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Jeannie Baker

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FRONT COVER
Northern Quoll (*Dasyurus hallucatus*) populations in Kakadu are disappearing as a direct result of Cane Toad invasions. PHOTO BY JEAN-PAUL FERRERO/AUSCAPE.

up front

Meri Oakwood is a self-confessed 'quollaholic' and has been studying quolls since 1992. In particular, she has focused on the Northern Quoll populations in Kakadu National Park in the hope of better understanding the ecology of these fascinating mammals. Then in 2001 Cane Toads reached Kakadu and Meri's research changed. She was now racing to discover the impact the arrival of toads would have on the Northern Quoll population. Meri discovered the answer and she tells her story on page 26.

Most ecologists don't take an interest in the urban environment, even though it's the very place where people and wildlife live closely together. This can mean that when neighbourly disputes arise, finding solutions can be hampered by a lack of knowledge. Kristen Sinden and Darryl Jones are two ecologists who are interested in the urban world and in particular how we get along with crows. Their article "Living with Crows" (page 36) is great reading for anyone who lives with these amazing birds, and their suggestion of how we could view crows and ravens in the future is fantastic.

Ian Hutton has lived on Lord Howe Island for over 20 years but recently started to notice that all was not as it should be in the island's Flesh-footed Shearwater colony. Bird carcasses full of bits of plastic began to turn up and chicks were sometimes too weak to fly away. Ian decided to investigate and his article on page 52 is important reading for all of us who care about the impact our actions have on the environment.

We also learn how scientists monitor the endangered Northern Hairy-nosed Wombat population without disturbing the wombats, take a look at one researcher's passion for a python, meet a bird that needs Sheep to survive, explore whether humans have always been at war, and go underground with a very unusual mammal.


MERI OAKWOOD

Finally, we are very proud to announce that *Nature Australia* has just won the 2004 Whitley Award for Best Zoological Periodical from the Royal Zoological Society of New South Wales.

These awards recognise outstanding publications that contain significant amounts of information relating to the fauna of the Australasian Region. Each year a committee consisting of both academics and non-academics reviews all the entries and recommends the assignment of awards in the various categories. For a publication to be successful in the Whitley Awards, it must either make a significant contribution of new information, or present a new synthesis of existing information. Evidence of excellence is sought mainly in the text but illustrations are taken into consideration, as well as standard of design, presentation and production. This year marks our 12th such award since 1987 and represents a recognition of our ongoing commitment to provide you with the best nature magazine in Australia.

— **JENNIFER SAUNDERS**
Publishing Manager

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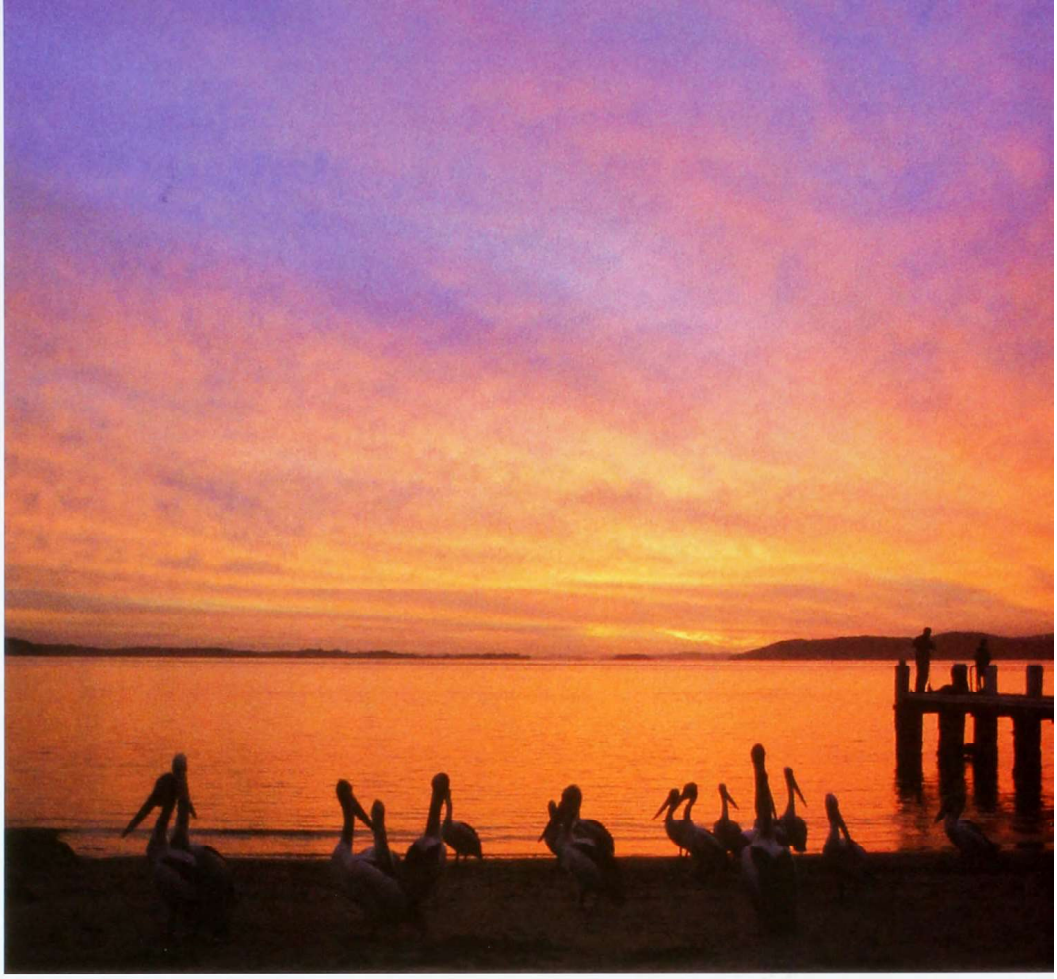

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letters

Tawny Tiffs

I greatly enjoyed Steve Van Dyck's article on Tawny Frogmouths (*Nature Aust.* Winter 2004), because I too have come across these birds unexpectedly in the bush, and I think they are amazing creatures. But I have a few bones to pick with him over nomenclature and etymology. This is probably pedantic, but it might be enlightening to your readers.

Steve mentions the apparent misnaming of the hamburger. But the origin of its name has nothing to do with its contents, but rather its city of origin. The minced beef rissole or pattie in a bread bun with salad etc. was a traditional meal in Hamburg, Germany.

Also, the generic name *Podargus* comes not from the French *podarge* (gouty feet), but from the earlier Latin (and even earlier Greek) *pod*, meaning foot, and *agra* meaning seizure or trap. The most common cause of a seizure in the foot is gout. Hence the meaning 'gouty feet', referring to the weak and short toes and legs of the frogmouth.

Steve is absolutely correct in saying that the specific name *strigoides* means owl-like. But that is exactly what it does mean. It does not mean that people thought it was an owl, but that it was like an owl.

—Alan Moskwa
Kensington Park, SA

Joining Forces

David Bowman is correct when he says solutions for ecological rehabilitation lie well outside the box (Last Word, *Nature Aust.* Winter 2004), but unfortunately his suggestions don't venture far outside the box either. What Tim Flannery is quoted as saying in the same article (how current debates have fallen into hidebound thinking, often suffused with 'beautiful lies') can be seen in the way politicians and experts keep trying to fix problems by treating symptoms, despite the fact that no problems can be fixed by treating symptoms; and in the way they continue to address environmental problems as single-issue problems, even though nothing about nature works in isolation.

Ever since the first civilisation, humans have been living on an 'environmental credit card', making minimum 'payments', due to conflicting economic and environmental policies, and building up an environmental debt that is rapidly reaching unserviceable levels.

It seems to me that the solution is to turn the equation around so the Force of Economics is working with the Force of Nature instead of against it. One would think such a simple concept would be readily seen, but when I try to discuss how it could be done with politicians, academics in various fields, and environmentalists themselves, I am met, not with agreement or disagreement, but with incomprehension, which does support Tim Flannery's observations.

—Eric Sorensen
Urangan, Qld

Paired for Life?

I live in an area in which two Black Swans have been there for as long as I can remember. Recently one of the swans was mauled by a Dog and had to be put down. The remaining swan just swims around honking like he is calling for the other one. If, as your recent "Curly Cues" article (*Nature Aust.* Autumn 2004) suggests, Black Swans form lifelong pairs, does this mean that the surviving swan will now be alone for the rest of its life?

—Layla Morrison
Ascot Waters, WA

Black Swan pairs tend to remain together between breeding seasons, but nobody has studied them for long enough to know whether they remain paired for the full extent of their lives. However, in our study population, we do know that breeding birds whose partners have died rarely remain alone for long. While there are plenty of unpaired birds of both sexes, those that have bred successfully before are very much in demand. Based on that, I would be surprised if your bird stays single for long, but it will probably depend on how many swans are in the vicinity.

—Ken Kraaijeveld
University College
London

Puggle Mail

Between 1978 and 1985 I had a number of very young orphaned echidnas to hand-raise. They received quite a lot of publicity and were photographed as they grew by numerous photographers. At about that time, my children had a toy called a Puggle. It was a fat, rounded and snouted critter that moved through their hands like an uncoordinated baby echidna. From then on, my kids called successive echidnas "Puggle".

Occasionally the name Puggle was referred to in stories published about my animals. Curiously, I myself never named animals in my care as it seemed very anthropomorphic to do so.

Sometimes the kids called injured echidnas "Foo" after the graffiti character once commonly seen around Sydney, but it was the name Puggle that stuck to the unfurred/unprickled young, and so it crept into hand-rearing, zoo-keeping language and beyond.

—Helen George
Beaumont, NSW

For the Record

Question 9 of the Quick Quiz (*Nature Aust.* Winter 2004) should have asked in which continent (South America) the largest living rodents are found.

—G.H.

Nature Australia **requests letters be limited to 200 words and reserves the right to edit them for sense. Please supply a daytime phone number and type or print your name and address clearly. The best letter in this issue will receive a copy of *The end of nature*. The winner this issue is Eric Sorensen.**

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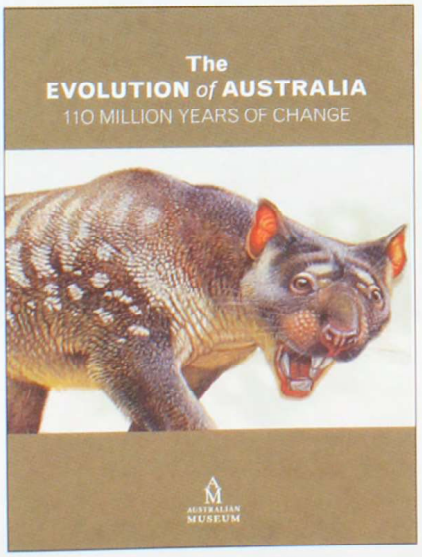

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Spring

Compiled by Geordie Torr and Martyn Robinson

Laughing Kookaburra.

G. CHAPMAN/AUSTRALIAN MUSEUM

HOLLOW LAUGHTER

Springtime is nest-building time for Laughing Kookaburras (*Dacelo novaeguineae*), and while some simply make use of an existing tree hollow, others take the DIY ethos to the extreme. Having selected a nice-looking termite nest high in a tree, the birds take turns to dive and swoop into it until they've chiselled out enough of a hollow to be able to sit in it. They then peck and scratch a deeper cavity, in which they'll make their nest. Laughing Kookaburras aren't the only Australian kingfishers to build nests in this manner, but their large size (they're the world's largest kingfisher) and rather ponderous flight make their nest-building spectacular to watch—even if you're afraid the birds' necks will break from the impact with the termite nest.

Often family members assist with nest preparation. Kookaburras are 'clan birds', the elder siblings staying on in their parents' territory and helping to raise the next broods. They also help feed the chicks and defend the nest, particularly against powerful marauders such as goannas. The closer to the nest the predator climbs, the more desperate and reckless the defence becomes as the birds employ the same power dives they used to build the nest.

You'll find more about these iconic birds at **www.amonline.net.au/factsheets/laughing_kookaburra.htm**

FROM THE DEEP

Each spring, a bizarre silvery creature with a trunk-like snout rises from the ocean depths and swims into shallow estuaries and bays to lay its golden-brown eggs in the sand and mud.

The Elephant Fish or Elephant Chimera (*Callorhinchus milii*) grows to over a metre in length and has a skeleton made of cartilage (like the sharks and rays to which it is related). While it spends most of the year at depths of 200 metres and more, it prefers to lay its eggs somewhere a little less frigid—hence the upward migration.

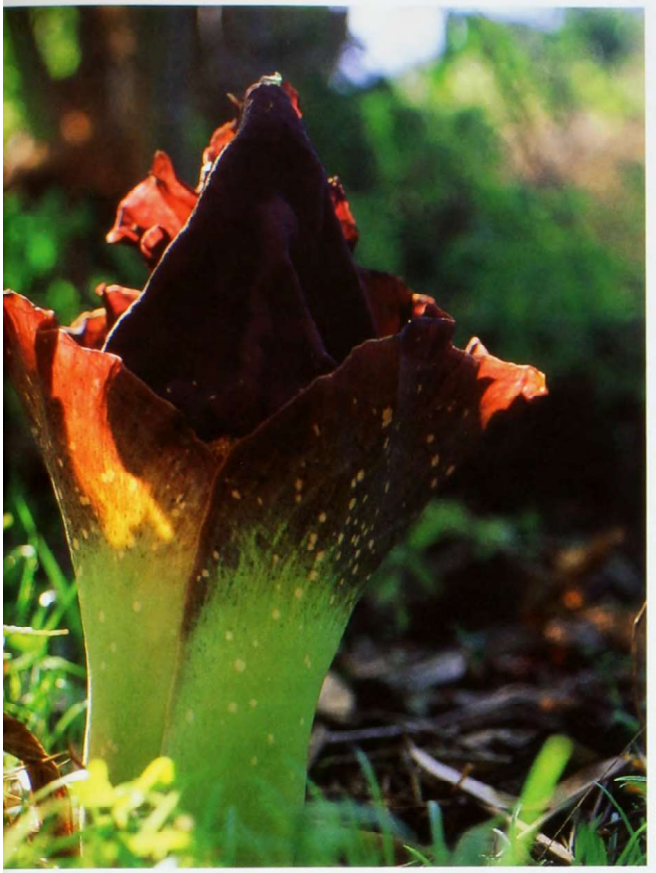
The eggs have peculiar wings that are thought to help anchor them into the substrate during the eight months they take to develop. Despite this, they are sometimes found washed ashore after storms. Once hatched, the young fish are in a land of plenty, surrounded by an abundance of the molluscs on which they prefer to feed. They then slowly migrate down to the depths as they grow.

For more on these deepwater denizens, visit **www.marinethemes.com/elephant.html** and **www.amonline.net.au/fishes/fishfacts/cmilii.htm**

THE STENCH OF SPRING

When spring comes to the monsoon rainforests of the far north, the stench of rotting flesh can be a sign of life, not death. The odour comes not from a corpse but from one of the largest and

Elephant Fish.



STEVE WILSON

Peony-leafed Voodoo Lily.

most bizarre flowers around, the 70-centimetre-tall inflorescence of the Peony-leafed Voodoo Lily (*Amorphophallus paeoniifolius*).

Edible forms of this widely occurring species are grown as a food plant in South and South-east Asia, due to its starchy tuber, which is known as Elephant Yam. Indeed it has been suggested that the plant was introduced to Australia by ancient traders via the Aboriginal people of the tropical coast, although today it occurs here as an acrid, wild-type form. Presumably it was traded when not in flower.

So why the stench? Well, if you can get close enough, you'll see and hear lots of flies, which are tricked into pollinating the flowers as they fly from one to another looking for the dead meat. Some deluded flies even lay their eggs in the flower, but the maggots are doomed as they're not vegetarians.

To see, but thankfully not smell, these fascinating flowers, visit **www.anbg.gov.au/gnp/interns 2002/amorphophalluspaeoniifolius.html**

FROM THE COLLECTION

This mantis specimen, collected in the Mount Lamington area in Papua New Guinea, was presented to the museum by C.J. McNamara in 1932. Clearly visible through the slit made in its belly is the parasitic juvenile stage of an unidentified gordian or horsehair worm from the genus Chordodes *and, because of this, it was displayed in the Australian Museum's old invertebrate gallery until 1963.*

Gordian worms belong to the phylum Nematomorpha, a small group with only about 320 known species (although there are almost certainly many others) and a worldwide distribution. The adults are typically aquatic and non-feeding, while the juvenile stage is an internal parasite that usually infests arthropods. Once inside the host, the parasite feeds by digesting the tissues and fluids, and absorbing the nutrients directly through its body wall. Once mature, the worm's tightly coiled body almost fills the body cavity of its host.

The adult worm usually emerges in spring and summer—and only in liquid—with the parasite somehow influencing its hapless host to seek out water. Specimens have been collected from swimming pools, toilets, even a cold cup of coffee, and a hollow or emaciated cricket, centipede, or similar invertebrate is usually found nearby. The adults are hard and wire-like to touch and, although they don't feed, they are active swimmers, moving through the water with a slow, serpentine motion. They also have separate sexes, and sometimes form impressive mating tangles—several males endeavouring to mate with a single female—that resemble the gordian knot of Greek mythology, hence the group's common name. For more on these worms, see **www.qmuseum.qld.gov.au/inquiry/oddspot/gordianworms.asp**

CARL BENTOS/NATURE FOCUS

Geordie Torr is a freelance science writer and Martyn Robinson is the Australian Museum's resident Naturalist.

nature strips

COMPILED BY GEORGINA HICKEY

RICHARD FULLAGAR, KARINA HOLDEN, KAREN MCGHEE, RACHEL SULLIVAN, ABBIE THOMAS, GEORDIE TORR AND STEPHEN WROE ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Shrinking Horses

When Cortez & Co. invaded America their horses struck fear into the hearts of Indigenous people. None had seen anything like it. But only 12,500 years ago horses were a signature species of the North American plains. The story of how they disappeared is inextricably linked with a still mightier whodunit: what killed the megafauna? The main culprits in this longstanding mystery are humans and climate.

Theories touting human causation, especially rapid overkill (blitzkrieg), appear to have gained favour in some quarters, but a paper by Dale Guthrie (University of Alaska) throws the onus back on climate, putting proponents of blitzkrieg on the back foot (*Nature* 426: 169). Guthrie examined the fossil remains of two Alaskan horse species and found that from the height of the last ice age, 20,000 years ago, the horses consistently shrank in size before going extinct 12,500 years ago. The earliest uncontested evidence for humans in Alaska is around 12,000 years old. Conceivably, human hunting might have produced this effect, but if so, it means that humans were there much earlier than generally accepted and that it wasn't rapid, but slow overkill.

The most likely explanation for Guthrie's results is that equine shrinkage followed a climate-induced reduction in food availability. These results resonate with significance on the subject of megafaunal extinction in Australia. In another article just out (*Alcheringa* 28: 291), my colleagues from the University of Sydney and I draw attention to the fact that here on the island continent, a conservative reading of the fossil record shows that as many as 38 species of megafauna may have disappeared before humans arrived.

—S.W.

Horses went through a long period of shrinking before disappearing altogether from America about 12,500 years ago.

SCORDER/PHONE AUSCAPE

Inflatable Octopus Penis

You would think, wouldn't you, that all of the body parts of a soft-bodied animal would be, well, soft—even their sex organs. Recently, however, US researchers discovered an octopus that not only gets erections, but also its erectile tissue is remarkably similar to mammals.

Joseph Thompson (now at St Joseph's University) and Janet Voight (Field Museum of Natural History) made the surprising discovery when they noticed an engorged 'ligula'—the suckerless tip of the mating arm that transfers sperm—during an unsuccessful copulation by the shallow-water Californian Two-spot Octopus (*Octopus bimaculoides*). Histological examination of the normally tiny ligula of this species revealed that, like mammal penises and clitorises, it contains well-vascularised cavities surrounded by collagen fibres that allow it to engorge with blood and extend in length (*J. Zool., Lond.* 261: 101). This structure is significantly different from the muscular ligulae of two deep-water species that were also examined.

The researchers speculate that the erectile tissue may represent an evolutionary compromise between opposing selective forces. The diurnal Californian Two-spot's ligula lacks the special pigment cells (chromatophores) that help camouflage the rest of the octopus and is bright white. Since this could make it a beacon for predators, keeping it small might help minimise the risk of predation. On the other hand, large ligulae can transfer larger spermatophores containing more sperm, so having an inflatable organ means that the octopus can make the best of both situations.

—R.S.

S WILBY & C CLANTAR/AUSCAPE

Aboriginal hand stencils from Carnarvon National Park, Queensland.

Stable Hands?

The left-handed minority often gets the rough end of the stick in Western societies, yet their proportion within the population seems to have remained remarkably stable over the last 30,000 years, according to a study of ancient and modern hand stencils (*Proc. R. Soc. Lond. B* 271: S43).

There are 507 known hand stencils that were 'spray-painted' on French and Spanish rock walls between 10,000 and 30,000 years ago. As they were all done the same way—with one hand holding a paint tube, the other hand facing down—it is possible to work out the handedness of the artists. (Even if the ochre was blown direct from the mouth without a tube, as some Aboriginal artists do in Australia, there would still be a preferred hand for placing pigment in the mouth.) Of the 343 stencils that can be unambiguously attributed to right or left hands, right-hand stencils make up 23 per cent, suggesting they were

The newly discovered iron-clad snail species, discovered at the base of a 'black smoker' two kilometres beneath the ocean's surface.

COURTESY ANDERS WARÉN

Molluscan Ironsides

Biologists studying hydrothermal vent fauna are used to finding new animals, but a group of researchers working on a vent field near the Indian Ocean island of Rodriguez encountered a species that took everyone by surprise—a snail armour-plated with iron.

Cindy Van Dover (College of William and Mary, Virginia) and her team were investigating the biology of the Kairei vent field in the Indian Ocean when a cluster of odd-looking snails came up in material collected from the bases of black smoker towers. Each was about the size of a garden snail, with an antique-like lustre to its shell, and strange leaf-shaped scales, overlapping like roof tiles, on the foot. When the researchers sent specimens to Anders Warén (Swedish Museum of Natural History), he knew immediately that this species was one of a kind (*Science* 302: 1007).

The snail's unique scales are formed from pinches of skin, which are enveloped in conchiolin, the protein that makes up the shell-sealing operculum in other snails. Coating the conchiolin is a layer of pure pyrite (iron sulfide) up to 0.2 millimetres thick. Whether the snail deposits this coating directly, or through the colonies of bacteria tucked in between the scales, is unknown, but the effect is to create a laminated armour, tough and flexible. Warén wonders if the scales protect it from the predatory snail *Phymorhynchus*, which catches prey by spearing it with a harpoon-like tooth and then injecting it with venom. *Phymorhynchu* gorges on the soft bodies of mussels, limpets and worms, but are its harpoons effective against iron plating?

—Bronwen Scott
Victoria University of Technology

produced by left-hand blowers.

Charlotte Faurie and Michel Raymond (University of Montpellier, France) compared this proportion with a sample of 179 University of Montpellier students who volunteered to blow through special ink pens to create their own hand stencils on paper. The proportion of left-handers was virtually the same—22.9 per cent.

Why has left-handedness remained stable for such a long time (at least in France)? Being part of the left-handed minority is thought to confer an advantage in certain activities like fighting, just as it does for some sports.

—R.F.

Marsupials Made in China

Marsupials were thought to have originated in North America about 100 million years ago, then beat a losing retreat through South America, Antarctica and Australasia in the face of blistering competition from superior placental mammals. Only here on the Island Continent did isolation spare these pouched throwbacks in real numbers. So the story went.

Of course, cracks appeared in this traditional interpretation of marsupial biogeography some time back. It now seems probable that marsupials and placentals both made it to Australia by 55 million years ago, but placentals lost the first round.

Now new evidence tendered by Zhe-Xi Luo (Carnegie Museum of Natural History) and colleagues contradicts the notion that North America is the marsupials' ancestral

homeland (*Science* 302: 1934). Mind-blowingly well-preserved fossils of the new species *Sinodelphys szalayi*, which include soft-tissue and fur outlines, place the ancestral stock for modern marsupials in China. The argument for an Asian origin isn't new, but aside from confirming this suggestion, *Sinodelphys* pushes the divergence of placentals and marsupials way back to well before 125 million years ago. This will force us to reassess the timing of major evolutionary events within the two dominant mammalian radiations.

However, as with most major findings, *Sinodelphys* raises as many questions as it answers. It's increasingly clear that early placentals and marsupials differed only in detail. Representatives of both groups were mostly small, scurrying insectivores. Indeed, early placentals quite possibly sported pouches. Why did placentals ultimately gain the ascendancy in most instances? We still really don't know why, but my hunch is it had little to do with innate placental superiority and a lot to do with good luck.

—S.W.

Reconstruction of the 125-million-year-old Chinese marsupial fossil *Sinodelphys szalayi*.

COURTESY MARK A. KLINGER/CARNEGIE MUSEUM OF NATURAL HISTORY

Borneo's Elephants

The Asian Elephant (*Elephas maximus*) is a species on the brink of extinction. Despite its

widespread distribution, wild elephants only exist in isolated pockets on the Indian subcontinent and in South-east Asia. One of the most isolated of these populations can be found on the island of Borneo. However, the origin of these elephants has always been a mystery. Separated from mainland Malaysia by 1,300 kilometres of ocean, it has been unclear whether Borneo's elephants are native or feral.

During the 16th to 18th centuries when elephants were a commodity traded amongst kings and emperors, it was thought that elephants from India might have arrived on the island, as a gift to the Sultan of Sulu. If this is the case, the dwindling population should be genetically similar to mainland species and compatible for breeding with other Asian Elephants.

Recently Prithiviraj Fernando (Columbia University) and colleagues examined the genetic makeup of Borneo's elephants and compared this with elephants from across Asia (*PloS Biology* 1: 110). It quickly became apparent that the island herd is genetically distinct and likely to have colonised Borneo in the Pleistocene, 18,000 years ago. During this time, the Indo-Malayan archipelago formed a single landmass before rising sea levels cut off the island...
and its elephants.

