their nests, which they utilise as a food source, and farm with a never-ending source of fresh plant material.

There are well over thirty species of mammal in Australia that consume fungi; hence fungi are an essential component of the diet for many species. Some mycophagous species include our native rodents, brushtail possum (*Trichosurus vulpecula*), and yellow-bellied glider (*Petaurus australis*), but potoroos (*Potorous* spp.), bettongs (*Bettongia* spp.), and bilbies (*Macrotis lagotis*) are the most reliant on fungi in their diet.

Many mycophagous specialists have an enlarged stomach that provides the host with sufficient time to digest fungi adequately. For example, whilst bettongs are fungi specialists, they also consume roots, tubers, and grasses. However, fungi are nutritionally diverse with different species containing varying levels of nutrients, hence some mycophagous species consume many different types of fungi to meet their nutritional needs. The northern brown bandicoot (*Isoodon macrourus*) eats plants, invertebrates, and fungi. The difference in the diet of the bandicoot, compared to other species, is also reflected in the anatomy of their digestive tract, which is regarded as much less complex than others (i.e., simple).

Australian mammals consume a diverse range of fungi found within three of the seven phyla (Ascomycotina, Basidiomycotina, and Zygomycotina). During their nocturnal foraging, they can travel long distances, throughout which they make regular deposits containing fungal spores, thus supporting fungi distribution throughout the environment. Hence, whilst many Australian native mammals rely on fungi for food, fungi are also reliant on mammals for dispersing their spores.

The eastern bettong (*Bettongia gaimardi*) eats seeds, bulbs, roots and insects, especially enjoying underground fungi, which may comprise as much as eighty percent of their diet. Image: Brett Vercoe.

Fungi are an important group of organisms in our environment. They include an extensive list of pathogens, are essential as decomposers, converting organic material into usable components for plants and animals, and are food items for many species. They are quite an underestimated group of organisms.

Family Psathyrellaceae is a member of common gilled mushrooms and allies. Image: Megan Fabian.

LA RÉSISTANCE!

Bolstering Frog Recoveries Through Applied Field Research

Matthew Mangan, Thais Sasso, Matthijs Hollanders, and Dr Laura Grogan

Amid surging public interest in conservation over recent decades, many charismatic animals are now protected as symbols of Australian wildlife. The status of koalas (*Phascolarctos cinereus*), platypuses (*Ornithorhynchus anatinus*), Tasmanian devils (*Sarcophilus harrisii*), and wombats are so intertwined with the Australian identity that vast swaths of government and grassroots support are directed towards their well-being. While increased protection for our furry mammalian friends is undoubtedly a cause for celebration, a difficult question remains unanswered – who looks out for the little guys?

People are often surprised to hear that amphibians are by far the most vulnerable class of vertebrates on earth. While habitat loss continues to displace countless species from their native environments, global climate change and worsening bushfires simultaneously make their remaining habitat even less hospitable. To make matters worse, encroachment of human industry into wildlife zones results in increased contamination of waterways with agricultural run-off and heavy metals. As amphibians can breathe, in part, through their skin, they can also easily absorb environmental contaminants, which may stunt their development and physical functioning.

Pretty bleak, eh? Well, fasten your seatbelts, because that is not even the worst of it. In addition to the festive cornucopia of threats described thus far, amphibians around the world are also being decimated by the most destructive wildlife disease in recorded history: amphibian chytridiomycosis (pronounced 'ki-TRID-i-o-my-CO-sis'). Chytridiomycosis is a skin disease caused by the fungus *Batrachochytrium dendrobatidis*, or Bd for short. Bd swims through waterways of all varieties and infects the skin of frogs. Because the skin is such an important organ in amphibian respiration and electrolyte balance, sweeping epidemics of Bd have been frequently documented to kill one hundred percent of frogs in a given population.

Over ninety species extinctions and hundreds of species declines have occurred worldwide in association with amphibian chytridiomycosis, but not all hope is lost! Despite ongoing declines in many amphibians, a small number of frog species are now showing promising signs of recovery. The mechanisms behind such recoveries are largely unknown, but many researchers suspect that these species are evolving novel ways to resist or tolerate Bd infection. In short, coexistence with this deadly fungus may be possible, and we aim to find out how.

The Frog Research Team (frogresearch.com) has been conducting intense fieldwork over recent years to understand amphibian recoveries at the population, species, and environment levels. Our primary study organism is Fleay's barred frog (*Mixophyes fleayi*), one of the three beautiful barred frog species inhabiting the Gondwana rainforests in south-east Queensland and north-east New South Wales. Fleay's barred frog experienced heavy declines in association with Bd in the 1990s, but population numbers are now recovering in certain parts of its range. Below, our PhD researchers Matthijs Hollanders, Matthew Mangan, and Thais Sasso will describe how their fieldwork gathers crucial intelligence in the fight against continuing amphibian declines.

Top: Fleay's barred frog (*Mixophyes fleayi*) is one of the dozens of Australian frog species that have experienced declines in association with chytrid fungus. Image: Dr Laura Grogan.

At the Population Level – Matthijs Hollanders

Once frogs appeared to be bouncing back after severe declines, we started intensively monitoring several populations in northern New South Wales. By conducting well over one hundred field surveys and collecting thousands of swab samples from individual frogs, we were able to compare the survival of frogs infected with Bd with those that were not infected. What we found was incredible. After just a few decades, many of these rainforest streams now boasted frog populations that seemed much more resilient to the pathogenic fungus. Although it appeared that some frogs still succumbed to the disease, the majority of individuals were able to live with the fungus, with many individuals frequently gaining and subsequently clearing infections. We are currently conducting laboratory experiments to further study the innate susceptibility of these surviving populations to Bd, but the results from the field are promising. We hope that other frogs are, in time, able to mount such a response to this deadly disease.

Matthijs staring down a terciopelo (*Bothrops asper*) during a nocturnal survey in Ecuador. Image: Matthijs Hollanders. Note, this image is not related to the subject of frogs in Australia.

At the Species Level – Matthew Mangan

While we have documented clear recoveries in a few populations of Fleay's barred frog, little is known about how they are faring throughout their whole distribution in eastern Australia. Surveying the changing numbers of these disparate populations would be a truly herculean endeavour, but thankfully modern genetic techniques allow for an easier solution. I have been gathering genetic samples from individuals in all the Fleay's barred frog populations that I can find. By looking at variation in the genes across a handful of individuals, I can estimate trends in the effective size and genetic health of each population! With the data I get from my field work, I can also explore how genes involved in the immune response are evolving to counteract Bd across populations. This could be really useful in helping other species still threatened by Bd epidemics.

I love my fieldwork dearly, as I often get to search for frog populations hidden deep in the bush of Australia's national parks. Some of these populations have not been seen in years or even decades, so I often feel like a true explorer as I tumble clumsily through the untamed forests. Admittedly, the rainforest is sometimes too untamed for my liking. During an ill-advised trip to some headwaters in Koreelah National Park, New South Wales, I found myself crawling through a muddy ravine of stinging nettle and stinging trees, desperately and pathetically croaking to attract the calls of Fleay's barred frog. I managed to find a handful of lethargic adults, but I ended the survey early after my tenth collision with a stinging tree that pushed me over the edge!

Matthew holding a giant barred frog (*Mixophyes iteratus*), the close cousin of Fleay's barred frog (*Mixophyes fleayi*) and one of the largest frog species in Australia. Image: Stephen Molan.

At the Environment Level – Thais Sasso

Throughout the 2019-2020 summer, I explored thirteen national parks in south-east Queensland and north-east New South Wales to gather data on where amphibian species were distributed, and document the severity of infection on the frogs. I noticed that my ability to find the frogs and their infection levels were associated with rainfall and temperature. During the drought just before the bushfires in 2019, finding frogs became a scavenger hunt. To overcome the difficulty of looking for frogs visually, I also attempted to find traces of them in the environment. With the help of over twenty volunteers, I collected water from thirty-one streams at varying altitudes to assess frog and Bd presence using a tool called environmental DNA (eDNA). All organisms, including pathogens such as Bd, may leave behind traces of DNA while interacting with the environment (e.g., water). This DNA can be collected to inform species presence without the need to observe the organism itself. Sampling for eDNA of pathogens like Bd is a fast method to evaluate its occurrence rather than directly looking for them on hosts such as the adult frogs, which can usually escape even from well-trained eyes.

Thais taking water samples to find frogs and *Batrachochytrium dendrobatidis* eDNA at Main Range National Park, Queensland, in a stream affected by the bushfires of 2019. Image: Thais Sasso.

Missing a frog during a survey is an issue all herpetologists must contend with in the field. Besides trying to spot the frogs' eyes with our headlamps, we improve our detection by also playing the male mating call repeatedly throughout the night. The male frogs, especially at the peak of the breeding season, call to advertise their location to females and other males. When we play the call at the stream, some frogs respond readily, even if buried under the leaf litter and impossible to find by visual survey only. We have to train our ears to locate where the call is coming from under the leaves and gently ease the frog out. Once, in a survey site south of Main Range National Park, Queensland, a frog came hopping rapidly towards me from five meters away as soon as I played the call! As not all frogs promptly volunteer to be swabbed like that, I will have to continue collecting eDNA to know where they are.

Two Fleay's barred frogs (*Mixophyes fleayi*) in amplexus (mating position) in a shallow riffle of a Queensland stream. Image: Matthijs Hollanders.

By analysing skin swab samples taken from the abdomen, thighs, and feet, we can determine whether frogs in the field are infected by *Batrachochytrium dendrobatidis* fungus. Image: Dr Laura Grogan.

After pumping stream water through a filter to collect environmental DNA, genetic methods are used to assess the presence of both *Batrachochytrium dendrobatidis* and target frog species in the waterways. Image: Dr Laura Grogan.

Red-Tailed Phascogales

Dr Julie Old, Dr Oselyne Ong, and Dr Hayley Stannard

Red-tailed phascogales (*Phascogale calura*) are dasyurids, or carnivorous marsupials. They are small cousins of the well-known Tasmanian devil (*Sarcophilus harrisii*) and the quolls (*Dasyurus* spp.). Red-tailed phascogales are mouse-like in appearance, however as their name suggests, they have a characteristic red tail with a black brush-like end; hence they differ in their appearance from the even more closely related brush-tailed phascogales (*Phascogale* spp.), which are more than double their size.

Being classified as carnivorous marsupials, it is not unexpected that the diet of the red-tailed phascogale includes small vertebrates such as dunnarts, mice, and birds, with quantities varying depending on seasonal abundance. However, the main component of their diet consists of insects.

Red-tailed phascogales were previously found throughout arid zones of central and southern Australia. However, they are now restricted to the south-west wheatbelt of Western Australia, having been impacted by habitat fragmentation and frequent burning of remnant woodland patches and introduced predators. These impacts, and others, have led to the decline of the species. They are currently listed as Vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act, and Near Threatened on the International Union for Conservation of Nature Red List of Threatened Species.

Red-tailed phascogales are arboreal, meaning they live in trees. In areas where they remain, they can be found in habitats with tall, dense vegetation, large areas of canopy cover and tree hollows. Often these areas contain dominant plant communities of rock oak (*Casuarina huegeliana*), wandoo (*Eucalyptus wandoo*) and *Gastrolobium* spp.

Both phascogale species, as well as Antechinus, have a rather unusual reproductive strategy. Mating occurs around June each year when the males reach sexual maturity at eleven months of age. Shortly after the breeding season ends, all the males subsequently disappear from the population. The disappearance of males from the population occurs as a result of all the males exhibiting huge surges of stress-related hormones, ultimately leading to stress-related diseases and hence their demise. This reproductive strategy is termed semelparity.

