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FRONT COVER
A Common Ringtail Possum (*Pseudocheirus peregrinus*) peers out of its bark-lined nest. PHOTO BY ESTHER BEATON.

up front

It sounds like a relatively simple task for a biologist—go to Western Australia and study the ecology of the Quokka. But there's a catch—the Quokkas to be studied are not those abundant animals on Rottnest Island, but the scarce mainland population that occurs in the south-west corner of the State. Matt Haywood gladly accepted the challenge and relocated across the country to the town of Dwellingup to begin his study. What the next three years had in store for Matt makes for great reading and you won't be sure whether to feel relief it wasn't you having to battle through densely vegetated swamps full of plants built to cut and tear looking for an elusive mammal, or envy at his moment with a wild Quokka that made all the hardships and frustrations worthwhile.

With Black Swans, it's a very different story. Despite their abundance and familiarity they seem to have been mostly overlooked. In the 17th century Europeans simply refused to believe they existed and in the three centuries that followed they have been rarely studied in the wild. This is despite the fact that these birds have some rather unconventional social and behavioural traits. Luckily Raoul Mulder and Ken Kraaijeveld find Black Swans intriguing. In particular they are curious to understand why Black Swans sport an elaborate ruffle of curled feathers. Their ongoing study has already provided some fascinating glimpses into the world of these unique birds.

Black Swans are also one of the Australian bird species that have been recorded displaying homosexual behaviour. Apparently around five per cent of adult male Black Swans form exclusive pair bonds with other males. These bonds may last over many years and involve raising young. The acceptance of homosexual behaviour as a natural one can be challenging for some people but there is a growing body of scientific literature suggesting homosexual behaviours are a natural subset of other sexual behaviours. Geoff MacFarlane and Kevin Markwell tackle this subject in their article on page 52.

We also take great pleasure introducing you to a turtle that breaks all the rules, a fish that has no eyes and a possum that likes to snack on its own poo.

—**JENNIFER SAUNDERS**
Publishing Manager

JOHN SHAW/AUSCAPE

The Black Swan (Cygnus atratus).

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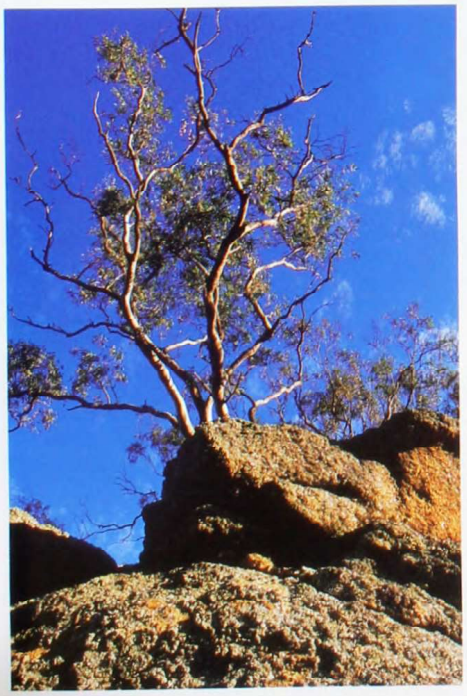
REGULAR FEATURES



COLUMNS

letters

One Snake or Two?

Never, never would I be so silly as to complain of an error of biological fact in your journal; but perhaps I might point out that your knowledge of Greek mythology may be a little astray.

In the Spring 2003 issue, in the seasonal spread, Geordie Torr and Martyn Robinson write that the staff of Aesculapius was a rod with two snakes entwined. This is not so. The God of Healing had only one snake. The staff of Mercury, the messenger, was similar, although it was winged, and it is the one that had the two snakes.

This error has been made before. The American Medical Association used the rod of Mercury as its logo, complete with two snakes and a pair of wings; it has been copied by several Australian associations, including the Queensland Ambulance. The British Medical Association sticks to Aesculapius, and has his one-snake rod on the cover of its journal. The Australian Medical Association, as far as I am aware, does not use either rod on their stationery, but subscribes to the single snake when referring to the mythical founder of their craft.

My comments will have no effect on the quality and veracity of your writings. Please continue.

—Pat O. Flecker
Townsville, Qld

Protective Plumes

In the article "The Fuzzy Frontier" (*Nature Aust.* Spring 2003), no-one appears to have considered whether or not feathers give better protection than fur. I have seen Chickens when chased by a Dog run into a bougainvillea bush and the Dog did not dare follow.

—Eric Harman
Darwin, NT

Aboriginal Puddy Cats

I read with interest Vincent Serventy's Letter (*Nature Aust.* Summer 2003–2004) regarding his theory that Cats did not exist in Australia before Europeans because his Aboriginal assistant used the word 'Puddy cat' instead of an Indigenous word. Unfortunately, the Aboriginal assistant's use of 'Puddy cat' probably had more to do with the person he was talking to rather than not having a word in his own language for Cat. Most likely he spoke English because he was talking to an English speaker, and assumed Vincent would not understand his language. I have worked with Warlpiri people (west of Alice Springs) for a number of years now and they have their own word for Cat, *minija*. In the Warlpiri dictionary there are also two synonyms for Cat, *ngaya* and *pujukati*. I have found that

L&O SCHICK/NATURE FOCUS

How much do Tasmanian Devils compete with Cats?

Warlpiri people speak English to English speakers because they do not expect English speakers to know their language. Perhaps this is similar for Indigenous peoples in other parts of Australia.

—Ren Barnett
Alice Springs, NT

In Defence of Rainbows

I did not appreciate the comment about Rainbow Lorikeets made by Sally Lake (Letters, *Nature Aust.* Summer 2003–2004). While I am aware that many Australian birds are becoming pests in our major cities, I am a keen birdwatcher and lover of birds. Comparing them to rats and Cane Toads was unjustified as both these animals are introduced and have a much more devastating effect on Australian wildlife than a native bird ever will.

—Philippa Fagan
Roseville, NSW

Cats & Devils

I read with interest your Last Word on introducing Tasmanian Devils to the mainland (*Nature Aust.* Summer 2003–2004). Oddly, the authors didn't mention Cats, which to me seem to be more direct competitors than Foxes.

—Pat Anderson
Richmond, N Yorks, UK

Pat Anderson raises an interesting point. We know little about Tasmanian Devil/Cat ecology. However, Cats are less likely to compete with Devils than are Foxes because Cats are much smaller and far less inclined to take carrion. Overall, the growing consensus seems to be that Cats have shouldered an unfair proportion of blame regarding marsupial extinctions. On my wish list, Fox eradication takes first place. Still, an understanding of Devil/Cat interactions remains highly desirable and this is something else we hope to study.

—Steve Wroe
University of Sydney

Women's Worth

Your story on hunter-gatherer societies (*Nature Aust.* Summer 2003–2004) reminded me of an article I read some years ago by an anthropologist who had spent time with a desert Aboriginal tribe and who had joined in the food-gathering expeditions that the women in the group undertook. Her comments would certainly reinforce the point made by Richard Fullagar about the importance of women's role in the provision of food. The women collected daily supplies of yams, berries, sugar ants etc., which the group as a whole relied on. The men's hunting activities were much more sporadic; in fact, she noted that some days the women had to have a 'poor collecting' day when the men went hungry in order to provoke them to go hunting. The story also reminded me of an essay by Ursula Le Guin in which she suggested that the most important invention made by humans was not the wheel, but the carry bag—used by women to carry food and water back to the camp.

—Jeanette Knox
Glebe, NSW

Platypus 'Birth'

I was surprised to see that Georgina Hickey's response to a query on what to call a baby Platypus (*Nature Aust.* Summer 2003–2004) referred to "the birth of Platypus twins at Taronga Zoo" without using quotation marks to indicate quotation from the *Sydney Morning Herald* article referred to or the use of a figure of speech. Did I miss something, or was that event even more remarkable than I had understood it to be?

Several of your authors, such as Steve Van Dyck, apply imagination and flair in their use of populist language to engage readers and lead them to see things from a new perspective, but the use quoted above was misleading rather than extending.

It appears to me, as a critic of children's science books, that the world 'hatch' may be gradually being dropped from current English usage. That would be a great pity because most animals begin life by hatching, and the mammals that give birth are unusual and remarkable. Perhaps the loss is a result of few people keeping chooks today and so not observing hatchings.

Please keep up the good work of introducing readers to many of the wonders of nature but please do it while retaining the richness of our language.

—Eleanor Stodart
Curtin, ACT

***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 *Plague species*. The winner this issue is Pat Flecker.**

Autumn

Compiled by Geordie Torr and Martyn Robinson

A False-eyed Hawk Moth caterpillar.

PAVEL GERMAN

EYES LIKE A HAWK-MOTH CATERPILLAR

Now is a good time to search for hawk moths. Chances are, though, you're most likely to see them in their larval form, as rather striking caterpillars. These often large, voracious consumers of garden plants have a prominent spike on their tails and are frequently colourful or unusually marked. One of the more interesting species is the False-eyed Hawk Moth (*Theretra latreillii*). When threatened, the caterpillar pulls in its head, which causes the first abdominal segment to puff out, inflating the skin to reveal what looks like a large pair of eyes. Look out for it on *Impatiens* and Virginia Creeper.

Most adult hawk moths are nocturnal, so you're unlikely to see them unless they are attracted to your backdoor light. They are very streamlined moths with narrow forewings, often sitting quietly, but sometimes they'll be vibrating all over as if barely containing their pent-up energy. When they take wing, they fly very rapidly and when they're away from the light's influence they can hover like hummingbirds to sip nectar using their long tongue (or proboscis).

If you want to identify the hawk moths that turn up in your garden, go to **www-staff.mcs.uts.edu.au/~don/larvae/sphi/sphingidae.html**

PARASITE DELIGHT

Although it's a year-round menace, the Paralysis Tick (*Ixodes holocyclus*) is most commonly encountered in autumn (from late summer to mid winter), when the larval stage is most active. It is found along Australia's east coast, from northern Queensland to Victoria.

Ticks are arachnids and, unlike their cousins the spiders and scorpions, they are parasites, not predators. The main hosts of the Paralysis Tick are bandicoots, but they may also latch onto other warm-blooded animals, including humans, that pass nearby. They are the most common human-biting tick in eastern Australia.

Ticks hatch out as tiny six-legged larvae that climb up to some vantage point such as a grass stem or twig and wave their front legs about, trying to catch a passing host. After their first blood meal (lasting four to six days), they drop off and moult to the nymphal stage carrying the more normal arachnid component of eight legs. A bit more blood and another change of 'skin' and the tick is a fully fledged adult, which is when things get a tad

Paralysis Tick.

ESTHER BEATON

A Short-tailed Shearwater in front of its burrow.

strange. While the female parasitises another warm-blooded host, the male parasitises the parasite—feeding off the female tick at the same time as trying to mate with her. Up to three males have been found attached to a single female. The female then drops off her host to lay 3,000 or so eggs and the cycle, which usually takes about a year, begins again.

For more on these blood-sucking blighters, see "Ticks" (*Nature Aust.* Autumn 1997) and visit **http://medent.usyd.edu.au/fact/ticks.htm.**

BURROW-BOUND BIRDS

Autumn is the time that the chicks of the Wedge-tailed and Short-tailed Shearwaters (*Puffinus pacificus* and *P. tenuirostris*) are making the big move out of their burrows.

The birds have spent the summer underground in the metre-long burrows in which they hatched. While each chick was still in the egg, its parents took turns to go out and fill up on krill, squid and fish. Each shift lasted for about two weeks, while the other bird neither left the burrow nor was fed by its mate.

After the chicks hatch, the adults work around the clock to provide them with plenty to eat. Towards the end of their burrow-bound stage, the chicks can weigh twice as much as their rather haggard parents. This childhood 'obesity' is vital because, after their parents leave, the chicks may spend a month in their burrows waiting to lose their down and grow flight feathers.

During this time they will make increasingly lengthy forays into the open air to exercise their wing muscles, before finally quitting their subterranean shelters for the long journey from the breeding colonies in south-eastern Australia to their winter feeding grounds in the north. For Short-tailed Shearwaters, these may be as far away as Alaska.