Now that Borneo's elephants have been revealed as indigenous inhabitants and not recent blow-ins, they deserve even greater conservation efforts. Interbreeding with other populations, for example, will be strictly out of the question.

—K.H.

Wife-beating Shrikes

Warning: unfaithful wives beware! Females of many species often sneak off for a bit on the side, and this is particularly common in birds. The strategy makes good sense: they might gain better genes from their little fling than from their mate, and when they return, faithful hubby is still there to help out with the chicks.

But is there a downside to this strategy? Francisco Valera (Natural Sciences Museum, Spain) and colleagues investigated whether the female Lesser Gray Shrike (*Lanius minor*), an endangered bird from Eastern Europe, cops any punishment if her mate thinks she's been dallying with another bloke (*Behav. Ecol.* 14: 403).

Valera trapped female shrikes and kept them for an hour before allowing them to return to their nest and partner. This absence made it appear she had been off with another, producing paranoia and suspicion in her mate.

While females were away, males sang far more than usual, and on their return, three-quarters of the females were 'punished' in some way. Males chased or pecked their mates, and even forced copulations, perhaps to show their displeasure or dominance. Interestingly, males only chased females that were fertile at that particular time. While the retribution usually lasted just a few minutes, one male just couldn't get over it, chasing his partner right out of the territory.

But in actual fact, despite the huffing and puffing of the males, Lesser Gray Shrikes are one species where it is extremely rare for females to wander away from their mates.

JEAN-PAUL FERRERO/AUSCAPE

Borneo's elephants are genetically distinct from other Asian Elephants.

Fossils of the earliest modern Europeans, from Peşura cu Oase, Romania.

Observations in the field have been backed up by DNA studies of the parents and chicks, which show infidelity hardly ever occurs between partners.

Is this faithfulness an evolutionary response to past misdemeanours, or just the way females prefer it? Either way, males certainly don't give them the benefit of the doubt.

—A.T.

First Modern Europeans

A fossil jawbone from south-western Romania has been radiocarbon-dated to 34,000–36,000 years ago, and, as such, is the oldest known definite early modern human in Europe. The adult jawbone was found in the Peştura cu Oase ('Cave with Bones'), and recently described by Erik Trinkaus (Washington University) and colleagues (*Proc. Natl Acad. Sci. USA* 100: 11231). Also described were skull bones and a teenager's facial skeleton (*J. Hum. Evol.* in press).

A range of unusual features, especially the huge wisdom teeth, and the robust and flaring cheek bones, suggests that immigrant modern human groups were not all that modern, and that evolutionary changes to the human face (at least) continued long after their dispersal from Africa.

The inside of the jaw also has an unusual bone growth, near a nerve opening, that is present in later European populations but absent among earlier groups—with the notable exception of local Neanderthals. Could this be evidence that Neanderthals and early modern humans interbred?

—R.F.

Myth of the Suicidal Lemmings

Ever since the 1958 Disney film "White Wilderness" erroneously portrayed suicidal lemmings hurling themselves over cliffs in an altruistic attempt to reduce an overpopulated area, the image has caused debate among scientists. But while these hamster-like rodents are not suicidal, they do have enormous population crashes, driven, it turns out, not by food or space shortages, but by the combined appetites of four predators into a clockwork boom-and-bust cycle.

For 15 years, Olivier Gilg (University of Helsinki, Finland) and colleagues studied Collared Lemmings (*Dicrostonyx groenlandicus*) and their predators—Stoats (*Mustela erminea*), Arctic Foxes (*Alopex lagopus*), Snowy Owls (*Nyctea scandiaca*) and Long-tailed Skuas (*Stercorarius longicaudus*)—in Greenland's High Arctic tundra.

They found that once every four years lemming populations increase a hundredfold, creating a

Ice-Age Cemeteries?

More than 40 Aboriginal people were buried in one of the world's oldest cemeteries on the sandy shores of Kow Swamp, beside the Murray River in Victoria. Previous research showed that these people had relatively thicker skulls and more heavily built faces than other Aboriginal groups, and that they were buried between 8,000 and 10,000 years ago. New work by Tim Stone and Matthew Cupper (University of Melbourne) suggests they were buried more than 10,000 years earlier: between 19,000 and 22,000 years ago, during the peak of the last ice age (*J. Hum. Evol.* 44: 99). Why is this significant?

Although there wasn't any ice at Kow Swamp during the Last Glacial Maximum, it was a lot drier and cooler than today, and it had been getting that way since at least 40,000 years ago. If these new burial dates for Kow Swamp are correct, then deteriorating climatic conditions, rather than different ancestries, might have caused the robust physical appearance, perhaps through a change in diet, which would have affected tooth size and, ultimately, head shape. However, as the researchers argue, these biological changes did not help in the long run, as populations with these robust characteristics did not survive after the ice age.

Alan Thorne (Australian National University), who excavated the remains over 30 years ago, questions whether the new research, which relied on dating of the sediments rather than the bones themselves, accurately dates the time of the burials, and maintains that a South-east Asian ancestry better explains their more robust physical appearance. Colin Pardoe, another leading Australian archaeologist, argues that the relatively robust morphology still survives in the Kow Swamp region's Aboriginal population, and that it is due partly to ancestry and partly to adaptation.

—R.F

FRANCOIS GOHIER/AUSCAPE

Collared Lemmings undergo enormous population fluctuations.

moving feast whose abundance attracts nomadic and migratory, generalist predators (foxes, owls and skuas) to the area, and encourages sedentary, species-specific predators (Stoats) to build up numbers.

It is the Stoats that are the key to this unusual predator/prey cycle, say the researchers (*Science* 302: 866). As lemmings increase, gradually more predators are attracted to the area and the sedentary Stoat population begins to increase as well. However, thanks to their slow reproduction rate, the Stoats take about a year to catch up, but by that time there are just too many predators so the lemming population crashes.

The generalist predators then leave the area in search of more plentiful prey, while most of the Stoats die off. This allows lemmings to rebuild their numbers and the cycle continues.

—R.S.

Monkeys on Strike

Monkeys, like humans, have evolved a cooperative lifestyle, often sharing both effort and resources. But capuchin monkeys, which readily share food with each other, have also developed a powerful sense of fair play. They get annoyed when they see another monkey get a better deal, and become even more peeved when the other gets a reward for making no effort at all.

Sarah Brosnan and Frans de Waal (Emory University, Atlanta) trained Brown Capuchin Monkeys (*Cebus apella*) to hand over a token in exchange for food. Then, they exchanged tokens with two monkeys, but gave one a cucumber and the other some grapes (a more desirable food). Cranking up the unfairness factor, some monkeys were also given grapes without even having to return a token—all this in full view of their partner, which still had to hand over a token for one lousy cucumber (*Nature* 425: 297).

As things became more unfair, monkeys that put in more work for less reward would respond by throwing away the token and even sometimes the cucumber! Normally capuchins quite like cucumbers, and so the researchers reasoned the monkeys must have felt pretty passionate to reject the food.

Like humans, capuchins have developed the ability to

COURTESY FRANS DE WAAL

Food sharing in Brown Capuchin Monkeys: they know when fair is fair.

TUI DE ROY/AUSCAPE

The genetics of Giant Tortoises can tell us a lot about their past.

judge what is a fair reward for a fair effort as part of a survival strategy based on cooperation. It seems they are able to compare their own rewards and efforts with others', and respond emotionally when things aren't fair. In earlier tests, the researchers discovered that females were less willing than males to make unfair exchanges, suggesting that, in the world of capuchins, females should be put in charge of the purse strings.

—A.T.

Galapagos Geology Drives Genealogy

Almost two centuries after Darwin made his history-making voyage to the Galapagos Archipelago, the island chain's famous fauna continues to provide important insights into the processes of evolution.

Some of the latest work involves the Giant Tortoises (*Geochelone nigra*) inhabiting Isabela, one of the most westerly of the celebrated islands. It boasts five major volcanoes, each with its own Giant Tortoise population. The largest, living on the slopes of the volcano Alcedo, comprises up to 5,000 individuals that belong to the subspecies *G. n. vandenburghi*.

The population's size suggests it should be among the most genetically diverse of Isabela's tortoise groups. But DNA investigations led by Luciano Beheregaray, now at Macquarie University, have shown Alcedo's tortoises to be the island's *least* genetically diverse (*Science* 302: 75). Modern statistical analyses of DNA data from extant tortoises pointed to a dramatic decline in numbers about 100,000 years ago, so severe it created a genetic bottleneck in the Alcedo tortoise population.

The researchers compared environmental and anthropological influences on Isabela's various tortoise populations and found just one key factor setting the Alcedo group apart. It was subjected to an explosive volcanic eruption about the same time the DNA evidence indicates the major decline in genetic diversity.

Alcedo's Giant Tortoise population would have been decimated when kilometres of prime tortoise habitat was covered with lava many metres deep. So devastating was the eruption's impact that Beheregaray and colleagues believe the population could have been reduced to just a few individuals of a single maternal group. Their study also suggests that volcanic eruptions can contribute to genetic changes in populations and may help fuel the process of evolution.

—K.McG.

New Frog for India

It's squat, purple, has tiny eyes, short stubby limbs and a pointy nose. No, it isn't a children's cartoon character; it's a newly described frog (*Nasikabatrachus sahyadrensis*) from southern India. It is so unlike any other known species that its authors, S.D. Biju and Franky Bossuyt (Vrije Universiteit Brussel, Belgium) have placed it in a new family, the Nasikabatrachidae (*Nature* 425: 711). This is the first frog family created for a new species (rather than

FRANKY BOSUYT

The extraordinary pig-nosed frog from India.

through taxonomic revision) since 1926.

The 70-millimetre frog's outward appearance suggests it is a burrower. But it's what's inside that has really made herpetologists sit up and take notice. Aspects of the frog's internal anatomy and DNA suggest it is very primitive, the lineage to which it belongs having originated about 178 million years ago.

The frog is most closely related to a family of frogs known as the Sooglossidae, members of which are only found in the Seychelles. This relationship supports what's known as the 'biotic ferry' model, which suggests that, following the breakup of Gondwana, India drifted northwards, carrying a complement of distinctive plant and animal groups. The scientists suggest that India may have been an important setting for the evolution of advanced frogs and for their passage to South-east Asia.

—G.T.

Whales Get the Bends

An international team of scientists has recorded some of the most compelling evidence yet that

GRAHAM ROBERTSON/AUSCAPE

Could military sonar play a role in whale strandings? Shown here are Long-finned Pilot Whales (*Globicephala melas*).

military sonar could play a role in whale strandings.

Increasing levels of oceanic noise generated by humans is widely considered one, and perhaps the most likely, cause of the bewildering phenomenon of cetaceans beaching themselves *en masse*. In particular, mounting anecdotal evidence implicates naval sonar, which often operates within the same intensity and frequency ranges used by marine mammals to communicate.

So when 14 beaked whales (various species) fatally beached themselves in the Canary Islands in 2002 within just four hours of a nearby military exercise deploying mid-frequency sonar, Antonio Fernández (University of Las Palmas, Canary Islands) and colleagues seized the opportunity to inspect the bodies.

They found ruptured blood vessels and haemorrhaging in vital organs caused by gas bubbles, damage consistent with decompression sickness (*Nature* 425: 575). Known also as 'the bends', decompression sickness afflicts human divers when they rise too fast in the water column. As a result of the rapid decrease in pressure, nitrogen in the blood forms artery-blocking bubbles.

While it's impossible to know exactly what gas was in the whales' bubbles, this study provides the best evidence yet that marine mammals can also develop the bends. The researchers believe sonar may startle deep-diving marine mammals into rising too quickly to the ocean's surface. Alternatively, the sound waves may directly cause the expansion of small pre-existing nitrogen bubbles in the blood.

While naval sources dispute the link with military operations, the researchers have been join by environmentalists in calling for further investigations on the impact of sonar on marine mammals.

—K.Mc

FURTHER READING
References for the stories that have appeared in this edition of Nature Strips are available online:
www.natureaustralia.net

Rumble in the Jungle

Imagine entering the darkest of New Guinea's jungles and hearing a series of deep, eerie rumbles coming from the undergrowth. It's a sound barely audible, and yet, like the roll of distant thunder, may send a chill down your spine. What ominous creature could produce such a sinister sound? It wouldn't be hard to imagine

dinosaurs in a long-lost world. But ornithologists in the know would tell you it is merely the call of a cassowary.

Andrew Mack (Wildlife Conservation Society, Papua New Guinea) and Josh Jones (Ocean Alliance, Massachusetts) have been on the cassowary trail for several years and have now recorded the unusual rumblings of these big birds (*The Auk* 120: 1062). Analyses show cassowaries have the lowest birdcalls ever recorded. The Southern Cassowary (*Casuarius casuarius*) produces frequencies down to 32 hertz, while its smaller cousin, the Dwarf Cassowary (*C. bennetti*), drops to just 23 hertz.

Given the dense rainforest habitat occupied by cassowaries, Mack and Jones believe that these ultra-low frequencies are used for making long-distance calls through the thick forest, just as whales use low-frequency sounds to communicate hundreds of kilometres underwater. They also suggest that the casque, the horn-like crest on the birds' heads, may function as an amplifier for picking up these sounds. It was previously thought these odd protuberances acted as a kind of crash helmet for bashing through undergrowth or as a weapon, although no behavioural observations support this. Considering cassowaries communicate in low frequencies, having a built-in aerial to pick up incoming calls may help keep the birds mobile.

—K.H.

Polar Drift

Polar Bears living on drifting sea ice don't need to go to the gym. For them, life is just one long turn on the treadmill.

While the bears roam around in search of food—primarily seals—the sea ice beneath them is in constant motion. A team led by Mette Mauritzen (Norwegian Polar Institute) used information from satellite telemetry, satellite images and atmospheric pressure readings to see how the active movements of 74 female Polar Bears (*Ursinus maritimus*) living on the Barents Sea compared with the movement of the ice (*Anim. Behav.* 66: 107).

Over the course of the 13-year study, they found that the bears undergo an annual migration. During the summer, when the ice is retreating, the bears' net displacement is northwards; during the winter ice advance, it's southwards. However, for most of the year, the bears are actually heading northwards in order to counteract the ice's constant southward drift.

The treadmill-like effect of the ice probably means that it's more energetically costly being a drift-ice bear than one that lives on the near-shore ice. However, this is most likely compensated by the greater abundance of big, fat, tasty seals farther out from the shore.

—G.T.

QUICK QUIZ

1. *Which is the only mainland Australian capital city that is free of Foxes?*
2. *What do you call sound that is below the frequency of a human's audible range?*
3. *Why doesn't the Moon have a blue sky?*
4. *What are sepions more commonly known as?*
5. *Do the Camels in Australia have one hump or two?*
6. *What type of animal would you expect to find in an Australian drey?*
7. *How many toes does an Emu have on each foot?*
8. *What's the most common element in the universe?*
9. *Where do Rapanui people live?*
10. *What's the world's second largest penguin?*

(Answers on page 82)

Like the Red Queen in Lewis Carroll's *Through the looking glass*, Polar Bears have to keep moving just to stay in the same spot.

ROBYN STEWART/AUSCAPE

Humpbacks: cannon balls & brains

Humpbacks have just about the same weight of testicles as they have of brains!

OF ALL THE BIZARRE SPIN-OFFS that come with a museum curator's job, few can compare with the monumental perk associated with whale undertaking...turning mountains of black suppurating mush on a beach into pearly white skeletons on an exhibition wall.

Like respectable funeral directors, we wait patiently with averted eyes while the politicians weep for TV cameras and tired conservationists tear themselves away from lost causes. Then, when the last drops of sentiment darken into the first drips of decay, we move in to salvage what we can from the grim arena.

One of the more odious tasks is getting the brain out of the dead whale's skull. It's most easily done with a hose. You push the hose into the hole at the back of the skull (the foramen magnum) as far as it will go, then turn the tap on full bore. The water displaces the brain, which balloons out like pink minced tripe if it's fresh, or rotten haggis if it's off. If you don't have a hose close by then you scoop the stuff out with your cupped hand.

But without fail, every time I thrust my hand inside the braincase of a big Humpback (*Megaptera novaeangliae*) I am staggered by the volume of what comes out. No-one could pretend not to be flabbergasted by how *little* there is inside. A 15-metre adult weighing in at around 40 tonnes has about five kilograms of brains. If you were to rest two three-litre milk containers on a Humpback's head and call it brains, you would be crediting it with too much.

Does this mean these fabulous mammals are a bit dull? In humans, the ratio of brain weight to body weight is around 1.93 per cent; in the Common Dolphin (*Delphinus delphis*) it's 0.666 per cent; in a horse it's 0.154 per cent and in a Humpback Whale it's 0.02 per cent. Not that this comparison really means all that much except that bigger animals have smaller brain-to-body weight ratios. But all things considered, in spite of our partiality to attribute almost human intelligence to big whales (because we do it for dolphins), the truth is that, when it comes to horse sense, Humpbacks probably fall in alongside Santa Gertrudis and Australian Illawarra Shorthorns.

As if to compensate for the lack of grey matter, however, Humpbacks have just about the same weight of testicles (four kilograms) as they have of brains! Does this mean that a lot of Humpback decisions get processed below the belt? If we can extrapolate from the human condition then the answer is probably yes. If human males can manage most of life's decisions using testicles that are 1/35th the size of their brains, then having cranium-sized testicles probably means nothing too new in the decision-making process, only the decisions come more often and with more grunt!

If male Humpbacks are preoccupied with sex then it's a real wonder, because for them sex comes at great personal risk!

Remember what it's like fishing off the rocks and slipping barefoot on barnacles? Imagine rolling around naked (and belly-down) on them! Every summer when Humpback Whales feed in Antarctic waters, tiny swimming barnacles attach to the whales and grow until, on any one whale, they might collectively weigh up to half a tonne. And where, among a few other places on the whale, do the barnacles grow in profusion? On their genital slits (both sexes), gateways to the rude bits.

Now a male Humpback Whale's doodle is two metres of highly sensitive sausage. And, while Humpbacks have long flexible flippers, they do not have fingers to help guide that slippery whopper when push comes to shove. Promise him any treasure, but no male with that much at stake is going to throw his vessel into the angry seas knowing full-well that without a pilot he's likely to be cut to pieces on the sharp rocks.

Humpback Whale

Megaptera novaeangliae

Classification
Family Balaenopteridae.

Identification
Fourth largest whale at around 14 m. Dorsal surface black; grooved throat and belly mostly white (mostly black in northern hemisphere). Pectoral fins 1/3 length of body. Individually distinct black/white pattern under tail.

Distribution
Worldwide, feeding in polar waters during summer, migrating to tropical waters to breed in winter.

Biology
In southern hemisphere feeds mostly on krill but fasts while migrating; in northern hemisphere eats small schooling fish. Swims at 8 kph. Renowned for breaching and curiosity around boats. Males sing complex, locality-specific songs (see *Nature Aust.* Autumn 2002). Most matings and births occur in tropical waters. Gestation 12 months. Probably breeds every second year.

BY STEVE VAN DYCK

K. AITKEN

Humpback Whales along the Australian coasts are increasing at a rate of 10.5 per cent per year.

So, if copulation meant excruciation, is that why Humpbacks became endangered? Is all the breaching and slapping and flopping just a function of terminal frustration? Evidently not! It seems that enough barnacles fall off in the warm breeding waters to allow for (careful) procreation. The thing that brought Humpbacks to their knees was the harpoon cannon.

Between 1900 and 1965, around 200,000 Humpback Whales were killed in the southern hemisphere oceans. Off Australia, Humpbacks did everything so close to the land that they were sitting ducks for the experienced Norwegian skippers that always fired the harpoons from the Australian fleet of gun boats ('chasers'). For example, between 1952 and 1962, the original eastern Australian stock of 10,000–20,000 Humpbacks was knocked down to 200–500 survivors. During those ten years the same population of Humpbacks ploughed along past the five eastern whaling stations. Byron Bay and Tangalooma alone harpooned and dragged 7,423 of them up the flensing deck. The pathetic images we see of migrating Wildebeests crossing crocodile-infested rivers are not much different.

The telling truth is that Humpbacks were not protected until the industry had rendered them down to the point where quotas could no longer be filled—one of the most shocking indictments of bungled Australian wildlife management.

But today's news is much rosier for Humpbacks. Numbers along Australian coasts are approaching half their pre-whaling estimates and increasing at a steady (phenomenal) rate of 10.5 per cent annually.

In spite of all the credit wildlife protection agencies might like to take for the recovery of Humpbacks in our generation, all that was needed was for the cannons to be banned...the rest the whales did for themselves. Or, as one other endangered humpback swinging from the bells in Notre Dame once put it, "A drop of water and a little pity—that is more than I can repay with my life." □

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DR STEVE VAN DYCK IS A SENIOR CURATOR OF VERTEBRATES AT THE QUEENSLAND MUSEUM WHERE HE HAS WORKED SINCE 1975.

Plains-wanderer

Plains-wanderers have been living alongside Sheep and Cattle for well over a century.

BY TIM LOW

THE PLAINS-WANDERER (*Pedionomus torquatus*) is a bird that now depends upon Sheep for its survival. Two national parks created to save it are the first in Victoria and New South Wales where Sheep are made to graze.

Fears for the fate of this shy ground-dweller date back to 1926. It once ranged widely between South Australia and northern Queensland, but viable populations are today confined to the Riverine Plain of northern Victoria and southern New South Wales—its stronghold—and the Channel Country of south-western Queensland, where it occurs more sparsely.

Plains-wanderers are very particular. They require grasslands or herbfields short enough to afford views of distant predators but tall enough to provide some scanty shelter. They need bare ground between tussocks to walk through and fallen litter to investigate for insects and seeds. They stay well away from trees, in which falcons may perch. Because grasslands rise and fall with rain, drought and grazing, Plains-wanderers are semi-nomadic, staying put when conditions are good but moving on when grass becomes too tall or short.

Grasslands in south-eastern Australia were among the first lands claimed by squatters, and Plains-wanderers have, by necessity, been living alongside Sheep and Cattle for well over a century. They have survived by rotating between farms, choosing heavily grazed paddocks in wet years and lightly grazed paddocks during drought. But their numbers have fallen, mainly because cultivation has eliminated much of their native grassland habitat. The population now peaks at about 5,500 in good years but drops below 2,000 after droughts, when many paddocks are grazed down to bare dirt.

Listed nationally as vulnerable, and endangered in The Action Plan for Australian Birds, they are threatened mainly by cropping, overgrazing and Foxes. Development of irrigated rice fields poses a double blow—habitat is lost, and Foxes that feed on the House Mice breeding in the rice then prey on birds in nearby paddocks.

Plains-wanderers fare best today on farms with a history of light grazing. Terrick Terrick National Park in Victoria, and Oolambeyan National Park in New South Wales, are recently acquired grazing properties, with some paddocks that retain a diverse flora of native grasses, saltbushes, daisies, lilies and peas. These parks were bought for their grasslands and rare plants as well as their rare birds.

The associated homesteads offer clues to their significance. Terrick Terrick's humble home has never been painted because the former owner was very thrifty. Free from financial pressure, she kept to the conservative stocking regime adopted by her father. Oolambeyan, in contrast, boasts a grand homestead with photos in the hallway of stud merinos that were bred there. Because stud rams are so valuable, stocking rates were kept low. Of the five properties most critical to Plains-wanderers today, three are (or were) merino stud farms and two were run conservatively by women.

Sheep are grazed in the two national parks from time to time to control weeds and keep the vegetation structure right. Without stock, grasses and weeds in the wetter years would smother the bare ground the birds need. Kangaroos are unsuited for this task because they feed too sparingly and avoid open plains. Fire has been trialed as another way of reducing pasture growth at Terrick Terrick but Sheep are easier to control and produce better results. Their impact will be reviewed at Oolambeyan by excluding them from several fenced plots.

Two parks alone cannot save the species, so the Department of Environment and Conservation (NSW) has put out a Habitat Management Guide for graziers illustrating good and bad pasture structure for these birds. Sympathetic farmers, guided by the photographs, can increase or decrease their stocking rates to create optimal Plains-wanderer habitat.

The Plains-wanderer is unique as the only member of the family Pedionomidae, its nearest relatives occurring far away in South America. It is also exceptional because no-one can quite explain how it fitted into the landscape before Europeans arrived. The Riverine Plain was mainly a shrubland, with wattles and saltbush, when settlers arrived. The other curious angle to this story, of course, is the role Sheep now play. Visiting the two national parks to see the birds, I could not quite reconcile myself to the bleating of Sheep by day and the twinkling of Sheep's eyes when I spotlighted at night. □

H EHMANN

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TIM LOW IS A BRISBANE-BASED BIOLOGIST AND AUTHOR OF SIX BOOKS, INCLUDING *FERAL FUTURE*

Diversity from adversity

Heathland flowers have grown more and more extravagant in the bid to attract scarce pollinators.

The delightful Rose Coneflower (*Isopogon formosus*) belongs in a genus (in the family Proteaceae) that boasts 27 species in Australia's south-west, compared with only eight in the south-east.

THE BELTS OF HEATHLAND IN south-western Australia and South Africa put on the best wildflower shows on Earth. They are biodiversity hot spots boasting thousands of plant species each. But these are unusually difficult places for plants. The soils are very infertile and rain is scarce during the hot summers.

But adversity can foster diversity. In rich soils the best-adapted plants often dominate, whereas domination in infertile (especially phosphorus-deficient) soils is rarely achieved. When fertilisers are added to heathlands many new plants invade and then prevail, and a less diverse community develops. It's much the same story in tropical waters, where diverse coral reefs prosper in low-nutrient waters, with algae taking over if farm-enriched runoff reaches the reef.

But the heathland story is more complex than this. South-western Australia's kwongan region and the African fynbos heaths not only support plants from many different families, they also carry large series of closely related plants, sometimes called 'species flocks'. The kwongan, for example, boasts more than 680 species from the one giant family (Proteaceae) and within this are more than 70 different hakeas, 80 or so grevilleas and 54 banksias. Wattles (*Acacia* species) run to more than 135 species and bearded heaths (*Leucopogon* species) to 64. Up to 25 different hakeas can occur within a very modest area. South Africa has a remarkably rich flora of heaths (*Erica* species), and the Proteaceae is also prolific there. Certain lineages have segregated again and again into many species with small distributions.