Female phascogales meanwhile give birth to up to thirteen young, a scenario called supernumerary, not unlike other species of dasyurid marsupials such as the quolls. However, female phascogales are only able to support a maximum of eight young in their pouch, as they only have eight teats. Hence, at birth, it is literally a survival of the fittest scenario because the newborns that are able to first locate and attach to a teat survive, whilst the remaining siblings perish. Those newborns lucky enough to attach to their mother's teat will stay permanently attached for around forty-four days and become fully weaned by 110 days after birth.

Top: A red-tailed phascogale (*Phascogale calura*). Image: Dr Julie Old.

Interestingly, genetic studies of phascogale young have also revealed female phascogales will mate with multiple males during the breeding season resulting in young with multiple paternity in the one litter. Further studies have revealed this occurs because female phascogales can store sperm; hence when females mate with multiple males, their resultant young vary in paternity.

Semelparity has been suggested to have evolved due to variable seasonal environments, perhaps due to a reduced likelihood of males surviving to a second breeding season. Therefore, it is plausible that this breeding strategy maximises reproductive output whereby males expend maximum energy mating with as many females as possible and results in complete male "die-off". In contrast, male phascogales rarely die in captivity after the breeding season ends. The precise reason for the lack of "die-off" is unknown; however, it is most likely due to more favourable conditions in captivity, having 'food on tap' and 'nice cosy living conditions'. However, despite male phascogales surviving in captivity beyond the breeding season, unlike female phascogales, they become infertile and thus unable to breed again in future breeding seasons.

In captivity, phascogales can breed readily if housed in favourable conditions, allowing reintroductions to occur. A successful soft-release reintroduction of sixteen phascogales from a captive colony at Alice Springs Desert Park occurred in 2007 into the surrounding fenced area. Seven of these individuals were tracked with radio collars and supported through supplementary feeding for one week after their reintroduction. A further introduction of phascogales in 2009 occurred at Wadderin Sanctuary, Western Australia. Five years post-reintroduction, it was reported that the phascogale distribution had extended beyond the fenced sanctuary, suggesting success. However, whilst these uniquely Australian species can be successfully housed in captivity and reintroduced, they remain under threat in the longer term. Impacts from habitat fragmentation, changing ecological characteristics in their habitat, and introduced predators remain threats to the survival of the red-tailed phascogale and continued efforts are required to ensure their survival into the future.

More recently, partnerships between Alice Springs Desert Park, Adelaide Zoo, National Parks and Wildlife Service, and the Australian Wildlife Conservancy have established captive breeding populations of red-tailed phascogales. In November 2021, sixty red-tailed phascogales, bred at Alice Springs Desert Park, were introduced into a 9,570-ha fenced feral predator-free refuge at Mallee Cliffs in New South Wales. A further fourteen animals that were bred at Adelaide Zoo were released into Mallee Cliffs in March 2022. Previously, red-tailed phascogales have been introduced into other feral-proof sanctuaries in Australia. In 2017 and 2018, 145 red-tailed phascogales were introduced into Mt Gibson Wildlife Sanctuary in Western Australia. In 2020, ninety red-tailed phascogales were introduced into Newhaven Wildlife Sanctuary in the Northern Territory.

A red-tailed phascogale (*Phascogale calura*). Image: SJ Bennet.

Australian Frogs are Dying En Masse Again,

and We Need Your Help to Find Out Why

Dr Jodi Rowley and Dr Karrie Rose

Last winter, thousands of dead and dying frogs were found across Australia. Instead of hunkering down and out of sight, frogs were spotted during the day in the open, on footpaths, highways, and doorsteps – often in the blazing sun.

These frogs were often thin, slow-moving, and with dark patches on their back or red bellies. They were seeking water in pet bowls or pot plants. And they usually died in a matter of hours.

A crash in frog populations could have very real consequences, particularly for already threatened frog species. The importance of frogs in freshwater and land systems means a crash in frog populations can also impact entire ecosystems.

Thankfully, reports of sick or dead frogs slowed as the weather got warmer, and by the end of last year, they had all but ceased. We hoped the awful spate of frog deaths was a one-off. But now, we fear it is happening again.

In the last few weeks, we have started getting scarily similar reports of sick and dead frogs from people across Australia.

From Warwick in south-east Queensland, we have received emails reporting green tree frogs (*Litoria caerulea*), discoloured and hunched up, sitting in the open, with the upsetting email:

> *"We normally have these beautiful creatures hopping around our house, but in the last week have only spotted two. Both were dead."*

From Sydney's North Shore, another report:

> *"I have just found a dead Peron's tree frog when raking up leaves in my garden."*

And most recently, one of our colleagues stumbled across a big green tree frog in the middle of the day while birdwatching in western Sydney. The bright green frog was sitting in the sun on an asphalt path. In only a few hours, the frog was dead.

How Many Frogs Died Last Year?

Photos of sick frogs started popping up on social media feeds in May last year. These reports were not initially alarming, as sick, old, or injured frogs are most likely to die in winter as their immune system slows down.

However, reports increased over late June and July, and we began to worry about just how many frogs were dying. Unfortunately, just as we began to worry, we were in lockdown, unable to venture out and investigate for ourselves.

So, we asked the community for help. We asked for reports of sick or dead frogs. We then aligned members of the public with local veterinary clinics willing to take in these frogs for examination, care, and diagnostic sample collection.

This help meant the welfare of frogs could be assured, and we could begin our scientific investigation into the cause once the lockdown ended.

Reports came flooding in. Each report often described dozens of dead frogs, making the grim tally in the thousands. Across Australia, a remarkable 1,600 people reported finding sick or dead frogs.

Although most sick and dead frogs reported were green tree frogs, this is likely because this species tends to hang around houses and be spotted more. Frog species less tolerant of suburbia are far less likely to be seen.

Despite this, more than forty species were reported, including threatened species such as the green and golden bell frog (*Litoria aurea*) and the giant barred frog (*Mixophyes iteratus*).

The true death count and a full list of species impacted are likely of higher magnitude.

Top: The green tree frog (*Litoria caerulea*) was the most commonly reported frog species found sick and dead. Image: Dr Jodi Rowley.

A green tree frog (*Litoria caerulea*) found dead. Image: Irene Leyshan.

Why Are the Frogs Dying?

We have been working with universities, government biosecurity, and environmental agencies to understand what caused frogs to die last winter.

Our investigation has only been made possible due to the efforts of people across Australia reporting sick and dead frogs, taking sick frogs to veterinary clinics, and freezing dead frogs for us to pick up and test ourselves.

In New South Wales alone, more than 350 people froze dead frogs for us to collect. Without this help, we would still be at square one with our investigation.

It is a murder mystery, and there are so many possible suspects. We have tested for parasitic, bacterial, viral, and fungal pathogens. These tests include looking for pathogens known to kill frogs and possible novel pathogens, which is by far the harder task. The potential role of toxins is also being assessed.

A green stream frog (*Litoria phyllochroa*) found dead on its back in Turramurra, New South Wales. Image: Dr Jodi Rowley.

Right from the very first frog deaths last year, our number one suspect has been the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*). This pathogen is a known frog killer responsible for causing frog population declines and species extinctions around the world, including in Australia.

The fungus attacks the skin of frogs, which is their Achilles heel – frogs use their skin to breathe, drink, and control electrolytes. Deaths of frogs due to this pathogen are often at cooler temperatures.

Our testing has revealed the amphibian chytrid fungus is certainly involved in this mass death event. Most of the hundreds of dead frogs tested so far have tested positive for the pathogen.

But we are not yet sure if the fungus is acting alone or is the primary cause of death. We continue to test for an array of other pathogens, toxins, and potential stressors.

Why Should We Care?

Australia has 247 known species of native frogs, forty of which are threatened with extinction, and at least four species are already extinct.

The impacts on Australia's frog species from such large-scale deaths are unknown, but scientific surveys of frogs, combined with large-scale citizen science data are underway.

Frogs are often extremely abundant and play an important role in the flow of energy, nutrients, and food webs. In places where amphibians have declined, the impacts are noticeable, with ripple effects across entire ecosystems as animals that rely on frogs for food start to disappear too.

We Need Your Help

To help us understand the scale and cause of any frog deaths this winter, please send any reports of sick or dead frogs to the Australian Museum's citizen science project FrogID via calls@frogid.net.au.

Please include your location and, if possible, photos of the frog(s).

To help us determine the impact of frog deaths on Australia's frogs and which species are likely to need our help the most, please download the free FrogID app and record calling frogs whenever you can.

Every recording will help us better understand and conserve Australia's frogs.

Another green tree frog (*Litoria caerulea*) found dead. Image: Patricia Packham.

A green tree frog (*Litoria caerulea*) found dead with clear, visible small white spots - a possible sign of a fungal infection. Image: Jayne Barrett.

Australian Wildlife Society

NATIONAL COLOURING-IN COMPETITION

The Australian Wildlife Society colouring-in competition is designed to inspire the younger generation to learn about Australia's native wildlife via visual art and creativity. We hope that the experience provides participants with the opportunity to explore and develop a deeper understanding of environmental and wildlife-related issues.

There will be one first, second and third place winner in each state and territory of Australia. The first place finalist in each state and territory will go into a draw to have their artwork published in the Society's magazine *Australian Wildlife*. All first place winners will receive an annual family membership, valued at $70, and a certificate of congratulations. Their artwork will be published in the Society's e-newsletter and social media platforms. Second and third place winners will receive a certificate of congratulations and their artwork will be published in the e-newsletter and social media platforms.

TERMS AND CONDITIONS

When you submit your entry, please include the following information:

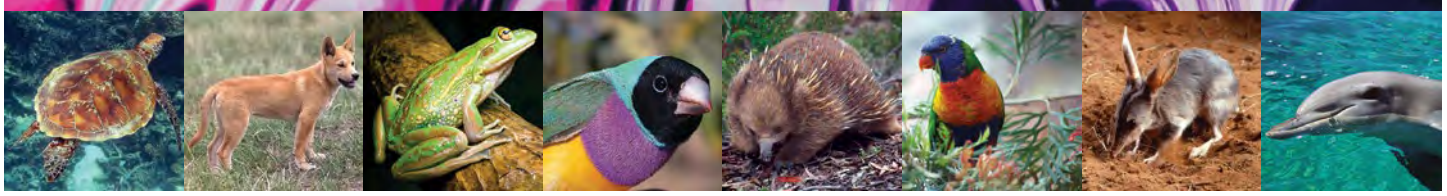
- Your name and age
- Your state of residence
- Telephone number and/or email address (this is how we will notify the winners)
- Parent/guardian's signature as consent for entry into the competition

SUBMITTING YOUR ENTRY

- Entries are limited to one (1) entry per person
- To submit your entry, please take a photo or scan the completed artwork and email a copy to info@aws.org.au
- Please name your file according to the format: Name, Age, State (For example: Mark5yoNSW)

CLOSING DATE FOR ENTRIES: 30th NOVEMBER

PARTICIPANTS WILL BE NOTIFIED BY EMAIL/PHONE IN MID-DECEMBER



The Queen's

Platinum Jubilee Ball
Government House, Canberra

Patrick Medway AM

Our Patron of the Society, His Excellency General the Honourable David Hurley AC DSC (Retd) Governor-General of the Commonwealth of Australia and Her Excellency, Mrs Linda Hurley, invited the President and Secretary of the Society to be their guests at the Platinum Jubilee Ball at Government House, Canberra, on Saturday 11 June 2022 to celebrate the Platinum Jubilee of Her Majesty The Queen.