To find out what happens next, visit **www.dpiwe.tas.gov.au/inter.nsf/WebPages/SJON-57374F?open.**

PAUL OVENDEN/NATURE FOCUS

FROM THE COLLECTION

In late autumn and early winter, the Aboriginal people of the Top End used to burn off the dry vegetation—the cooler temperatures resulting in small, patchy fires that created a mosaic of burnt and unburnt land. Plants in the burnt areas grew new shoots, which attracted game animals such as kangaroos and Emus, while the unburnt areas offered cover for hunters and shelter for smaller game.

The fires were initially created using a pair of fire sticks, such as these two from Kaparlgoo Mission, South Alligator River, Northern Territory, acquired in 1901 from an S.A. Newshame. The sticks comprised a hardwood drill and a somewhat softer 'hearth board'. The drill stick was twirled rapidly between the hands while pushing downwards on the thin end, which rested in a notched groove in the hearth board. The friction caused glowing embers to form and drop into tinder—some dried kangaroo dung or similar—placed below. Blowing on the embers would then make the tinder catch on fire.

To learn more about how Aboriginal people created fire, check out Sylvia Hallam's Fire and hearth *(1979).*

A drill stick and heath board used to make fire.

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, MICHAEL LEE, KAREN MCGHEE, RACHEL SULLIVAN, ABBIE THOMAS, GEORDIE TORR AND PAUL WILLIS ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Are Chimps Just Hairy Humans?

Anatomists, physiologists and even behaviouralists have identified for well over a century that humans and Chimpanzees (*Pan troglodytes*) share much in common. Now, in the era of the human genome project when our DNA and that of many other species is being scrutinised intimately, scientists are finding the relationship could be even closer at the molecular level than previously thought.

Some of the most compelling work in the area has been carried out recently at Detroit's Wayne State University School of Medicine, where Derek Wildman and colleagues compared 97 human genes, their Chimpanzee equivalents and, where available, those of Gorilla, Orangutan and Old World monkeys. They found we share all but just 0.6 per cent of our most critical DNA with Chimps.

This is closer than previous evaluations, the reason being that it is based only on the most 'functionally important' DNA sites.

So close are the genetic links between Chimps and humans that the researchers believe there's a case for reclassifying them, and their 'pygmy' relatives the Bonobos (*Pan paniscus*), as the only other living members of the genus *Homo*.

Wildman and colleagues believe Chimpanzees and humans diverged from a common ancestor between five and six million years ago, with Gorillas branching off as much as one to two million years before that. Bonobos and Chimps went their separate ways within the last three million years.

—K.McG.

Dinner on a Denticle

With fins instead of fingers and a mouth crammed with teeth, feeding for most sharks is not a pretty sight. But one shark, the Lesser-spotted Dogfish (*Scyliorhinus canicula*), uses some decorum at dinner, having found a novel way to cut food up into manageable

Chimpanzees are even more similar to humans, genetically, than previously thought.

JEAN-MICHEL LABAT/AUSCAPE

pieces.

The skin of all elasmobranchs (sharks and rays) is covered in rough, tooth-like denticles. This jagged membrane minimises drag in the water and also protects against predators and ectoparasites. But as Emily Southall and David Sims from the Marine Biological Association in Plymouth, UK, have observed, the Lesser-spotted Dogfish also uses this rough surface for food preparation. A dogfish usually breaks up prey into bite-sized chunks by clamping down and violently shaking its head. But when food is bigger than the mouth gape, it abandons head banging for skin grating. By rapidly whipping the head around to the tail, the dogfish snags the food on its sharp denticles, creating the opposing force necessary to pull the food apart.

Southall and Sims noted that this skin-grating behaviour is especially common in juvenile dogfish, which are unable to generate the large biting forces necessary to break up firm prey. However, the talent is not lost in adults—and with teeth on both the outside and the inside, why limit mastication to the mouth?

—K.H.

KLEI/HUBERT-BIOS/AUSCAPE

When Dogs have a problem they ask their owners for help.

Dogs Get the Point

As every Dog owner knows, Dogs have an uncanny ability to read human body language. And it is this ability that may have separated the earliest domestic Dogs from their wild wolf brethren.

Ádám Miklósi (Eötvös University, Hungary) and colleagues tested the abilities of four Grey Wolves (*Canis lupus*) to locate food hidden in one of two containers, with their handlers either pointing from various distances or touching the correct container. Touching the container or pointing to it from nearby helped them locate the food, but only after long practice did one wolf respond correctly to pointing from afar.

The researchers say that, to be able to correctly interpret a distant gesture, the animals need to look at both the containers and the handler's upper body; without doing this they would be unable to perceive the directionality of the signal.

This formed the basis of their second experiment, which compared how Dogs and Grey Wolves looked to their handlers for behavioural cues, when

JJ BRUN-EXPLORER/AUSCAPE

What do Stonehenge and female genitalia have in common?

faced with the seemingly insoluble task of retrieving meat from a locked container. The researchers found that seven of the nine Dogs immediately turned to their handlers and gazed at them, as if asking for guidance, while only two of the seven wolves looked back at all.

That any wolves looked back indicates certain animals may be predisposed for successful selection to occur, and the researchers say that selecting for this human-like communicative trait would have been a key part of the domestication process, opening the door to a long and mutually beneficial relationship.

—R.S.

Vagina Megaliths

The massive arches of Stonehenge on England's Salisbury Plain are an international symbol of prehistory, and form the logo of the journal *Antiquity*. While no-one doubts the engineering skills required to erect the largest stones or megaliths (over 20 tonnes), theories about Stonehenge's construction, which began over 4,000 years ago, range from the astronomical and memorial to the bacchanalian and fantastic (alien landing strips!).

The latest idea suggests that Stonehenge is a symbol of life and birth. According to Anthony Perks and Darlene Bailey (Obstetrics and Gynaecology, University of British Columbia), the mothers and fathers of the past are represented by the trilithons—pairs of smooth (= female) and rough (= male) upright stones united by horizontal lintels. Furthermore, they point out the henge's uncanny resemblance to the female genitalia. They believe the outer stone circle represents the labia majora; the inner circle of trilithons the labia minora; the inner 'horseshoe' arrangement of bluestones is the outline of the vagina or birth canal; with the clitoris at the 'altar stone', and the anus and cleft found around the back near the ditch.

Perks and Bailey propose that this resemblance to the female vulva is no accident and that Stonehenge was built as a symbolic representation of the opening by which the Earth Mother or Goddess gave birth to the plants and animals on which the people were so dependent.

While we may never know the real purpose of the henge, so many explanations have been offered that sometimes I think archaeology tells us more about ourselves than it does about the past!

—R.F.

Underwater Vision

Under the clear blue waters of the Andaman Sea, the Indigenous Moken people have taken human sight to a new extreme. Known as the 'sea gypsies' of South-East Asia, these nomadic seafarers rely on the sea for hunting and gathering. Moken children dive for clams and sea cucumbers, spending hours of each day under water with no flippers, no snorkel, and no goggles. Their submarine lifestyle has resulted in an extraordinary ability to see under water, but just how they do it remained a mystery.

To test whether the children's eyes were specially adapted, Anna Gislén (Lund University, Sweden) and colleagues compared the

vision of 17 local Moken children with that of 18 European children. Out of the water, they found no significant differences, but below the water, the Moken could see fine detail twice as well as European children. They achieved this by doing something quite unexpected, in fact just the opposite of what the European children did. Rather than open up their pupils to accommodate the lowered light levels under water, they actually constricted their pupils. This increases the sharpness of vision by decreasing the 'blur circle' on the retina.

Moken children can contract their pupils to just 1.96 millimetres across—20 per cent smaller than the Europeans' pupils. They can also change the shape of their lenses to the known limit of human performance. Gislén believes that, through their reliance on the sea, the Moken have learnt to control the tiny muscles that shift their lenses and pupils. However, it is also possible that, over thousands of years, evolution favoured those who used 'submarine vision' so that the talent might now be passed on genetically. Whether inherited or learnt, the sea gypsies' superior underwater vision is certainly put to good use in their watery environment.

—K.H.

COURTESY ANNA GISLÉN

Photograph of a Moken child taken under water with infrared light. Note the pinprick pupils—all the better to see with.

Loved to Death

The ritualised male killings by female Black Widow Spiders after sex are legendary. But there is one spider that takes male self-sacrifice to an even greater extreme. Matthias Foellmer (Concordia University, Canada) and Daphne Fairbairn (University of California, Riverside) have discovered that males of the orb-weaving spider *Argiope*

Dinosaurs Dine Out on Relatives

A collection of dinosaur bones found in Madagascar has been presented as the first definitive evidence of cannibalism in meat-eating dinosaurs (theropods).

According to Raymond Rogers (Macelester College, Minnesota) and colleagues, bones of several different dinosaurs from the island's late Cretaceous fossil beds have tooth marks on them that can only be attributed to the medium-sized, two-legged theropod *Majungatholus atopus*. In itself this was not too surprising, but what was unusual was that a considerable number of the bitten bones came from specimens of *Majungatholus* itself.

The tooth marks, found mostly on ribs and vertebrae, were readily identifiable on several grounds, including the size and formation of the bites, as well as details of tooth structure reflected in grooves produced on the bones. Other known predators from these deposits included two crocodilians and another smaller theropod. These other possible perpetrators were ruled out as either being too small or having the wrong type of teeth and tooth arrangements to produce the regularly spaced bite marks seen on the bones.

While cannibalism has long been suspected among dinosaurs, there has been precious little evidence of it. The only previously cited example, a specimen of *Coelophysis* from the late Triassic of New Mexico, may in fact be an artefact of preservation rather than a true case of sibling gobbling. Recent work suggests that the second individual may be under the first, rather than in it.

Whether *Majungatholus* actually killed each other or just scavenged on each other's carcasses as opportunities presented themselves, remains a mystery.

—P.W.

***Majungatholus atopus* snacks on its own kind.**

COURTESY DEMETRIOS VITAL, UNIVERSITY OF MINNESOTA

aurantia die spontaneously after mating, without any 'assistance' from the female.

Like all spiders, the males of *Argiope aurantia* have two intromittent organs (pedipalps) located near their fangs that they use, one after the other, to transfer sperm. As soon as the second pedipalp is inserted, the male undergoes what appears to be a fatal seizure. This was observed in actual matings, in experimental manipulations, and even when an overly amorous male tried to copulate with a dead beetle.

What could be the evolutionary advantage of this programmed self-destruction? As in some other spiders, the dead male might provide nourishment for the inseminated female and their offspring. But while female *Argiope* do consume their dead mates, the small size of these males would not make for much of a feast. Alternatively, the dead males, which remain in coitus until eaten, might function as effective mating plugs, making it harder for

rival males to inseminate the female.

—M.L.

Taste Test for Virgins

How do you find out if the girl you fancy has been sleeping around?

There's nothing that turns a bed bug on more than a good feed of blood, and straight after gorging, female bed bugs will mate with up to five different males in quick succession. But while the girls might appreciate all this sex, the males have to be careful they don't waste precious time or sperm on a female that is already fertilised. So how do you find out if the girl you fancy has been sleeping around?

Michael Siva-Jothy and Alistair Stutt (University of Sheffield) timed copulation duration and measured ejaculates of male bed bugs (*Cimex lectularius*) mating with virgin females. They then painted bed bug 'penises' with sperm from other males to fool them into thinking they were having sex with already-mated females.

When they found that males produced fewer sperm and took less time mating non-virgins than they did when mating virgins, the researchers took a closer look at the bed bug 'penis', and discovered short, peg-like features on the tip, believed to be chemosensory. These structures, the researchers suggest, enable the male to 'taste' the female with his penis to find out if she's been 'seeing' other bugs.

But why do male bed bugs produce less sperm if they aren't the first on the mating scene? It may be that there is no point mating with a female that is already fertilised. But also, lurking within the female's sperm-storage organ are cells that grab sperm and destroy them. The downside of being the first male on the block may be that he has to produce lots of sperm, just to make sure that any survive.