Frequent fires play a role here. How quickly a species can evolve depends partly upon how long each individual lives. Fruit flies, to take an animal example, can evolve quickly because several generations can live and die in one year. Trees evolve slowly because individuals may live hundreds or even thousands of years. The dry summers in South Africa and Western Australia, and the flammable sclerophyll vegetation, ensure frequent hot fires, so that many plants have generation times of a decade or less. Species flocks are mostly dominated by plants that die from fire and recruit prolifically from seed, not those that resprout reliably from roots or trunks (and produce fewer seeds).

Botanists are still struggling to provide a convincing evolutionary explanation for the diversity in the two regions, but in Western Australia, at least, it may go something like this. A plant spreads widely during favourable times, then the climate alters and it is stranded in a few small refuges, each with slightly different soils and climate. Regular fires promote the speedy evolution of each colony into a species better adapted to its own location. The climate then improves and each population expands its range. Under an alternative scenario, very large fires would be expected to promote speciation (without climate change) if a fire was followed by a poor growing season in which every seedling died. The small populations surviving on the peripheries of burnt areas could then evolve in isolation into separate species.

The splitting of lineages has gone on for many millions of years, with Australia and Africa escaping the severe ice-age chills that so disrupted life in the far north. In South Africa the diverse landscape has fostered speciation, different lines evolving on nearby mountain chains. On the plains of Western Australia 'islands' of different soil have probably served as breeding grounds for new forms. South-eastern Australia has not offered the same opportunities because the soil is richer and there is

BY TIM LOW

PHOTOS: TIM LOW

South-western Australia is famous for its colourful wild flowers, which attract camera-clicking tourists as well as pollinating insects and birds.

summer rain to constrain fires. Mediterranean regions elsewhere in the world also are characterised by richer soil and lower diversity.

The extravagant floral displays in kwongan and fynbos probably signify competition for pollinators. Few animals are available to pollinate all the flowers, because these heathlands are plant-rich but animal-poor. Most of the meagre nutrients are locked up in the vegetation, and animals are few in number and variety. The tough nutrient-poor foliage provides particularly unappealing food for all but a few specialised insect larvae. Heathland flowers have grown more and more extravagant in the bid to attract scarce pollinators. Many have enlisted birds and even small mammals (rodents and possums) to do the work. By evolving very distinctive and alluring flowers adapted to certain pollinators, plants are less likely to have their pollen wasted by animals wandering between different species of plant.

Most visitors to the kwongan or fynbos are happy enough just enjoying the colours. But to the curious botanist with enough courage these landscapes offer endless opportunities for enquiry, although the very complexity that makes them so attractive makes studying them difficult. Interestingly, from a theoretical point of view, the drivers of diversity in these heathlands—fire and nutrient poverty—turn out to be very different from the drivers in that other plant-rich place, the tropical rainforest. But that's a story for another day. □

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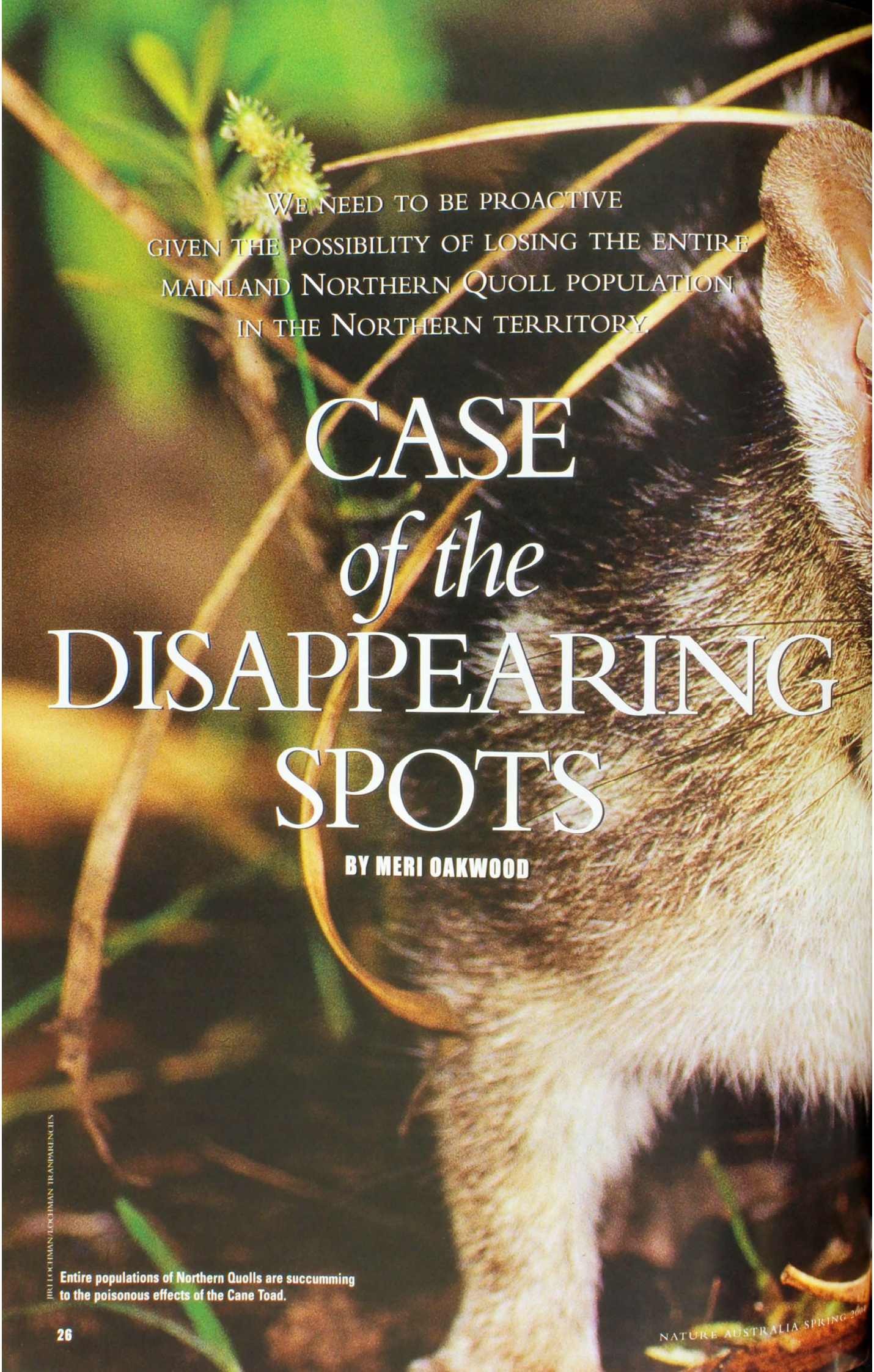
TIM LOW IS A BRISBANE-BASED BIOLOGIST AND AUTHOR OF SIX BOOKS, INCLUDING *FERAL FUTURE* AND *THE NEW NATURE*. HE LOVES EXPLORING THE KWONGAN AND FYNBOS.

WE NEED TO BE PROACTIVE GIVEN THE POSSIBILITY OF LOSING THE ENTIRE MAINLAND NORTHERN QUOLL POPULATION IN THE NORTHERN TERRITORY.

CASE *of the* DISAPPEARING SPOTS

BY MERI OAKWOOD



JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Entire populations of Northern Quolls are succumming to the poisonous effects of the Cane Toad.

"HURRY UP AND GET UP here", urged the voice over the phone. "Cane Toads have been sighted 15 kilometres from your study site." It was just before Christmas 2001 and I spent the next few hours organising a mad dash to Kakadu. I had to get to my study site before the toads arrived and we had no idea how long they would take. So why the hurry?

The rush was because of the quoll populations in the area. Northern Quolls (*Dasyurus hallucatus*) are fascinating animals. They are the smallest of the four Australian quoll species and, like all quolls, sport white spots on their reddish-brown fur, have pointy noses and bright eyes, and are predominantly nocturnal. Up until the 1970s and 1980s, the conservation status of the Northern Quoll had been considered widespread, common and secure. However, in the late 1980s to early 1990s it became clear the species was declining, particularly in savanna habitat, and it was subsequently listed as 'Lower Risk, Near Threatened' by the IUCN. We knew so little about this species. Even the details of its basic dietary and habitat requirements were unknown at that time, so how could we possibly hope to rectify the causes of decline?

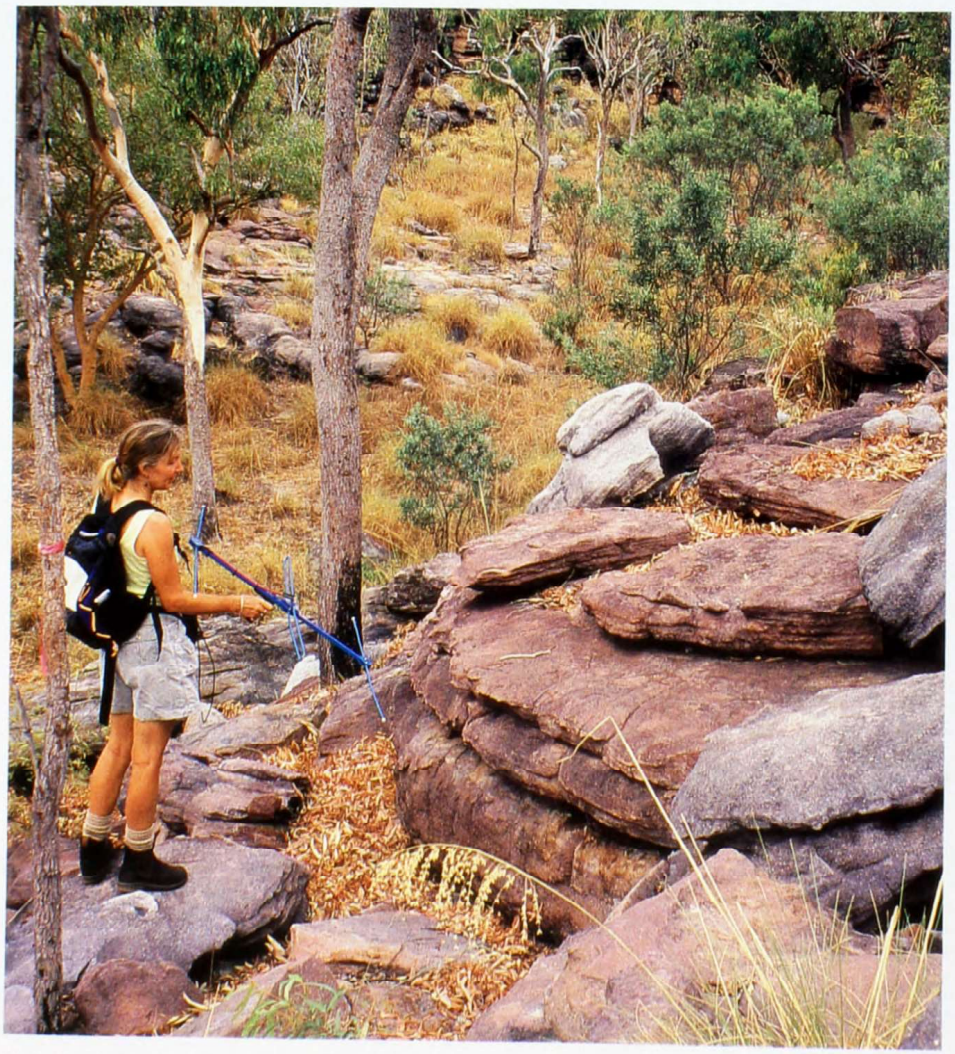
To try to fill this gap in information I began studying their ecology in savanna habitat in Kakadu National Park in 1992 for my Ph.D. I soon became a 'quollaholic' and have been following them around ever since. So what have I found out so far?

NORTHERN QUOLLS ARE SEXUALLY dimorphic, with the males larger than the females. They breed only once each year and the average litter size is seven, although each mother often manages to wean just two or three per year. One of the unique features of this species is that the males are the largest known mammals to exhibit a very bizarre phenomenon: they all die after mating (semelparity). Most males die within a couple of weeks of mating, barely making it beyond their first birthday, although one male I recorded reached 19 months of age. Female Northern Quolls are also short-lived with the oldest recorded wild female being just three years old. These extremely short life spans make this species particularly vulnerable to local extinction. If any event causes a particular breeding season to fail, then there will be no males left for a subsequent breeding season the following year.

Northern Quolls are highly opportunistic in their diet, consuming a wide range of prey, particularly those that are abundant or easy to catch. Quolls are inordinately fond of beetles and grasshoppers but will also tackle venomous species such as spiders, scorpions and centipedes. They consume large quantities of fruit, their favourite being the Wild Grape (*Ampelocissus acetosa*), and they enjoy nectar from eucalypt and grevillea flowers. They are not averse to dining on road-killed carrion and human refuse from campsites or around houses. Northern Quolls also hunt a wide variety of vertebrate species, such as the Northern Brown Bandicoot (*Isoodon macrourus*), the Common Brushtail Possum (*Trichosurus vulpecula arnhemensis*), rats, Sugar Gliders (*Petaurus breviceps*), insectivorous bats, quails, bird eggs, snakes and frogs. Frogs are eaten regularly in the wet season with at least seven species being taken, including large native frogs such as the Green Tree Frog (*Litoria caerulea*) and the Giant Frog (*Cyclorana australis*).

Enter the Cane Toad. The Cane Toad (*Bufo marinus*) is a native of Central America that was introduced from Hawaii to Australia in 1935, in a failed attempt to control Sugarcane pests. From the 101 individuals that were brought to Gordonvale, near Cairns in Queensland, the Cane Toad has spread (often with human assistance) south down the coast into northern New

As the Cane Toad invades new territory, it has a devastating effect on the native species.



MERI OAKWOOD

Annette Cook radio-tracking at the East Alligator study site, Kakadu. Tracking each day begins at dawn, with all radio-collared quolls located every morning to check that they are alive. If a transmitter emits the mortality signal, we immediately search for a body, to determine the cause of death before scavengers disturb the evidence.

MERJ OAKWOOD

A Northern Quoll in a trap that was set in a den tree. At this particular savanna site, Dingoes regularly disturbed the traps. Placing the traps in trees helped reduce disturbance.

South Wales, north up to the tip of Cape York and west across Queensland and into the Northern Territory, reaching Kakadu National Park in April 2001.

Cane Toads have a large pair of parotoid glands on their neck from which they secrete toxic substances for defence. The toxin, a mixture of bufotoxins and other compounds, is able to kill a variety of reptiles, birds and mammals, possibly even humans. As the Cane Toad progressed northwards there were anecdotal reports of death adders, goannas and Northern Quolls disappearing. But unfortunately, there has been very little methodical scientific monitoring of native species during and after invasion. We do know that a pet Western Quoll (*Dasyurus geoffroii*), a close relative of the Northern Quoll, died soon after mouthing a toad in a suburban backyard in Brisbane.

FIVE FEMALES DIED

from apparent toad poisoning in the first two months after toad arrival.

When the toads reached Kakadu, Parks Australia North became increasingly concerned about their potential impacts on native species. A report assessing the risk of Cane Toads in Kakadu National Park suggested that 11 species of predatory vertebrates were definitely at risk, comprising five lizard, three mammal and three snake species. Another 16 species or species groups were probably susceptible and the remaining 127 that were assessed were possibly susceptible to Cane Toads. Northern Quolls were placed in the highest risk category because they are highly opportunistic predators that are known to eat several species of native frogs.

Due to concern about the Northern Quoll, Parks Australia North commissioned me in June 2001 to examine the impact of the Cane Toads. I chose two study sites with high densities of quolls—one in southern Kakadu, in the Mary River district, and one in the north, in the East Alligator District. We began trapping at these sites to establish the baseline (before toad impact) abundance of Northern Quolls. Then in December 2001, a ranger from the Mary River district spotted toads just 15 kilometres from our southern site. This was when we got the phone call. We raced up there to fit radio-transmitter collars onto the animals so we could monitor their fate before and after the

toads arrived. The transmitters used in this study had a mortality sensor so that, if a transmitter did not move for seven to eight hours, the radio pulse would double, alerting the trackers to the fact that the quoll had either died or lost its collar.

We attached radio-collars to as many females as we could, with up to 22 being tracked at any one time. We decided to focus on females for several reasons. Males travel much farther and are much rougher in their treatment of collars. But more importantly males are only short-lived compared to females due to the post-mating die-off. Although die-off death is distinctive, leaving males emaciated, balding and parasite-infested, we wanted to avoid any possible confusion with toad-related deaths so we decided to radio-track only females. We also conducted road surveys at night to monitor the progress of the toads. Then in February 2002, the first toads arrived at the northern end of the study site and immediately some of our radio-tracked females were found dead. Five females died from apparent toad poisoning in the first two months after toad arrival.

How do we know these females died from toad poisoning? To begin with, the timing of the arrival of the toads and the first deaths coincided. These individual quolls had been examined during the two weeks prior to their deaths and they were healthy with no disease and no heavy parasite infestations. At death, they had no signs of predator damage or accidental injury, but showed some unusual features including red irritation on the lips and gums, occasional nose and ear bleeds, red skin on the nose, ears, roof of the

Northern Quolls eat a wide range of prey, including both invertebrates and vertebrates. They also consume fruit and nectare.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

MERI OAKWOOD

Spot the quoll. Northern Quolls are extremely adept climbers in rocky habitat. Rocky crevices like these at the East Alligator study site provide excellent protection from predators.

Northern Quoll

Dasyurus hallucatus

Classification

Family Dasyuridae. One of 4 species of quolls found in Australia.

Identification

Brown with white spots on back and rump. Underside cream. Up to 1.2 kg, males larger than females.

Habitat and Distribution

Rocky escarpment, but also open forest and open woodland. Several disjunct populations: Pilbara, Kimberley, Top End, Groote Eylandt, Cape York to Rockhampton, Carnarvon Gorge. Southern limit uncertain. Has declined dramatically over much of its range.

Biology

Breeds once per year with mating mid year; 3-week gestation; av. litter size 7. Young in pouch 8–9 weeks, then left in nursery dens until weaned at 5–6 months of age. Life span: males 1 yr, females 3. In savanna, females maintain territories of about 35 ha, males range over 150 ha, overlapping with other males and females. Food includes invertebrates, vertebrates and fruit.

mouth and in the pouch, and bright purple teats. Unfortunately the toxins decompose rapidly and we could not locate anyone in Australia who was capable of testing for bufotoxins from carcasses in this field situation. Post-mortem dissection revealed no internal injuries, no evidence of disease and no heavy parasite infestations, but there were some abnormalities in the colouring of organs: one quoll had half its stomach discoloured red, another had dark red lungs and a red brain. No toads were found in the stomachs, although we know from the observation on the pet Western Quoll that ingestion is not necessary to cause death. There were no obvious changes in the habitat at the time except for the arrival of the toads. By the process of elimination, we decided that the most likely cause of death in these five females was toad poi-

A Northern Quoll is released after it has been examined, weighed and measured. Radio-collared quolls were caught every fortnight to check their collar fit and general health.

MERI OAKWOOD

soning. The wet season is normally a time of high quoll abundance and high mortality as the young become independent and compete for the limited number of territories, so these deaths at this time had little impact on the population as a whole.

The dry season arrived and the toads became less obvious as they retreated to shelter sites near water. We continued monitoring the quoll population by trapping and it followed the usual pattern of slight decline as the dry season progressed. The mating season was normal, all of the females had pouch young and, by October, the young were kept in nursery dens. The population at this stage was very similar to that of the previous year. October is always the month of lowest trap success for quolls in Kakadu as most, if not all, of the adult males are dead and the young are not yet weaned. Then, towards the end of the month, the rains began and the toads began dispersing again. As the mothers found the toads and died from poisoning, whole litters starved to death. By December 2002, the population had crashed with only three individuals captured during trapping. In January 2003, again only three were trapped (one adult female and two young). This was in stark contrast to January the previous year when seven adults and 21 young were caught. In March 2003, we caught no quolls. We trapped again in May, July, September and November 2003, and in January and June 2004—still no quolls. So it appears that we were the sad witnesses of local extinction. The quolls at the Mary River site apparently became extinct between January and March 2003.

Additional compelling evidence that the population crash at the Mary River site was caused by toad invasion was that the northern study site, the East

MERI OAKWOOD

Northern Quoll females usually carry seven or eight young in their pouch. These young, with their spots showing and covered in fine fur, are about eight weeks old. Within the next week they will be ousted from the pouch and kept in a nursery den.

AMBER HOCKE

(Above) Dead adult female Northern Quoll killed by Cane Toad poisoning. The extremely bright red colour of the lips is the irritation caused by the toxins. These quolls often have dirt in their mouths, as though they were trying to remove the taste or feeling of the toxins. (Right) This juvenile Northern Quoll is about four months old. At this stage they are usually kept safely hidden in a nursery den, however this one was found in the roof of a house and handed in to the Territory Wildlife Park.

Alligator area that was toad-free at that time, still had a superabundant quoll population. Tragically, Cane Toads have now arrived there too. Already six quolls are dead from toad poisoning and it looks like there will be a repeat of the Mary River experience.

SO WILL THESE LOCAL EXTINCTIONS be permanent, or will the quolls recolonise the areas at a later date? Some native species that are social, such as crows, appear to be able to consume toads safely by turning them over and devouring only the stomach region. Unfortunately Northern Quolls are solitary hunters, so it is unlikely they will learn safe toad-consuming behaviour from watching others. Another native species that has been reported to successfully eat toads by focusing on the non-toxic parts is the Water Rat (*Hydromys chrysogaster*). This may be an extension of existing behaviour as many Australian frog species have toxic skin secretions. Since Northern Quolls already consume native frogs, perhaps there is a small chance that some individuals may adopt precautionary behaviour.

In order to determine whether recolonisation occurs, we will endeavour to continue monitoring both the sites, but this will be dependent on funding. Ideally these sites should be revisited at least once a year until about 2010 and perhaps beyond. The only way that we can scientifically address the question of long-term impact is to conduct methodical long-term monitoring.

In the meantime we need to be proactive in establishing 'rescue programs'. Given the possibility of losing the entire mainland Northern Quoll population in the Northern Territory, it is imperative that we support any project that may assist us to conserve this species, including captive-breeding programs and translocations to islands. Then, at some time in the future, the quolls' descendants may be able to be returned to the wild once—indeed, if—the Cane Toad menace passes.

It's the 'if' that is the problem. There are just so many gaps in our knowledge of the impact of invading species in Australia. Our study provides a unique opportunity to increase our understanding of this process. And, by documenting the drastic result of Cane Toads on at least one species, we hope to emphasise the need to find management solutions as quickly as possible. □

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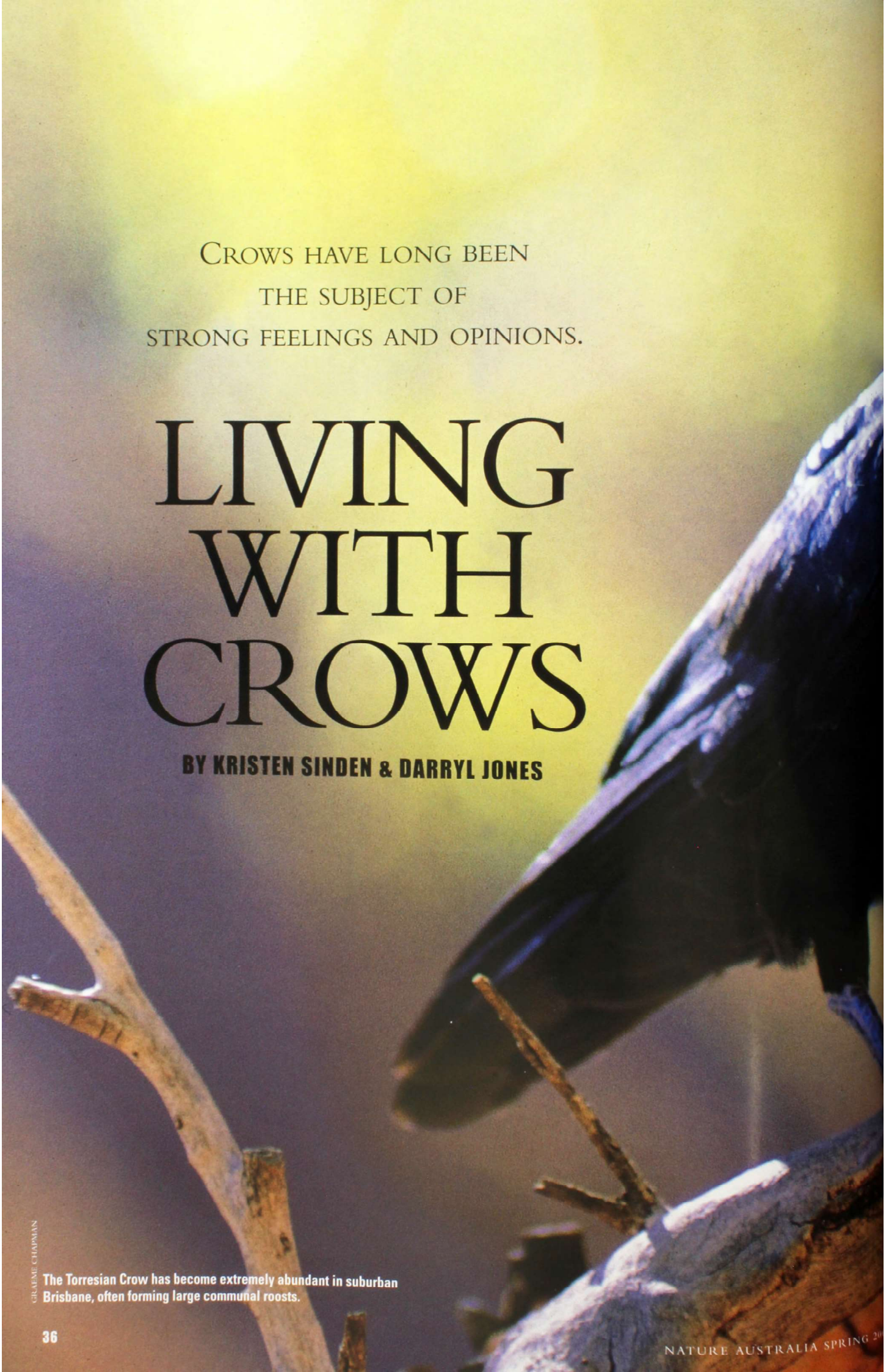
DR MERI OAKWOOD (ENVIROTEK) IS AN ECOLOGIST WHOSE RESEARCH HAS FOCUSED ON QUOLLS FOR THE PAST 12 YEARS. SHE IS PARTICULARLY INTERESTED IN THE PHENOMENON OF MALE DIE-OFF AFTER MATING AND IN CONSERVATION BIOLOGY.