The President, Dr Julie Old, was accompanied by the Company Secretary, Patrick Medway AM. They were immensely proud to represent the Society among the 250 other guests invited from a wide range of community service organisations across Australia.

We were welcomed into Government House by the sound of bagpipes and a military guard of honour when we arrived at the portico entrance. Attendants formally welcomed us, and souvenir photographs were taken before being escorted into the lounge area to see a display of historic royal tour photographs dating back to 1954 and the first Royal tour to Australia by Her Majesty The Queen.

His Excellency welcomed everyone to the Platinum Jubilee Ball in his opening address and thanked every organisation for their tremendous voluntary community service work for the wider community. He then proposed the loyal toast, and we proudly acknowledged Her Majesty the Queen of Australia and her long reign as our Monarch and Head of the Commonwealth of Nations.

L to R: Patrick Medway AM, Candice Lambert, Andrew McQuiggin, and Dr Julie Old.

Company Secretary, Patrick Medway AM, at the Platinum Jubilee Ball.

President, Dr Julie Old, at the Platinum Jubilee Ball.

President, Dr Julie Old, and Company Secretary, Patrick Medway AM, on arrival at Government House, Canberra.

Her Excellency, Mrs Linda Hurley, wrote and then sang a special song to mark the momentous occasion and was accompanied by the Australian Army Band.

We were seated at table twelve and hosted by Assistant Manager, Andrew McQuiggin. Other guests at our table included Robert de Castella AO, MBE (former world champion marathon runner and 1983 Australian of the Year), and his wife, Theresa, John Sharples and Peter from the Australian Men's Shed Association based in Cessnock, and Ahalya and Jodi from the Emergency COVID-19 Response Team in Canberra.

The Platinum Jubilee Ball menu was an exciting and exotic one with a delicious three-course meal accompanied by local wines from Canberra, Margaret River in Western Australia, and a Hallmark Cuvee from Tasmania.

After the formalities, His Excellency invited all guests to join him and Mrs Hurley on the dance floor for his favourite dance – the Scottish reel 'Strip the Willow' to the rousing music from the military band. Over one hundred guests did their best in this traditional dance routine, a very enthusiastic dance designed for a cold evening.

The Jubilee Ball was held in a large, specially constructed marque with purple lighting and excellent heating. The large dance floor adequately handled the enthusiastic dancers throughout the evening.

All too soon, the night came to an end, and guests started to depart but not before passing an impressive array of tea, coffee, port, and chocolates to enjoy on the way out.

We are incredibly grateful to our Patron for his very kind invitation to attend the 2022 Platinum Jubilee Ball at Government House, Canberra, and to the Society's Board of Directors for approving our acceptance of the invitation.

The Role of Australian Wildlife in Mosquito-Borne Diseases

Dr Oselyne Ong and Dr Julie Old

Mosquitoes are the deadliest animal in the world due to their ability to transfer numerous diseases. In Australia, there have been more than three hundred mosquito species identified. Some of these mosquitoes are vectors to mosquito-borne diseases, which are amplified as a result of urbanisation and climate change, and pose a risk to human health. However, despite their significant importance, the role Australian wildlife play in the transmission of these diseases is not widely known.

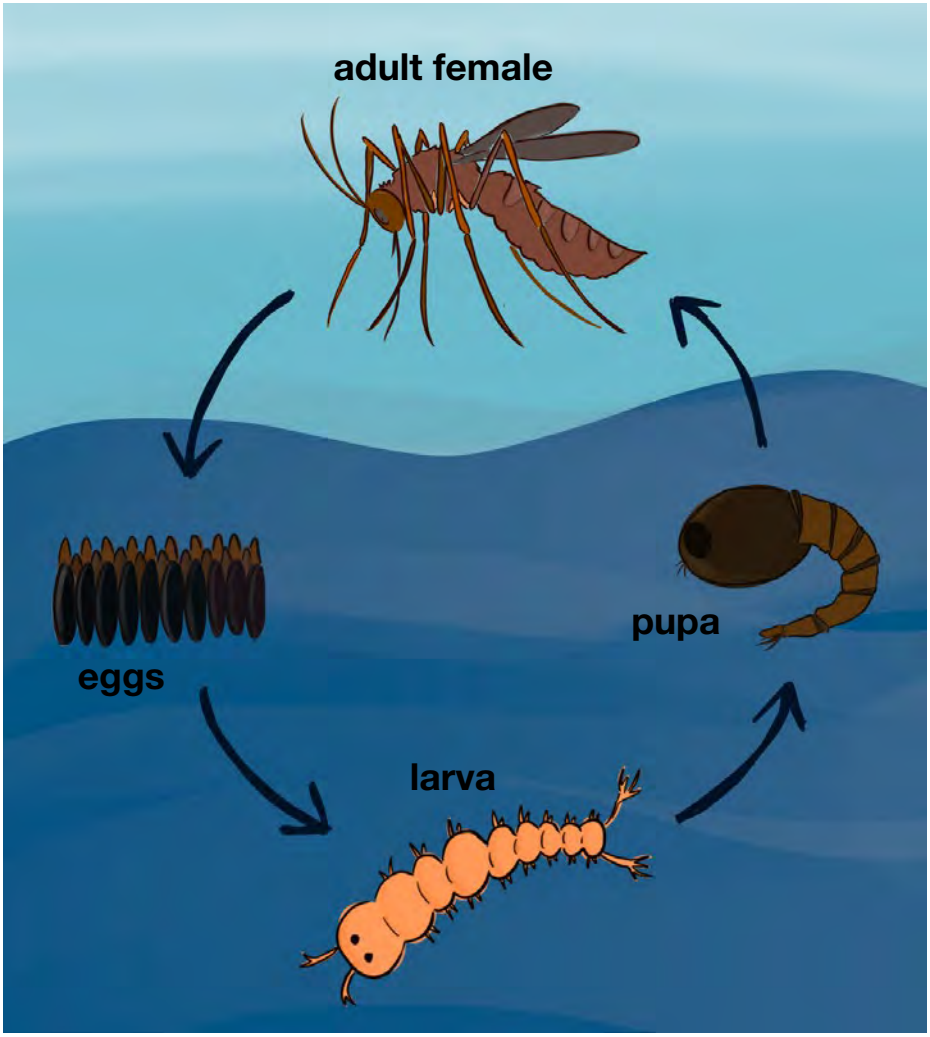
Mosquitoes lay eggs on water surfaces or near water that hatch into larva, larva develop into pupa, which eventually develop into adult mosquitoes. Both adult males and females have a proboscis, a mouthpart used to feed on nectar and other sources of sugar. Adult females also use their proboscis to pierce through skin and feed on blood, providing nutrients to produce eggs. Not all mosquitoes bite animals or people, however if they do, they have the capability of transmitting diseases, making them a disease vector. Mosquitoes do not become sick from these diseases, however some pathogens are known to affect their behaviour to increase disease transmission. Mosquitoes transmit diseases by swallowing viruses or parasites from one host and deposit those same viruses or parasites through their saliva to another host while acquiring blood meals. In addition, studies found that mosquito saliva enhances the pathogenicity of some diseases, including dengue.

While some mosquitoes are generalists, others have been shown to have specific feeding patterns preferring one host species over another. However, overall feeding patterns of mosquitoes in an area are largely dependent on the availability of hosts. As humans continue to live near livestock and wildlife, there is a high probability of transmitting mosquito-borne diseases from animals to humans. In combination with mosquitoes accidentally imported, global travel, and suitable breeding environments, these factors have led to an increased probability of rare mosquito-borne diseases spreading across Australia, affecting urban environments.

Prior to 2022, Japanese encephalitis virus infections were rare in Australia. Currently, the Japanese encephalitis virus poses a real concern along the Australian east coast. It has been found across Queensland, New South Wales, Victoria, and South Australia within the span of a month. Japanese encephalitis virus caused mortality in Victoria, New South Wales, and South Australia prior to March 2022. While ninety-nine percent of infected individuals do not show any symptoms of the Japanese encephalitis virus, twenty-five percent of symptomatic cases develop encephalitis, and the disease can be fatal.

Culex annulirostris, also known as the common banded mosquito, is Australia's most common host for the Japanese encephalitis virus. The disease occurs sporadically, influenced by migratory birds, travelling mosquitoes, close proximity to pigs (*Sus scrofa*), and possibly black flying foxes (*Pteropus alecto*). The extreme weather in Australia, particularly noting the recent La Niña-dominated weather, most likely caused an increase in mosquito populations, including *Culex annulirostris,* because they thrive in wet, humid environments, and the flooding increased the number of vulnerable hosts, including people affected by the floods.

Top: A silhouette of a mosquito. Image: Laszlo Fatrai.



Mosquito life cycle. Mosquitoes have four life stages: egg, larva, pupa, and adult. Image: Dr Oselyne Ong.

Australian wildlife also play a critical role in distributing and spreading mosquito-borne diseases. For example, Ross River virus is endemic and enzootic in Australia and Papua New Guinea, and, while not fatal, causes substantial morbidity in humans. Previously only found in rural parts of Australia, the virus is now present in metropolitan areas in all Australian states. Ross River virus affects approximately 5,000 Australians per year and has a wide variety of mosquito vectors, although there may be higher infection rates due to changes in human behaviour due to COVID-19 and climate change. Marsupials, particularly macropods, have an extensive length of viremia, meaning that the virus is present in their bloodstream for longer than usual. A recent study has also illustrated that koalas (*Phascolarctos cinereus*) could be reservoirs for the Ross River virus, expanding the Ross River virus reservoir species. Eutherian mammals and Australian birds can also transmit the Ross River virus.

Marsupials are not only reservoirs for Ross River virus, but are considered potential reservoirs for other viruses including, Barmah Forest, Sindbis, Murray Valley encephalitis, West Nile, Kokobera, Gan Gan, and Trubanaman. While some of these mosquito-borne diseases are so rare that they are often

The banded mosquito (*Culex annulirostris*) is an insect native to Australia. Image: Prof Richard Russell.

misdiagnosed or unheard of, some of these viruses could potentially impact humans and animals, including wildlife. Most marsupials can develop high viremia to mosquito-borne viruses while being unaffected by them. This means that while marsupials appear healthy, they can still be infected with mosquito-borne diseases and, in turn, infect other humans and other animals through mosquitoes. Hence, it is important to understand the relationship between Australian wildlife and mosquito-borne diseases as we do not yet know what diseases may be carried into Australia by mosquitoes and what exposure to these potential new disease threats may pose to our unique wildlife.

Globally, urbanisation and climate change are influencing wildlife distribution and behaviour. Urbanisation creates habitat fragmentation and destroys wildlife habitats, increasing anthropophilic mosquito populations that take advantage of man-made objects and human behaviours. These changes expose wildlife to stress and reduce populations and diversity. A low diversity of animals has been linked to higher disease transmission, and Australia has one of the highest extinction rates of mammals in the world. Climate change causes unpredictable weather that makes it difficult to predict the consequences of mosquito-borne diseases, and undoubtedly also changes the movement and behaviour of Australian wildlife and mosquitoes. The major floods in 2022, largely affecting parts of Queensland and New South Wales, led to the wide-spread physical movement of species, and increased mosquito distributions and the spread of mosquito-borne diseases, as evidenced by the recent spread of Japanese encephalitis virus.