—A.T.

Birds Say it with Citrus

Many animals, including humans, produce odours that are thought to have social functions. Mammals, reptiles, frogs, fishes, even insects, all produce chemicals, known as 'social odours', that affect the behaviour of members of their own species.

Up until now, however, no-one had managed to find a convincing case of a bird that produced a social odour, despite the fact that some birds are known to have a well-developed sense of smell and many have odours that humans can readily detect.

DENSEY CLYNE

They come and they go: males of some orb-weaving spiders (*Argiope*) undergo post-mating sudden death syndrome. Shown here are the male and larger female of St Andrew's Cross Spider (*A. keyserlingi*).

COURTESY IAN L. JONES

During courtship, Crested Auklets nuzzle into each other's necks, as part of the 'ruff sniff' display.

The Crested Auklet (*Aethia cristatella*), a monogamous seabird, produces a distinctive smell, said to be similar to that of a tangerine, during the breeding season. The smell is particularly strong in the neck region and, during courtship, the birds nuzzle each other's nape feathers in a stereotyped display known as the 'ruff sniff'.

To test whether the tangerine scent did in fact influence Crested Auklet behaviour, Julie Hagelin (Swarthmore College) and colleagues conducted a series of experiments in which they placed birds in a T-shaped maze and presented them with a choice of different odours. The birds were attracted to the smell of auklet feathers, and to two chemical compounds isolated from the plumage odour itself, whereas they showed an aversion to the skunk-like odour of mammalian musk, and no response to the novel smell of banana essence.

These results, combined with a chemical analysis that showed the odour was most concentrated during the breeding season, led the researchers to conclude that the citrus scent of Crested Auklets was the best known example of a social odour in any bird.

—G.T.

He spent two-and-a-half years watching couples kiss at airports, railway stations, beaches and parks.

The Right Way to Kiss

Have you ever rushed up to your lover for a kiss and clashed noses instead? Perhaps you are one of the minority who doesn't turn their head to the right.

Onur Güntürkün (Ruhr University, Germany) spent two-and-a-half years watching couples kiss at airports, railway stations, beaches and parks, in Germany, the United States and Turkey, and found that almost two-thirds of people turn their heads to the right.

Keen to put aside suggestions of voyeurism, Güntürkün says he focused particularly on airports because people from so many cultures meet and mix within their confines. Criteria for a scientifically valid kiss were also strict: it

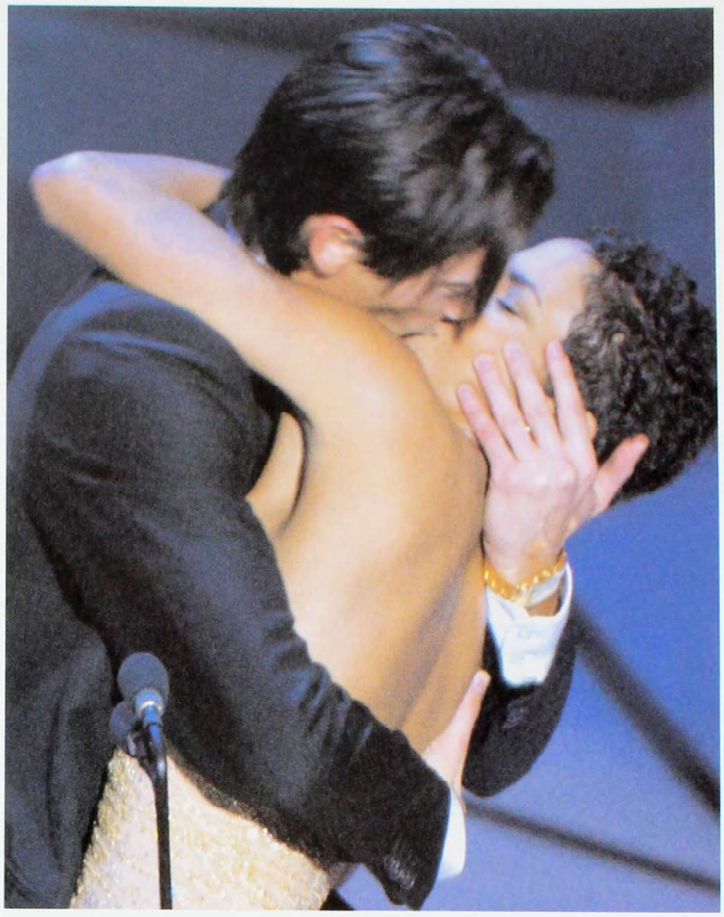
only counted if it was the first observed between a couple, was face-to-face, and was on the lips. Any kisser who carried something in his/her hands was disregarded (for this might influence the delivery of the kiss), as were pecks on the cheek because of the cultural influences deeply affecting cheek-bussing encounters.

Such stringent criteria meant that valid kisses were surprisingly rare, with Güntürkün recording only 124 over the duration of his study. Of these, 80 turned their heads to the right and 44 to the left. He says the almost 2:1 ratio matches our preference for the right foot, eye and ear, and probably has its basis in our tendency to turn our heads to the right in the womb and for up to six months after birth.

Most people turn their heads to the right for a kiss.

Interestingly, the incidence of right-handedness is about 8:1 and so is unlikely to be the result of the same inborn tendency to turn the head to the right. Güntürkün suggests that either the genetic origins of right-handedness are different or that cultural factors may have profoundly affected an original 2:1 pattern.

—R.S.



KEORK DJANSEZIAN/AP/AAP

Furless Humans

Our closest relatives are all spectacularly hairy. So why are we humans the only primate and one of few mammal species not covered by a dense layer of fur?

According to the most

COLLECTION/AUSCAPE

Why are humans the only 'naked ape'?

popular viewpoint, hairlessness evolved to make life cooler on the scorching African plains where modern humans are thought to have emanated. More controversial is the idea that our lack of hair dates back to an unconfirmed period when our ancestors may have led an aquatic or semi-aquatic existence. Now a new theory nominates biting bugs as the driving force behind the evolution of furless humans.

Cultural developments such as the use of shelter, clothing and fire would have made thick fur superfluous for regulating body temperature. And losing it, according to Mark Pagel (University of Reading) and Walter Bodmer (Oxford University), would have been highly advantageous in controlling external disease-causing parasites such as mites and fleas. Furless individuals would, as a result, have become more desirable as mates.

Head and facial hair may have been retained because it continued to be physiologically useful, perhaps for sun protection. And, despite enhancing the warm, moist conditions favoured by parasites, thick pubic hair may have remained desirable because of its role in enhancing pheromone signals to mates.

—K.McG.

Animal Magnetism

Much has been written about the amazing homing feats of pigeons. But it now seems the navigational capabilities of the Caribbean Spiny Lobster (*Panulirus argus*) are just as remarkable.

Research by Larry Boles and Kenneth Lohmann, from the University of North Carolina, has found these migratory crustaceans are among the few animals (and the first invertebrates) known to possess true navigation. Put simply: when moved to unfamiliar locations they can find their way home without needing any obvious cues such as landmarks.

In a series of relocation experiments, the researchers went to exhaustive lengths to confound and disorient the lobsters by obscuring every possible visual, chemical and magnetic cue while transporting them from their coral-reef homes. Kept inside covered containers filled with magnets that would disrupt the orientation of most compasses, they were taken via meandering routes up to 37 kilometres from their capture sites and freed with rubber caps covering their eye-stalks.

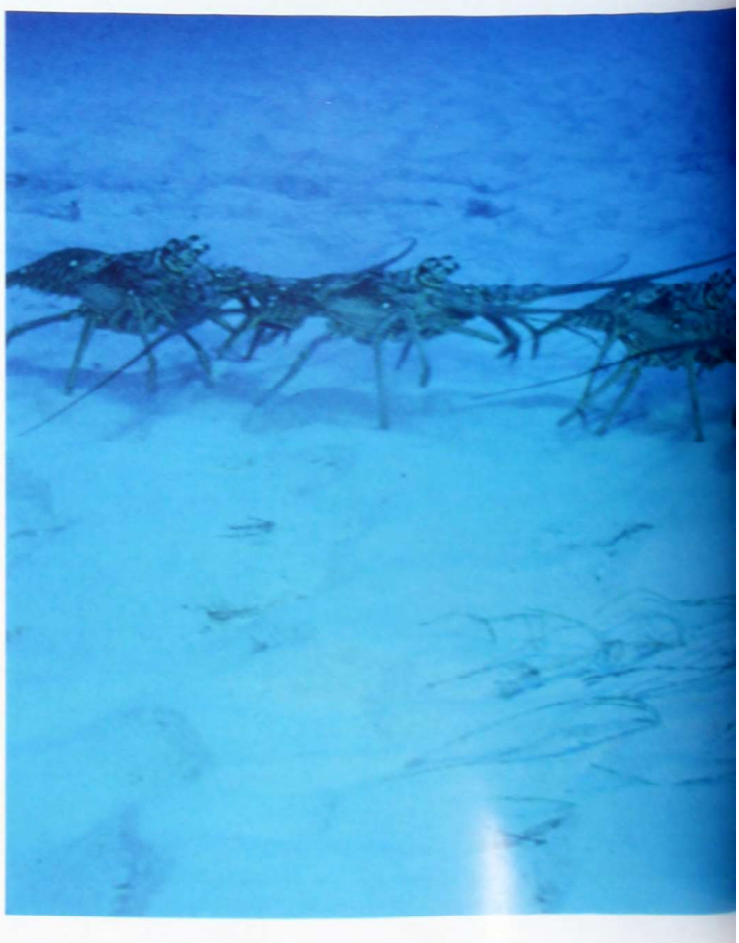
Nothing seemed to affect the lobsters' innate navigational skills and they all headed straight for home after release.

Previous work by Boles and Lohmann found the lobsters contain their own inbuilt compasses. The researchers believe they may use these to detect the Earth's magnetic fields and tell them where they are on the planet at any particular place and time, and which direction is home.

The ability for so-called 'magnetic mapping' in animals has been theorised about since the mid-1800s but this is likely the closest anyone has ever come to proving that it really exists.

—K.McG.

Caribbean Spiny Lobsters know their way home.



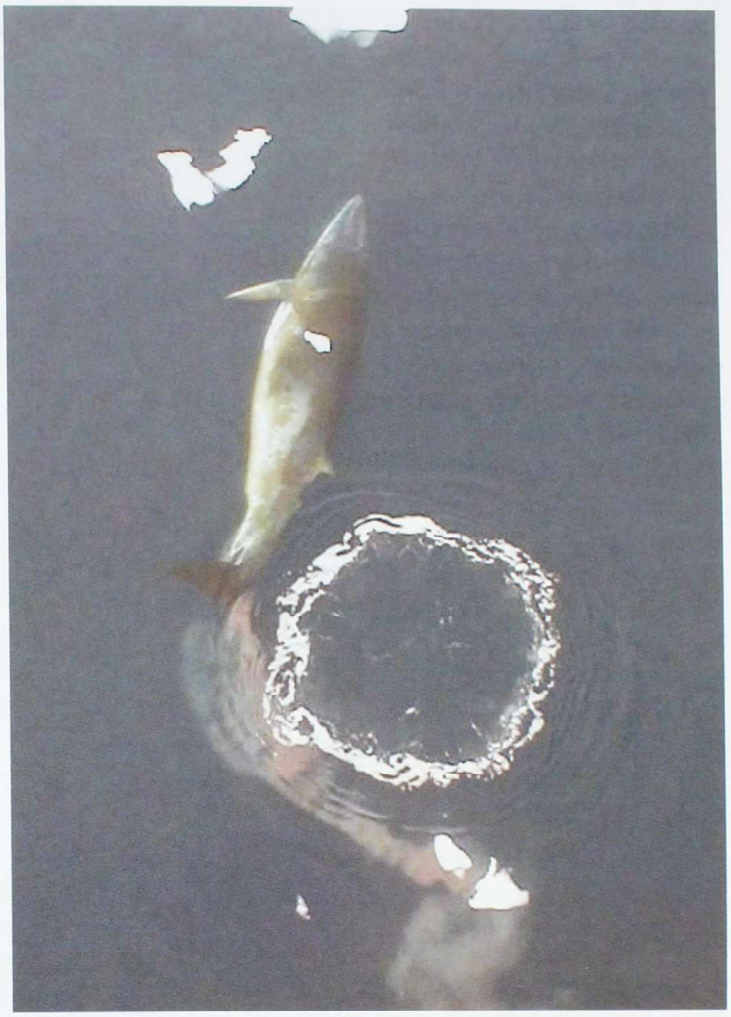
Windy Whales

You do it. I do it. Dogs, cats and cows do it. Even marine mammals do it, as captured in this amazing photograph of a fart from a Minke Whale (*Balaenoptera acutorostrata*), obtained from the Australian Antarctic Division. The photo was taken in Charlotte Pass, Antarctica, in February 2002, by Captain Joe Borkowski, from the bow of the US research vessel *The N.P. Palmer*. The pink plume is the whale's faeces (the colour comes from its krill diet) and the circle is the outline of the enormous gas bubble or fart. (The solid white bits are ice floes.)