SHE THANKS PARKS AUSTRALIA NORTH FOR FUNDING THIS PROJECT.

CROWS HAVE LONG BEEN THE SUBJECT OF STRONG FEELINGS AND OPINIONS.

LIVING WITH CROWS

BY KRISTEN SINDEN & DARRYL JONES



GRAEME CHAPMAN

The Torresian Crow has become extremely abundant in suburban Brisbane, often forming large communal roosts.

IF ASKED TO NOMINATE THEIR favourite bird calls, most people would be quick to name such melodic examples as the carolling of the magpie, the flute-like notes of the butcherbird, or maybe even the laughter of the kookaburra. Crow caws are unlikely to rate a mention. In fact, for many people the repetitive 'arh' of these birds is their most annoying trait, especially in cities where corvids (the collective name for crows and ravens) are becoming increasingly common. The noise associated with large groups of these birds results in many complaints to local authorities (Brisbane City Council, for example, receives hundreds of complaints each year) and appears to be just one more reason for some people to despise an already unpopular species.

Crows have long been the subject of strong feelings and opinions. They have frequently featured in tales and myths as portents of bad fortune and death. Their poor reputation is often reinforced with their big, black and 'evil-looking' appearance. In rural areas they scavenge on dead or dying animals and have consequently been accused of killing valuable farm animals. Although these misconceptions have been largely disproved, animosity remains widespread in the rural community. In urban centres, however, crows fare no better, often being blamed for the declines in small native bird populations, even though there is no evidence to support this charge.

AUSTRALIA IS HOME TO FIVE species of crows and ravens (see box). Since about the middle of last century, certain corvid species have responded very positively to the activities of humans, and some have increased dramatically in numbers in urban areas. For example, Australian Ravens (*Corvus coronoides*) are now common in Perth, Sydney and Canberra, while Little Ravens (*C. mellori*) are abundant in Melbourne. In Brisbane, since about the 1950s, the Torresian Crow (*C. orru*) has been increasing steadily in numbers and is now found throughout the city and suburbs. Somewhat surprisingly, only two of the Australian species—Little Ravens and Torresian Crows—form large communal roosting groups, sometimes numbering in their hundreds and, needless to say, producing a lot of noise.

And while shift-workers and the parents of light-sleeping babies may seriously dislike crows and their noise, most people's reactions are probably somewhere between apathy and mild disdain. They are not alone: in general, most ecologists are not too fussed about crows, or indeed anything to do with the urban environment. The ecology of the city has only recently become something that ecologists have taken an interest in. This neglect of the very place where wildlife and humans live together also means that attempts to manage urban wildlife are often hampered by a lack of knowledge. This is one of the reasons that we belong to a group of ecologists dedicated to understanding urban

GRAEME CHAPMAN

A Little Raven showing its throat hackles.

GRAEME CHAPMAN

The most social of Australia's corvids, a group of Little Crows forage for insects and carrion on a road.

wildlife. And if there was one species about which we knew very little, it was Brisbane's urban crow.

Something we did know, however, was that corvid calls, while sounding superficially simple—just an endless variation on 'arh, arh, arh'—are among the most complex of all animal vocalisations. Recent research on European Common Ravens (*Corvus corax*), for example, has found that, apart from their huge repertoires, crows exhibit an extraordinary level of learning and even 'cultural transmission', in which different calls are shared within families and among group members. No doubt these superior communication skills, shared by other corvids including the Torresian Crow, have contributed to their success and ability to exploit new environments. But becoming common has not been greeted with much appreciation by large numbers of Brisbane residents! The places of greatest conflict tend to be where large communal roosting areas are situated within the suburbs. These roosts are used every night by crows that arrive around dusk and depart the following morning before sunrise. The conflict arises because there is considerable crow 'conversation' associated with these arrivals and departures.

We conducted most of our research at a large Torresian Crow roost in the Brisbane suburb of Mt Gravatt that has been used continuously since at least the late 1970s. Numbers peak during autumn, when breeding has finished, with up to 400 birds settling into about six adjacent trees. On a typical night between 80 and 160 crows used one particularly large *Eucalyptus* tree, and, being the most accessible, we used this site for recording the crows' roosting and calling behaviour.

Their 'conversation' began about an hour before sunrise (which is pretty early in summer!) and the rate of calling escalated until most birds had left the roost just before dawn. Unfortunately for those people who live near such roosts, this coincides with one of their most important biological needs: sleep. When this essential requirement is disrupted daily by a group of rowdy crows, residents can become tired and angry. But are they justified in their

GRAEME CHAPMAN

An Australian Raven showing its characteristic throat hackles. Only the three Australian 'raven' species have obvious throat bulges but none is as conspicuous as seen in this species.

Australian Corvids

Corvus spp.

Australia has 5 native species of crows and ravens (listed below in approximate order of size), which are all extremely similar in most features. The House Crow (*Corvus splendens*), although occasionally arriving aboard cargo ships from Asia, has never established breeding populations.

Australian Raven (*C. coronoides*)
The common corvid of coastal and inland NSW. Does not form large flocks.

Forest Raven (*C. tasmanicus*)
Only species in Tas.; also found in uplands of central coastal NSW and patchy distribution in southern Vic.

Little Raven (*C. mellori*)
Typically prefers open inland areas of southern Aust., although common in Melbourne.

Torresian Crow (*C. orru*)
Found throughout northern half of the continent, common in many Qld cities.

Little Crow (*C. bennetti*)
Abundant in dry interior, often becoming confiding in small inland towns.

complaints? Nobody complains when magpies or kookaburras contribute to the dawn chorus, yet they can be just as 'noisy'. Was there something particular about crow vocalisations that was especially aggravating? With these questions in mind, we set out to investigate just what it was about crow noise that caused so much grief.

USING SOUND EQUIPMENT normally used in the assessment of industrial noise pollution, we arrived in the dark, well before dawn, to record two aspects of crow calls at the roost: loudness (measured as sound pressure) and frequency (or pitch). The results were very revealing. First, the noise produced at a roost of about 100 crows was remarkably loud. We found that the sound-pressure level often peaked as high as 82 decibels, which is similar to that produced by nearby heavy traffic. Indeed, this is getting close to the critical threshold of 85 decibels, widely regarded as being capable of causing hearing problems if experienced consistently over a prolonged period of time. Thankfully, no group of crows was this loud for more than a few minutes on any given morning. Our data do show, however, that a big roost of crows can be very noisy.

Equally important, though, was the fact that the range of the sound-pressure levels varied considerably over time, with many peaks occurring throughout the recording. These highly irregular rises and falls in loudness contribute to what is referred to as 'impulsiveness', a term that conveys something of the unpredictable and erratic structure of the sound. It is this impulsiveness, as opposed to a steady continuous sound, that is associated with significant annoyance in humans. Sound, even unpleasant

GRAEME CHAPMAN

The Little Raven has successfully moved into suburban and down-town Melbourne.

sound, that is continuous, repetitive and thoroughly predictable, we quickly become habituated to; our brains simply stop interpreting that type of input as being worthy of attention. Think of the continuous hum of a highway, compared with the repeated stop-start of the garbage truck working its way up your street. If crows called in long unbroken sequences, they might just be ignored.

However, there is more to crow calls than just loudness or the absence of pattern to the noise: it is the combination of both the sound-pressure level (typically 25–70 decibels) and the frequency or pitch (between 1.2 and 2 kilohertz) that makes crow calls so noticeable to humans. Most bird songs are typically much higher in frequency and are also considerably quieter than crow calls. (This is somewhat surprising because corvids belong to the group of birds known as the passerines, or songbirds, renowned for their 'song', as opposed to the less musical non-passerines.) In contrast to the melodic notes of the Australian Magpie, for example, the calls of the Torresian Crow (or any corvid) are loud, even when given by a single bird, distinctly unmusical, and relatively low in pitch. Indeed, crow calls are remarkably similar to the sounds produced by human speech, especially that of adult men talking loudly or shouting.

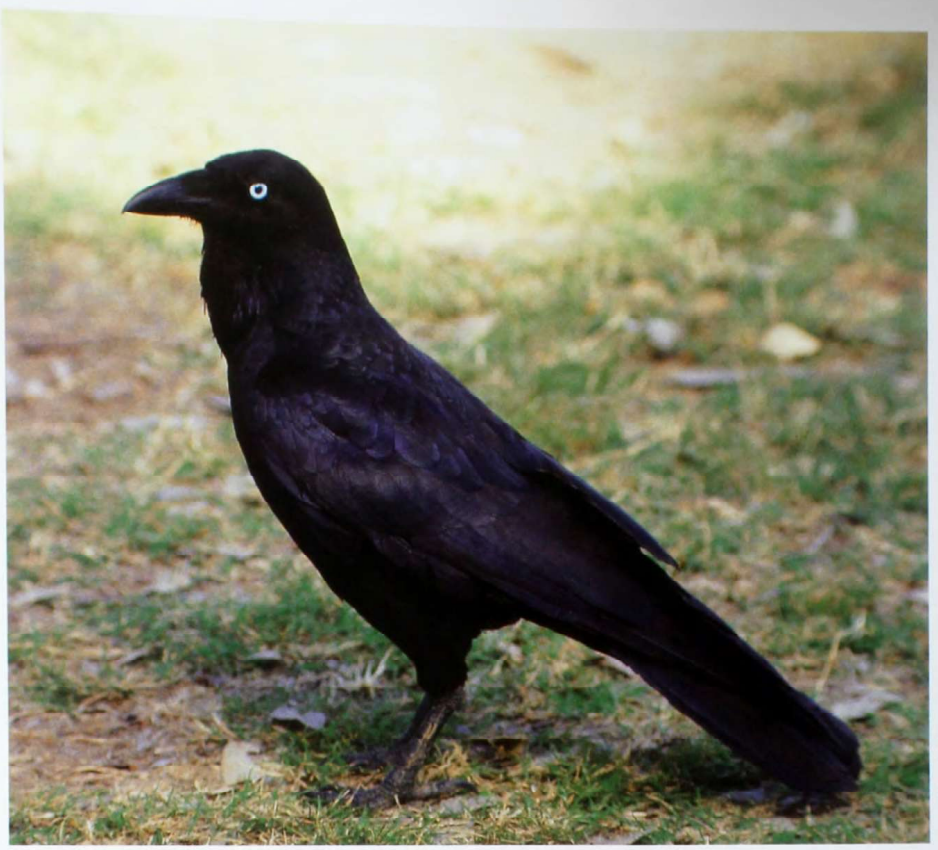
If so, this may provide at least part of an explanation for why many people have a remarkably strong and negative reaction to an otherwise natural noise. Anything that sounds like an adult male's voice shouting or yelling loudly is likely to be something that is hard to ignore or habituate to. There is a strong possibility that human aural perceptions evolved to be acutely aware of potentially threatening situations, and being sensitive to loud—and very probably male—voices would have been obviously important. Being easily disturbed by crow calls, therefore, is wired into our brains!

NOT EVERYONE, OF COURSE, reacts so negatively to crow noise, even among people living directly under a large crow-roosting tree. In an earlier study of all the people living within a kilometre of the Mt Gravatt roosting site, visiting Canadian researcher Susie Everding found that only about one person in five (18 per cent) rated the problem as 'serious' and about the same proportion regarded it as simply a 'moderate issue'. Indeed, most (62 per cent) had no particular opinion about crow noise or were actually positively inclined toward them. Given the hundreds of complaints received by various Brisbane authorities, it would have been easy to have assumed that 'everyone hates them', as many people repeatedly assert. The reality is, however, that while many—even the majority—of people do not perceive crow noise as a 'problem', for those that do, the issue is serious and sometimes highly disturbing.

This demonstrates the complexity

GRAEME CHAPMAN

of trying to understand and deal with what is essentially a wildlife management conflict in an urban area. The notoriously inconsistent nature of human perceptions complicates planning solutions to conflicts such as this. In the case of urban crows, the issues are particularly problematic: not only are attitudes about the birds themselves distinctly polarised, so are reactions to the associated noise. Although there are numerous things that can be done to deter crows from specific locations (such as scaring birds away from roosting sites, and manipulating the structure of the roost trees), the long-term solution must be one of increasing the community's tolerance of corvids in cities. However, achieving this may be quite a challenge. As intimated earlier, crows come prepackaged with an unfortunate public relations image. Overcoming these perceptions will necessitate some powerful counter-messages. Without diminishing the scale of the difficulties involved, there are two aspects of corvid biology that might be employed to this end.



GRAEME CHAPMAN

Australian Ravens, like most Australian corvids, forage almost entirely on the ground. This is the common 'crow' seen in Sydney.

The two 'crows', like this Torresian Crow, have whitish feather bases while the feathers of 'ravens' are greyish.

First, corvids are smart. Recent publicity over the remarkable tool use by both the European Common Raven and the New Caledonian Crow (*Corvus moneduloides*) points to astounding mental abilities within the group. The success of corvids worldwide is clearly related to their advanced level of intelligence (see "Bird Brains", *Nature Aust.* Summer 2003–2004).

Second, it is now clear that all those crows living among us in our towns and cities are responsible for a truly heroic street-cleaning and public-health service. Astonishing amounts of organic rubbish and road-killed animals—most of which would decompose and decay with very unpleasant results—are removed with ruthless efficiency before most of us rise from our beds. Indeed, if the 'racket' of the pre-dawn crow roost could be re-thought of as the sophisticated conversations of highly intelligent animals preparing to clean the streets as a free service for the resident humans, just maybe they might be regarded a little more positively. □

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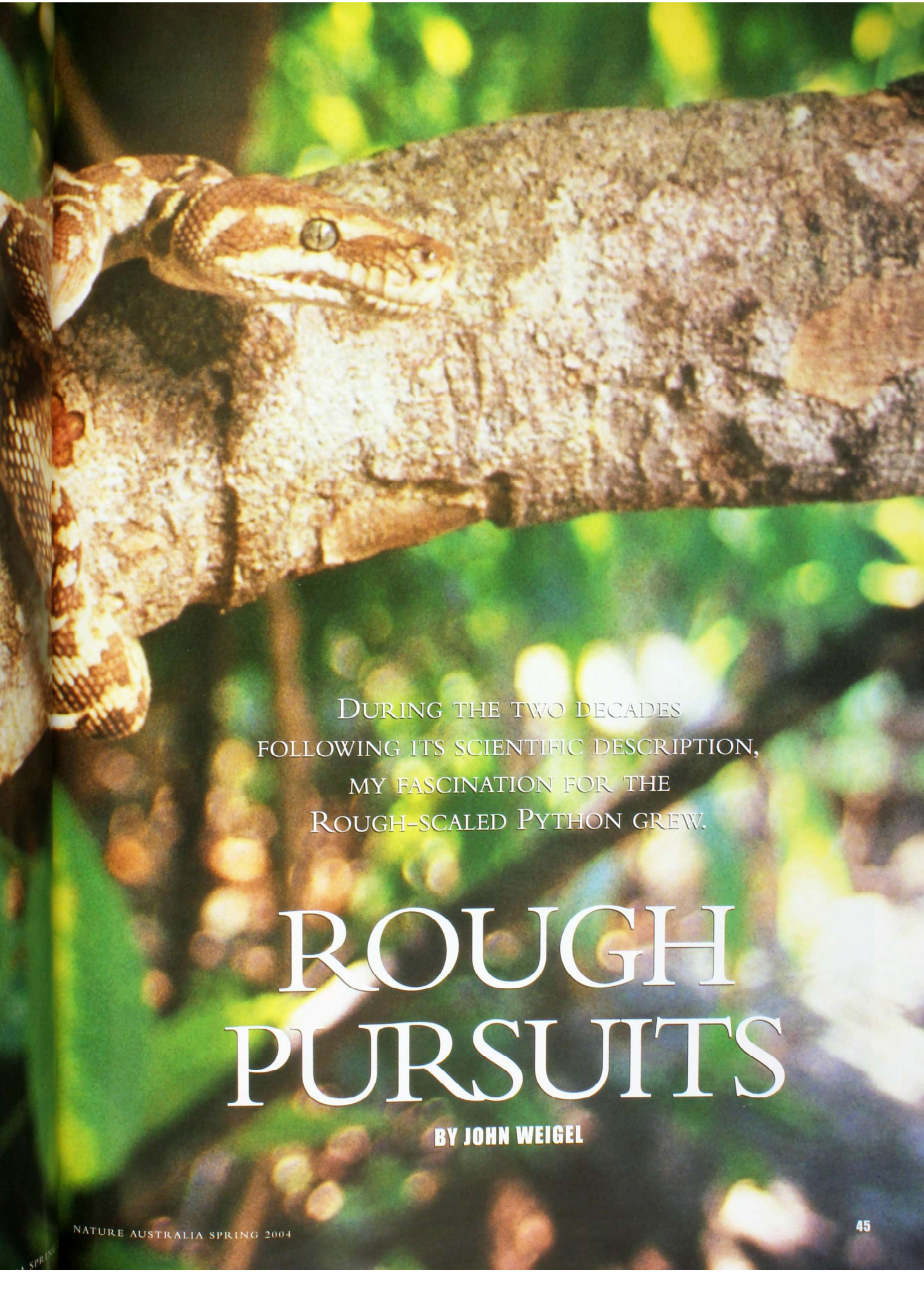
KRISTEN SINDEN RECENTLY COMPLETED A DETAILED STUDY OF URBAN TORRESIAN CROWS FOR HER HONOURS DEGREE AT GRIFFITH UNIVERSITY IN BRISBANE. DR DARRYL JONES HEADS THE SUBURBAN WILDLIFE RESEARCH GROUP AT GRIFFITH UNIVERSITY, AND IS INVOLVED IN STUDYING THE URBAN ECOLOGY OF A VARIETY OF SPECIES.

JOHN WEIGEL

This Rough-scaled Python was found within the tiny rainforest patches of the Hunter River.



During the two decades following its scientific description, my fascination for the Rough-scaled Python grew.

ROUGH PURSUITS

BY JOHN WEIGEL

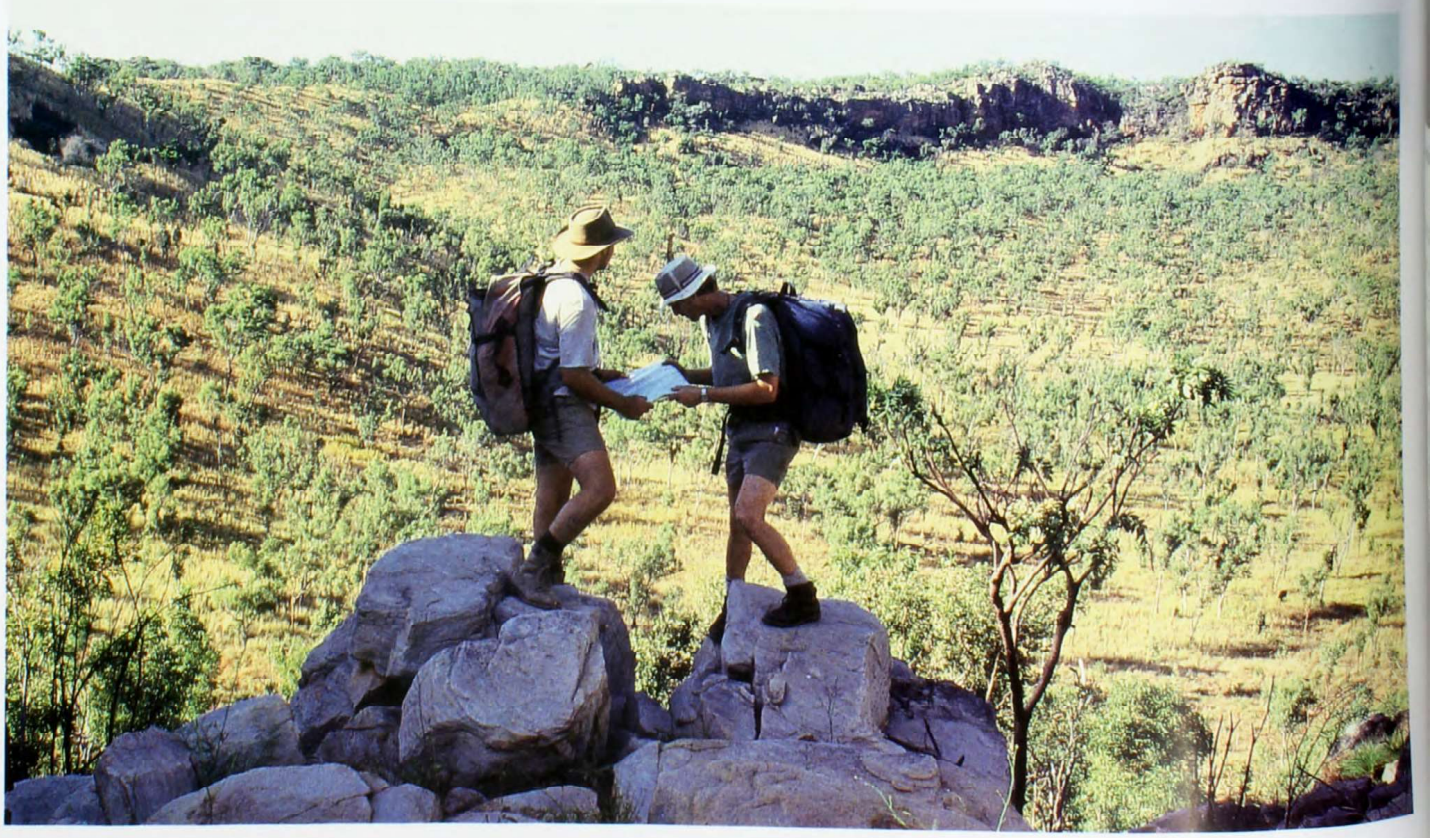
I FIRST HEARD ABOUT THE Rough-scaled Python (*Morelia carinata*) in 1981, when Laurie Smith of the Western Australian Museum (WAM) published his scientific description of the species, based on a specimen collected in 1976 from the Mitchell Falls area of the Kimberley. The python was encountered in a sandstone cave where researchers had taken temporary refuge during a storm. I had just begun my career as a reptile keeper at the Australian Reptile Park in Gosford, New South Wales, and was captivated by the idea that such an extraordinary discovery could be made in recent times.

This python has a head shaped like a figure-of-eight and a tall snout to accommodate extremely long teeth. In this way it resembles the Green Tree Python (*Morelia viridis*) from the northernmost rainforests of Queensland and beyond. However, unlike other pythons, which have smooth body scales all over their bodies, *M. carinata* has a dorso-laterally oriented keel at the centre of most of its scales. The function of these rough scales remains unknown (but see "Rough Ideas" box).

During the two decades following its scientific description, my fascination for the Rough-scaled Python grew. Through good fortune and the graces of an understanding workplace and family, I have made 16 separate trips to the north-west. During the 1980s my search was largely confined to the vicinity of the Mitchell River, but with no luck. Then in June 1987, I heard of a second specimen of Rough-scaled Python. It was collected during a survey of the Kimberley rainforests (semi-deciduous vine thickets) by the Western Australian Department of Conservation and Land Management (CALM). It was 1.4 metres long and found by day perched on an upper tree branch adjacent to a steep cliff. It was the only Rough-scaled Python encountered during the three-year survey.

One of the valuable outcomes arising from this study was the production of a series of satellite-generated maps revealing, as yellow flecks or ribbons, the locations of most of the 1,500 or so rainforest fragments in the region. Most of the rainforest stands are smaller than a football field, and in all, they take up less than 0.005 per cent of the Kimberley landscape. Working on the assumption that *Morelia carinata* was restricted to the vicinity of rainforest (admittedly not a safe assumption, based on only two specimens), the new maps steered us towards Prince Frederick Harbour, about 40 kilometres west of the Mitchell River, where the greatest profusion of rainforest fragments occurred.

Another important development at about this time was the commencement of a seasonal 'joy-flight' helicopter service at Mitchell Falls. It was a disbelieving young pilot that reluctantly dropped me off, along with workmate Trent Russell, on a remote mudflat at the mouth of the Prince Frederick Harbour in May 1993. The pilot's uneasy parting words were "You fellas sure you'll be 'right?" These would echo in my head often during the challenging two weeks ahead. The mudflat had offered the nearest landing position to the extensive rainforest patch that had yielded the second Rough-scaled Python six years before. However, after a failed effort to find an overland route from the mudflat to our intended destination, we had to overcome our misgivings about crocodiles, and paddle our two-metre-long



JOHN WEIGEL

Access to the habitats that were most likely to support Rough-scaled Pythons required exhaustive overland treks. In 1993 the author and Trent Russell found their way to the source of Prince Frederick Harbour—the Hunter River.

JOHN CANN

Like other pythons, the Rough-scaled Python has pits alongside its lips that may help detect heat from warm-blooded prey.

inflatable dinghy through the mangroves, and into the harbour, from where we would travel the 16-kilometre journey upstream to the freshwater reaches of one of the branches of the Hunter River.

Six gruelling hours of paddling later, we finally reached a rocky point that protruded from thick mangrove growth. We clambered uphill well away from the mangroves, and set up camp. After a good night's sleep and a four-hour hike the next morning, we arrived at the breathtaking kilometre-long rainforest gorge that we immediately dubbed 'Shangri-la'. Our quest to encounter the third-known specimen of *Morelia carinata* could finally start in earnest.