Most animals are asymptomatic when infected by mosquito-borne diseases but play a huge role in spreading viruses. Knowing more about the complex interactions between wildlife, mosquitoes, and mosquito-borne diseases is essential. The opportunity to conduct surveillance for potential disease outbreaks by monitoring sentinel species and capturing blood-fed mosquitoes can provide researchers with early information to detect circulating diseases in an area before the outbreak of a disease. Furthermore, understanding the complex relationship between wildlife and mosquito-borne diseases can help develop strategies to minimise outbreaks of mosquito-borne diseases in us and our unique wildlife. This is important because the effects of climate change will likely increase the spread of mosquitoes and the diseases that they carry.

After reading this, you may think we should eradicate mosquitoes to remove any potential disease threats to ourselves and our precious wildlife, however there are also benefits to having mosquitoes in the environment. Mosquito larvae are aquatic and provide important food resources for many species of fish, birds, reptiles, amphibians, and other insects. They also consume large volumes of algae and detritus (biological waste) and sometimes other mosquito larvae, converting them into frass (insect faeces). Hence, they are both environmental cleaners and provide aquatic plants with nutrients. Furthermore, given the number of species of mosquitoes, only females of a limited number of species feed on blood, with most mosquito species playing important roles in plant pollination.

Of course, maybe that familiar buzzing we often hear is suggesting to us that it is time to go inside or to stay out of a particular environment, or perhaps it is just a hungry female mosquito looking for a blood meal. Either way, maybe we need to think about the pros and cons of our mosquitoes, and whilst they are perhaps not as cute and cuddly as other species, they are just as unique as some of our larger fauna, and maybe reaching for the roll-on repellant is a better option?

Dr Oselyne Ong in the Mosquito Control Laboratory. Image: Totally Wild.

2022 University Research Grant 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 $3,000 are awarded. Grants are available for research projects of direct relevance to the conservation of Australian wildlife (flora or fauna). Grants may be used to purchase equipment and consumables, travel expenses related to field research, or attend conferences at which you are presenting your research.

The Australian Wildlife Society is delighted to announce the winners of the ten grants of $3,000 each to honours or postgraduate students conducting research that will contribute to the conservation of Australian wildlife. **The winners for 2022 are:**

ADAM YANEY-KELLER
School of Biological Sciences,
Monash University

Project Title:
Disentangling the long-term effects of marine debris on Australian fur seals

CLAIRE BUTLER
Institute of Marine and Antarctic Studies,
University of Tasmania

Project Title:
Comparative effects of ocean warming on kelp-herbivore interactions on Australian temperate reefs

ELISE OAKMAN
School of Life and Environmental Sciences,
University of Sydney

Project Title:
Does restoration return insect pollinators to our endangered ecosystems?

ERICA FONSECA
School of Biological Sciences,
Queensland University of Technology

Project Title:
Social-ecological drivers and outcomes of conservation in private lands

JACLYN HARRIS
School of Biological Sciences,
Monash University

Project Title:
Fire and Reptiles: An investigation into threatening processes and potential management solutions

JAVIERA OLIVARES-ROJAS
School of Biological Sciences, Monash University

Project Title:
What is required to recover Australian threatened ecosystems?

JESSICA KEEM
School of Ecosystem and Forest Sciences,
University of Melbourne

Project Title:
Refuges are vital for the survival and persistence of fauna in the wake of disturbance events

NICHOLAS MACDONALD
School of Life and Environmental Sciences,
Deakin University

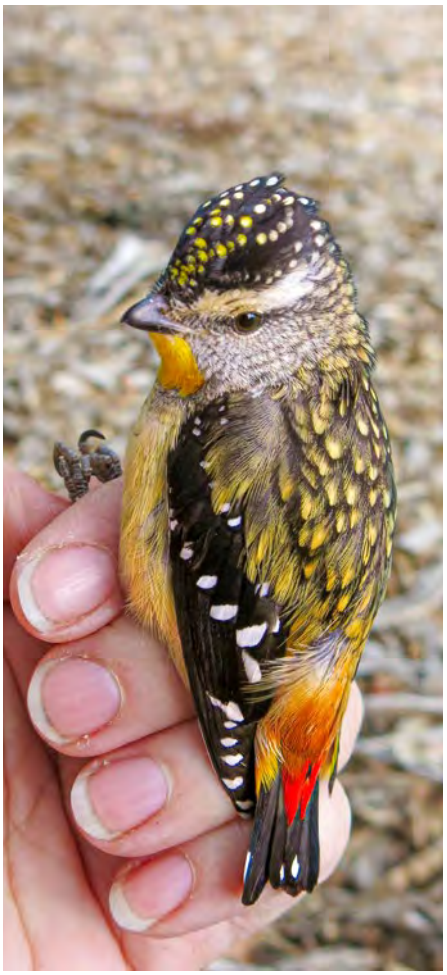
Project Title:
Investigation of the immune response of the Tasmanian devil (*Sarcophilus harrisii*) to cancer and altered environmental conditions

NICOLE LYNCH
School of Life and Environmental Sciences,
University of Sydney

Project Title:
Spot the quoll: tactical use of olfactory information to improve detection and conservation of a rare, native carnivore

SHAWN SCOTT
UniSA STEM,
University of South Australia

Project Title:
Post-fire population recovery and chytrid occurrence in frogs of the Mount Loft Ranges, South Australia



Prevalence of Feather-Degrading *Bacillus* spp. on the Plumage of Birds in Australia

Dr Nadya Marie Sotnychuk

The world is full of diverse microbial communities; the microbial community on or around an individual can shape the life history and ecology of its host. Feathers and feather quality are extremely important to birds, especially regarding flight, sexual signaling, and thermal regulation. However, research into the role of feather microbial communities and how they shape avian life histories are limited. Studies have shown that feather microbial communities do impact the fitness of their hosts. For example, higher microbial loads can lower feather conditions and, therefore, negatively influence things such as flight and moult patterns.

In 1999, researchers discovered the first evidence of plumage microbes that broke down beta-keratin in feathers. These microbes are called feather-degrading bacteria and now include several species of bacteria and some fungi. The primary types include: *Bacillus licheniformis, Bacillus subtilis, Bacillus plumulus,* and *Bacillus cereus.* Feather-degrading bacterial loads vary based on the characteristics of the host, including habitat, foraging type, bird condition, and species. However, the phenomenon is widespread. Feather-degrading bacteria have been found on birds in North America, Europe, and South America. They have also been found on decomposing penguin feathers in Antarctica and the soils of Asia and Africa on poultry waste. Initial studies of feather-degrading bacteria were conducted primarily on wild birds, but more recent studies have focused on the implications of such bacteria in the poultry waste industry. Therefore, much of the research has moved to in vitro or the lab.

Evidence of feather-degrading bacteria on wild Australian birds did not exist, so our research was the first study to quantify the prevalence of the *Bacillus* species and feather-degrading bacteria in Australia. We captured birds using mist nets and snap traps and sampled three habitat types (temperate rainforest, dry sclerophyll forest, and heath). Captured birds were sampled for microbes, banded for identification, and all appropriate measurements were taken, including wing and tail feather-wear scores. The bacterial samples were brought back to the lab and inoculated under different conditions depending on the media type. After incubation, the number of colonies was counted and defined based on morphology. The number of colonies on a plate ranged from zero to over 350 colonies. This data set has 777 plates. The total number of presumptive *Bacillus* species colonies counted per bird determined the total plumage bacterial load.

We sampled 254 Australian birds, representing twenty-five species (thirteen families). Of these, 216 birds (eighty-five percent) harboured presumed *Bacillus* spp. Total plumage

Top Left: A male spotted pardalote [*Pardalotus punctatus*]. Image: Dr Nadya Sotnychuk.

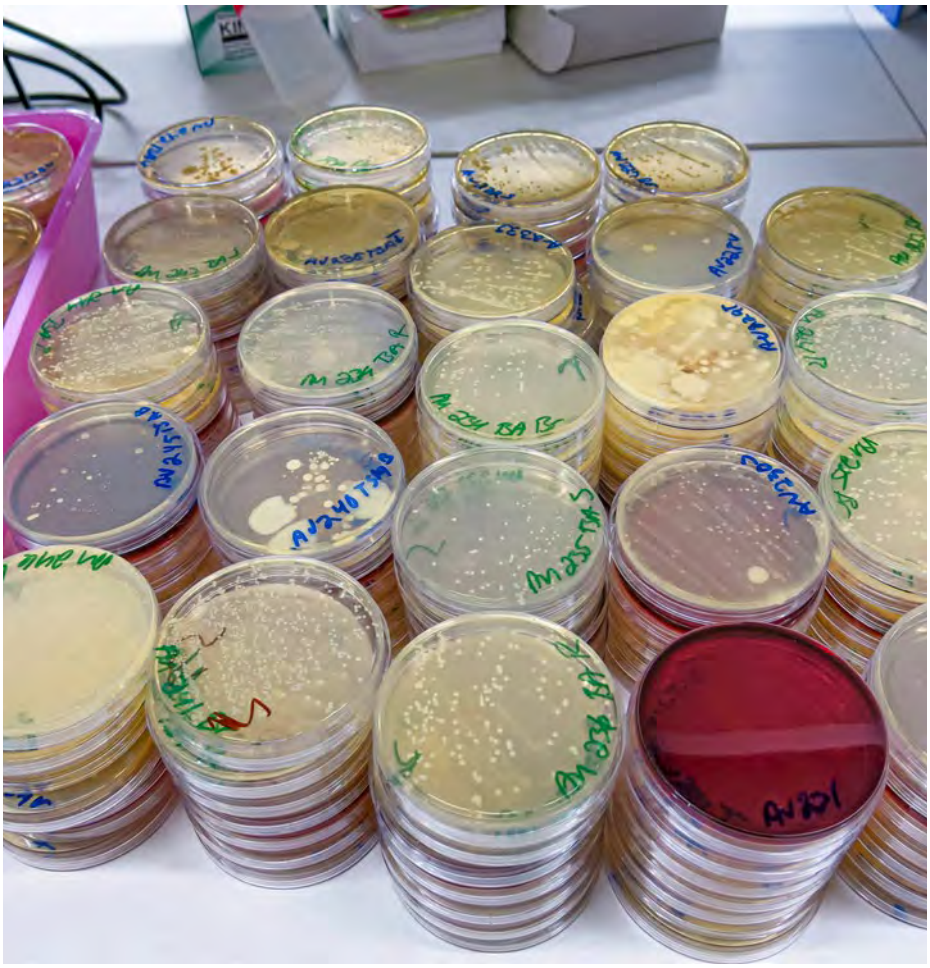
Top Right: A mail eastern spinebill [*Acanthorhynchus tenuirostris*]. Image: Dr Nadya Sotnychuk.

An inoculated Tryptic Soy Agar plate with various species of microbial colonies. Image: Dr Nadya Sotnychuk.