Flatulence, in all animals, is the result of bacterial breakdown of partially digested food in the large intestine, and the gases released include nitrogen, carbon dioxide, methane, oxygen and hydrogen sulfide. (It's the hydrogen sulfide component that makes some farts stink, and the oxygen and methane that makes them worth lighting!)

The photo was taken as part of a broader study into the diets of Blue, Fin, Humpback and Minke Whales. By analysing the DNA in whale faeces, scientists like Simon Jarman and Nick Gales (Australian Antarctic Division) can determine, in a non-invasive way, the exact prey species eaten, which we need to know for successful whale conservation. Most whale researchers are kitted out with whale stool-sampling kits to use whenever and wherever an opportunity presents itself.

—G.H.

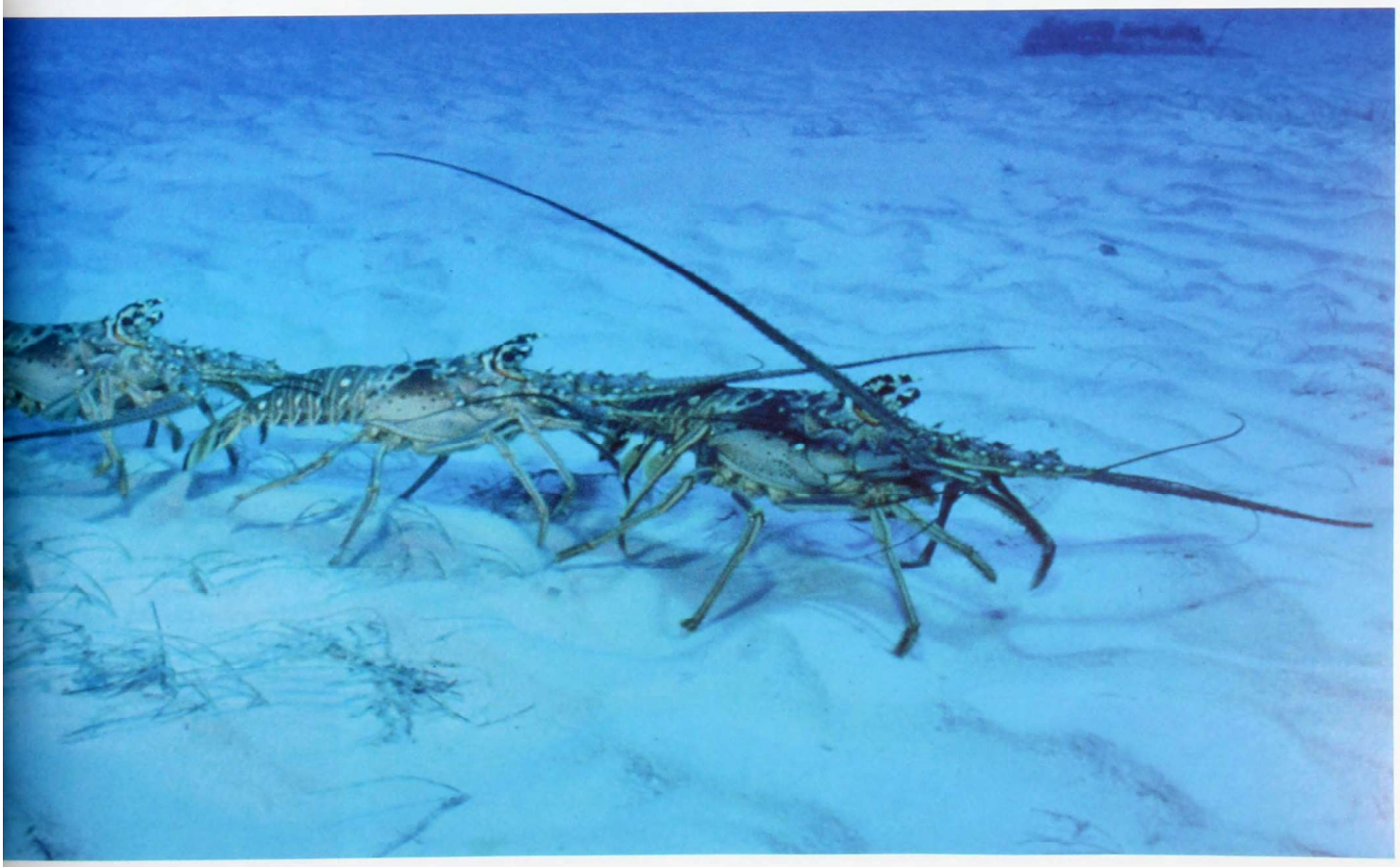


COURTESY AUSTRALIAN ANTARCTIC DIVISION

Minke Whales do it too.

Marsupial Murder Mystery

When six partially decomposed bodies



HOWARD HALL-OSF/AUSCAPE

and the intestinal remains of another were discovered in Epping Forest National Park in central Queensland, scientists were called in to investigate.

Sam Banks (Monash University) and colleagues used DNA analysis to establish that there were indeed seven victims: six males and a single female. They were even able to identify three of them from a genetic database.

The next step was to see if they could identify the killer or killers. A search of the area turned up some vital clues: four sets of faeces. The scientists managed to isolate DNA from the faeces that revealed both the identities of the killers and tied them directly to one of the killings. It turned out that the victims—all Northern Hairy-nosed Wombats (*Lasiorhinus krefftii*)—were killed by a pack of at least three Dingoes. The researchers believe this is the first time that DNA techniques have been used to show that a specific individual animal 'murdered' another specific individual animal.

It is the sex lives of animals—not their size—that put many of them at risk.

The investigators relied on circumstantial evidence to show that the Dingoes had killed the wombats, rather than just scavenging on already dead animals. First, Dingo packs rarely feed on carrion. Second, when Northern Hairy-nosed Wombats die of natural causes, they typically do so in their burrows. And finally, the seven deaths all took place within an eight-week period during which Dingo levels in the park were the highest ever recorded.

With only about 110 Northern Hairy-nosed Wombats left in the wild, this predation event was extremely significant and the identification of the killers as Dingoes led to the erection of a Dingo-proof fence around the single known colony.

—G.T.

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DNA from the Northern Hairy-nosed Wombat has helped pin down its predators.

The Problem with Being Faithful

Wildlife managers struggling to save ecosystems worry about which species in their care are most vulnerable to extinction. Until now, it was thought that the largest and slowest to reproduce (and usually the most charismatic), or most isolated animals were most at risk. But new research by Justin Brashares (University of British Columbia) challenges some of these beliefs.

While isolated populations are still probably most prone to local extinctions, it is the sex lives of animals—not their size—that put many of them at risk.

Brashares analysed 41 species from west African Ghana for traits such as fecundity, body size, mating behaviour, and preference by hunters, and compared this with their survival rates in the past three decades. He found species that had already gone extinct, or that were headed that way, were either monogamous, or had very small harems.

This may be because, in monogamous societies, all the males are paired up with females, so if one is killed his partner will remain unmated. In polygamous societies, on the other hand, virtually all females produce offspring.

Monogamy can also make life riskier, because faithful

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

***Homo sapiens idaltu:* compelling evidence for the 'out of Africa' model of human evolution.**

mates tend to look out for each other. For example, if a female is killed by hunters, the male will come to investigate and is easily taken too. The findings suggest conservationists should consider behaviour alongside more traditional methods of determining a species' viability, if they are to avoid catastrophe.

—A.T.

Earliest Modern Funerals

The dominant theory of modern human origins proposes a recent expansion out of an African homeland about 100,000 years ago, and predicts (on the basis of fossil and genetic data) that the earliest evidence will be found in Africa. Proof of the theory has been frustrated by lack of well-dated human remains in the critical period between 300,000 and 100,000 years ago. However, Tim White (University of California, Berkeley) and colleagues have discovered three fossil hominid skulls from Herto in Ethiopia's Afar depression. These early humans were living sometime between 160,000 and 154,000 years ago, and provide compelling support for the 'out of Africa' model.

The researchers compared the skulls (two adults and a child) with archaic African fossils, Eurasian Neanderthals and anatomically modern humans. The skulls show a mix of archaic and modern features, and represent a population on the cusp of becoming fully modern. As such they have been classified as a human subspecies *Homo sapiens idaltu*. They share none of the Neanderthal features, suggesting that Neanderthals were not the ancestors of modern humans. The associated stone artefacts also have features that are both archaic (handaxes and picks) and more modern (flaked tools).

They share none of the Neanderthal features, suggesting that Neanderthals were not the ancestors of modern humans.

The late J. Desmond Clark (University of California, Berkeley) and colleagues have shown that all skulls have clear traces of deliberate modification soon after death. Cut marks indicate that sharp stone tools were used to remove flesh from the bones. While evidence of defleshing and disarticulation (removing the head from the skeleton) has been found on older African hominids, parallel scratch marks (decoration?) and a polished sheen (which suggests repeated handling) on two of the skulls are new discoveries that may also indicate ritualised mortuary practices.

The Herto finds are unlikely to be the funeral for the competing 'multiregional' theory of modern human origins (which proposes that modern humans arose simultaneously in several different places as a result of mixing with ancient hominids), but it does seem to put one more nail in the coffin.

—R.F.

QUICK QUIZ

1. *Which animal's jaw was combined with an ancient human skull to create the forged fossil known as 'Piltdown Man'?*
2. *What colour is the male Gang-gang Cockatoo's head?*
3. *In which State is the World Heritage Site of Riversleigh?*
4. *What (apart from Greater Public Schools) does GPS stand for?*
5. *Do fish drink?*
6. *What are the larvae of saufly wasps known as?*
7. *Which end of the rainbow has the longest wavelengths of light?*
8. *What is the difference between a meteoroid and a meteorite?*
9. *Which is the world's largest living lizard?*
10. *What do you call a baby echidna?*

(Answers on page 83)

Ring-picking tales

For a Common Ringtail, daytime poo-eating is a drowsy, pampering pastime.

UNTIL RECENTLY I USED TO wonder what went on in Australian mammalogists' heads when it came their turn to christening animals. Botanists had so often attached lyrical names to trees like Blush Butternut, Satin Sycamore, Brown Bollywood. Ornithologists could roll off names like Zitting Cisticola and Spangled Drongo. Even cold-blooded herpetologists occasionally waxed poetic with words like Scarlet-sided Pobblebonk or Retro Slider. But what flush of inspiration propelled mammalogists into calling a dreamy, caramel-eyed, monkey-faced, woolly-furred, flower-sniffing possum...a Common Ringtail? Such a soulless name, and so parochial because there are any number of places where this ringtail is just not found.

Then the penny dropped when I remembered that those very people who gave everyday names to mammals were probably about the same vintage as my grandmother. It all suddenly made sense, but only because I'd been caught by her so many times picking my nose or peeing in the roses. On those occasions she referred to me as being "a common boy". At her end of the generation gap any activity that could not be undertaken comfortably in the company of Queen Elizabeth was regarded as 'common'.