On our first night of search, we observed an assortment of gecko and snake species, but alas, no Rough-scaled

JOHN WEIGEL

The discovery of this juvenile specimen was the culmination of many trips to the northern Kimberley. At a length of approximately 80 centimetres, it was probably between one and two years old, and possibly feeding primarily upon frogs and geckos.

JUSTIN WELSH

Perseverance paid off when Trent Russell encountered a juvenile Rough-scaled Python—the third specimen ever to be recorded.

Rough-scaled Python

Morelia carinata

Classification
Family Boidae (boas and pythons).

Identification
Medium-sized python, 150–200 cm. Differs from all other pythons by having strongly keeled upper body scales.

Distribution and Habitat
Appears to be confined to monsoon forests and associated sandstone gorges and scree slopes in far north-west Kimberley, WA.

Reproduction
Mating occurs early Aug. In captivity lays 10–12 eggs late Oct., hatching early Jan.

Diet
In the wild, known to feed on Kimberley Rock-rat (*Zyzomys woodwardi*). In captivity, native rats are favoured over other foods offered, including non-native wild rats, and various birds. Captive-bred hatchlings enthusiastically accept frogs.

Status
Full distribution unknown, but may prove to be extremely limited.

Pythons. The next morning we repeated the search, using binoculars to search treetops and penlight torches to peek into hundreds of crevices—still no result. Then, on the fifth 'night walk', as we worked our way upstream on opposite sides of the creek, the beam of Trent's head-torch revealed a snake on the top of a two-metre-high boulder. He called out "Children's Python!", then "No, it's a Carpet Python! No! It's a Rough-scaled Python!!". There, stretched out to its full length, lay an 80-centimetre-long juvenile Rough-scaled Python. At last we had found what we were looking for.

Although we continued searching the rainforest and surrounding rocky settings during our remaining five days in Shangri-la, we found no more Rough-scaled Pythons. However, a year later (1994) the two of us would be back at Prince Frederick Harbour for another look. This time it would be my turn to find a Roughie—a 1.4-metre-long individual encountered in a low branch of a very small Lilly Pilly tree, in what appeared to be an ambush-feeding pose.

AFTER THE EXCITING RESULTS achieved in 1993 and 1994, I was encouraged by Rick Shine (University of Sydney) to apply for a permit from CALM to collect a founder group of Rough-scaled Pythons for the purpose of captive study and breeding at the Australian Reptile Park. The project was approved in July 1998, and a new, grander approach to the challenge of finding Rough-scaled Pythons began.

It would take three extended trips to secure the five 'founder' specimens—three males and two females. During these ventures all of the principal tributaries of Prince Frederick Harbour were explored. The first trip, in May 1998, yielded no Rough-scaled Pythons. A year later, undeterred, eight of us arrived to search along the Hunter River with renewed focus. But after nine long hard days and nights, hope of success was waning. While exploring the rainforest some 300 metres from camp, Rob Porter (Australian Reptile Park) took a

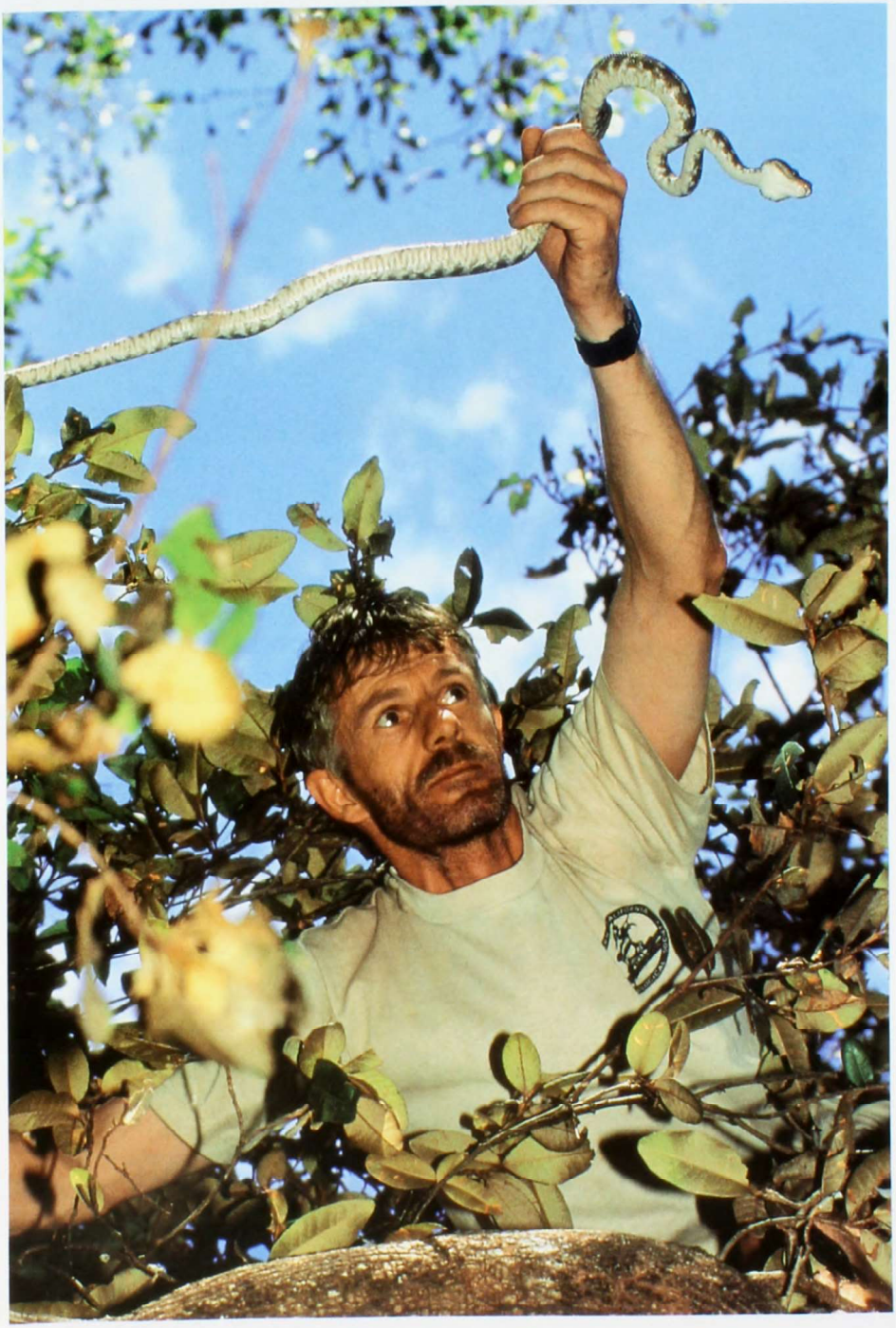
lunch break from his efforts and, while indulging in his rationed two muesli-bar meal, lay on his back beneath the shade of a six-metre-high tree. He nearly choked on his second muesli-bar when he unexpectedly distinguished the coils of a Rough-scaled Python perched on a branch about four metres above his head. The python proved to be a male, and represented a fine start to the breeding program. As luck had it, that very night Alf Britten (New South Wales Forestry) nearly stepped on a female Rough-scaled Python. Although no further specimens were encountered, it was a happy team that returned to Gosford with a potential breeding pair of the rare pythons.

Another year later, four of us from the Reptile Park took off again, this time for a full month. Alf rejoined us, as did two CALM officers, documentary adventurer Mark O'Shea, and others. Once again, finding the snakes proved to be a real challenge and, after 11 days and nights, discouragement had begun to creep into camp. However, late that night, while inching my way along a protruding cliff-face ledge, six metres up from the forest floor, I spotted a 1.6-metre-long female Rough-scaled Python stretched out on the still-warm narrow shelf ahead. Her swollen girth indicated that she had recently fed, and I was able to grab and bag her relatively easily. She later disgorged a partially digested Kimberley Rock-rat (*Zyzomys woodwardi*). Indeed, the python's exceptionally long teeth may be an adaptation for feeding on rock-rats, which have the ability to shed patches of fur and escape predators with less penetrating grips.

Two days after capturing this female, and just a few hours before the helicopter was due to shuttle half the team out of Shangri-La, Alf made a pre-dawn run to check some mammal traps he had set along a ravine. He was about 400 metres away from camp when his shouting heralded another Roughie. What's more, as Mark, Rob and I raced toward the commotion, he called out that it was a Rough-scaled Python being constricted by an Olive Python! Unfortunately, the extraordinary scene broke up moments before we could witness it for ourselves. But then the race was on to catch the two snakes. Alf and Mark stumbled after the 2.5-metre-long Olive Python (*Liasis olivaceus*) that was heading downhill fast, while I easily nabbed the somewhat disoriented, 90-centimetre-long Rough-scaled Python. The Roughie was a young male and, despite having been wrapped in the coils of a snake nearly three times its length, appeared to have no significant injuries.

A few hours later Mark was in the helicopter waving goodbye, with a foam box containing the two Rough-scaled Pythons resting on his lap. While they headed for Gosford, the rest of us continued the search for more pythons.

Five nights later, while making my way along the base of a cliff, I encountered a young Rough-scaled Python as it descended ten metres down a tangled mass of fig-tree roots and vines. When nearly at ground level, and exposed without any escape option, it squared up to greet me, adopting a threat behaviour that I believe is unique to this species. While securing its tail and posterior body around a vine, it gathered the front half of its body into a lateral S-shaped bend in preparation to strike.



PETER BEEH

After nine long days and nights of searching, Rob Porter, while resting beneath a shady rainforest tree, happened to look up and was rewarded with a male Rough-scaled Python.

PHOTOS: JOHN WEIGEL

When first confronted, this young male adopted the impressive gaping threat pose that has only been observed in Rough-scaled Pythons at the time of capture.

But before doing so it opened its mouth widely, revealing an arsenal of needle-like teeth. While maintaining the impressive gape, it struck forward to a fully extended position and remained rigidly outstretched for two or three seconds before retracting again to the strike-ready position and momentarily closing its mouth.

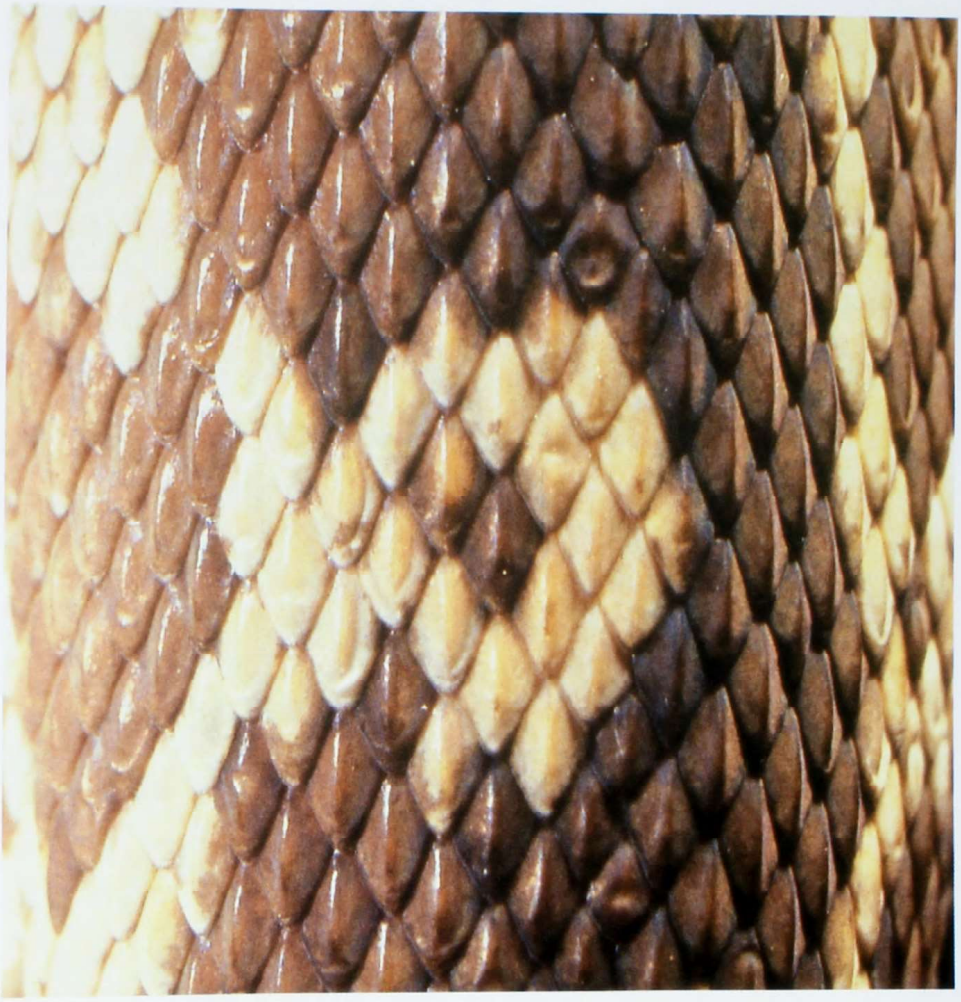
About half the Roughies we encountered showed this remarkable defensive behaviour when first confronted. Although I attempted to distract this particular young python with my right hand, while grabbing it with my left, I paid the usual price: a painful bite, this time on the knuckles. While it held fast to my bleeding left hand, I unwound its tail from the vine and could see that it was probably a male. All pythons possess a pair of small claws—one on either side of the vent—vestiges of a long-lost legs. In males, the spurs are much more developed than in females, and are used to tickle and titillate females prior to mating. Interestingly, the spurs of male Rough-scaled Pythons are only marginally bigger than those of females, and in both sexes, appear to be considerably smaller than they are in other similar-sized python species of like sexes. The maleness of the captured snake was nonetheless confirmed later than night by 'probing'—a common snake-keeping technique employing a small blunt metal probe to determine the presence or absence of the paired, retracted copulatory organs present in male snakes (see "Snake Penises", *Nature Aust.* Winter 2000).

THE NEXT STAGE OF THE PROJECT was now well and truly underway: the captive breeding of *Morelia carinata*. Our hard-gained field observations, and those recorded previously by WAM researchers, provided only tantalising glimpses into the private lives of Rough-scaled Pythons. Captive observations, however, would prove far more helpful in providing answers to some basic questions about the ecology of the species. Four of the five 'founder' pythons adjusted quickly to captivity, although the small male rescued from the predatory grip of an Olive Python remained flighty and was disinclined to eat for nearly a year before settling down.

All were (and are) maintained individually in large holding enclosures fitted with horizontally positioned branches and other furnishings to allow climbing/perching behaviour. Because the normal breeding season for the species was not initially known, from time to time male specimens were introduced to female specimens with the intention of eliciting courtship.

The first two founder specimens, collected in May/June 1999, matured quickly and exhibited courtship behaviour in early August 2000. Nearly three months later, on 30 October 2000, the female laid 12 eggs, approximately 33 x 50 millimetres and 30 grams each. In typical python fashion, the brooding mother used her turban-like coils to hide the clutch. In nature, she would have chosen a very specific location for the two-month-long period of incubation; in captivity, where conditions of moisture and temperature may be less suitable, artificial incubation is the best option. So, hours after being laid, I placed the eggs in a controlled incubating environment (31° C with 80 per cent relative humidity). For several days after removal of her eggs, the python remained tightly coiled, seemingly unaware of the loss. However, when offered a freshly thawed rat about a week after the theft, she responded enthusiastically and thereafter abandoned the phantom incubation.

All of the eggs hatched during the first two days of January 2001. Upon emergence, each of the hatchlings was about 43 centimetres long and 17 grams. The hatching event was a cause for great excitement at the Reptile Park—so many staff members had been involved in the project in one way or another, always with this achievement as our central aim. Photographs of the event—the first ever for the species in captivity—appeared in newspapers worldwide.



The keeled scales of the Rough-scaled Python are unique amongst the world's pythons. The course texture may assist in camouflaging these pythons when roosting by day on rainforest tree branches and sandstone ledges.

This female went on to produce similar clutches in November of 2001, 2002 and 2003, each time following matings of early to mid-August. A different founder male was used in each year to optimise the genetic diversity of the young produced. The second female, the only founder specimen that appeared to be fully mature at the time of capture (June 2000), proved to be less inclined to breed initially, and it wasn't until early August 2002 that mating was observed. Following the established pattern, she produced 12 eggs about ten weeks later, with hatching occurring in early January 2003.

Many of the young pythons that have been produced have been transferred to other Australian zoological facilities, and a studbook for the species is being maintained with a view to coordinating regional breeding.

Perhaps most relevant to the conservation of the species is the fact that hatchling specimens are now known to be extremely fond of frogs. This raises the question of what impact the inevitable arrival of the introduced and highly poisonous Cane Toad (*Bufo marinus*) will have on this highly localised species. □

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JOHN WEIGEL, WITH HIS WIFE ROBYN, RUNS THE AUSTRALIAN REPTILE PARK, NOW IN SOMERSBY, NEW SOUTH WALES, WHERE HE HAS WORKED SINCE 1981.

Rough Ideas

Why do rough-scaled pythons have 'rough' scales? Many snake and lizard families have strongly keeled scales, and the function, in some species, is widely agreed upon. Explanations range from provision of a better grip on slippery prey such as fish or frogs (for example file snakes, *Acrochordus* spp.), to retarding the ability of predators to extract the snake from narrow crevices (for example Cunningham's Skinks, *Egernia cunninghami*). For me, the question of why *Morelia carinata* has strongly keeled scales was at least partially answered the first time I saw a live specimen in the context of its natural environment.

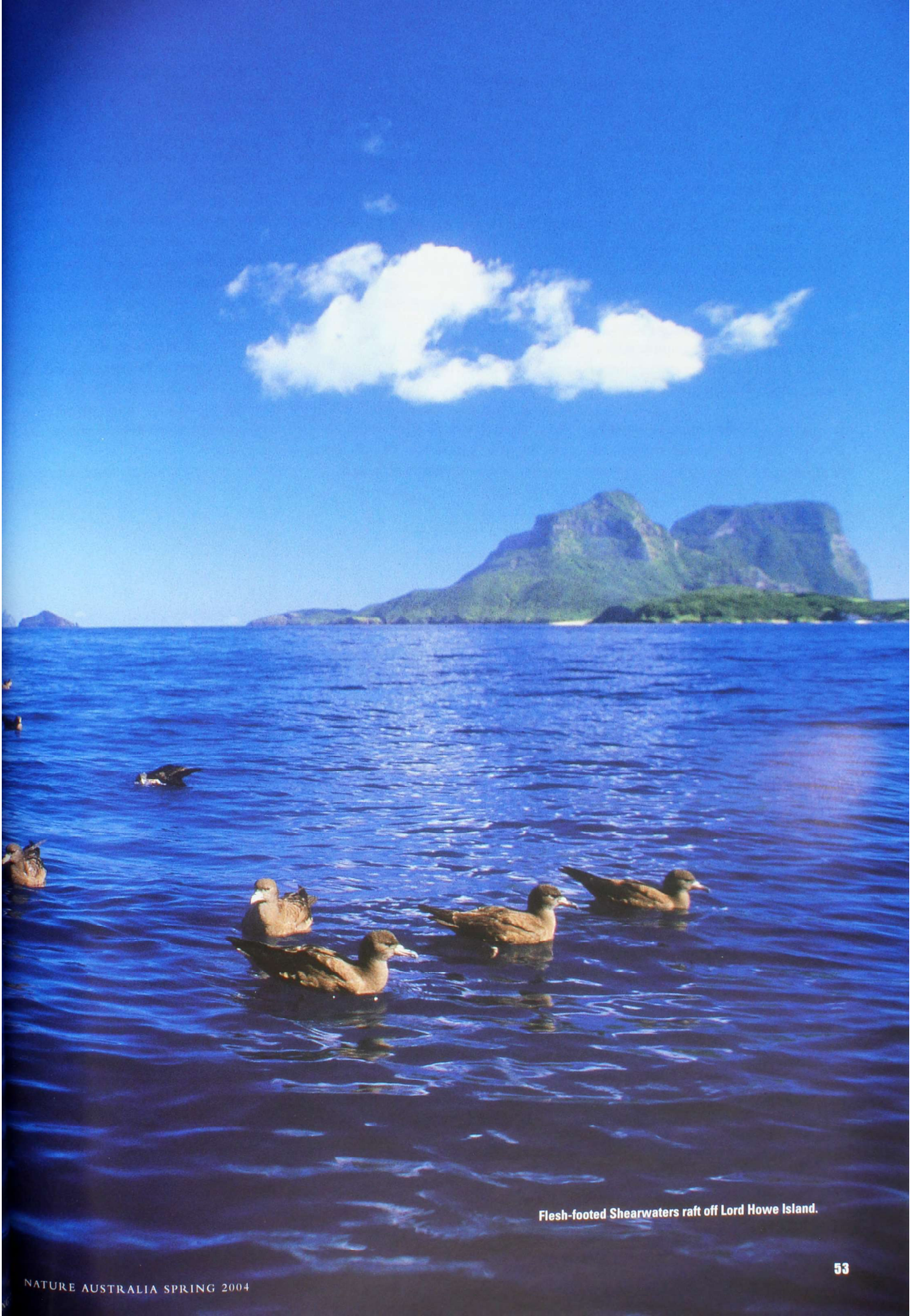
Whether perched on a weathered Kimberley sandstone shelf or lichen-covered rainforest tree branch, the rough texture of the skin, in association with it 'camouflage' colour pattern, greatly enhances the ability of the exposed python to 'melt' from view. This provides an important advantage for Rough-scaled Pythons, which are among the few tropical pythons that routinely roost by day on tree branches, well away from any safe retreat.

Several other Australian python species have colour patterns that are vaguely similar to that of the Rough-scaled Python. However, the non-reflective skin of the latter, coupled with an extraordinary ability to lighten or darken its overall skin colouration depending upon the environment, greatly enhances this python's ability to remain unnoticed by avian predators (and herpetologists).

PLASTICS ARE LIGHTWEIGHT, STRONG AND DURABLE, BUT IT IS THESE CHARACTERISTICS THAT ALSO MAKE THEM A SERIOUS HAZARD FOR THE MARINE ECOSYSTEMS.

PLASTIC PERILS FOR SEABIRDS

TEXT & PHOTOGRAPHY BY IAN HUTTON



Flesh-footed Shearwaters raft off Lord Howe Island.

AS YOU STROLL THROUGH the Flesh-footed Shearwater colony on Lord Howe Island, all seems serene and in order. The sandy forest floor is pockmarked with the large holes that are the birds' burrow entrances. But as you scan the ground, something catches your eye. It's a piece of blue plastic—nothing too alarming, but a bit farther on another, and to the right a few more—some blue, some white. Walking off the track into the forest reveals a more sinister sight—a seabird skeleton with a ribcage full of plastic. What is going on here?

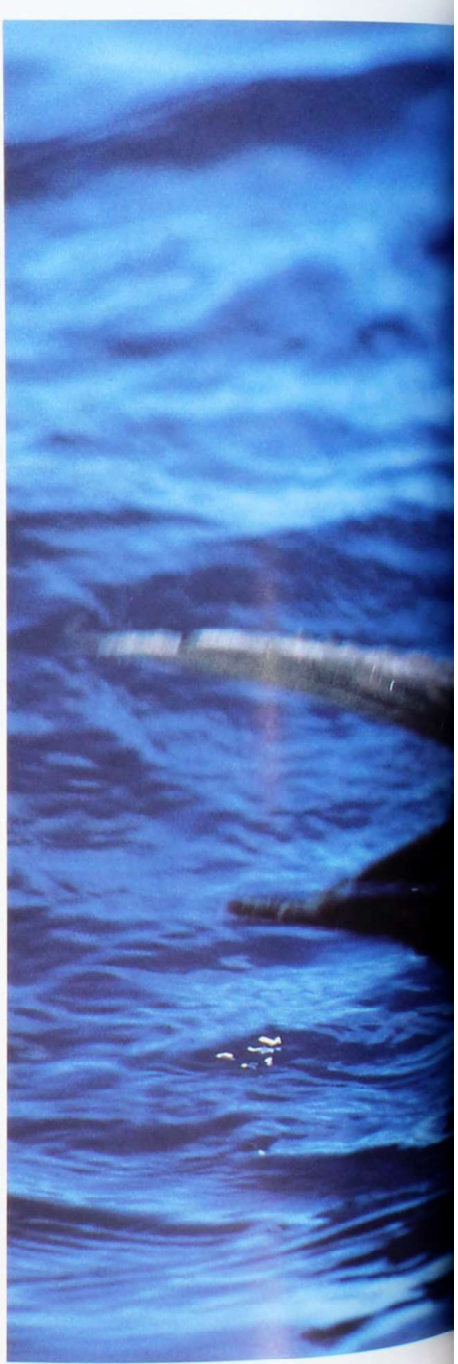
I DECIDED THEN TO KEEP A SPECIAL watch over the colony throughout the following breeding season (September to May). But it wasn't until the end of this season that I noticed something odd. In May 2002, after the Flesh-footed Shearwater chicks had fledged, I found 14 dead birds in various states of decay. All were identified as fledglings by the small amounts of down on the feathers and all the carcasses had plastic inside the stomach area. Four dead fledglings found washed up on nearby Middle Beach also had plastic inside their stomachs.

Flesh-footed Shearwaters (*Puffinus carneipes*) are medium-sized seabirds with a wingspan of over a metre. This allows them to cruise effortlessly over hundreds of kilometres of ocean in search of food. After the breeding season, they stay on the move for over four months, flying across the equator around the Sea of Japan, and returning to the island in September. They spend the next few months courting, pair-bonding and re-digging their burrow, then in early December they lay a single white egg. After 57 days incubation the chick hatches and the male parent stays with the chick for the first few days. Then the chick is left at the end of the burrow, which can be up to two metres in length, and both parents forage widely over the ocean, returning every six to ten days with food for the chick. The parents feed the chick as much as possible during the three months it is in the burrow so that it has enough body fat to fledge successfully.