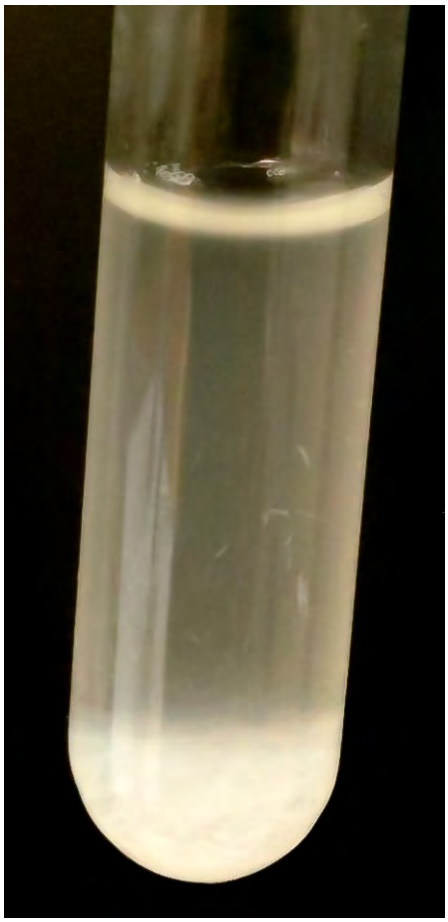
bacterial load, quantified as the total number of *Bacillus* spp. colonies, varied with habitat. Birds in heath habitats had a lower total plumage bacterial load than birds in temperate rainforests and dry sclerophyll forests. Heath habitats have dry soil with low nutrients. The environment is not conducive for *Bacillus* spp. growth as they are soil-dwelling bacteria that thrive in hot and humid environments.

An additional test of *Bacillus* spp. was conducted to determine if the colony was a feather-degrader. This test was done by extracting the colonies from a feather collected from the bird's ventral side (belly) during sampling. Of the 254 feathers collected, 137 (fifty-four percent) hosted *Bacillus* spp., and 85 (sixty-two percent) of those hosted feather-degraders. Isolates that broke down a white feather and were gram-positive were considered feather degrading bacillus species.

Wing and tail feather-wear data were collected to determine if there was a correlation between wear and the prevalence of feather-degrading bacteria. Contrary to our predictions, we found no correlation between the prevalence of wing and tail feather-wear and total plumage load or feather-



Inoculated Agar plates with growing bacterial colonies. Image: Dr Nadya Sotnychuk.



Tubes showing the feather-degrading test. This tube shows a completely degraded feather.
Image: Dr Nadya Sotnychuk.

degrading bacteria. Although studies suggest otherwise, we found no effect of foraging type on bacterial load. Likewise, we tested for an effect of flocking status and found none.

Our research indicates that feather-degrading bacteria are prevalent on the plumage of wild birds in Australia. With feather-degrading bacteria now found on nine orders (addition of order Psittacidae-Parrots) and over 168 species (addition of eighteen species) of wild birds on four continents.

First published in 2020 (https://bit.ly/avestudy), this research is the first study of feather-degrading *Bacillus* spp. on the plumage of wild Australian birds. More research is needed to confirm similar trends under different circumstances. From our results, we identified two areas for future research:

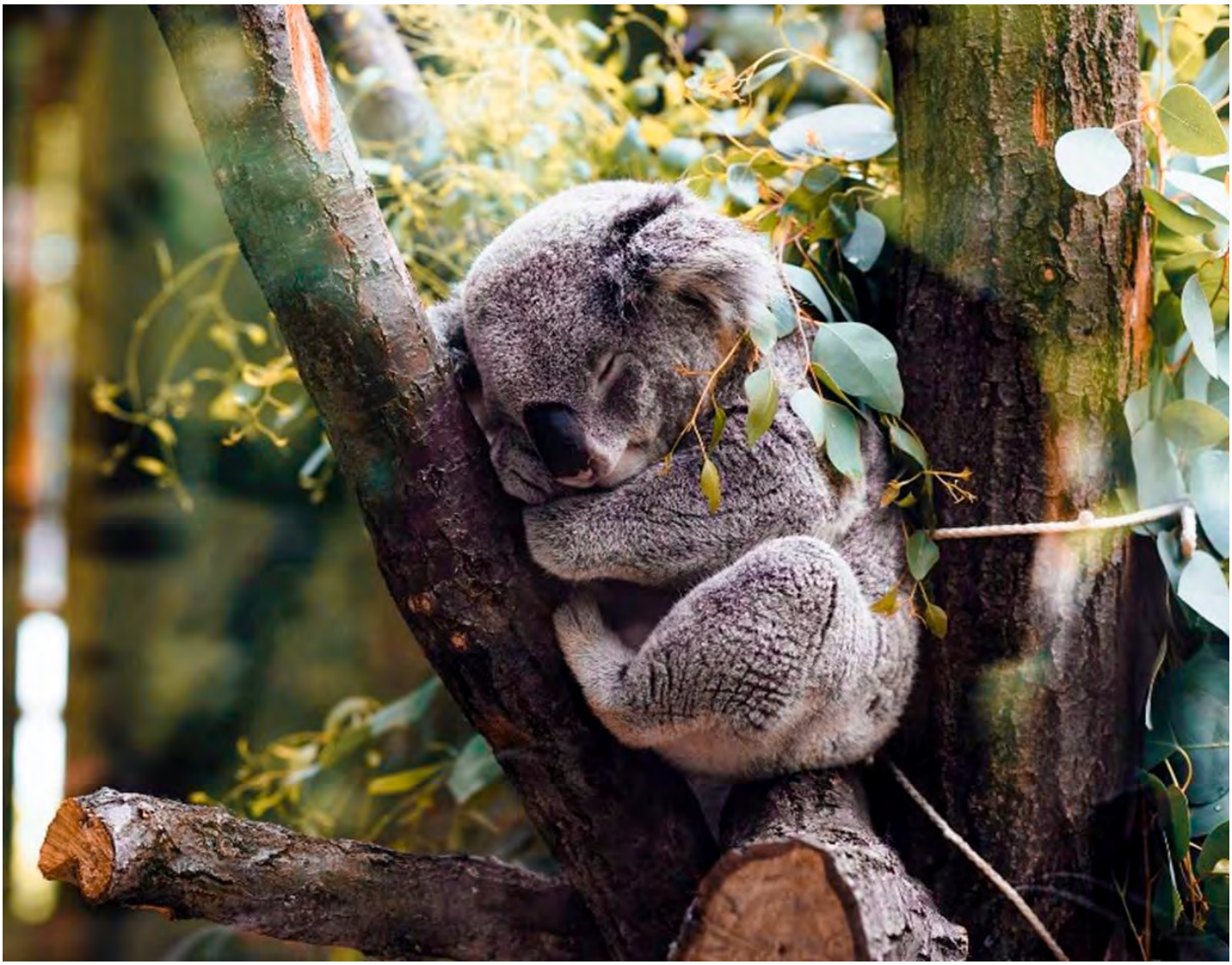
1. Comparing the genetics of feather-degrading species internationally to better understand how these bacteria have evolved in different geographic locations, and
2. An exploration into the impact of UV light on feather wear and microbial abundance as this might have influenced our wing and tail wear results.

Sampling the tail of a Crimson Rosella (*Platycercus elegans*) with an Eosin Methylene Blue Agar. Image: Dr Nadya Sotnychuk.

Tubes showing the feather-degrading test. This tube shows a feather that did not degrade. Therefore, the bacteria were not listed as a feather-degrader. Image: Dr Nadya Sotnychuk.

A crimson rosella (*Platycercus elegans*). Image: Dr Nadya Sotnychuk.

Grey shrikethrush (*Colluricincla harmonica*). Image: Dr Nadya Sotnychuk.



Conserving the Mornington Peninsula Koala Population

Marina Tidmarsh, Mornington Peninsula Koala Conservation Volunteer

Koala (Phascolarctos cinereus) populations in Queensland, New South Wales, and the Australian Capital Territory have recently been listed as Endangered under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. Koalas are not listed as Endangered in Victoria but, like all wildlife in Victoria, are protected under the Wildlife Act 1975. Although koalas are not yet listed as Endangered in Victoria, some of the state's populations are struggling, particularly in Ballarat and Gippsland.

In the 1800s, Mornington Peninsula's original koala population completely disappeared due to hunting for the fur trade. Today, habitat loss and fragmentation are the most predominant reasons for their decline. Other factors include attacks by predator animals such as dogs, disease, road deaths, invasion of exotic species, and unsustainable habitat due to development.

The Australian Koala Foundation explains that mainland koalas were introduced to French Island, where they thrived, and were later reintroduced to Victoria. The population was stable until approximately forty years ago, and the continual decline in habitat means the transfer of koalas from French Island is no longer an option.

Victorian koala populations are very isolated. A study done by Deakin University showed that sixty-nine percent of available koala habitat is on private property and very fragmented, as depicted in the Mornington Peninsula koala distribution study map.

The destruction and fragmentation of habitat results in koalas spending more time on the ground moving from tree to tree rather than moving through tree canopies. Travelling on the ground makes koalas highly vulnerable to road accidents and attacks by dogs, foxes, or cats. The increased exposure to threats also means they have higher stress levels, making them more prone to disease and sickness.

Genetic diversity is essential as it gives species a better chance of survival. Koalas on the Mornington Peninsula are not genetically diverse (like most other Victorian koalas). As koala numbers decline and populations are separated by fragmentation, genetic diversity decreases due to inbreeding.

Other factors such as land use, land management, ecological history, edge effects, and spreading weeds and pest species make it particularly challenging when conserving vulnerable species.

Top: The Koala (*Phascolarctos cinereus*) is listed as Vulnerable on the *International Union for Conservation of Nature Red List of Threatened Species*. Image: Mornington Peninsula Koala Conservation.

Why is the Conservation of Koalas Important?

The koala is one of the world's most iconic animal species. Being endemic to Australia makes them an attraction for tourists, and one of Australia's most identified species. Their cute and cuddly appearance makes them an ambassador for Australian native wildlife.

Koalas are important for the ecosystem as their scat deposits fall to the forest floor, promoting woodland understory growth and regeneration. Their droppings are also known to be a source of food for insects and many small mammals.

Besides conserving the koala, increasing tree cover will provide habitat for native bird species such as lorikeets (*Trichoglossus moluccanus*), kookaburras (*Dacelo novaeguineae*), and the Endangered powerful owl (*Ninox strenua*).

Bio-corridors linking vegetation will also benefit mammals such as possums, bats, echidnas, kangaroos, and wallabies. Regeneration of the understory will provide food and habitat for species such as native mice and rats, lizards, snakes, frogs, countless insect species, and microorganisms.

Conserving and regenerating biodiversity in Australia and the Mornington Peninsula is one of the most important challenges we face today. Biodiversity is essential for all processes that support life on earth, and maintaining a healthy ecosystem means clean air, clean water, a stable climate, and an abundance of food.

The koala population stability on the Mornington Peninsula is directly linked to the availability of habitat trees, particularly Eucalypt trees such as manna gum (*Eucalyptus viminalis*), swamp gum (*Eucalyptus ovata*), messmate (*Eucalyptus obliqua*), and narrow-leaved peppermint (*Eucalyptus radiata*).