I can think of a thousand reasons why a brushtail possum might qualify as 'common'. The Common Brushtail (*Trichosurus vulpecula*) nests, copulates and brawls inside your ceiling, its urine percolates through your walls, and its gurgling, choking and heavy breathing make you wonder which side of the grave you've woken up on. But surely not 'common' our charming ringtail *Pseudocheirus peregrinus*?

Its realm is one of quiet composure, functional happy families, delicate vegetarian cuisine and gently swaying treetop nests. True, there are always the usual challenges of the 6pm–6am shift—tightrope-walking along the electricity lines, dodging cars on the highway, escaping from Dogs, Cats and big owls, maybe even dropping flinty nuggets and golden showers on humans with torches below. But the 6am–6pm shift makes up for it all; rocking slowly in the breeze way up in a cosy nest, sleeping, yawning, snuggling up to mates and the babies, scratching, looking out at the view.

What smutty particulars did early mammalogists know about this ringtail but chose to stay tight-lipped about?

Well, here is one suggestion revealed by the research of Michael Chilcott (while at the University of New England) as late as 1984. Between 6am and 6pm the ringtail is not just sleeping and yawning, snuggling and scratching. Oh no! In spite of a night spent eating gum leaves, mango flowers and rosebuds, it's still thinking, "Where is my next meal coming from?". The answer to that question is...it's own derriere!

Around 16 times a day, while curled into an innocent ball that has the animal's face resting conveniently in its crotch, the charming possum nuzzles its cutlery toward the oven and pulls out three or four steaming hot, juicy profiteroles that it then chews up and swallows. Now, could 'one' comfortably perform that act in the presence of ERII? No, and hence the name Common Ringtail! Some might even say Very Common Ringtail!

Coprophagy (poo-eating) can be a confronting issue, but there is coprophagy and coprophagy. I remember being simultaneously fascinated and appalled when, as a young zoo-goer, I used to see many a captive Chimpanzee take delivery of a nasty-looking handful of its own yellow faeces and, with an eye on covetous neighbours, transfer the load to where its puckered bottom lip could slowly skim off enough for it to mumble on for five minutes or so. Polishing off the whole fistful might occupy the Chimp for half an hour, just like a Dairy Queen might occupy a bored child for a similar period. But Chimps don't do this naturally. In those days the bored, frustrated creatures were

Common Ringtail Possum

Pseudocheirus peregrinus

Classification
Family Pseudocheiridae.

Identification
Colour varies (grey to brick-red) with locality. Body fur woolly (never shaggy), tail thin (never bushy) and tip always white. Sexes similar in size, head–body length 320 mm, tail 320 mm, weight around 1 kg.

Habitat and Distribution
Rainforest to dry woodlands, heaths to capital cites, in a broad 'coastal' sickle-shaped band along eastern Aust. and Tas.

Biology
Nocturnal and mostly arboreal. Lives in small family groups. Usually silent but produces cricket-like whistles and warning 'tock-tock' calls. Eats leaves, flowers, fruit. Builds basketball-like nest ('drey') in thick crown vegetation. Twins born autumn to spring.

BY STEVE VAN DYCK

Just how appropriate is this ringtail's common name?

PAVEL GERMAN

kept in impoverished conditions that bred compulsive, unnatural behaviours, coprophagy being one of many.

Natural coprophagy, on the other hand, is most often encountered in Rabbits and rodents. To the horror of many owners, their pet rats and Guineapigs are often found munching on their own stools. But (and in spite of Hilton accommodation) this behaviour is completely normal. In fact, Guineapigs have been shown to die after seven days if denied access to their first-rounders. By re-working their droppings these animals are provided with more essential nutrients than were yielded up by cellulose-fermenting bacteria on the initial passage through the gut. The re-chewing further reduces food particle size meaning microbial fermentation can act on a far greater surface area of cellulose the second time than it could the first, so more energy is released.

But how does a coprophagic animal know which ones to recycle and which ones to dump? In Common Ringtails it's all a matter of timing. They produce two distinctly different faecal pellets. There is the 6am–6pm caecum-special that is irresistibly soft, moist, high in nutrients and very aromatic, and then, after dark, there is the rectal-standard, that is hard, dry, fibrous and bland—best dropped and forgotten. By recycling, the Common Ringtail increases enormously not only its nitrogen intake but also the amount of digestible energy retrievable from a diet that is often nothing more exciting than a bunch of gum leaves.

For a Common Ringtail, daytime poo-eating is a drowsy, pampering pastime not so many evolutionary steps away from that encountered in the Common Human where, curled up in a lounge chair, a semiconscious individual may still manage to transfer small brown nuggets from its lap to its mouth while occasionally grunting, passing wind or cheering, before sliding back into a coma...Sunday afternoon football and beer nuts. What could be closer to life in the trees?

So, enlightened by all this modern science, is it time to give the Common Ringtail an exciting new name that celebrates its unique marsupial achievement, say the Ginger Dunggobbler? I can't really see this endearing the species more to humans or raising its profile in the conservation stakes. Maybe we should just stick to Common Ringtail and keep the tacky secret to ourselves. Or maybe a compromise... the Common Ring-picker.

And what would my purse-lipped grandmother's generation say to that? "We are not amused"! □

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Blind Gudgeon

This was the first aquatic cave-dwelling vertebrate described from Australasia.

WHEN THE BLIND GUDGEON (*Milyeringa veritas*) was described in 1945, from specimens collected at Milyering Well, on the North West Cape of Western Australia, it sent ripples through the scientific community. This was the first aquatic cave-dwelling vertebrate described from Australasia.

The Blind Gudgeon, which attains a modest length of five centimetres, has a white translucent appearance, lacking eyes and skin pigmentation. Eyes are surplus to the needs of a fish that spends its entire life in darkness. The scale-less head is ornamented with elaborate rows of sensory papillae, capable of detecting pressure waves in the water. This well-developed sensory system acts like a motion detector, enabling effective navigation and location of prey in a sun-starved environment.

Since its original description, the known distribution of the Blind Gudgeon now includes a wider area of the coastal plain and the Cape Range of the North West Cape, and Barrow Island, farther to the north. It lives in various habitats, including small rock pools, shallow open caves, flooded sinkholes, deep bores, old wells and deep inland caves, all within limestone beneath the ground. Groundwater levels in these subterranean systems rise and fall with the tide, for up to about 3.5 kilometres inland. The fish are found close to the coast and up to 4.3 kilometres inland in a system where fresh to brackish water overlies a seawater layer that is affected by marine tides.

Little is known of the biology of the Blind Gudgeon, but analysis of its gut contents shows it feeds primarily on terrestrial invertebrates (isopod crustaceans, ants and cockroaches) that are accidentally introduced into the aquatic system, but also blind aquatic shrimps (family Atyidae). By necessity, the gudgeons sampled were from 'portholes' where access allowed collecting. Such sites represent less than one per cent of the total area of their potential habitat, so these dietary data are biased towards gudgeons living near these windows to the underworld. Gudgeons living away from sources of terrestrial insects may rely more heavily on shrimps.

Eyes are surplus to the needs of a fish that spends its entire life in darkness.

The Blind Gudgeon moves widely in the water column and may hover in mid- and surface waters. Movements appear slow and deliberate (almost casual), as it has no known natural predators. It shares its aquatic subterranean habitat with the Blind Cave Eel (*Ophisternon candidum*). Together, these two fishes comprise the only vertebrate troglobites (permanent cave dwellers) known from Australia.

The Federal *Environment Protection and Biodiversity Conservation Act* 1999 lists the Blind Gudgeon as Vulnerable, while the Western Australian *Wildlife Conservation (Specially Protected Fauna) Notice* 2002 lists the species on Schedule 1 ('Fauna that is rare or likely to become extinct').

Although some of the caves and wells inhabited by the gudgeon fall within the Cape Range National Park, a number of potential threats still linger. Water extraction for urban and rural communities may lower the watertable and increase groundwater salinities. Limestone quarrying, mineral exploration

BY JOHN POGONOSKI

and associated road construction may contribute to declining water quality from terrestrial pollution sources. Infilling or siltation of wells and boreholes reduces habitat availability. And recreational SCUBA diving in the Bundera Sinkhole can disrupt the complex chemico-physical attributes of the water body.

Caves are open systems, and changes to the catchment or cave entrances that alter inputs of water and organic material may have major effects on cave communities. However, our lack of knowledge of groundwater habitats often hampers informative management of potential threats. Difficulties arise in distinguishing human-induced changes from naturally occurring fluctuations. Accurate monitoring of groundwater levels and salinity could contribute to our understanding of these complex systems. In addition, the continuity of the coastal aquatic fauna beneath the Cape Range is unknown because the fauna has not been sampled in areas that lack wells or similar portholes. Uncertainty about the extent of the interconnection of the fauna in the coastal system(s) complicates potential management of the region.

Rigorous scientific investigation of the unique subterranean fauna and habitats of the North West Cape and adjacent Cape Range will help elucidate the gudgeon's secrets. □

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GEOFF TAYLOR-LOCHMAN TRANSPARENCIES

Rainforest: defining the impossible

Australians use the 'R' word more promiscuously than anyone else.

Rainforest trees were once thought to differ from open forest trees by not having tough leaves, but Scrub Cherry (*Syzygium australe*) is one of many rainforest trees with leaves that are anatomically sclerophyllous.

TO BE AN EXPERT MEANS TO question matters everyone else just takes for granted. Take rainforest in Australia. Botanists can't agree about what, exactly, it is. Arguments about its meaning have raged in the land courts. Almost every possible defining feature, from a need for ample rain and fertile soil to an absence of tough leaves, fails under close scrutiny. Some experts have tried to banish the word altogether. To botanist David Bowman (Charles Darwin University), a critic of every definition, rainforest is "a terminological warzone". He has written a whole book about its meanings and doubts an accepted definition will ever emerge.

While everyone agrees that the dark, wet forests in northern Queensland are rainforests, uncertainty mounts when you visit drier and colder places and when you consider certain plants. Classic rainforest is tall and evergreen with a closed canopy, but venture west from the mountains of eastern Queensland and you encounter related vegetation types that are variously stunted, deciduous or open. The 'dry rainforests' of inland Queensland are accepted as rainforests because they share species with wetter rainforests, and are linked to them by intermediate plant communities. But travel far enough and your definitions collapse.

One Northern Territory botanist rattled colleagues by classifying a wattle shrubland (dominated by Lancewood, *Acacia shirleyi*) as rainforest. When wattles, eucalypts, cypress pines and Brush Box (*Lophostemon confertus*) mingle with obvious rainforest plants they trigger nomenclatural anguish, for these are the very kinds of plants that epitomise what rainforest is not. Botanist Alex Floyd has argued that Brush Box on steep shady slopes is a rainforest tree, but Brush Box in fire-prone sites is not.

In Tasmania, rainforest in the mountains grades effortlessly into subalpine and alpine heath, obliging botanists there to apply an arbitrary cut-off point, whereby heath turns into rainforest when its canopy exceeds five metres. Mangroves are sometimes included as rainforests but most botanists don't like this idea, partly for the simple reason that mangroves are managed as wetlands.

Botanists overseas cannot help us clarify our meanings because Australians use the 'R' word more promiscuously than anyone else. What they call 'monsoon forest', for example, is usually a type of rainforest to us. As Bowman said in a talk on rainforest, "Australians have taken a word and changed it, stretched it, and actually made it incredibly interesting." African botanists until recently seldom mentioned rainforest at all, just saying 'forest'. North Americans apply the label to redwood stands on the west coast but not to the hardwood hammocks of Florida, although these fit the criteria of rainforest, having closed, evergreen canopies and a ground cover of leaf litter and ferns. I suspect that many Australian botanists, if let loose in the northern hemisphere, would classify beech and oak forests as 'rainforests', with good reason.