But it is clear that food is not the only thing the parents bring back. The birds are obviously picking up plastic as they wander the ocean for food—perhaps several hundred kilometres or more away from Lord Howe Island. The parents return and regurgitate food and plastic into the mouth of the hungry chick. Some chicks are unable to regurgitate the plastic, and so the stomach remains full and they cannot take in as much food as they otherwise might. Without the ability to take the full amount of food given throughout their period of growth, a chick's fat stores at fledging are likely to be inadequate for its longer-term survival.

After I had collected the plastic items from each fledgling carcass, I measured the area and the volume of plastic that each bird had been fed. Spread out flat, the plastic pieces covered areas that ranged from 66 to 182 square centime-

Rubbish from all over the world ends up on the beaches at Lord Howe Island.



tres, with volumes of 7–33 millilitres. Sizes of individual pieces of plastic ranged from 5 x 5 millimetres to 50 x 30 millimetres. The plastic was mainly flat sheets from bottles and containers, but also included golf tees, biro tops, bottle caps, plastic bag ties and strapping tape. The colour of the various pieces of ingested plastic was interesting. About 80–90 per cent was white, 10–15 per cent blue, and the remainder red or green. This may reflect either the percentage of different coloured plastics used in packaging, or the birds' preferences for certain colours they may associate with food. Certainly, in the open ocean, many surface-living marine creatures are coloured white, silver or blue. However, while on a walk along Ned's Beach collecting plastic fragments, I found that the percentage composition of the various colours matched that inside the dead birds, suggesting that adult Flesh-footed Shearwaters are not discriminatory in regards to the colour of plastic they pick up.

THE BIRDS ARE *obviously picking up plastic as they wander the ocean for food.*

Although I only examined 18 individual birds (14 collected from about ten per cent of the nesting area, and four from the beach), the fact that all dead birds had some plastic indicates the problem could be widespread. Five small piles of plastic found on a patch of grass adjacent to the colony, however,

A Flesh-footed Shearwater forages at sea.

44 PER CENT OF ALL SEABIRD SPECIES

ingest plastic and the problem may be underestimated since the majority of victims are undiscovered.

suggest that some fledglings, having left the burrow, may have managed to regurgitate the plastic and move on. Perhaps those birds survived; perhaps they didn't. Further research is required to learn how widespread this problem is on Lord Howe Island.

PLASTICS ARE LIGHTWEIGHT, STRONG and durable, which makes them ideal for disposable storage containers, but it is these characteristics that also make them a serious hazard for the marine ecosystems. They float and persist for many decades, spreading around the globe in ocean currents.

A number of studies on marine debris around the world indicate that plastic makes up a total of 66–80 per cent of all marine litter. This litter has many sources—ships dumping at sea, recreational boats along the coastline disposing of rubbish thoughtlessly, and rubbish floating down rivers or municipal drainage systems.

Many seabirds are affected by plastic ingestion; a study in 1997 showed that 44 per cent of all seabird species ingest plastic and the problem may be underestimated since the majority of victims are undiscovered, either sinking to the bottom or being eaten by predators. On Lord Howe Island it is mainly the Flesh-footed Shearwater that is being affected by plastic ingestion, with only very occasional pieces of plastic seen in areas where the smaller Wedge-tailed Shearwater (*Puffinus pacificus*) breeds. Why this is so is not clear—maybe the Wedge-tailed Shearwater is more discerning when foraging for food. Or it could be that their natural prey has fewer plastic look-alikes. For example,

A Flesh-footed Shearwater at its breeding colony on Lord Howe Island.

Flesh-footed Shearwaters cruise long distances low over the Tasman Sea in search of food.

the Laysan Albatross (*Phoebastria immutabilis*) ingests large plastic objects, while the Black-footed Albatross (*P. nigripes*) tends to take only pieces of fishing line. This may reflect the Black-footed Albatross' preference for flying-fish roe, which is linear, and the Laysan's preference for squid.

Apart from reducing storage volume in the birds' stomachs and thus the ability to accumulate fat reserves necessary for migration, reproduction and moulting, ingestion of plastic may also physically damage the gut or intestines of the bird, block gastric enzyme secretion, leak organochlorides from the plastic into the birds, and lead to reproductive delay or failure. But it is the effect on the fledglings that appears to be having the biggest immediate impact. This must be affecting total numbers of some seabird species, many of which are fac-

Flesh-footed Shearwater

Puffinus carneipes

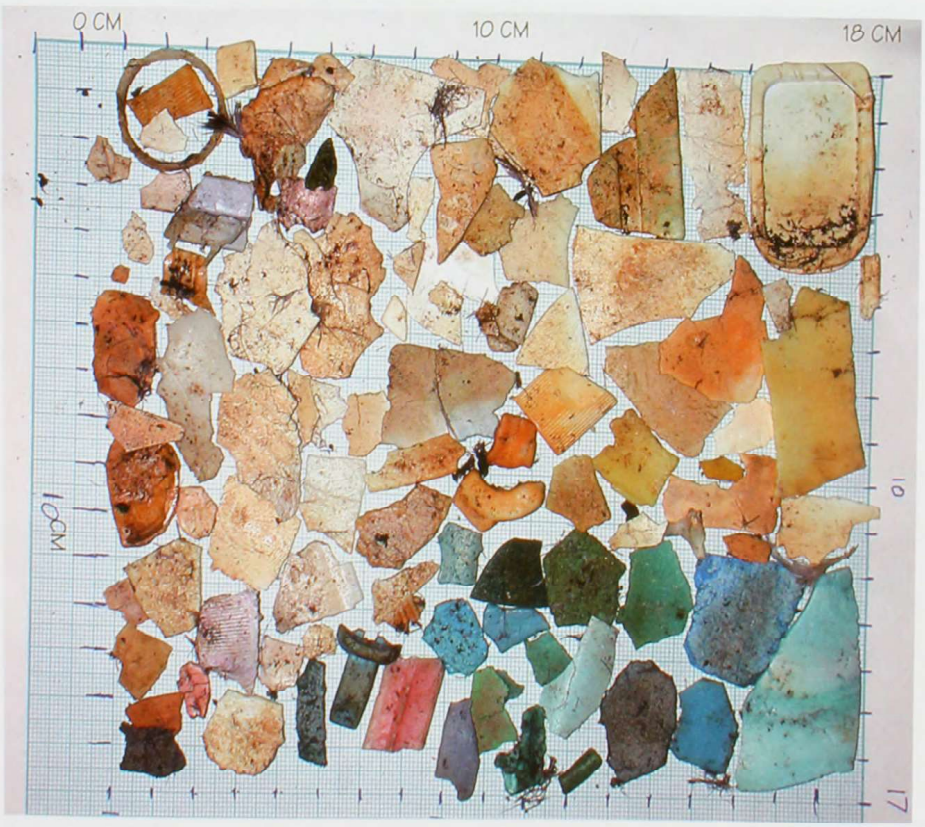
Classification
Family Procellariidae

Habitat and Distribution
Southern temperate waters. Breeds on Ile Saint-Paul (Indian Ocean), offshore islands in WA, Lord Howe Island, and islands around northern NZ. Western population overwinters in Arabian Sea; eastern population off Japan.

Identification
Entirely blackish brown; flesh-coloured feet; bill a pale horn colour with blackish tip. Length 44 cm; wingspan 105 cm; bill 42 mm.

Biology
Breeds Sept. to Apr. in dense colonies, visited only at night. Parents share incubation and care of young. Nest chamber at end of 1–2-m-long burrow. Eats small fish, cephalopods and crustaceans, diving freely to 10 m. Migrates away from colonies in winter.

The skeleton of a Flesh-footed Shearwater showing its ribcage full of plastic.



The plastic recovered from inside the skeleton of a Flesh-footed Shearwater on Lord Howe Island.

ing other threats such as by-catch from the fishing industry. Unless something is done about it, some species may be wiped out.

But why is it only relatively recently that plastic ingestion has been noticed on Lord Howe Island? It may just be a cumulative effect as more and more plastic is added to the ocean each year, coupled with the long time it takes for the plastic to be broken up into sizes likely to be selected by the birds.

WHAT CAN BE DONE TO REDUCE the problem? The human population of all countries needs to be made aware of the dreadful consequences of discarded plastic packaging. Children are more easily persuaded to change their habits, and take their ideas back to the family, so education at schools is important to bring about long-term

results. More beach clean-up days could be encouraged to prevent any plastic washed up onto beaches being taken back out to sea on the next tide. All storm-water drains should be covered, and grills fitted to outlets to catch rubbish before it flows into rivers and oceans. And plastic producers should accept responsibility for the fate of their products, and design them for recycling and disposal.

Governments could help by sponsoring research into biodegradable plastic that breaks down in the marine environment. Conventional plastics photodegrade, slowly breaking down into ever smaller pieces; but even the plastic molecules are indigestible to bacteria and it may take 500 years or more for constituents of plastic to be fully recycled into the environment. For many years there have been biodegradable plastics available that have been made using polymers produced from wheat and corn starch. However the cost is high (two to ten times the cost of plastics made from petroleum oil). If cost is the barrier to wide-scale use of biodegradable plastic, then the solution lies in the investigation of low-cost options to produce them. At some time governments of the world and producers need to embrace a tax system that includes the environmental costs of products, and that uses the tax for research into environmental problems caused by these products. Currently it is legal to dispose of plastic at sea if it minced up, but perhaps this was a backward step, as it leads to lots of bite-sized pieces for seabirds. This needs to be looked into.

Most importantly, funds should be allocated to study the effects of plastic ingestion by seabirds, particularly to set up long-term monitoring programs to ascertain the effects on whole populations of species. This would provide input for conservation management, strengthen education campaigns, and provide more evidence for authorities to mitigate the problem.

Australia can be green if it wants to be. During the recent Sydney Olympic Games, for example, over 600 tonnes of waste was generated each day at its venues, and of this an impressive 76 per cent was collected and recycled. Part of the success was due to the use of biodegradable plastics used in the packaging of fast foods. So it can be done; and it has to be done to save our wildlife and the ecosystems to which we are all connected. □

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IAN HUTTON COMPLETED STUDIES IN BIOLOGY AT MACQUARIE UNIVERSITY. HE HAS LIVED MAINLY ON LORD HOWE ISLAND SINCE 1980, DURING WHICH TIME HE HAS STUDIED, PHOTOGRAPHED AND WRITTEN ABOUT THE NATURAL HISTORY OF THE ISLAND, INCLUDING SCIENTIFIC PAPERS ON THE SEABIRDS.

In May, some weak Flesh-footed Shearwater chicks do not have the strength to fly away.

THE USE OF GENETICS IN CONSERVATION WILL LEAD TO A MUCH DEEPER UNDERSTANDING OF WOMBATS.

HAIR TODAY, NOT GONE TOMORROW?

BY ANDREA TAYLOR & PAUL SUNNUCKS

EMERGING FROM THE COOL DEPTHS OF ITS BURROW HIDEOUT, THE ANIMAL PAUSES AT THE entrance, sniffs the evening air and is vaguely aware of an unfamiliar smell. It continues along the burrow runway and brushes up against a root that was definitely not there yesterday. From the animal's point of view it has just started its nightly feeding bout, while from our point of view it has unwittingly sacrificed several hairs to our cunningly placed, double-sided sticky-tape 'root' (suspended between two posts), in the name of conservation management. The animal in question is one of only 100 or so elusive Northern Hairy-nosed Wombats (*Lasiorhinus krefftii*), which hang on grimly as a single population inhabiting the grassy woodland of Epping Forest National Park, central Queensland. In blissful ignorance, the wombat settles down to dine for two hours on the smorgasbord of native and introduced grasses that surrounds its burrow.

PAUL SUNNUCKS

To many people, wombats are surprisingly large. Here Andrea holds a Northern Hairy-nosed Wombat.

To understand the significance of what we have just described, we need to go back to 1993, when a population-wide trapping census was completed, suggesting an estimated population size of 65 individuals (see "The Invisible Wombat", *Nature Aust.* Spring 1994). Population censusing is a vital management tool for such a critically endangered species, both to monitor trends in relation to environmental and other natural factors, and to measure the population's response to management actions.

However wombat trapping is highly disruptive to the animals and their environment, and it may introduce biases from individual or sex-specific trap responses, which are known for many mammal species. In any case, trapping at the intensity required to produce a population estimate with any precision would be prohibitively time-consuming and labour-intensive. Capitalising on emerging DNA-profiling techniques that identify individuals and their gender based on minute quantities of DNA seemed to offer a useful alternative worth exploring. As well as being less disruptive and more practical, 'non-invasively' or 'remotely' collected DNA sources such as hairs are much less likely to be prone to sampling biases than is trapping.

SAM BANKS

SAM BANKS

(Top) The wombats' burrows and runways are ideal places for the sticky hair-sampling tapes. (Bottom) A hair tape showing DNA-laden wombat follicles.

WOMBATS MAY NOT PLAY BALL when it comes to being observable or trappable, but they are consummate hair donors. In fact, if one were to

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With so few Northern Hairy-nosed Wombats left in the wild, reliable and non-invasive censusing methods are critical for their conservation.

design an ideal animal for non-invasive genetic sampling, wombats would be it. Probably their most charitable attribute in this regard is their use of extremely obvious burrow runways and entrances leading to their indispensable daytime refuges. This really takes the guesswork out of where to erect hair-trapping sticky tapes! This convenient feature provides major benefits for sampling design, ensuring tapes can be examined and replaced in a systematic manner, and allowing the entire colony to be sampled simultaneously. That broad wombat back, reputed to squash Dogs against burrow ceilings, provides a highly accessible and expansive area from which the tape can pluck hairs. Finally the wombat's endearingly trundling gait ensures the tape is generally left intact between the posts, rather than dragged irretrievably down the burrow or lost in the bush, as might result from the activities of a more boisterous animal!

The only uncooperative feature of Northern Hairy-nosed Wombats as hair donors (which does not apply to the other two wombat species) is their inconveniently low level of genetic diversity—amongst the lowest measured for any mammal. This means that we can only use single hairs as DNA sources, since with low genetic power it is more difficult to recognise a sample that contains hairs from multiple individuals.

We were acutely aware of the bad press that non-invasive DNA-profiling was generating for itself early in its development, with several studies at the

COURTESY ANDREA TAYLOR

Epping Forest National Park from the air. Vegetation has recovered substantially since Cattle were fenced out in 1981.

Northern hairy-nosed wombat

Lasiorhinus krefftii

Classification
Family Vombatidae (wombats). One of 3 extant species.

Identification
Large wombat with silky grey fur, black eye-rings, and hairy broad snout.

Habitat and Distribution
Open woodland with pastures of native perennial and introduced Buffel Grass, on sandy soil. Restricted to Epping Forest National Park, central Qld.

Biology
Nocturnal. Feeds on grasses and sedges. Females disperse, possibly after breeding. Births occur mainly late spring to early summer. Individuals mostly solitary but burrows arranged in clusters containing groups of animals.

time reporting (or not!) high error rates that could seriously affect the accuracy of data interpretation. Since these problems are known to be due to low DNA concentrations, our single-hair constraint was potentially problematic. Fortunately, wombat hairs have pronounced follicles that seem to ooze DNA. As long as we could maximise the amount of DNA recovered, we hoped this would be sufficient for accurate DNA profiling.

Ex-Honours student Mathew Sloane (Monash University) developed and tested the best way to extract DNA from hairs while in the field. Simply boiling the hair in a specially prepared solution on the camp stove got the thumbs-up from Recovery Team Manager Alan Horsup (Queensland Environment Protection Agency) and his small band of dedicated volunteers, to whom this task ultimately fell. Importantly, the technique provided heartenings sensible information—the remotely collected hair DNA profiles matched exactly those of wombats trapped in the same burrows during the preceding week.

Flushed with pilot study success, we were eager to push on and count how many wombats remained. It had been seven years since the last census, with little indication in the meantime of how the population was faring. Sam Banks (Monash University) took the handball pass from Matt Sloane and led a hair-collecting raid on Epping Forest in September 2000. The team's mission? To tape simultaneously every active burrow entrance for a number of successive nights, and thereby collect hair samples from as many wombats as possible. Single hairs were painstakingly picked off and processed from sixty of the hair tapes collected over each of seven consecutive nights.

A few intensive months later, Sam emerged from the lab having detected 81 different profiles amongst the 420 census samples, equating to 81 wombats. Following a 'mark and recapture' analysis on the DNA profiles, the magic number of 113 wombats was arrived at

SAM BANKS

A volunteer places a hair tape over the entrance to a Northern Hairy-nosed Wombat burrow.

as the estimated population size. This analysis uses information from the numbers of wombats that were detected only once, twice, three times and so on to estimate the number of others that were present but not sampled at all. This is the reason for the disparity between the estimated population size and the number of distinct profiles detected. Juvenile tracks and signs during the preceding few years had been more numerous than ever recorded before, so the apparent population expansion was probably due to enhanced reproduction and juvenile recruitment following the breaking of the drought in the mid 1990s. Certainly over half of the wombats detected in the hair census were previously untrapped, consistent with their being recent recruits.

THE SECOND SIGNIFICANT OUTCOME to date from the 2000 hair-census data was confirmation of an unequal sex ratio in the Epping Forest population. It seems male Northern Hairy-nosed Wombats outnumber females by around three to one! As well as being frustrating to the amorous aspirations of male wombats, this sex ratio distortion has the potential to impact negatively on population growth, since it is the number of fertile females that limits reproduction. How has this sex bias, apparent only for the last decade or so, arisen: through sex-biased birth, recruitment, dispersal or death?

MALE NORTHERN

Hairy-nosed Wombats outnumber females by around three to one!

Of 11 pouch young and juveniles observed during trapping in 1999, eight were male. Although not statistically significant, this male-biased birth rate may warrant further investigation. Environmental and genetic explanations are often bandied around to explain such patterns of sex bias in species of conservation concern, but these are highly speculative.

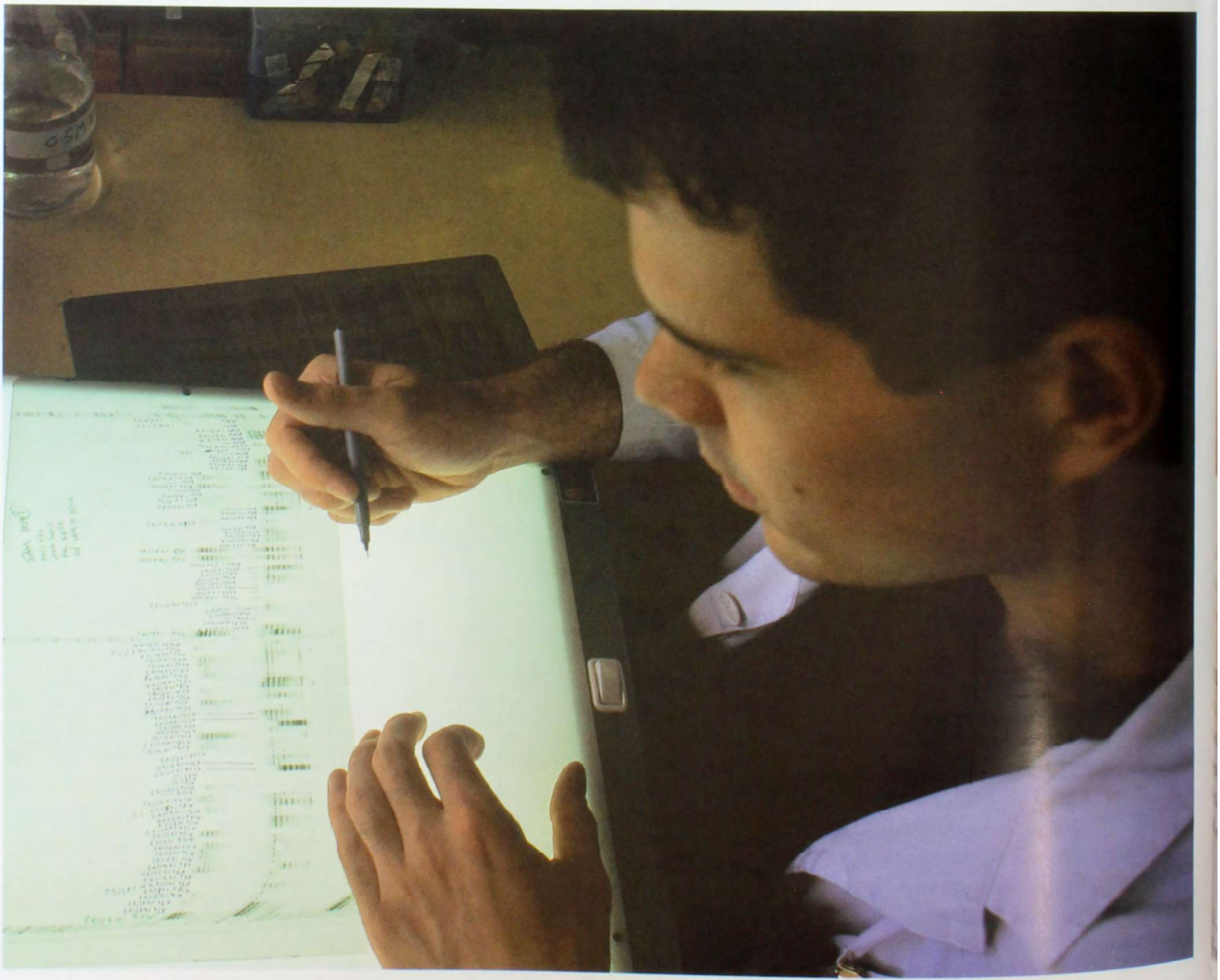
A male-biased population might also be expected if females emigrated from the colony but were not replaced by immigrants from elsewhere. It is becoming increasingly certain that females in fact are the dispersing sex in wombats. This was first suggested for Northern Hairy-nosed Wombats by Chris Johnson (James Cook University) over a decade ago, and recently demonstrated genetically for the other two species of wombat (by Sam Banks for the Common Wombat and Monash Ph.D. student Faith Walker for the Southern Hairy-nosed Wombat). As Epping Forest is the only known population of Northern Hairy-nosed Wombats, there is little possibility of female immigration to Epping Forest, but are resident females obeying the call of nature and bravely departing to explore unchartered territory? We may never

know for sure, but we may eventually gain some insight via a tragically ironic route.

During the September 2000 hair-collecting trip, the grisly discovery of seven dead wombats was made (see "Marsupial Murder Mystery", *Nature Aust.* Autumn 2004). Evidence that Dingoes had attacked them, despite ongoing baiting, prompted the hasty erection of a Dingo-proof fence around the area inhabited by the wombats. If female wombats have previously been departing, and if the flow is stemmed by the presence of the fence, then we should see a gradual restoration of an equal sex ratio in the population. This would be a great relief because, if the paucity of females is due to other factors, there may be nothing much we can do about it given the woeful state of our understanding of the reproductive biology of the species.

WHILE THE WOMBATS MIND THEIR own business at Epping Forest, Monash Masters student Birgita Hansen is hard at work analysing hairs collected from the 2001 and 2002 population. This will provide not only a fine-scale estimate of population trends, but will also inform us of the burrow-sharing patterns of individuals, in the short and long term, as well as their relatedness to one another. Hair censusing will also provide vital information on the reproductive health of the population. Although not every previously unrecorded profile will indicate a newly recruited juvenile, a certain proportion will, and this will increase over time as the adult population becomes better 'known'. In theory we could confirm new profiles as being from recent recruits (since DNA is inherited it can be used to identify parent–offspring pairs). In reality, however, despite the individual specificity possible with our current genetic assay, the more demanding parentage information remains elusive due to the low genetic variation of the species.

This relatively low-cost, high-impact use of genetics in conservation has drawn extensively on the efforts of research students and volunteers. The data collected have numerous applications other than the remote census, and will lead to a much deeper understanding of the social biology and interaction of wombats with their environment. The availability of this non-invasive monitoring tool adds enormously to our ability to manage the conservation recovery of these enigmatic excavators. In particular, planning for the establishment of a second colony will rely heavily on accurate data on the Epping Forest population size and sex ratio. DNA hair-profiling, for example, will make



ANDREA TAYLOR

Sam Banks pores over an autoradiograph in the laboratory during the first complete census of Northern hairy-nosed Wombats.

PAUL SUNNUCKS

One of the authors takes a blood sample from an anaesthetised wombat for genetic analysis. This has now been rendered unnecessary by the advent of remote, non-invasive sampling by hair collection.

the targeting of useful founder animals much easier. It will also be crucial in tracking the fate of relocated animals and, with any luck, their descendants. □

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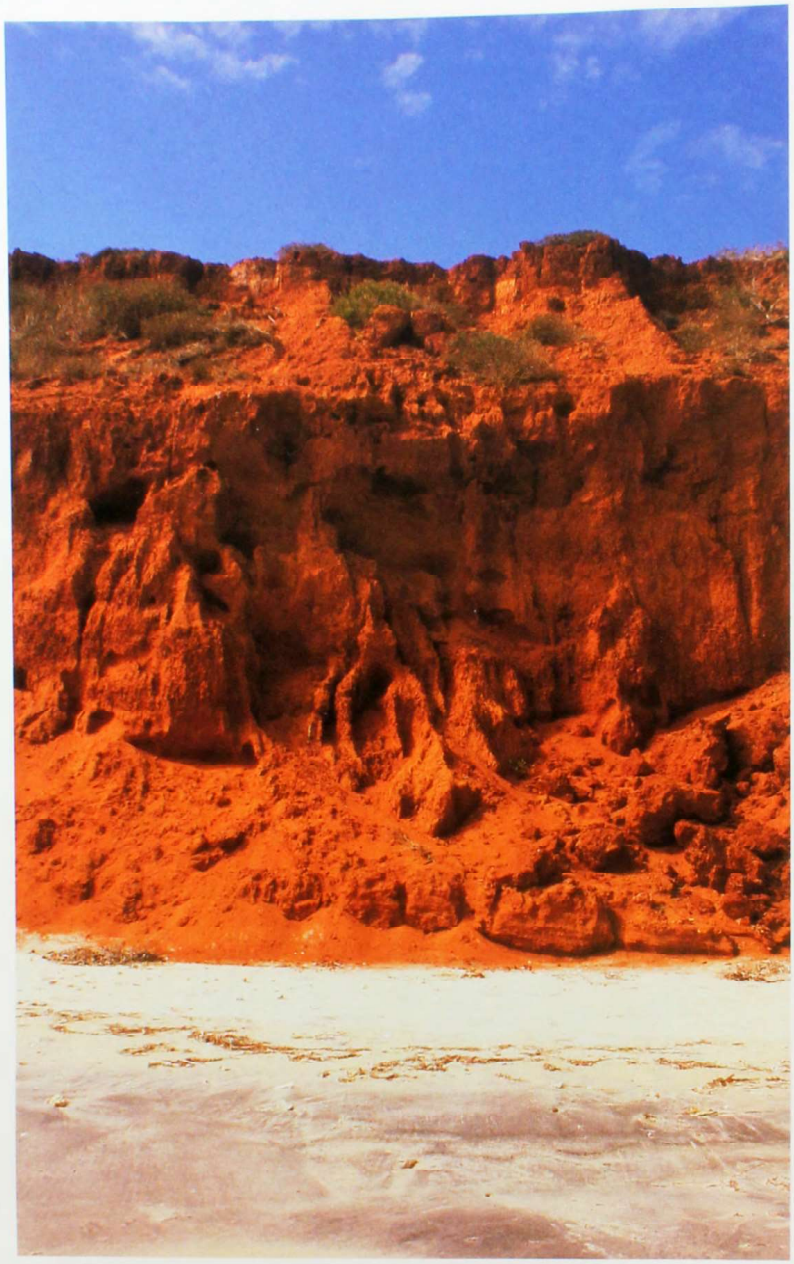
The colours of Peron Peninsula, Shark Bay, WA.