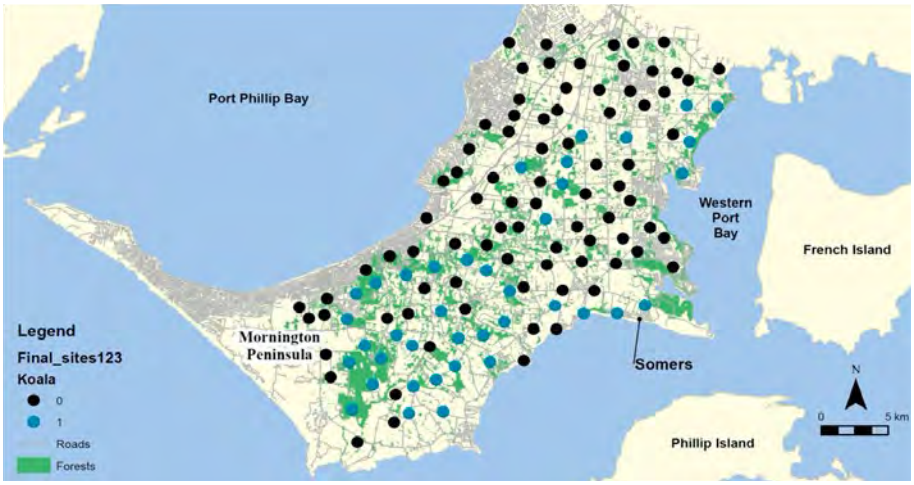
Mornington Peninsula Koala Conservation

The alarming news that one of our most iconic species is at risk has inspired community groups into action. The Mornington Peninsula Koala Conservation Group works to raise awareness of the challenges koalas face on the Mornington Peninsula.

As a large group of volunteers, we work to protect and increase significant koala habitat. We organize habitat restoration activities on the Peninsula with a focus on creating and connecting koala habitats. We also provide information to the community and trees to property owners to increase the native vegetation in suburban areas.

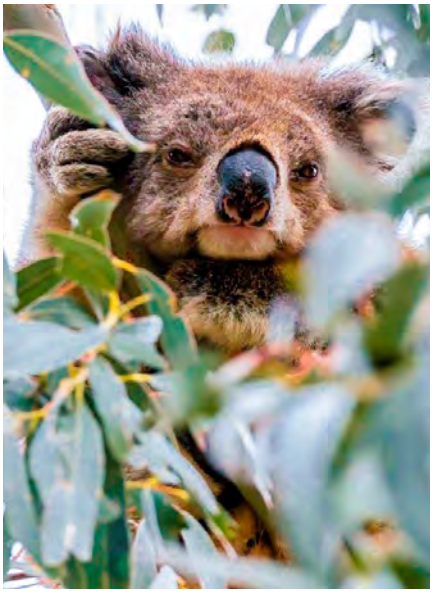
Trees were planted in Arthurs Seat State Park, Victoria, in 2021. Image: Mornington Peninsula Koala Conservation.

A tree planting day in Somers, Victoria, in 2021. Image: Mornington Peninsula Koala Conservation.



A Mornington Peninsula koala distribution study map. The blue dots represent koala sightings, and the black dots represent koala habitat. Image: Paola Rivera, Deakin University, 18 August 2020.

Eucalyptus seedlings for the 2021 planting project grown by the Conservation Collective. Image: Mornington Peninsula Koala Conservation.



A koala sighting in Main Ridge, Victoria. Image: Mornington Peninsula Koala Conservation.

How You Can Help Koalas

1. Preserve and plant native trees. Where possible, preserve native trees and other areas of bush that connect koala habitat in your area. Plant koala food trees, especially manna, swamp, and narrow-leaved peppermint gums,
2. Plant local indigenous plants. Plant guides can be found at bit.ly/IndigenousPlantGuide
3. Report your sightings of koalas at mpkoalas.org.au
4. Reach out to your local council and local Member of Parliament to let them know that koala conservation and mitigating climate change are important to you,
5. Become a member of Mornington Peninsula Koala Conservation. Every membership helps to plant five trees,
6. Be alert when driving. Drive slowly when driving through koala habitat,
7. Ensure fencing is koala-friendly. A koala-friendly fence is one that koalas can easily climb over, through, or under, allowing them to move freely around their habitat, and
8. If possible, keep your dog inside or in an enclosed area at night and check your yard before leaving your dog unsupervised.

Funds provided by the Australian Wildlife Society assisted the Mornington Peninsula Koala Conservation Landcare Group in maintaining and increasing available habitat for Mornington Peninsula's koalas through tree planting and raising community awareness and education, particularly around road safety.

BRINGING HOPE TO THE MORNINGTON PENINSULA KOALAS

Mornington Peninsula Koala Conservation Group members are planting trees for local koalas to provide hope for their future. Image: Mornington Peninsula Koala Conservation.

Mighty Mussels: The Livers of the Rivers

Alan Lymbery

When I was ten years old, my parents gave me a small canoe, and for the next seven years, I spent most weekends paddling along the river near my home. What most fascinated me then, and still does today, were the little creatures that are often overlooked: things like water fleas, dragonfly larvae, water boatmen, and caddisfly larvae. The most unobtrusive of these invertebrates, but probably the most important for the health of the river, are freshwater mussels.

There are 958 species of freshwater mussels throughout the world, found on every continent except Antarctica. In Australia, eighteen species have been described. The number of species of freshwater mussels is probably underestimated because most of these species have not been studied genetically. In south-west Australia, where most of my research is conducted, there is only one described species, Carter's freshwater mussel (*Westralunio carteri*). However, DNA sequencing studies have revealed two very different genetic groups, one on the west coast and one on the south coast. These two groups probably represent two different but morphologically very similar species. Genetic investigation of other Australian mussels might uncover more cryptic species.

The Secret Life of Mussels

Freshwater mussels are quite different from the marine mussels that you might see in large clumps in the sea or an estuary. They do not attach to each other, and they spend their days buried in the bed of a river or lake, often using their muscular foot to move around. They are slow-growing and very long-lived, with some species reaching 150 years of age. They also have a very unusual life history.

To breed, male mussels release sperm into the water column. Female mussels filter the sperm from the water and fertilise their eggs internally. The fertilised eggs are held in a specialised pouch in the animal's gills, where they develop into tiny larvae called glochidia. When fully developed, glochidia are released into the water and attach to fish, becoming an external parasite on the skin or gills. During their parasitic phase, which usually lasts for a month or two, the glochidia metamorphose into baby mussels, which then drop from the fish and bury into the sediment. Many mussels have evolved elaborate lures to attract fish, giving the glochidia a greater chance to find their hosts.

Livers of the Rivers

Mussels are ecosystem engineers, vital to the health of freshwater environments. They spend their long lives filtering organic matter, such as algae and bacteria, from the water column, improving water quality for other organisms. This is especially important in the dry season in much

Top: Carter's freshwater mussels (*Westralunio carteri*) stranded on a sandbank in a drying river. The mussels will bury into the sediment, where they can survive out of water for a time, but prolonged exposure to hot, dry conditions will kill them. Image: Alan Lymbery.

Dr Alan Cottingham, from Murdoch University, measuring mussels found in wetlands on a rehabilitated Iluka mining site near Capel, Western Australia. Image: Stephen Beatty.

Carter's freshwater mussels (*Westralunio carteri*) in the Harvey River, Western Australia. Freshwater mussels can be found at high densities in summer refuge pools. Image: Jake Daviot.

of Australia, when rivers usually stop flowing and all water life has to survive in disconnected pools. Our studies of Carter's freshwater mussel show that each adult mussel can filter 2-3 litres of water per day. With fifty mussels per square meter of a riverbed, an average density often seen in dry season pools, a mussel population will filter the whole of a 40,000-litre pool in less than a week.

As well as improving water quality, freshwater mussels perform many other important functions. By filtering energy and nutrients from the water column and depositing them (in the form of faeces and undigested "pseudofaeces") in the sediment, and by oxygenating the sediment as they move around, they are increasing the abundance and diversity of life in the river. They also provide food for a variety of predators, including wading birds and rakali (native water rats). In the past, they were an important food source for Indigenous Australians, as evidenced by shell middens found along riverbanks, flood plains, and lakes. The shells of mussels, both when they are alive and after they die, are also used as shelters by other aquatic creatures.

On the Brink

Although mussels are necessary for the proper functioning of freshwater ecosystems, they are one of the most endangered groups of animals in the world, with forty percent of known species categorised as Near Threatened, Vulnerable, Endangered, or Critically

Alan Lymbery, Director of the Centre for Sustainable Aquatic Ecosystems in the Harry Butler Institute, Murdoch University. The work by this team on the conservation of freshwater mussels is supported by the Australia and Pacific Science Foundation and the Water Corporation of Western Australia.

Endangered by the International Union for Conservation of Nature's Red List of Threatened Species. Only two Australian species have so far been listed as threatened, but that is probably because the extinction risk of most mussels in Australia has not been examined in detail.

The two species on the International Union for Conservation of Nature's Red List of Threatened Species are the Glenelg freshwater mussel (*Hyridella glenelgensis*) and Carter's freshwater mussel. The Glenelg freshwater mussel is Critically Endangered. The species is found in only one short section of the Glenelg River in Victoria, and fewer than 1,000 individuals remain in the wild. Carter's freshwater mussel is more numerous and widespread throughout south-west Australia, but by comparing the current distribution with historical museum records, my graduate student, Michael Klunzinger, found that the range of the species has contracted by almost fifty percent over the last fifty years.

Finding Solutions

My research, carried out with colleagues at the Harry Butler Institute, Murdoch University, is focused on identifying threats to the survival of Carter's freshwater mussel and finding ways to overcome those threats. One of the major threats to mussels and all freshwater organisms is the loss of permanent water bodies. The rivers of south-west Australia, like those in many parts of the country and many parts of the world, do not flow all year. During the Noongar seasons of Bunuru and Djeran (late summer/autumn), river flow stops, sections of the river become dry, and all freshwater life relies on isolated refuge pools to survive.

A freshwater mussel filter-feeding in a river in the Kimberley, Western Australia. The exhalant siphon, on the left, expels water and waste. The inhalant siphon on the right, fringed with sensory cilia, brings water and food particles into the shell. Image: Adam Harman.

South-west Australia has been especially hard-hit by climate change, with a dramatic decrease in rainfall leading to a fifty percent reduction in annual streamflow since the 1970s. Natural refuge pools are becoming fewer in number, smaller in size and more disconnected. Freshwater mussels, being relatively sedentary except in the initial, parasitic phase of their life cycle, are often stranded in rapidly drying riverbeds and perish in the hot, dry conditions.

One way we can help mussels cope with the changing climate is to provide artificial refuge pools to take the place of the natural refuge pools that are being lost from our rivers. We are working with community organisations and government agencies to identify the characteristics of farm dams, fire-fighting waterpoints, and wastewater drains that will enable them to serve as mussel habitats. These artificial structures often hold water over the long, hot summer and reconnect to rivers when the rains come. We have found that many of them can sustain viable populations of mussels, as well as other aquatic invertebrates and native fish.

For freshwater creatures such as mussels, climate change is not a distant threat; it is happening now and is seriously affecting population abundance and distribution. Artificial refuge pools may buy us some time to protect species against extinction. However, this will only be a temporary reprieve unless serious action is taken immediately to limit global warming.

Most freshwater mussels are very long-lived. The ages of the mussels pictured here range from less than five years to approximately thirty-five years. Image: Ashley Lymbery.

Bell's Turtle: An Iconic New England Species

Dr Geoff Hughes

Readers from Queensland and northern New South Wales may be well-acquainted with the saw-shelled turtle (*Myuchelys latisternum*). These small turtles are commonly found in streams and dams throughout much of north-east Australia. Widespread and numerous, the saw-shelled turtles have some less-fortunate cousins living to their south: the Manning River turtle (*Myuchelys purvisi*) and Bell's turtle (*Myuchelys bellii*) are both listed as Endangered, while the Bellinger River turtle (*Myuchelys georgesi*) is Critically Endangered. For the last four years, my work has been focused on the conservation ecology of the Bell's turtle.