'Rainforest' has evolved a unique meaning in Australia because fire is so central in structuring our habitats. Eucalypt forests tolerate repeated fires; rainforests cannot. Bushfires draw sharp boundaries between the two habitats, killing any rainforest saplings that dare sprout in the eucalypt understorey, sharpening the sense of what is rainforest and what is not. Rainforest in Australia is more about flame than rain. 'Vine forest' has been offered as an alternative name because most vines, having thin bark, cannot tolerate fire and do best in rainforests. ('Closed for-

BY TIM LOW

est' has been promoted as another alternative name.) One could almost define rainforest as forest that does not tolerate repeated fire, except there are other habitats like this, notably mangroves, alpine heathlands, and thickets of mulga, cypress and she-oaks.

The latest contribution to this terminological saga comes from Jasmyn Lynch (Australian National University) and John Neldner (Queensland Herbarium), who have published a new definition of rainforest in the *Australian Journal of Botany*. It is unavoidably cumbersome, so I won't repeat it here, but one criterion they use to define rainforest plants is the ability to germinate in the dim light of forests or in small natural canopy gaps. This rules out most wattles and other interlopers. But they were troubled by wet sclerophyll forests, where obvious rainforest plants grow beneath tall eucalypts as part of a successional process.

Will their definition take hold? Time will tell, although Bowman doesn't think so. A workable definition really matters, because a designation as 'rainforest' may save a forest from logging. The word also matters conceptually, because 'rainforest' is taken to be our oldest surviving vegetation type, the habitat in which many animal lineages arose. But it's difficult to define something that varies so much across a continent, from montane Tasmania to gorges in the Kimberley and sand dunes in Queensland.

The botanist Robert Hill (University of Adelaide) has ably summed up the problem: "Rainforest is difficult to define in Australia for one very obvious reason—it is more than one thing. We are obsessed with definition because it allows us to order a complex world. However, sometimes our definitions fail because the world is too complex for them. Such is the case with rainforest in Australia." □

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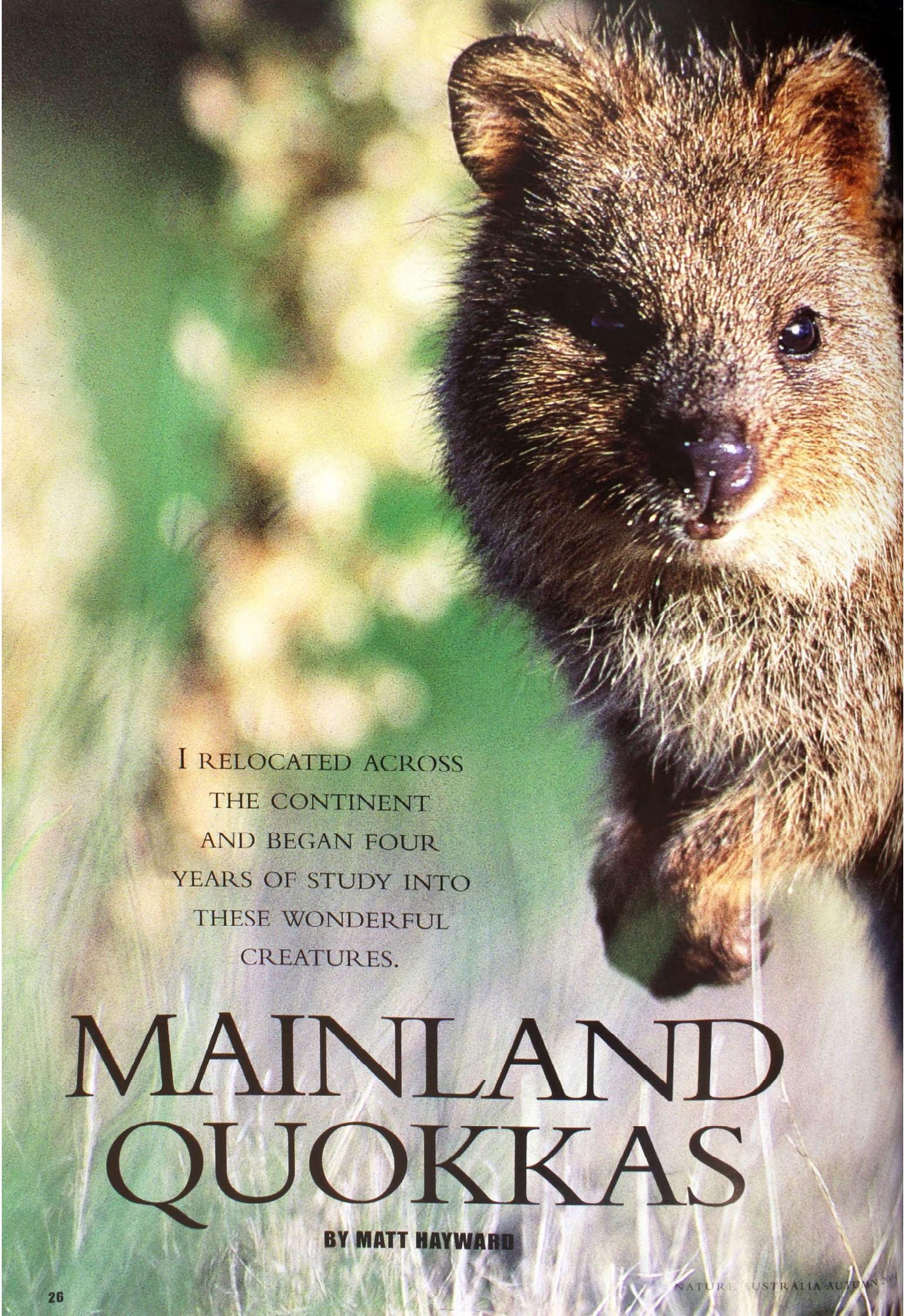
PHOTOS: TIM LOW

Peanut Tree (*Sterculia quadrifida*) is an example of a rainforest tree with deciduous leaves, often found in monsoon forests. The black nuts borne in the red capsules are edible.



I RELOCATED ACROSS THE CONTINENT AND BEGAN FOUR YEARS OF STUDY INTO THESE WONDERFUL CREATURES.

MAINLAND QUOKKAS

BY MATT HAYWARD

While Quokkas are common on Rottnest Island, they are rarely seen on the mainland.

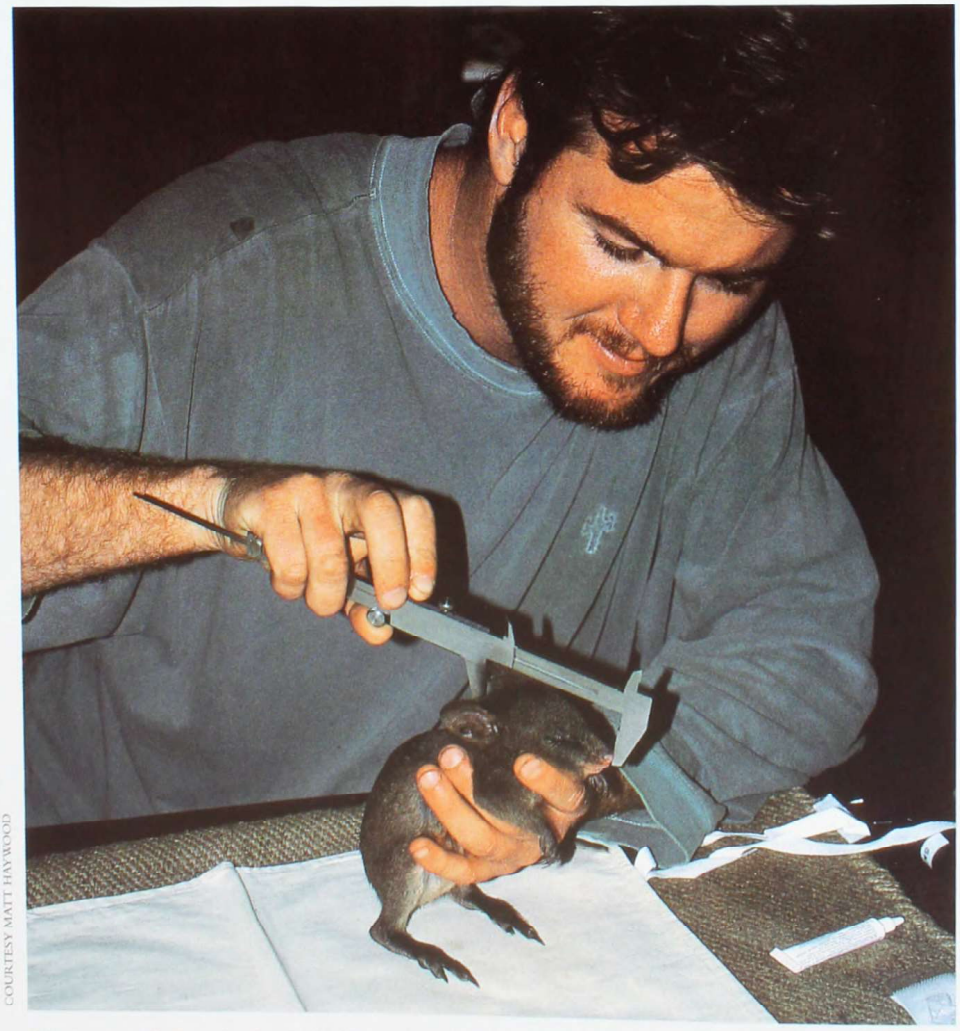
JEAN-PAUL FERRERO/ARDEA.COM

In 1658, Dutchman Samuel Volckertzoon explored the west coast of Australia and mentioned a small "wild cat" he found on one of the offshore islands. When his countryman Willem de Vlamingh landed on that same island 38 years later, he described the animal as a "kind of rat as big as a common cat" and named the island 'Rottenest' meaning 'rat nest'. Today we spell the name differently, but the tourist Mecca of Rottnest Island, 18 kilometres west of Fremantle in Western Australia, has become synonymous with the animal these early explorers described. The 'rat-like' creature was originally known by the local Aboriginal people as the Quokka and this remains its common name today.

Its abundance and the ease with which the Quokka can be studied on Rottnest Island put it at the forefront of Australian marsupial research in the 1960s and '70s. Yet today few people are aware that the Quokka also occurs in the south-western corner of the mainland. Here the species is scarce and considered vulnerable, and in 1998 the Western Australian Department of Conservation and Land Management sought detailed knowledge of its mainland ecology to help conserve it. I was fortunate enough to be selected for the research project. I relocated across the continent to a tiny town in the heart of the Jarrah forest called Dwellingup and began four years of study into this wonderful creature.

Quokkas (*Setonix brachyurus*) originally occurred along the coast and adjacent high-rainfall, forested areas from Jurien Bay, 200 kilometres north of Perth, to 50 kilometres east of Albany. The arrival of the European Fox (*Vulpes vulpes*) in the 1930s coincided almost exactly with a dramatic decline in this distribution and, coupled with altered fire regimes and urban development, the Quokka now occurs as isolated populations on the Darling Plateau to the east of Perth, south through the Jarrah and Karri forests and along the coast to Two Peoples Bay. There is also an isolated population in the Stirling Ranges. The Quokka still occurs in abundance on Rottnest Island, as well as Bald Island on the south coast. I decided to conduct my studies in the northern half of the Jarrah forest, which is the northern limit of the Quokka's range today. My goal was to gather basic ecological data on the Quokka and try to work out the causes of the decline and its continued threatened status.

I first set about trapping Quokkas.



COURTESY MATT HAYWOOD

After two months trapping I was finally rewarded with an adult female Quokka with this large joey in her pouch.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Quokkas on Rottnest Island often seek vegetation and logs as refuge from the heat during summer. In the mainland swamps, the dense vegetation provides refuge from Foxes as well as climatic extremes.

This was no easy feat as the Quokkas live in densely vegetated swamps, making placement of the one-metre-long traps extremely difficult. Nearly three years of bleeding arms and legs from such botanical terrors as Saw-toothed Acacia (*Acacia divergens*), Prickly Moses (*A. pulchella*) and Holly-leaved Mirbelia (*Mirbelia dilatata*) attested to that. And the presence of Water Bush (*Bossiaea aquifolium*), whose cupped leaves carry water long after it has rained, and regular winter flooding meant that fieldwork was not entirely as I had dreamt. Still, the sight and smell of these plants during the spring wildflower season made up for it.