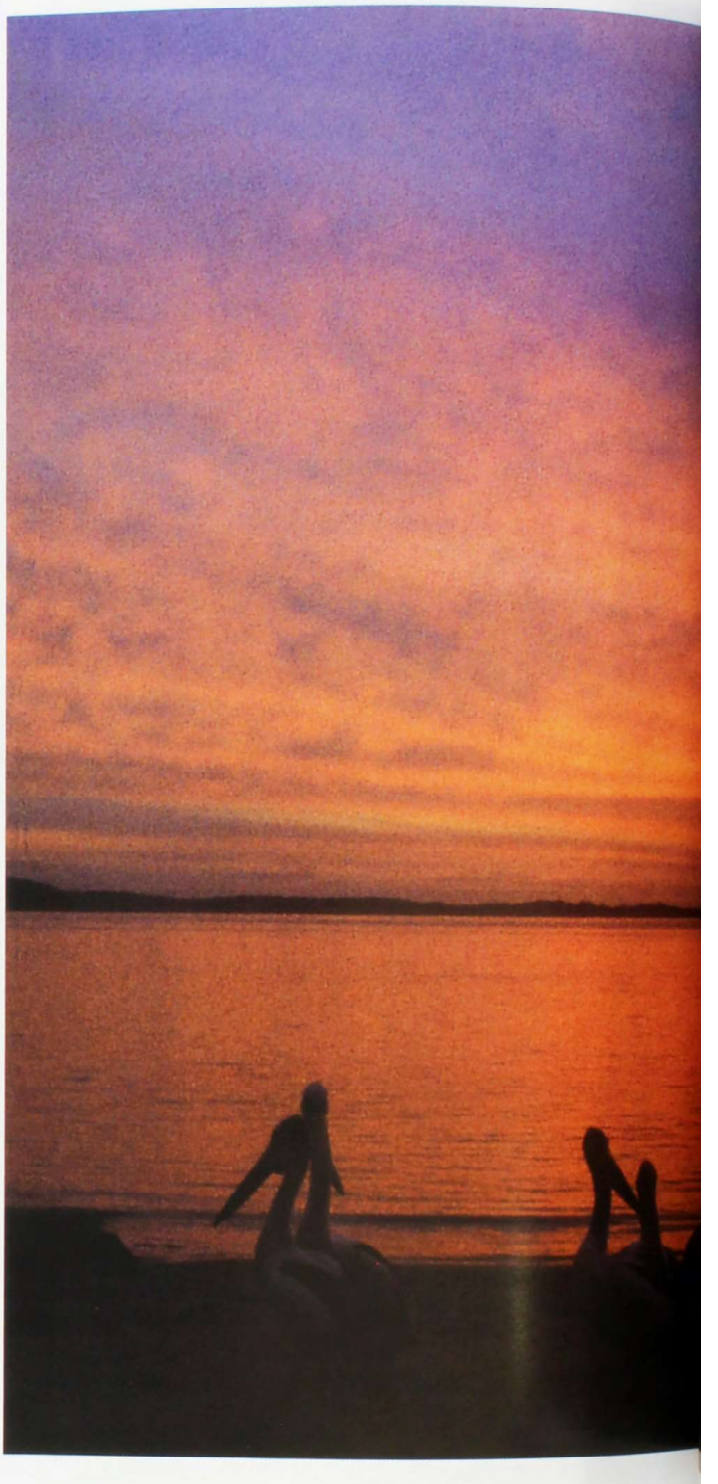
Intermediate Egret (*Ardea intermedia*), Kooragang Wetlands, NSW.

Bottlenose Dolphin (*Tursiops aduncus*), Forster, NSW.

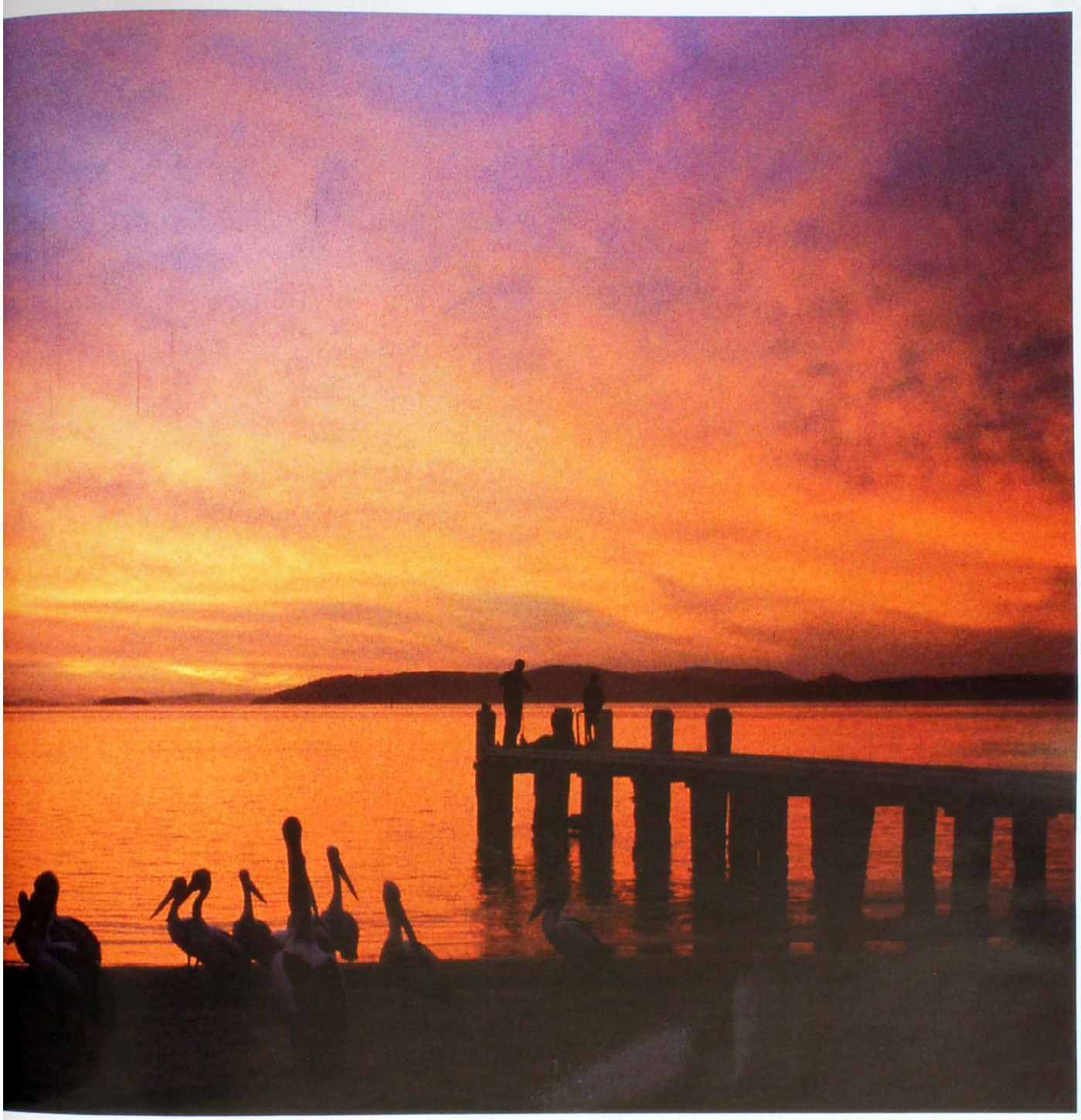
coastal collection

BY SIMON ALLEN

A lone crab, WA



Australian Fur Seals (*Arctocephalus pusillus*), The Skerries, Vic.



Australian Pelicans (*Pelecanus conspicillatus*),
Port Stephens, NSW.

Queens of the desert

Naked Mole-rats give birth like mammals, keep warm like reptiles, and live in colonies like social insects.

IT'S A SUBTERRANEAN DYNASTY ruled by a queen who, like her subjects, looks like a four-legged penis with a tail and buck teeth. The Naked Mole-rat (*Heterocephalus glaber*) is a seven-centimetre, pink, nearly hairless mammal that lives underground in the arid regions of Kenya, Somalia and Ethiopia in East Africa.

What makes Naked Mole-rats (and also their hairy cousins the Damaraland Mole-rats, *Cryptomys damarensis*) really odd is that they lead a life that has more in common with bees and ants, than mammals. They are eusocial, where only the queen and a couple of male concubines breed. The other colony members (usually around 100 for Naked Mole-rats) are doomed to a life of celibacy while they cooperate to find food and care for the young. Other African mole-rats (there are at least 15 species) are solitary.

Eusociality most likely evolved in Naked Mole-rats because their stable diet of underground roots and tubers is widely scattered between barriers of hard soil. By forming large social groups that cooperate to build a vast network of tunnels to search for food, these mole-rats have been able to exploit an ecological niche, where individuals or a small group would be unlikely to survive. The reproductive sacrifice made by most of the colony is offset by an extraordinarily high degree of genetic relatedness. By caring for such closely related individuals, they ensure their own genes are passed on, in spite of not reproducing themselves.

When a female Naked Mole-rat emerges as the queen, often after battling to the death other queen 'wannabees', she increases the distance between her vertebrae, thus lengthening her body by a third. Becoming a living stretched-limousine allows her to have large litters of pups (usually 11–12, but up to almost 30) and still fit through the colony's numerous tunnels. Her breeding mates are usually the biggest males, and it is thought that her aggressive interactions with the minions keep them reproductively suppressed.

Becoming a living stretched-limousine allows her to have large litters of pups and still fit through the colony's numerous tunnels.

It was not until 1981 that Jennifer Jarvis (University of Cape Town) described the Naked Mole-rat as the first eusocial mammal. Her initial insight into the animal's unique social organisation came when she noticed how individuals from different colonies fought among themselves. Naked Mole-rat colonies are extremely xenophobic and everybody in a colony wears the same scent, which is acquired by rolling around in the colony's toilet chamber. Anybody not wearing the colony cologne is quickly attacked, and so in this way the whole colony behaves like a very territorial individual.

Individuals from two different Naked Mole-rat colonies encounter each other in a tunnel. Such meetings usually end in fighting.

Naked Mole-rats are perfectly adapted for living underground and excavating a huge network of tunnels through hard soil. Although the oxygen levels in the colony are low and the carbon dioxide levels would suffocate most mammals, Naked Mole-rats have a metabolism that ticks over at half the rate of other rodents and they also have more efficient haemoglobin in their blood to capture the available oxygen.

The point of all these little pink earth-moving machines burrowing randomly through the underworld is to tunnel into what they need for food and water—the succulent roots and tubers that are formed by many of the plants living in arid areas. As discovered by Timothy Judd (Oakland University) and Paul Sherman (Cornell University), when a Naked Mole-rat hits paydirt, it runs back to the colony with a piece of the booty and chirps a specific "I've-found-a-tuber" chirp, as it waves it in their faces and fills the air with tuber perfume. This leads to a stampede of recruits that follow the chemically marked route back to the roots.

The lower two of the four enlarged incisors on Naked Mole-rats can move independently, like chopsticks, for more effective digging, and their lips close behind the incisors to stop them getting a mouthful of soil. These wrinkly walrus lookalikes have hairs between their toes that they use as brooms to sweep soil away from digging sites, and sensory whiskers on their faces and tails allow them to move their cylindrical bodies backwards and forwards through the tunnels. In the style of an assembly line, the animals at the front dig through the dirt, while a line of workers sweeps soil through the tunnels to an opening at the surface where it is kicked out to form little volcano-like mounds.

Unlike all other mammals, Naked Mole-rats have lost their warm-bloodedness and have a body temperature only one degree higher than the surrounding ambient temperature. Since

BY SIMON D. POLLARD

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the burrow is usually a toasty 30° C, it probably was not worth the metabolic effort to maintain a constant body temperature, because they live in a thermo-stable environment. However, if the temperature in the burrow does drop, they huddle together to keep warm. Some Naked Mole-rats may even become communal hot-water bottles by heating themselves up in tunnels close to the surface. They return to the sleeping masses to share their warmth and contribute to the collective dream of central-heated burrows paved with tubers.

Naked Mole-rats give birth and lactate like mammals, keep warm like reptiles, and live in colonies like social insects. As Francis Bacon wrote in an essay on beauty, "There is no excellent beauty that hath not some strangeness in the proportion". Nothing could be more true for the adorably ugly Naked Mole-rat. □

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Always were warriors?

Since the first writing appeared, scribes have jotted down the winners, losers and prisoners of war.

Aboriginal warfare, as depicted in 4,000–6,000-year-old rock art, Kakadu National Park.

BY RICHARD FULLAGAR

THESE DAYS IT IS IMPOSSIBLE to open a newspaper without reading about the war in Iraq, the Middle East, or even *Lord of the Rings*. Why do humans go to war? Have we always been a warring species? Aggression is certainly an ancient human emotion, but war itself involves organised, intergroup fighting. Still, conflicts don't need to be big to be classified as war, just as you don't need weapons of mass destruction to start a war.

The origin of war—and its evolution from individual killings to raiding parties, pitched battles and the full catastrophe—has been studied from several perspectives. Some see war as the recent invention of civilised societies. Others have argued that war is part of being human, and is typical of all societies past and present (townsfolk, farmers, hunters and gatherers). A few researchers suggest that war is not even peculiar to our species but is an outcome of socio-biological evolution, perhaps beginning with the common ancestor of humans and Chimpanzees.

For anthropologist Margaret Mead, war was a cultural invention and absent in early hunter-gatherer societies. Aspects of warfare, particularly weaponry, certainly appear to be discoveries, like the wheel, pottery and agriculture, of early civilisations. Since the first writing appeared, about 5,000 years ago in ancient Mesopotamia (around southern Iraq), scribes have jotted down the winners, losers and prisoners of war. There is little doubt that the best evidence for warring societies comes from historical records (which is not to say that war did not occur among early villages that lacked writing).

Historians have documented the proximate causes of wars, the theories, the necessary conditions, the triggers and the battles. And there is no shortage of evidence—peace is not that common. In his book *The causes of war* (1973), Australian historian Geoffrey Blainey, who studied international conflicts over the last 300 years, explodes a number of myths: the flawed ideas that an innate love of fighting can explain the outbreak of war, or that trade guarantees peace. He also argues that an arms race does not necessarily lead to war; nor does war occur by chance. Even if the war in Iraq turns out to be based on misinformation about WMDs, few will see it as an accident. Instead, war functions to establish the pecking order between nations that have contradictory views about relative strengths. Blainey asserts that historical patterns of causation remain relevant today even with nuclear weapons. Still, the historical factors that lead to war and peace are complex and intermingled.

Some think primitive societies were forced to war because of bad economic conditions in marginal environments. Recent archaeological evidence challenges this scenario. Defensive structures, skull racks and hieroglyphic writing from Oaxaca, Mexico, convince anthropologists Kent Flannery and Joyce Marcus (University of Michigan) that inter-village raiding evolved into war about 2,000–3,000 years ago in Mesoamerica. A critical precondition for war may have been the establishment of large populations, which split into groups (such as clans). This, according to Raymond Kelly (University of Michigan), changed homicide from an *individual* offence to an offence against the *whole group*. Such 'group mentality' produces raids at the slightest real or imagined insult. Kelly makes the point that early raiding was never about food; on the contrary, in marginal environments people had to get along or everyone starved.

But it is *not* only civilised societies that wage war. Parts of Aboriginal Australia, renowned as a continent of hunter-gatherers, sustained some remarkably sedentary societies with bounded or marked cemeteries, high populations and evidence of violence (both in historical records and in bone injuries visible archaeologically). Paul Taçon (Australian Museum) and

Christopher Chippindale (University of Cambridge) describe an Australian rock-art image, probably 4,000–6,000 years old, that portrays Aboriginal men lined up in battle with spears and shields. Battles, similar to those witnessed soon after European colonisation, probably have an ancient past.

One problem with studying warfare among recent hunter-gatherers is the potential for outsiders to inflame the conflict. For example Napolean Chagnon, in his 1968 book *Yanomomö: the fierce people*, describes the endless fighting within this South American society. Yet Brian Ferguson (The State University of New Jersey, Rutgers) has recently proposed that the warfare Chagnon witnessed was a consequence of European colonisation. Ferguson acknowledges that war is found in all sorts of society, but maintains it really only kicks off about 10,000 years ago, after property and land ownership became a feature of civilised sedentary life.

Lawrence Keeley (University of Illinois) notes that, despite low populations, the frequency of war and death rates among hunter-gatherers can be equally high or higher than in 'State' societies (those with towns and centralised government). He concludes that warfare may occur in some early civilisations but not all of them, and that the emergence of civilisation is *not* a good predictor of when war starts. For example, there is no evidence of violence among the Natufians—foraging people and the first to settle in permanent villages about 12,800–10,500 years ago around modern Turkey, Israel and Jordan; nor is there any history of war in the succeeding Neolithic farming culture. However, archaeological remains indicate that mobile hunter-gatherers in the Nile Valley 12,000–14,000 years ago were very violent—spearheads were found stuck in 24 out of 59 skeletons in a graveyard.

Like Keeley, archaeologist Steven Le Blanc (Harvard University) argues that ecological balance in early societies—living in harmony with nature and each other—is a myth and that warfare probably spans most of human history. Johan van der Dennen (University of Groningen) agrees but goes one step further. He starts by asking why war, defined as "violent intergroup interaction", is confined to humans and Chimps (*Pan troglodytes*), and why males in these species are almost always the warriors, whereas females are the predominant aggressors in other primates and social carnivores (Amazons are just a myth). The answers lie in our early evolution where a combination of ethnocentrism (group identity), territoriality and Machiavellian intelligence (deception and cunning) encouraged male coalitions like the male raiding parties that Jane Goodall first described among Chimpanzees. If not sheeting the blame on men, van der Dennen proposes that the origin of war is ultimately found in the different reproductive strategies of the sexes that developed millions of years ago.

Even if the roots of war are in our genes, does it mean that war is inevitable? The consensus is no. We can study societies with limited or no warfare: peaceable societies (past and present) found on all continents, and coenobites—groups like the Amish who live in religious communities. We can promote the conventions adopted to counteract or mitigate war, such as international jurisdictions, trade, diplomacy, intercommunity rites like gift exchange, and substitutes (sport?). Sounds better than Mao Tse-Tung's philosophy that "war can only be abolished through war". □

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PHOTOS: PAUL TACON/AUSTRALIAN MUSEUM

Closeup of the top left panel.

Scratching the surface

Discoveries of underground orchids have revealed but a small sample of what actually lurks beneath our feet.

HOW DO YOU FIND A PLANT that grows entirely underground except for a single flower that emerges only briefly through the leaf litter? Time-honoured ways include ploughing a paddock, scouring a disturbed mining site, excavating soil for a new home, or kicking over the mallee-root of a felled eucalypt. Botanist Peter Bernhardt, from St Louis University, concludes that these documented discoveries of Australian underground orchids have revealed but a small sample of what actually lurks beneath our feet, and that "the earth conceals many more tantalising stories of botany".

One such story surfaced recently. A new species of fairy lantern or *Thismia*, not an orchid but closely related, was discovered in Morton National Park near Bundanoon. This was only the second report of the genus from New South Wales. Local naturalist Pat Jordan discovered this strange plant while taking part in a fungal survey program (Fungimap) in her local rainforest. Pat first thought she had the 'egg shell' of a bird's nest fungus, such as *Nidula*—a bizarre fungus with a cup-shaped basket containing a handful of rounded spore packages. However, it looked odd enough for her to pickle it in alcohol and send to fungal expert Tom May at the Royal Botanic Gardens in Melbourne. Tom realised it wasn't a fungus and by chance showed it to freelance botanist Kevin Thiele.

Kevin immediately recognised it as the fruit of a fairy lantern, a plant that grew in his own backyard in East Gippsland. He asked Pat Jordan to look out for the flowers. The following Christmas Pat reported excitedly that she had found what looked like a group of slender coral fungi (*Clavaria*) but discovered they were the tips of almost buried fairy lantern flowers. Kevin rushed up to Bundanoon and together they collected and described the new species *Thismia clavarioides* ('like the coral fungus').

There are 30 known species of fairy lanterns, mostly in South-east Asia and South America. Before this species was discovered there were only two known from Australia—one in Cape York, the other scattered around southern Australia. In New South Wales there was a single record from Werrikimbe National Park, inland from Port Macquarie. All species grow almost entirely underground and produce no leaves, relying on fungi growing on their roots for all food and nutrients. The Australian species have a single red to orange tubular flower, with a mitre-like cap, and the Bundanoon species has long tentacles that just poke up into the leaf litter. The whole plant is usually about three centimetres long.

All species grow almost entirely underground and produce no leaves, relying on fungi growing on their roots for all food and nutrients.

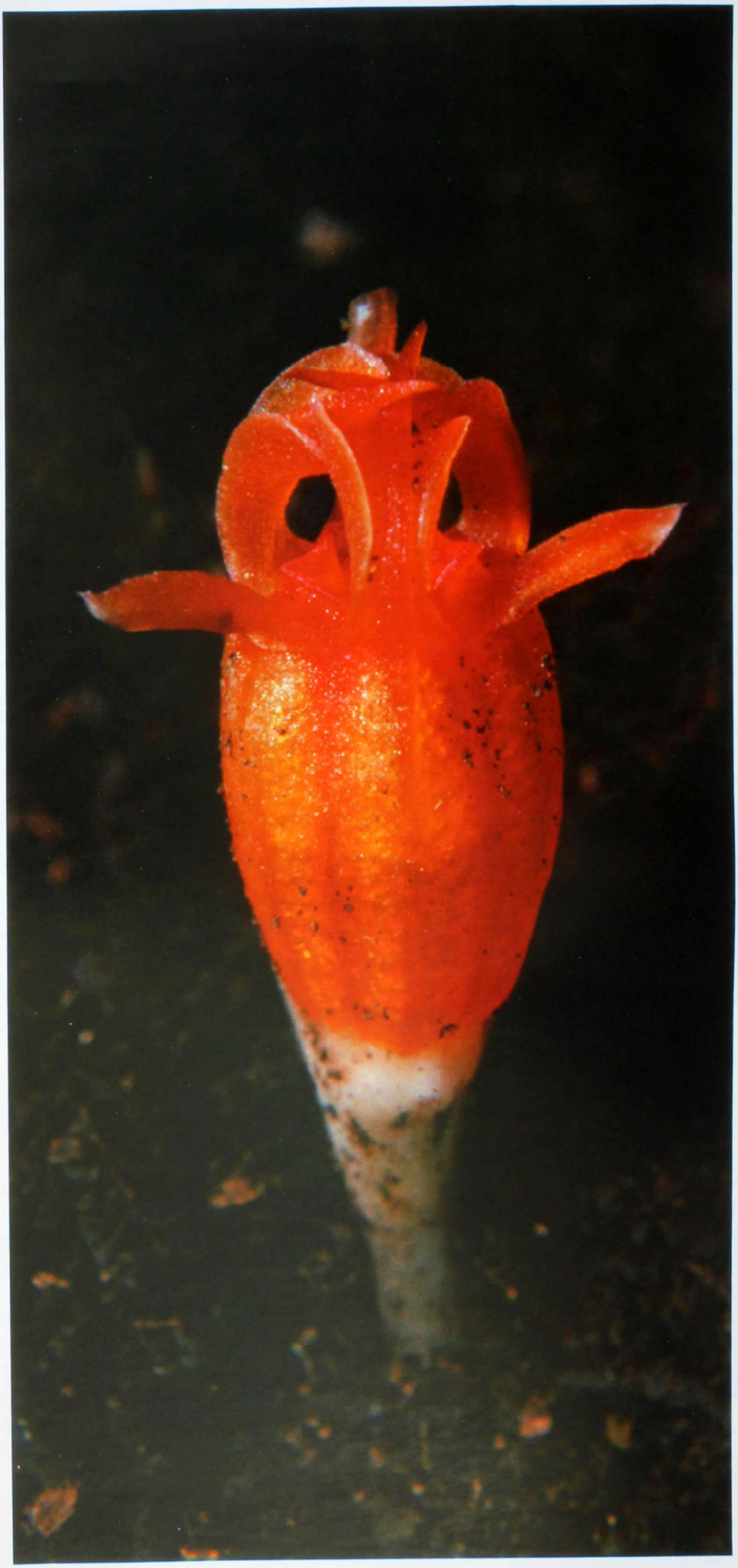
Fairy lanterns are closely related to orchids. The huge orchid family, Orchidaceae, includes over 20,000 species, of which only two grow underground. Also dependent on fungi to supply food and nutrients, they both belong to the genus *Rhizanthella*, first discovered in 1928 near Corrigin in south-western Western Australia, and so far unknown outside Australia. *Rhizanthella gardneri* grows in dry woodland and scrub in the west, while *R. slateri* is found in open forest in the east (from Lamington National Park south to Springwood in the Blue Mountains). Every now and then, by chance, a new location is found for either species. Presumably much of their natural habitat has been replaced by farms and cities, and what we find are just remnants of their past range.