Like many of Australia's turtles, the Bell's turtle ("*yiwaang*" in the Nganyaywana language or "*yiwanga*" in the Dhanggati language) is endemic to a single catchment in the upland headwaters of the Murray-Darling Basin. They are the largest members of the genus *Myuchelys,* with females exceeding 30 cm in length while the smaller males often reach no more than 23 cm long. They have short necks covered in bumpy scales, yellow chins, and very large heads with bolt-cutter jaws. You do not want to be bitten by a Bell's turtle! Fortunately, they are gentle and flighty animals, and it is easy to avoid getting a nip.

I came to Australia in January of 2018, having studied turtles in my home country of Canada for more than a decade previously, and got stuck into a PhD position tackling some of the issues that Bell's turtles face. The turtles suffer high rates of nest depredation from the invasive red fox (*Vulpes vulpes*), and one of my main goals was to trial new ways to protect these nests.

First, I tried a targeted baiting program, with baited chicken eggs buried as close to the water as I could legally set them, specifically targeting foxes hunting for turtle nests. It did not work; new foxes replaced the old ones as quickly as they were eliminated. So, I next tried spreading the highly concentrated fox attractant scent over nesting beaches, figuring that I could mask the smell of the eggs with this distracting new scent. Strangely, it seemed to drive the foxes away altogether, so I tested that as a possible tactic instead. My thinking was that perhaps all that overwhelming scent seemed to the real foxes that a scary, dominant individual fox was in the area, an "uberfox" if you will. In the end, it also did not work; either the real foxes figured out that uberfox was bogus, or more likely, I misunderstood what had happened with the original experiment. In truth, a part of me was glad that it did not work, as the attractant scent was horrible stuff to work with: it smelled like rotten meat stewed in kerosene and looked like actual vomit.

In the end, I settled on another method to trial for the thesis. I built large structures out of wood and chicken wire, with a narrow entrance protected by an electrified wire. A small Bell's turtle could enter, but a fox or other predator would get a belt across the nose if it tried. I based these nesting refuge structures on a similar design that was successfully used in the United States for diamondback terrapins (*Malaclemys terrapin*), and they did show promise here, too! Foxes were recorded near the entrance but never successfully got in, and in the

Top: A large female Bell's turtle (*Myuchelys bellii*). Image: Dr Geoff Hughes.

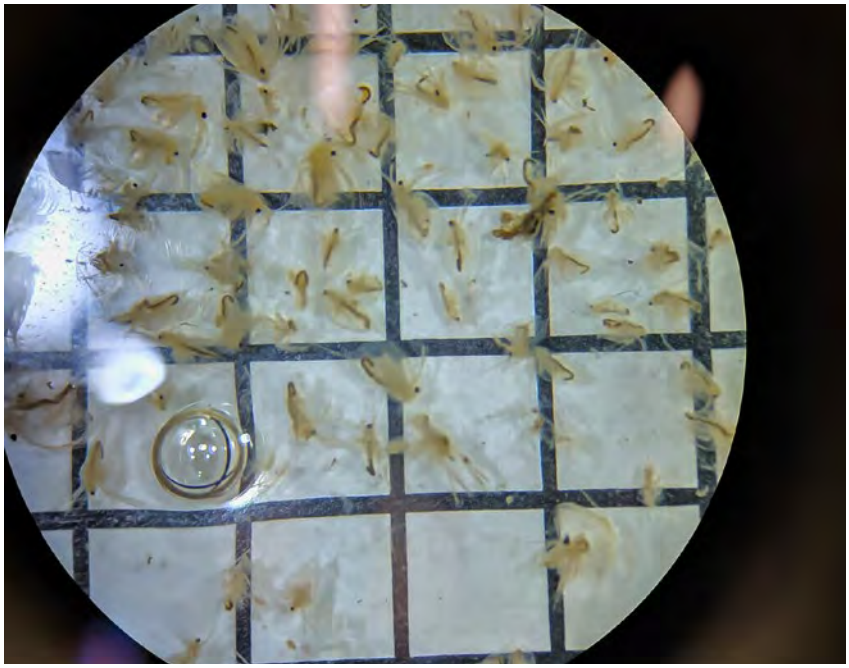
second year of the study, a female entered the structure and dug a little, although she ultimately did not nest. Given time, the structure design could have been tweaked until the females would readily nest inside, but there was another problem. Bell's turtles nest very close to the river's edge, and Australian rivers are prone to flooding. Some of my structures were inundated for a day or two; one, though, I found 300 m downriver, wrapped around a tree! There is just no way to design a cost-effective structure that can stand up to that kind of force.

Not everything about my work was so unsuccessful. For example, using electron scanning microscopes on fragments of turtle eggshells, I was able to identify some promising features that can be used to tell the eggs of different turtle species apart. This identification could benefit researchers working in areas with multiple turtle species. Building on what I have found in the future, other researchers could take eggshells from raided turtle nests and be able to tell what species the eggs came from.

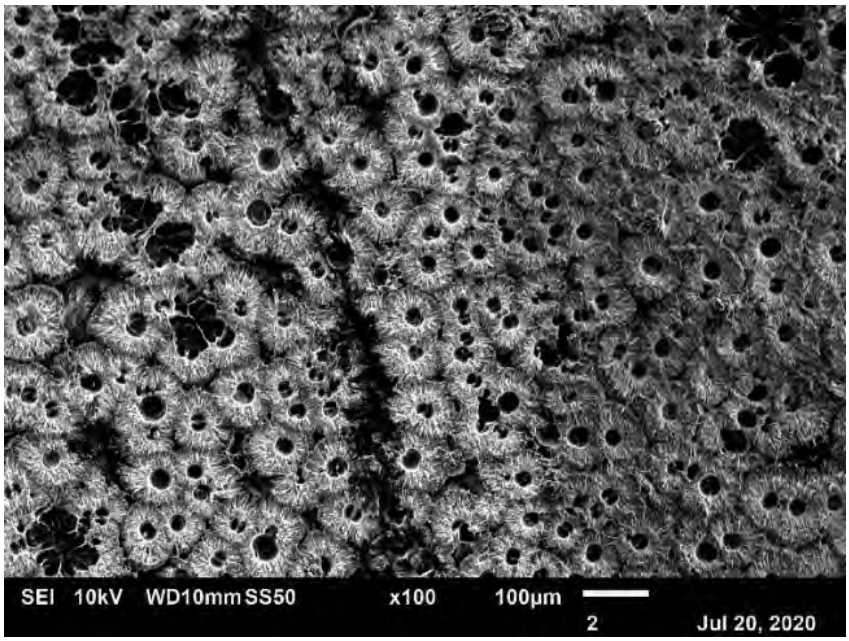
Perhaps the neatest thing that I discovered was that Bell's turtles might be eating foods that are unusual for such large turtles. One day in spring 2019, some volunteers and I caught a pair of Bell's turtles and gently flushed their stomachs out with water to see what they may have been eating. What came out was a yellow-brown goo, and like any good scientist, I put that goo under a microscope. It turned out to be thousands upon thousands of *Daphnia*, tiny crustaceans that float and swim around the water. Before that, we knew that Bell's turtles ate larger prey like aquatic insects and crayfish, along with algae and other water weeds, but this was something new. Indeed, looking into the literature, it seems that no one has found such large turtles eating such tiny prey in these mass quantities before. Several questions arise: are the Bell's turtles nipping them out of the water one at a time, or are they filter feeding like tiny whales? Are *Daphnia* a common food item for Bell's turtles, or was this unusual?

To finish off, I must thank the tireless efforts of the Turtles Forever project. Rarely have I had the pleasure of working with such a dedicated and passionate group of people. Not only have they provided me with support, training, and data, but it was Turtles Forever that organised the funding for my PhD through the NSW Environmental Trust's Saving Our Species initiative. The Holsworth Wildlife Research Endowment provided additional funding. In the time that I have remaining in Australia, I fully plan to continue my participation with Turtles Forever, to keep trying to find solutions to the myriad problems faced by the Bell's turtle. I can only hope that my efforts, and those of the rest of the organisation, have helped preserve this iconic New England species for the future.

Nesting refuge structure employed to protect nesting female Bell's turtles (*Myuchelys bellii*). Image: Dr Geoff Hughes.

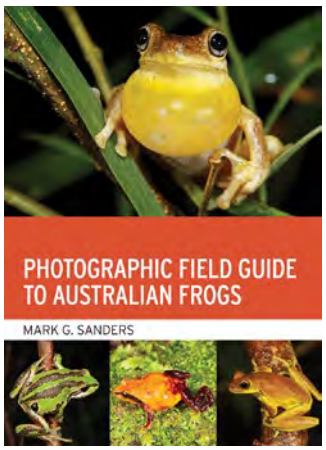


Daphnia spp. flushed from a Bell's turtle (*Myuchelys bellii*) stomach. Image: Dr Geoff Hughes.



A scanning electron microscope image of a Murray River turtle (*Emydura macquarii*) eggshell. This image shows the underside of the mineral layer after being separated from the organic membrane layer. Image: Dr Geoff Hughes.

Book Reviews



Photographic Field Guide to Australian Frogs – *Mark Sanders*

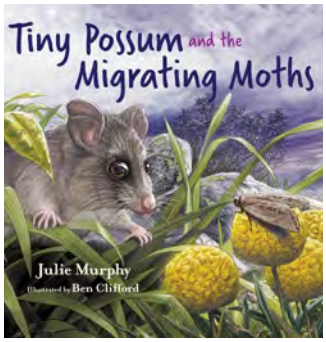
Australia is home to more than 245 species of frogs, many of which cannot be found anywhere else in the world, including the Tasmanian froglet (*Crinia tasmaniensis*), a ground-dwelling frog endemic to Tasmania, and the Kutini boulder frog (*Cophixalus kulakula*), which inhabits the boulder fields of Mt Tozer, Queensland. Multiple photographs of each species show variation in colour and pattern as well as features used for identification such as thigh colouration, skin texture, eye colour, and extent of webbing between the toes. With a strong focus on illustrating variation and key diagnostic features, this guide will enable frog enthusiasts, environmental professionals, and research scientists to identify Australian frog species with a high level of confidence.

Publisher: CSIRO Publishing | RRP: $49.99

The First Book of Bush Sounds – *Fred Van Gessel*

From growling koalas to stridulating crickets, whether you are five years old or sixty-five years old, it is never too late to get to know the evocative sounds of the Australian bush. From the grey-headed flying-fox (*Pteropus poliocephalus*) to the yellow-bellied glider (*Petaurus australis*), and the southern boobook (*Ninox boobook*) to the bush stone-curlew (*Burhinus grallarius*), this beautifully illustrated sound guide includes fascinating facts about each animal and the relevant sounds at the push of a button. It is great fun for all the family and perfect for helping to foster an interest in the unique wildlife around us.

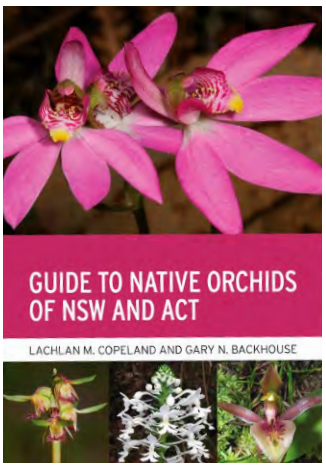
Publisher: New Holland Publishers | RRP: $26.99



Tiny Possum and the Migrating Moths – *Julie Murphy and illustrated by Ben Clifford*

High in the Australian Alps, Possum needs to find enough food and shelter to survive the harsh alpine winter. She will spend up to seven months hibernating under a blanket of snow, but will she last through the year to successfully raise a new family? The Critically Endangered mountain pygmy-possum (*Burramys parvus*) is dependent on the insulation provided by snow and its primary food source, the bogong moth (*Agrotis infusa*), for its survival. Once thought to be extinct, there are now around 2,500 mountain pygmy-possums in the wild. However, they need help more than ever before. The threat of climate change and the decline of its primary food source is placing this species at risk of extinction. Will community support and conservation efforts prevent this species from becoming extinct?