After two months of setting traps for Quokkas at sites where they had been captured several years previously, I hadn't seen or captured even one individual and things were looking bleak. My mother was so concerned that she flew from Sydney to Perth and insisted I accompany her to Rottnest Island so that I could see what a real live Quokka looked like. (I was relieved to learn that I hadn't been releasing Quokkas under the assumption they were just funny-looking bandicoots!)

Eventually I was rewarded and on a sunny spring morning in 1998 I caught my first mainland Quokka. It was a fluffy-faced female—nothing like the haggard-looking Quokkas I had seen on Rottnest—and she had a fully furred joey nervously peeping from her pouch. I took her back to the Dwellingup Research Centre and, under the tutelage of my colleague Paul de Tores, sedated her, weighed and measured her, and attached a radio-transmitter around her neck.

New individuals at this site trickled into my traps and the low recapture rate suggested the population was tiny (less

BILL BELSON/LOCHMAN TRANSPARENCIES

(Left) An almost fully weaned Quokka joey with its mother.

Quokka

Setonix brachyurus

Classification

Family Macropodidae. Sole member of the genus *Setonix*.

Identification

Adult females 1.6–3.3 kg, males 2.5–4.5 kg. Head–body length 47–55 cm; 30–cm-long, almost hairless tail with rings not dissimilar to those of rats. Fur grey-brown with rufous tinges between ears and on chest of males.

Habitat and Distribution

On mainland restricted to higher-rainfall areas of south-west Aust. where it inhabits dense vegetation and is restricted to *Agonis linearifolia* swamp shrublands in Jarrah forest with a mosaic of post-fire age classes. Also occurs on Rottnest and Bald Islands, WA.

Biology

Breeds throughout year on mainland, while on drier Rottnest Island gives birth in late summer and autumn to wean young in spring when there is plenty of food. Browses on a wide range of shrubs, but targets *Dampiera* and *Thomasia* shrubs in the Jarrah forest.

Status

Vulnerable.

ELIZABETH TASKER/WILDLIFE IMAGES

than 15 individuals). The frustrations and difficulties of fieldwork were immediately forgotten on the 281 out of 21,287 occasions that I opened the traps to find a Quokka. Nonetheless, I continually lamented the fact that Quokkas on Rottnest Island can be captured by simply tossing a net over them or even by hand.

I trapped at eight sites in total—each of which was previously known to have a Quokka population, or where there was evidence (scats or characteristic runways) that Quokkas were present. Three of these were found to now be extinct, one possessed a lone adult male, two had populations of less than 15, and the other two each had over 30 individuals. Despite six years of feral-predator control (mostly for Foxes, but Cats as well), Quokkas on the mainland appeared not to be responding.

Perhaps predation wasn't a big issue for Quokkas. I attached radio-transmitters to almost 60 individuals and measured their survival for two years. Only eight collared Quokkas died and, of those where the cause of death could be identified, three were eaten (two by Foxes, one by a Cat) and two males were hit by vehicles as they crossed a road. A simple life-history model of births and deaths suggested that current rates of adult and juvenile survivorship should allow population recovery. The fact that this hadn't happened suggested pouch young mortality may be the problem, although I haven't been able to confirm this.

The radio-transmitters also allowed me to track the Quokkas' movements. I was concerned that the Quokkas might only have been able to move small distances, which would inhibit their ability to colonise new sites. However, I found that their mean home-range size is a sizeable six hectares, linear in shape (100 metres by 600 metres) and centred on a swamp. I also found that Quokkas often

(Right) The diet of the Quokka is catholic, ranging from the succulent Pigface (*Carpobrotus*) and saltbush on Rottnest Island to over 27 shrubs and sedges on the mainland. They have also been reported eating snails, and feasting on human refuse at the garbage dump on Rottnest Island.

travel the length of their home range in an evening, which would be adequate for them to colonise new areas. Still, despite being able to move such distances, there was no evidence of any dispersal between sites. Perhaps this is because of their low population densities. Maybe when populations reach carrying capacity we can expect to see greater dispersal.

I also studied the habitat use and preferences of the Quokka to see if habitat availability was limiting the anticipated population increase following predator control. In the northern Jarrah forest, Quokkas inhabit swamp shrublands on the wetter, western side of the Darling Plateau, dominated by the Swamp Peppermint (*Agonis linearifolia*). These swamp shrublands are common throughout the Jarrah forest and there is no reason to think that habitat availability at this scale is a limiting factor.

On closer inspection however, habitat may well be inhibiting Quokka increases. Quokkas show a distinct preference for areas of swamp shrubland that have been recently burnt (within the last ten years). When I investigated the diet of the Quokka in the region, I understood why. The bulk of the Quokka's diet is made up of a few plant species (notably the succulent leaves of *Thomasia* and *Dampiera* shrubs) that are more common in recently burnt swamps. So dietary requirements appear to drive the Quokka from a site when it gets too long after a fire.

A SMALL HEAD *poked out from behind a bush and a Quokka looked me up and down without concern.*

However it's not quite that simple, because the Quokkas also need long-unburnt areas within the swamp. The importance of these long-unburnt areas is obvious when one sees the immediate effects of fire on the swamp. Often the entire swamp burns, either directly killing any Quokkas present or leaving no vegetation for shelter from predation. However, occasionally small patches remain after a fire and these patches offer refuge, and also some food, until the Swamp Peppermint resprouts within weeks of the fire. Small patches of unburnt habitat allow Quokkas to survive at a site during and after a fire.

NEIL VINCENT PHOTOGRAPHY

The presence of water throughout the year on the mainland allows the Quokka to breed continuously in contrast to Quokkas on Rottnest Island, which give birth in late summer and early autumn. This, and the presence of Foxes on the mainland are the two major reasons for the ecological differences between the two Quokka populations.

ONCE I PUT ALL THIS INFORMATION together I was able to make recommendations on how best to manage the Quokka's mainland habitat to maximise its chances of survival. Most importantly, the monthly feral-animal control must be continued at known Quokka population sites, as well as being increased to any new sites discovered. Although Quokka numbers haven't soared as a result of control, they would probably collapse without it. Second, a regime of tiny and delicate prescribed burns at known sites should be implemented every ten years. By creating a mosaic of vegetation age classes we may be able to accommodate the habitat requirements of other

JEAN-PAUL FERRERO/AUSCAPE

species that live in the region but do not thrive in recently burnt areas. One such example is the Red-winged Fairy-wren (*Malurus elegans*). A broader version of this fire regime should also be used on the surrounding region so that Quokkas can disperse and colonise new territory.

After being in and around the Quokka swamps of the Western Australian mainland almost continuously for three years, I can fully understand why so few people are aware of the existence of Quokkas on the mainland. I saw only three free-ranging Quokkas in this entire time, two of which I almost ran over as they scuttled across the track in front of me. And the only thing distinguishing these brown flashes as Quokkas was their radio-collar. On the third occasion, however, I did manage to get a good look. I was radio-tracking at about 3am when I heard the crackling of leaves that signified something was approaching me in the dark. Every time I turned off the loud 'beep' of the receiver, the sound stopped. This continued for a while until I had convinced myself I was about to be murdered. Then suddenly a small head poked out from behind a bush and a Quokka looked me up and down without concern. It moved out into the open, sniffed at me, and then casually hopped back down toward the swamp.

One minute of observation of a wild mainland Quokka in three years. But it's one minute I will never forget. □

Observations like these in the swamps of the Jarrah forest were just a pipedream. I only saw three mainland Quokkas outside traps in the three years I spent looking for them.

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DR MATT HAYWARD STUDIED MAINLAND QUOKKAS FOR HIS PH.D. OBTAINED THROUGH THE UNIVERSITY OF NEW SOUTH WALES. HE IS CURRENTLY CONDUCTING POST-DOCTORAL RESEARCH ON BUSHMEAT HUNTING IN AFRICA AT THE UNIVERSITY OF TRANSKEI.

A SET OF ELEGANTLY CURLED WING FEATHERS IS MANDATORY DRESS CODE FOR BOTH MALE AND FEMALE BLACK SWANS.

CURLY CUES

BY RAOUL MULDER & KEN KRAAIJEVELD

A Black Swan showing off its curly wing feathers. Both sexes possess these ornaments, which are the main focus of the authors' research project.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

IT IS AN EARLY, CHILLY MORNING in Ballarat, and the shores of Lake Wendouree—a popular recreational site—are abandoned, save for a small group of people huddled over a prostrate swan. The group is a team of researchers from the University of Melbourne, and the swan is being subjected to a curious operation. One member of the research team has just snipped off a large, flat feather from the swan's left wing. She selects another large but elaborately curled feather from a boxed collection, and deftly superglues this into the hollow shaft remaining in the skin. The same procedure is applied to another five feathers, so that the bird now sports 15 curly feathers on each wing rather than the 12 it had to start. After a few routine measurements, the swan, a young unpaired male ring-tagged with the code Z-23, is released and waddles indignantly back to the water's edge.

This feather manipulation is part of an experiment we designed to test the function of the Black Swan's elaborate ruffle of curled wing feathers. Arranged in three neat rows, these feathers play no obvious role in generating lift or propulsion for flight, and so appear to be purely ornamental. The Black Swan is the only one of the seven swan species to possess these curly feathers. In the course of our research over the past four years, we have learned that these seemingly frivolous feathers play a surprisingly important signalling role in swan society. In fact, it seems that in the contest for sexual and social success, a set of elegantly curled wing feathers is mandatory dress code for both male and female Black Swans.

FOR ALL ITS FAMILIARITY, THE BLACK Swan (*Cygnus atratus*) is a bird that has rarely been studied in the wild, and many aspects of its biology and behaviour remain enigmatic or controversial. Swans, of course, are potent icons in history and mythology, symbolising purity and lifelong fidelity. But the familiar image is that of the White or Mute Swan (*C. olor*), from Europe and central Asia. To 17th-century Europeans, black swans were simply mythical creatures that symbolised evil, and early reports that they were real were dismissed. It wasn't until two birds were actually caught in Western Australia and despatched to Batavia that the European scientific community could be convinced of their existence.

In the three centuries following its discovery, the Black Swan has been the subject of only a handful of studies, most of which have dealt either with birds in captivity, or with feral populations introduced to such diverse places as New Zealand and Austria. These studies nevertheless suggest that the Black Swan's singular appearance is matched by some unconventional social and behavioural traits. For example, one of the most enduring perceptions of swans is that males and females engage in faithful, monogamous pairings that last the whole of the birds' lives. Yet a study of captive Black Swans in the late 1970s revealed highly 'flexible' mating arrangements, with nesting recorded not only by normal male–female pairs, but also by lone females, lone males (deserted by their females after completion of the clutch), homosexual pairs (two males) and trios consisting of one female and two males.

We were intrigued by these accounts of swan behaviour, but it was their peculiar curly plumes that really captured our attention. What function did they serve? To find out, we first needed to catch some birds. This almost proved to be an insurmountable problem early in the study. We visited a

A Black Swan parent leading its cygnets to the lawns around the lake to feed. Competition between families over access to the best sites is intense.