The complete distribution of such underground plants is not the only mysterious thing about them. So too is their method of pollination. The flowers of fairy lanterns and underground orchids appear to rely on tiny flies, ants and termites, or other insects that flit about in the litter layer. Yet many ants—the most common visitors to the Western Australian underground orchid—secrete a potent antibiotic called metapleurin that should kill pollen. How the orchid overcomes this, we don't know. In the case of fairy lanterns the flowers are designed like yabby traps. Kevin Thiele postulates that insects can escape the trap but only after squeezing past a gland (that may secret glue) and the pollen sacs. The fruit of all these underground plants is probably dispersed by small marsupials searching for underground 'truffle-like' fungi, but again we can't be sure.

In a nice twist, given that the new fairy lantern was initially mistaken for a fungus, radio announcements of the Bundanoon discovery triggered other bizarre sightings around Sydney, including misidentifications of the Starfish or Anemone Fungus as a fairy lantern. Emerging from an 'egg' to spread its spores, this partly buried 'stinkhorn' fungus is a frequent yet surprising sight

BY TIM ENTWISLE

The red flower of the fairy lantern *Thismia rodwayi*, one of only a few species of Australian plants to grow almost entirely underground.



JOHN EICHLER/VIRIDANS BIOLOGICAL DATABASES

in home gardens and school grounds in New South Wales. Its scientific name is *Aseröe rubra*, meaning (literally) 'disgusting red'. It looks like a sea anemone, with outstretched red tentacles and an evil-smelling brown-green slime in the centre. The very unpleasant odour, like rotting meat, attracts flies, which then spread the spores. This charming fungus grows naturally on rich humic soils in eastern Australia, New Zealand and New Caledonia, with related species farther afield. Around Sydney (and elsewhere, including New Zealand), it also emerges from wood-chip mulch in gardens and parks.

Interestingly the Starfish Fungus was the first species of fungus to be collected and described from Australia. Jacques Labillardière, a member of the D'Entrecasteaux expedition, collected a specimen in May 1792, from Recherche Bay in southern Tasmania. The species was described in 1800 and by 1820 the Starfish Fungus had emerged in a glasshouse at Royal Botanic Gardens Kew in London, an unwanted guest on soil imported from Australia. You could say this malodorous mushroom is payback for the many people, stock and plants that were exported (deliberately or accidentally) into the former colony and that now compete for existence with the likes of fairy lanterns and underground orchids. □

FURTHER READING

Bernhardt, P., 1990. Wily violets and underground orchids: revelations of a botanist. *2nd ed. Allen & Unwin: North Sydney.*

Royal Botanic Gardens Melbourne, 2003. Fungimap. *http://fungimap.rbg.vic.gov.au*

Thiele, K. & Jordan, P., 2002. Thismia clavarioides *(Thismiaceae), a new species of fairy lantern from New South Wales.* Telopea *9: 765–771.*

DR TIM ENTWISLE IS EXECUTIVE DIRECTOR AT THE BOTANIC GARDENS TRUST, SYDNEY.

reviews

Famous Australian Birds

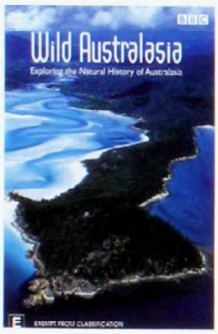
By Gisela Kaplan. Allen & Unwin, NSW, 2003, 48 pp. $29.95 rrp.

GISELA KAPLAN HAS CHOSEN EIGHT AUSTRALIAN BIRDS THAT ILLUSTRATE DIVERSITY IN ANATOMY, behaviour and life histories. She draws on her academic background and experience as a wildlife carer, to write unique accounts of the Laughing Kookaburra, Australian Magpie, Sulphur-crested Cockatoo, Superb Lyrebird, Emu, Eastern Rosella, Tawny Frogmouth and Wedge-tailed Eagle.

Large fonts, short paragraphs and plenty of blank space make the book very readable; technical words are explained in a glossary. The pages are peppered with fact files, 'did you know' text boxes, lengthy descriptive captions and colour photos that document the development of young birds and illustrate behaviour. A section, "Living with Birds", highlights conservation issues for some of our favourite species. The book concludes with a short index and a table comparing life-history characteristics.

The cover might suggest this is just another picture book for young children. That is unfortunate, because *Famous Australian birds* is written in a style that should appeal to all ages, and contains a wealth of information. The stories of hand-reared birds will captivate anyone who loves animals, and explanations of behaviour answer many of the questions that arise when people take an interest in their backyard birds.

—ELIZABETH CAMERON
AUSTRALIAN MUSEUM



Wild Australasia: Exploring the Natural History of Australasia (DVD)

BBC Worldwide Ltd, 2004, $49.95 rrp.

"WILD AUSTRALASIA" IS AN AMBITIOUS SIX-PART NATURAL-HISTORY DOCUMENTARY SERIES that sets out to explore the unique landscapes and wildlife of the region. The sheer enormity of the task is probably the only reason why a series like this hasn't been made before.

This problem of scale has been turned into one of the series' strengths. Programs illustrate a particular environment or theme by using spectacular examples and then link them with map graphics. The result is that you get a feeling of travelling through the region and dropping in on its wildlife wherever you like. You travel from Tasmania's rainforests to Kakadu's wetlands in seconds but despite this, gain an appreciation of the awesome size and many contrasts of the place.

The producers also seem to have deliberately set out to break down many of the stereotypical images of Australian wildlife, showing them in a new light. Wombats trundle around in the snow, roos swim and bound through flooded forests, and a cuddly young Koala tucks into a meal of its mother's fresh runny dung. There's hardly a mention of anything deadly; funnel-web spiders and Great White Sharks don't even get a look-in. Instead, many lesser-known but equally worthy animals are introduced, like Numbats, potoroos and gliders.

This is a DVD that every nature lover should watch.

—ANDREW DONNELLY
AUSTRALIAN MUSEUM

A Field Guide to Reptiles of New South Wales

By Gerry Swan, Glenn Shea and Ross Sadlier. 2nd ed., Reed New Holland, Sydney, 2004, 304 pp. $34.95 rrp.

UNLIKE BIRDS, WHICH ARE USUALLY EASY TO IDENTIFY ON THE BASIS OF SIZE, SHAPE AND COLOUR, reptiles are not so easily distinguished in the field. Therefore, to write a field guide for this group would have been a real challenge, which was ably met when Gerry Swan produced the first edition of this book titled *A field guide to the snakes and lizards of New South Wales* (1990). This second edition encapsulates the many taxonomic changes that have occurred since 1990 and includes turtles, tortoises and sea snakes, as well as an additional 26 species of lizards and snakes that have been described or recorded in New South Wales.

All species are illustrated with colour photographs taken in natural habitats and, where appropriate, these are supplemented by sketches and identification keys. The only factual error I found was the statement that the Bell's form of the Lace Monitor occurs west of the ranges. While true, it is also widespread in the Clarence Valley, east of the ranges. The authors can be forgiven for this oversight as distribution was determined primarily from museum specimens. It appears I will have to send a smelly roadkill to the museum to correct the record.

These minor criticisms aside, I recommend this book to herpetologists, both professional and amateur, and to anyone with an interest in natural history. It will definitely accompany me into the field during my fauna survey work.

—GREG CLANCY

Environmental, Coastal and Wildlife Sciences

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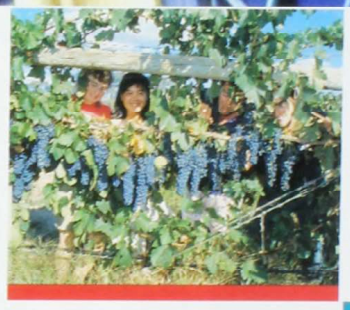

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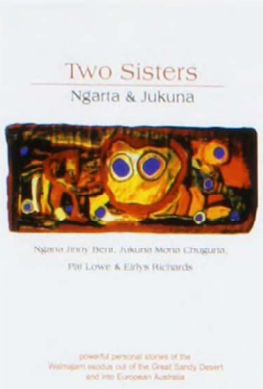


Two Sisters: Ngarta & Jukuna

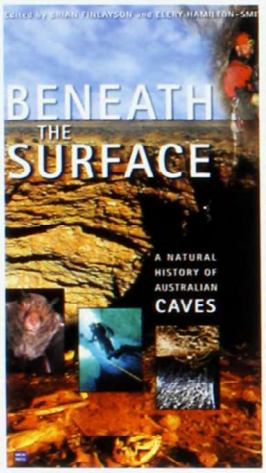
Pat Lowe and Eirlys Richards. Fremantle Arts Centre Press, Fremantle, WA, 2004, 144 pp. $24.95 rrp.

TWO SISTERS IS AN EXTRAORDINARY ACCOUNT OF AN UNKNOWN HISTORY. THE BOOK consists of two stories told by two women, Ngarta and her older sister Jukuna. They are Walmajarri women from the Great Sandy Desert in far north-western Australia. Ngarta's story tells of her experiences in the desert before contact. Jukuna's story is complimentary, dealing primarily with her contact experience.

The women's stories are chilling in their austerity. These are true stories told in a manner that only Aboriginal people can tell. Detached from romantic pretence, Ngarta and Jukuna deal with life in the desert as it was and came to be: a time of incipient change and unimaginable hardship, danger and fear.

I have heard such stories before but have not quite understood them and have not been game to retell them. I have seen the tracks and camps of Yawa, a serial killer who is central to the women's lives. He continued to live alone in the desert until the early 1990s. He may now be dead. Ngarta and Jukuna reveal his astonishing part in their story. I now know what he did and why he continued to live alone, so completely isolated, for the entirety of his life. I am thankful for Ngarta and Jukuna's accounts, yet saddened by their life stories. This is real history—great history—told, thankfully, by the people who lived it.

—SCOTT CANE



Beneath the Surface: A Natural History of Australian Caves

Ed. by Brian Finlayson and Elery Hamilton-Smith. University of New South Wales Press, Sydney, 2003, 182 pp. $49.95 rrp.

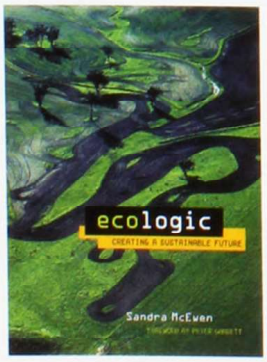
SPELEOLOGY, THE EXPLORATION AND STUDY OF CAVES, HAS A LONG AND ACTIVE HISTORY IN Australia. This excellent book provides a timely overview of caves and karst in the Australian context—a natural history of Australia down-under.

A raft of luminaries from the multidisciplinary world of cave science and exploration provide expert but highly accessible résumés in their respective fields. The first chapter, "Black Holes", explains the many processes involved in the development of caves, followed by a review of Australia's limestone and lava karst areas and their major cave systems. This is followed by "The Crystal Gallery", which explores those iconic cave features, the speleothems, fascinating not only for their decorative variety, but also for their modes of formation and as a resource for dating environmental change. "Mud and Bones" deals with cave sediments, depositional processes and their interpretation, as well as the processes of accumulation and preservation of bone deposits in caves and their palaeontological analysis, with notable examples from Wellington, Naracoorte and Riversleigh.

The animal life of Australian caves is introduced with a chapter on cave-dwelling bats, followed by an excellent overview of the invertebrate fauna. The final chapter is an entertaining and informative historical review of the interaction between people and caves, dealing with the discovery, cultural and scientific significance, and uses and abuses of caves from Aboriginal and European perspectives.

The book is copiously illustrated with informative maps, diagrams and photographs, and many quite stunning colour plates. I highly recommend it to anyone interested in caves and caving.

—MIKE GRAY
AUSTRALIAN MUSEUM



Ecologic: Creating a Sustainable Future

By Sandra McEwen. Powerhouse Publishing, Sydney, 2004, 105 pp. $35.95 rrp.

THIS BOOK CONTINUES THE THEME THAT THE POWER HOUSE MUSEUM EXHIBIT, OF THE SAME name, started: namely, what you can do towards creating an ecologically sustainable future. Sandra McEwen has pitched the language, content, photos, graphs and diagrams at the high-school student's level. She invites students to think about their energy usage at home and to consider what is being done at the cutting edge. Throughout the book well-known products from the amazing Holden ECOmmodore prototype to Kettle Chips are photographed with exciting information on what these everyday names are doing to save resources. The book itself is printed from Bagasse Fibre—a waste product of the sugar industry. Teachers will find the book useful for the student researcher who wants up-to-date material on what government and industry are doing to protect the environment or for instructing the class on what the consumer can do to conserve fragile resources. Parents can use the book to educate their children about the need for the family to be responsible citizens.

—HUGH TURNBULL

SOCIETY PAGE

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Contact: Hon. Treasurer

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Contact: Mary Lou Simpson

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Contact: Mimi Pohl

Royal Society of SA
SA Museum
North Terrace
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Ph: 08 8223 5360
Web: *www.agwine.adelaide.edu.au/industry/RSSA/*
Contact: John Love

REPTILES & AMPHIBIANS

Hawkesbury Herpetological Society Inc.
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EMERTON NSW 2770
Ph: 02 9832 9013
Contact: J.A. Banks

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q&a

Answers to Quiz in Nature Strips (page 19)

1. *Darwin*
2. *Infrasound*
3. *Because it doesn't have an atmosphere.*
4. *Cuttlefish bones*
5. *One*
6. *A possum*
7. *Three*
8. *Hydrogen*
9. *Easter Island*
10. *King Penguin*

Thirsty Finches?

Q: *In March, a friend and I walked across the Simpson Desert. The temperature was often in the low to high 40s (° C) and there was no surface water for many kilometres. Yet during this time I observed flocks of Zebra Finches. Where do they get their water from?*

—Kim Shegog
Launceston, Tas.

A: Birds can obtain their water in several ways. The most obvious is to drink directly from an open pool or other source. The other approach is to get the water from the food they eat, either preformed water (that is, from the food itself, usually insects or fruit) or metabolic water (processed from other chemicals contained in the food).

People working in arid regions of Australia have long used the presence of Zebra Finches (*Taeniopygia guttata*) as a sign of the proximity of open water. In the wild, these birds will drink several times a day. Zebra Finches are seed-eaters, so their food does not contain preformed water. However, they are very efficient at obtaining metabolic water from the seeds they eat. One experiment with captive finches demonstrated they could survive in good health on a diet of nothing but dry seeds for a year and a half. In the wild, though, these birds would never remain in an area where open water was unavailable for more than a short period.

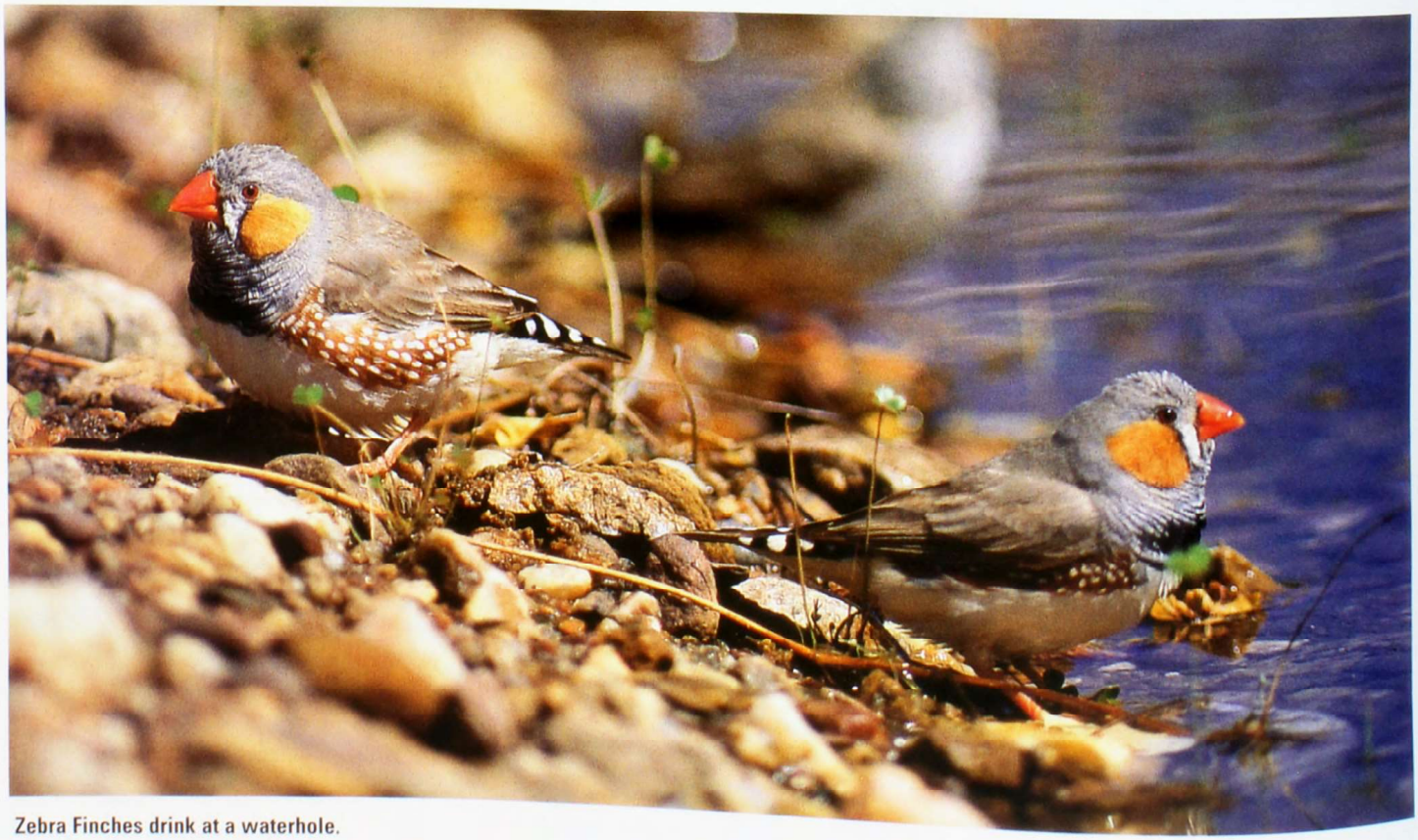
—Walter E. Boles
Australian Museum

Aquatic Apes?

Q: *I have been told that primates in general (excluding humans), and in particular the apes, cannot swim. But is it not perhaps rather a fear of water that inhibits the apes, rather than a physical incapacity?*

—Anne Drover
Wollstonecraft, NSW

A: In the 1930s a researcher in South-east Asia, while on a riverboat with his pet gibbon (*Hylobates* sp.), put the gibbon over the side into the water. It thrashed about helplessly and had to be rescued. However, many primates can swim quite well, and three species do so regularly. These are the Long-tailed Macaque (*Macaca fascicularis*) of South-east Asia, which tends to



JIRI LOCHMAN-LOCHMAN TRANSPARENCIES

Zebra Finches drink at a waterhole.

COURTESY CATHERINE BOND

Red-painted Noctuid Moth.

live in the vicinity of rivers, and swims and dives for some foods; the Proboscis Monkey (*Nasalis larvatus*) of Borneo, which lives in big troops in mangrove regions and alongside rivers, sleeps in trees by rivers at night, and regularly swims or wades across the rivers and mangrove creeks; and the Northern Talapoin (*Miopithecus ogouensis*) of West-central Africa, the smallest of the Old World monkeys whose 60-strong troops likewise sleep on branches above water and, when disturbed, simply drop into the water and swim away.

In the Sangha River region in the Gabon/Cameroon/Congo border region of Africa, there are large forest clearings called bais, which are partially flooded. Gorillas (*Gorilla gorilla*) emerge from the surrounding forest and wade waist-deep into the water and gorge on aquatic plants. Yet elsewhere Gorillas often seem afraid of water, as are Chimpanzees. Orang-utans (*Pongo pygmaeus*), too, have been seen wading through standing water, and in captivity they seem to adapt to water much more easily than Chimpanzees or (most) Gorillas.

—Colin Groves
Australian National University

Banded Moth

Q: *Last summer I took this photo of a colourful moth sitting on my backyard fence. Please can you tell me something about it?*

—Catherine Bond
Carseldine, Qld

A: This is the Red-painted Noctuid Moth (*Donuca rubropicta*). It is a member of the family Noctuidae, in the subfamily Catocalinae, which has the general common name of 'underwing moths' as many of the species have cryptically coloured forewings and brightly coloured hind wings. Eyespots, as seen in this species, are also a frequent feature of the group. When at rest, the broad white bands on the wings line up, giving the impression of a false axis. This may help the moth escape from predators, such as birds. The moth also has a bright red abdomen, revealed when the moth lifts its wings.

Despite being a relatively common species, occurring from the Northern Territory to Queensland and northern New South Wales, the larval food plants are not known.

—Dave Britton
Australian Museum

Pic Teaser

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *Greeniology*. Winter's Pic Teaser was a Spiny Lanternfish (*Myctophum spinosum*).

AUSTRALIAN MUSEUM

Without a licence to kill

All States list illegal hunting as a problem to be tackled.

"Red-tailed Black-Cockatoo, .22-calibre or shotgun". "Squatter Pigeon, .22". "Flying-fox, .22 or air rifle at 20 metres".

These were the responses I got from rural school children in northern Queensland to questions designed to test their knowledge on native species. One 12-year-old claimed the only things he knew about bats were that they were all blind, and that a .22-calibre body shot was the most effective means of dispatching them. All this with a bright-eyed Spectacled Flying-fox (*Pteropus conspicillatus*) hanging from my arm in front of him.

Equally disquieting was the chap at a Brisbane shooting range who decided that, because I was toting a gun and firing at targets, I would empathise with his plight. His new neighbours were complaining about his indiscriminate shooting of crows, and had inquired whether or not he had a permit. He didn't, of course, and subtle questioning revealed that, as far as he was concerned, all crows were the same.

Although hunting for sport or damage mitigation is mostly conducted in a responsible manner, illegal shooting of native species may be a serious conservation concern. The Action Plan for Australian Birds (2000) identified illegal shooting as a threat to the Wedge-tailed Eagle (*Aquila audax fleayi*) in Tasmania, where the single sub-population consists of just 500 individuals. On the one hand conservationists develop innovative programs to discourage farmers in northern Queensland from illegally killing Red-tailed Black-Cockatoos (*Calyptorhynchus banksii*), while on the other hand ten-year-old children happily discuss the most appropriate calibre to use.

Much of this type of hunting is justified by the belief that it serves to help the community, saves the livelihood of embattled farmers, or more bizarrely actually helps the ecosystem in some way. Certain species are often perceived as pests by the shooter, irrespective of the law or conservation status. The Forest Raven (*Corvus tasmanicus boreus*) of New England, for example, has probably declined to 50 per cent of its former density, but to the hunter or landowner who shoots 'crows' this means nothing. The Action Plan also identifies the Australian Bustard (*Ardeotis australis*) as under pressure from illegal hunting, but as a child informed me, they make great target practice.

Both continue to yell at each other with their fingers in their ears.

The concern appears to be widespread—all States list illegal hunting as a problem to be tackled, and studies indicate that several other species, including Blue-billed Ducks (*Oxyura australis*), Bush Stone-curlews (*Burhinus grallarius*) and Spotted-tailed Quolls (*Dasyurus maculatus*), suffer from illegal killing.

Part of the problem is in the apportioning of blame. A communicative chasm exists between the hunters on one side and conservation agencies and concerned individuals on the other. How can one expect people to understand ecological processes or genetic diversity when they barely recognise one species from another? Conversely, is it any wonder that shooters make these kill decisions when they are based on information they believe to be correct? And both fraternities continue to yell at each other across the chasm with their fingers in their ears.

Once the children I was talking to learned that I too owned guns (to shoot Pigs), their suspicion of me as a 'greenie' waned and I was able to cross the chasm and begin verbally navigating my way towards a constructive discussion. The concept, of course, is as old as the Pilbarra—you relate to them and they respond. Most of these kids had never held a live flying-fox, and were also fascinated to learn that the upper mandible of parrots is moveable at a point along its ridge (rhynchokinesis).

Conservationists must recognise that citing legislation and finger-pointing is not appropriate in all situations, as their perspective on the natural environment may be very different to that of their would-be students. In turn those who kill native species must have a basic understanding of species diversity and their potential impact on it. With this knowledge they might also recognise that not all calls for changing hunting practices are aimed at constricting their 'rights'. To avoid widening the chasm, both 'sides' must refrain from blanket statements regarding hunting, and hunting publications have an obligation to strongly discourage illegal shooting. All parties should have their sights set on a mutual target—a greater understanding and appreciation of the natural environment that surrounds us. □

BY FIACHRA KEARNEY

Fiachra Kearney is a post-graduate conservation biology student at the University of Queensland and the ecological advisor to the Queensland Hunting and Conservation branch of Sporting Shooters Association Australia.

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Some of our unique native plants and animals are under threat, but we're working on it. The Australian Government has put in motion the largest environmental rescue plan ever to conserve and restore vital habitat for plants and animals.

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On South Australia's Eyre Peninsula, local groups are working to rebuild and protect the endangered species' habitat.

Armed with $30,000 of Australian Government funding, they have been working with the local landholders, conserving and rebuilding the bird's native habitat, and protecting the bird's eggs and chicks.

Project officer Sarah Way said the number of breeding pairs of birds in the area has increased, and the population has grown to between 30-34 birds at last count.

This is just one example of the thousands of environmental restoration projects happening across the country with support from States, Territories and communities. You too can help in your local region. Together, let's give our land a hand.

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