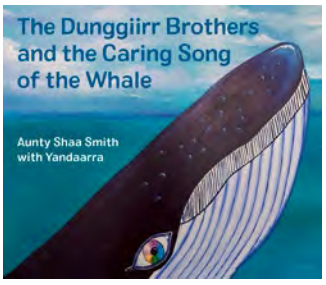
Publisher: CSIRO Publishing | RRP: $24.99



Guide to Native Orchids of NSW and ACT – *Lachlan Copeland and Gary Backhouse*

This comprehensive guide describes the 582 species of wild orchids that occur in New South Wales and the Australian Capital Territory. From the slaty helmet orchid (*Corybas incurvus*) to the streaked rock orchid (*Dendrobium striolatum*), these regions cover the richest area for wild orchids in Australia. Orchids found in these regions include the tallest, heaviest, smallest flowered, and most bizarre orchids in Australia, including elusive underground species. Featuring orchids with a dazzling array of colour and form, this is the essential guide for all orchid enthusiasts.

Publisher: CSIRO Publishing | RRP: $49.99



The Dunggiirr Brothers and the Caring Song of the Whale – *Aunty Shaa Smith and Yandaarra*

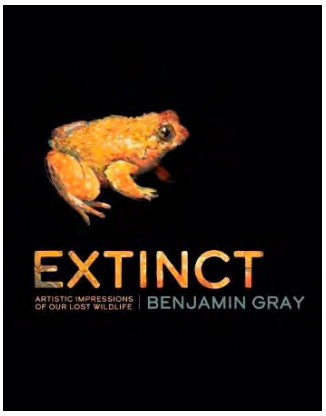
This stunning picture book from the Yandaarra Caring for Country community group, a project led by Gumbaynggirr elder Aunty Shaa Smith, in association with the University of Newcastle, helps us learn the stories of Ngambaa Country on the mid-north coast of New South Wales. The story also spreads a welcome and beautiful message of care and understanding to the broader community. *The Dunggiirr Brothers and the Caring Song of the Whale* is a lovely picture book and a unique resource that will connect children to the landscape and the remarkable stories of the Gumbaynggirr people.

Publisher: Allen & Unwin RRP: $24.99

Symbols of Australia: Imagining a Nation – *Melissa Harper and Richard White*

Symbols of Australia: Imagining a Nation offers illuminating and unexpected insights into the symbols surrounding us: from Uluru to the Australian flag, the rainbow serpent to the kangaroo, the Southern Cross to the Great Barrier Reef. Entertaining, provocative, informative, and often surprising, the book reveals a great deal about the ways nations are imagined. Where do national symbols come from, and what makes them popular? Why are some symbols so hotly contested? Does Australia have more than its fair share? At a time when Australian identity is contested, *Symbols of Australia: Imagining a Nation* provides invaluable insight and context, overturning long-held assumptions, and will make you re-think who we are and where we came from.

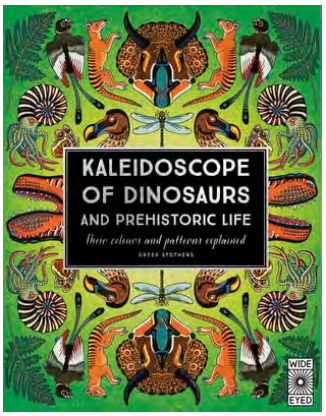
Publisher: NewSouth Publishing | RRP: $39.99



Extinct: Artistic Impressions of Our Lost Wildlife – *Benjamin Gray*

Australia is home to an incredible diversity of native animals. While Australian animals are among the most unique worldwide, they are also among the most endangered, with hundreds currently on the brink of extinction. *Extinct* is a collection of artworks from established and emerging Australian fine artists, each depicting an Australian animal that has already tumbled over the edge into extinction, one of these species being the Gould's mouse (*Pseudomys gouldii*) – a species of rodent in the murid family. The stunning artworks are accompanied by stories of each animal, highlighting the importance of what we have lost so that we appreciate the species we have not yet lost.

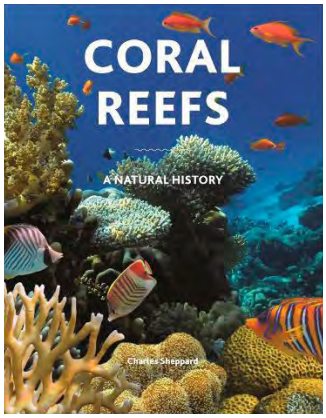
Publisher: CSIRO Publishing
RRP: $59.99



Kaleidoscope of Dinosaurs and Prehistoric Life: Their Colours and Patterns Explained – *Greer Stothers*

This colourful first book of palaeontology explores cutting-edge theories of how dinosaurs and other extinct animals might have looked. Take a walk through time and discover feathered dinosaurs, the colourful secrets of the fossil record, primitive plants, and species that have come back from the dead. When we lack the bodily remains of prehistoric animals, we move to other clues such as artwork. Indigenous Australians' oral legends and ancient artwork give shape and colour to several extinct animals, including the painting of a Diprotodon discovered on a rock face in Queensland, Australia. The book concludes by highlighting the actions people can implement to help prevent the extinction of our precious flora and fauna.

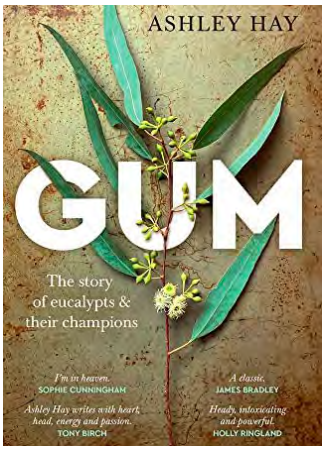
Publisher: Allen & Unwin
RRP: $29.99



Coral Reefs: A Natural History – *Charles Sheppard*

Corals are among the most varied lifeforms on Earth, ranging from mushroom corals and leather corals to button polyps, sea fans, anemones, and pulse corals. Bridging the gap between plant and animal, these marine invertebrates serve as homes to reef fish and share symbiotic relationships with photosynthesising algae, which provide corals with their nourishment. This stunningly illustrated book profiles the astonishing diversity of the world's coral groups, describing key aspects of their natural history and explaining why coral reefs are critical to the health of our oceans. From Shark Bay, where living parts are made up of a complex mixture of algae, cyanophytes, and bacteria, to Ningaloo Reef, a World Heritage Site home to a rich diversity of marine life, the book covers everything from identification to conservation. An essential resource for marine biologists, divers, and anyone fascinated by these remarkable marine invertebrates.

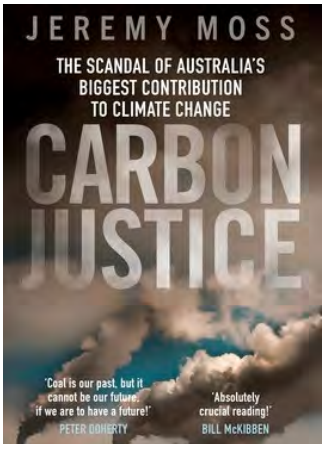
Publisher: Princeton University Press
RRP: $49.99



Gum: The Story of Eucalypts and their Champions – *Ashley Hay*

Gum: The Story of Eucalypts and their Champions tells the extraordinary story of eucalypts. Award-winning author, Ashley Hay, pens a powerful and lyrical exploration of these magical, mythical, and medicinal trees, as well as the big ideas and curious people around them. You are more than likely to see a eucalyptus tree in Australia no matter where you look. First Nations people have long known the abilities of the eucalyptus. And as part of the raft of changes wrought by the arrival of colonial Australia, botanists have battled in a race to count, classify, and own the species – a battle that has lasted more than two hundred years.

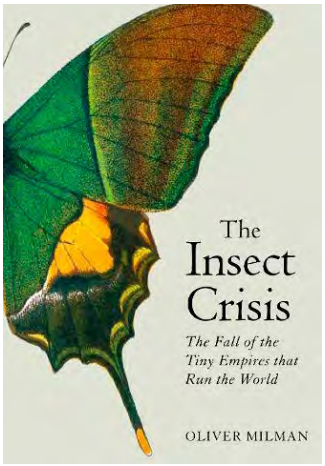
Publisher: NewSouth Publishing | RRP: $29.99



Carbon Justice: The Scandal of Australia's Biggest Contribution to Climate Change – *Jeremy Moss*

The emissions produced annually by Australia's major gas, coal and oil companies are more significant than the emissions of all twenty-five million Australians. Jeremy Moss uncovers how these companies have escaped scrutiny and sets out an ethical framework for the way forward. Understanding the moral responsibility of Australia's major carbon exporters is a crucial first step in determining how to fairly share the burdens of a climate transition. In Carbon Justice, leading political philosopher, Jeremy Moss, sets out an ethical framework to establish the cost of the harms of these major exporters and what we should do about it. What they do next will shape Australia's response to climate change.

Publisher: NewSouth Publishing | RRP: $29.99



The Insect Crisis: The Fall of the Tiny Empires that Run the World – *Oliver Milman*

How would we live if insects no longer existed? We rely on insect pollination for the bulk of our agriculture, and they are a prime food source for birds and fish. A groundswell of research suggests insect numbers are in severe decline worldwide – by over ninety percent in some places. In a compelling and entertaining investigation, the author speaks to the scientists and entomologists studying the catastrophe and asks why these extraordinary animals are disappearing. The author refers to the 2019-2020 bushfires and its impact on Australia's insects, and the Australian Butterfly Sanctuary and their work to help support Australia's insects. Furthermore, the author identifies the fears surrounding the lives of larger animals that rely on insects for their survival, such as the mountain pygmy possum (*Burramys parvus*) that depend on the bogong moth (*Agrotis infusa*) as their primary food source, which is now in decline. Part warning and part celebration of the incredible variety of insects, the book highlights why we need to wake up to this impending environmental disaster.

Publisher: Allen & Unwin
RRP: $29.99

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Conserving Australia's Wildlife since 1909

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Magazine: Receive the quarterly issue of Australian Wildlife via email or post to keep up-to-date with the collective work promoted nationally.

E-Newsletter: Receive the monthly e-newsletter. Keep up-to-date with news from our members and on the work of the Society.

AWS Portal: Access the Members' Resource Centre – your destination for resources and materials on various wildlife-related topics.

Social Media: Contribute to our social media platforms: Instagram, Twitter, Facebook, LinkedIn, YouTube, and Website.

Right to Vote: You have the right to vote on important matters at Society general meetings (financial members only).

Other Benefits: Awards, Scholarships, Grants, and the opportunity to network with like-minded people.

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Threatened Wildlife Photographic Competition

Giant burrowing frog (*Heleioporus australiacus*). Image: Ian Cairney – 2021 entrant.

Kuranda tree frog (*Ranoidea myola*). Image: Adam Brice – 2018 entrant.

Giant barred frog (*Mixophyes iteratus*). Image: Jacqui Forest – 2020 entrant.

Booroolong frog (*Litoria booroolongensis*). Image: Brooke Hay – 2019 entrant.

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