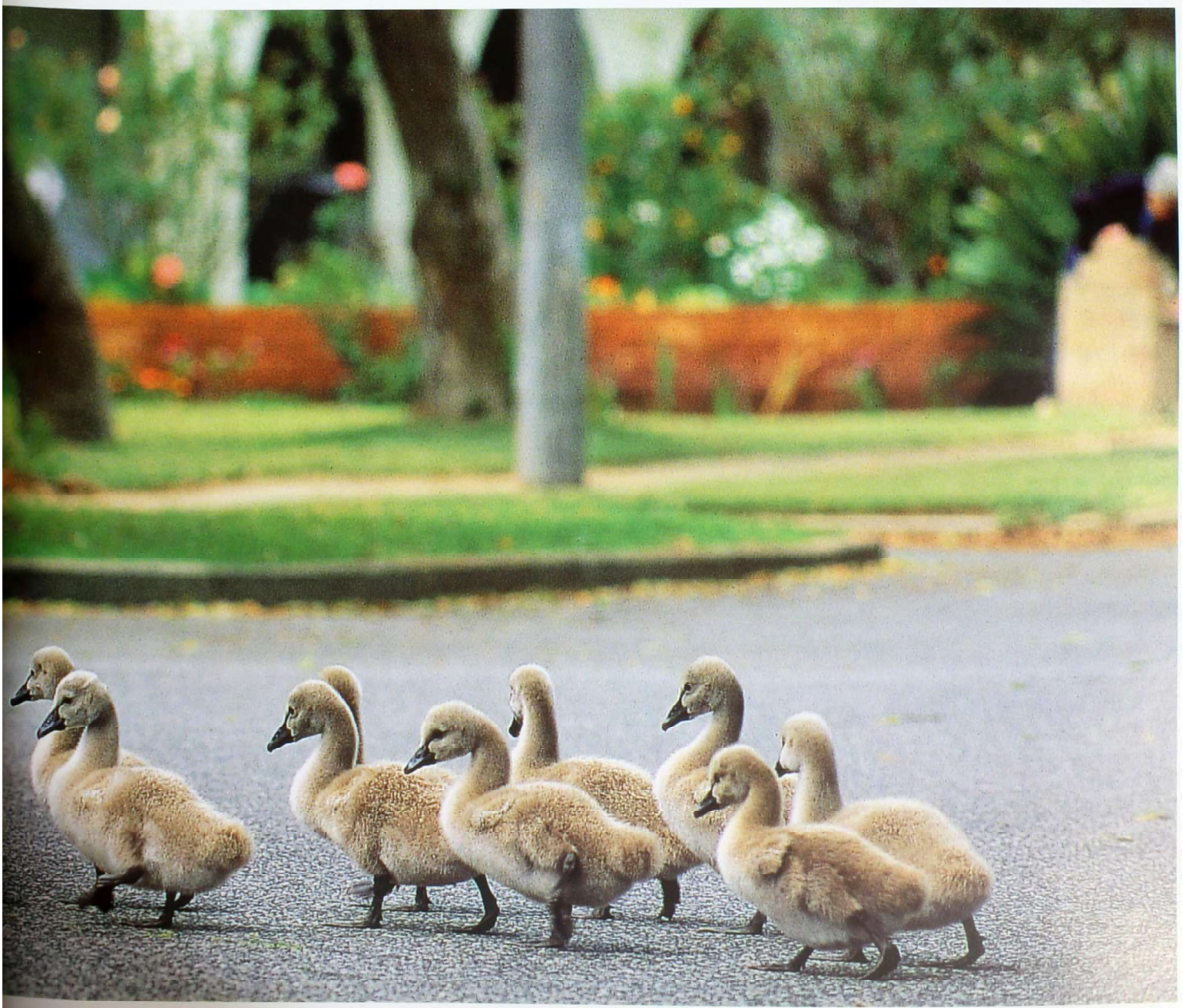
number of promising sites, only to find that the birds were so wary it was impossible to get near them. Even when we used the traditional Aboriginal technique of pursuing the birds in a canoe during their moult (when the birds are temporarily unable to fly), we couldn't outpaddle a single swan.

Lake Wendouree offered a key advantage as a study site. Decades of handouts along the shores of the lake from locals and visitors have made the swans absurdly tame. Lured by a morsel of bread, most individuals will eagerly waddle out of the water and onto shore, where they can easily be surrounded and captured by hand. Although swans have a reputation for aggressive belligerence when cornered (swans are reportedly able to break human arms with powerful blows of their wings), we have found that, once captured, the birds are surprisingly docile.

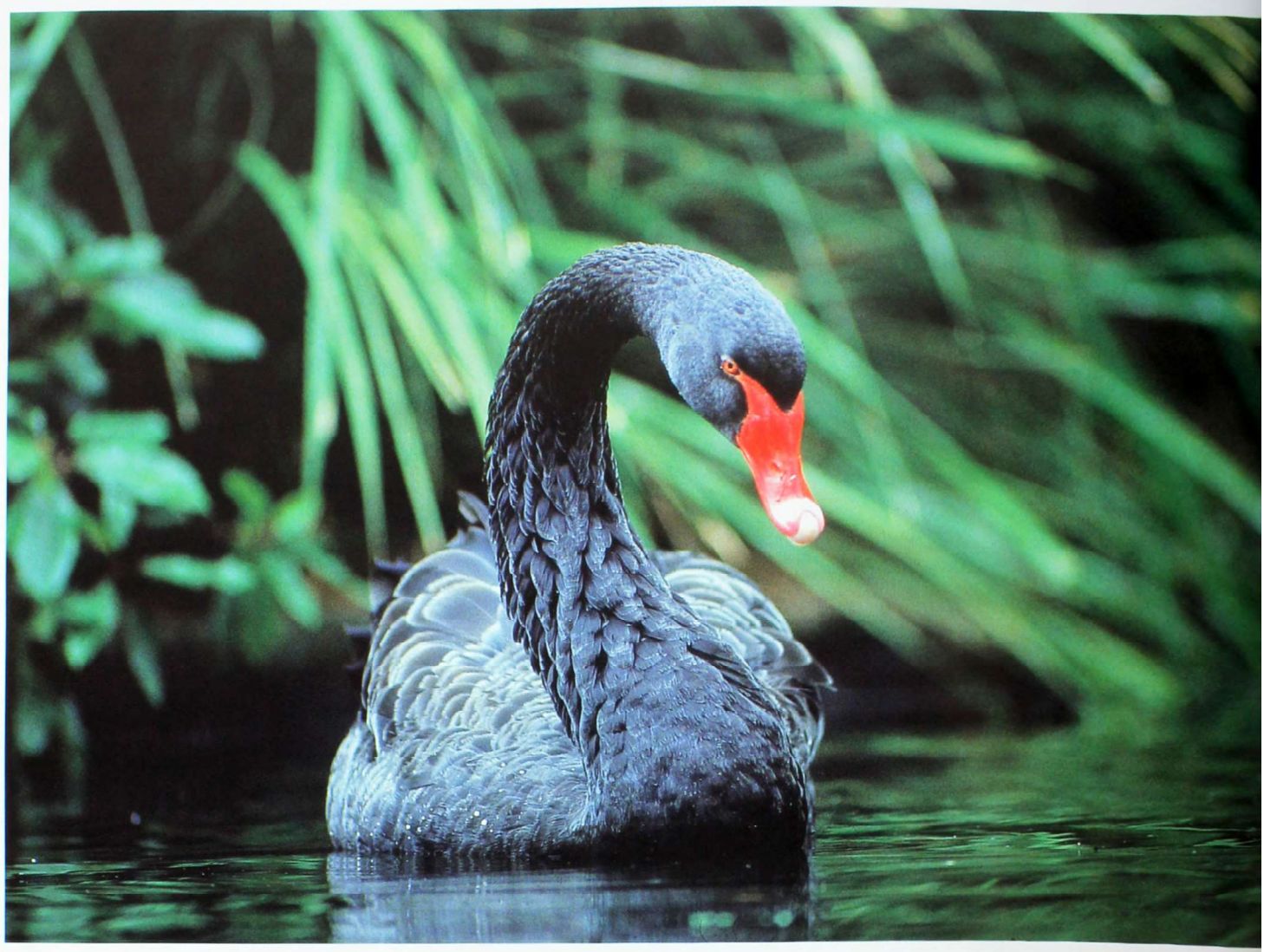
TO 17TH-CENTURY *Europeans, black swans were simply mythical creatures that symbolised evil, and early reports that they were real were dismissed.*

One of our first discoveries was that, among birds the same age, paired individuals (whether males or females) had a greater number of curly wing feathers than unpaired ('bachelor') birds. Furthermore, there was a strong correlation between the numbers of curled feathers displayed by the male and a female of a given pair. This suggests that individuals pay close attention to these ornamental feathers when selecting mating partners. By practising a form of mutual admiration (termed 'mutual sexual selection'; see "Mutual Admiration Societies" box), individuals choose mating partners with ornaments similar to their own.

The ruffles are displayed during the elaborate ritual that precedes and follows mating. Either the male, or the



DENNIS SAXON/COCHRAN TRANSPARENCIES



JOHN SHAW/AUSCAPE

Black Swan

Cygnus atratus

Classification

Order Anseriformes, family Anatidae. One of the world's 7 spp. of true swans.

Identification

Only entirely black swan species. Males and females identical, but males larger on average. Plumage of juveniles greyish brown, with brown tips to flight feathers. Weight 4–8.5 kg, wing length 44–56 cm.

Habitat and Distribution

Common in permanent and ephemeral wetlands across eastern and south-western Aust., and Tas. Uncommon in tropics. Introduced to NZ and Europe.

Biology

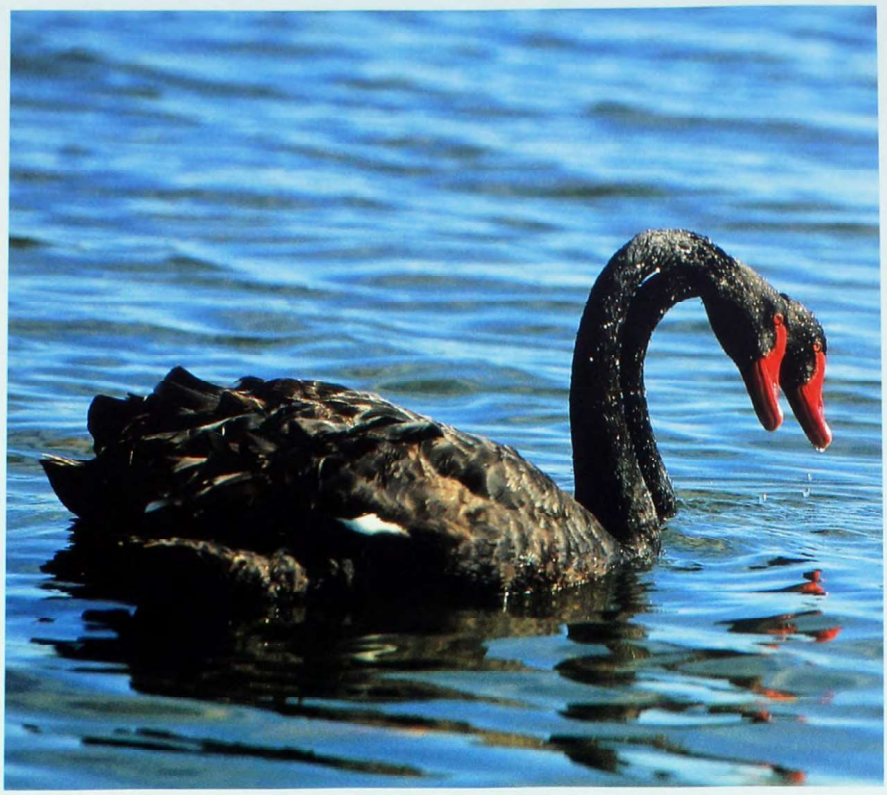
Breeds between July and Dec. Forms socially monogamous, lifelong pairs. May form colonies of hundreds of pairs. Nest is a large platform of floating debris built in reeds. Lays 5–8 eggs per clutch, generally one clutch per season. Both sexes incubate clutch for about 41 days. Cygnets stay with parents for up to 8 months.

(Above) Bachelors of both sexes hang around for years until they get the opportunity to pair up and breed.

female, may approach its mate with its neck stretched out low over the water, at times dipping it under the surface. This is a cue for its partner to respond with identical behaviour. As the two birds come together, the aquatic ballet begins in earnest. The swans now cross their necks and commence neck-dipping in synchrony for up to 20 minutes, each gracefully curved neck arched over the body of its partner. The copulation that follows this flawless choreographic routine is almost comically clumsy by comparison. The male grasps a tuft of feathers on the female's neck for purchase and heaves himself laboriously onto her back. Given that he is considerably heavier, his weight causes her to sink beneath the surface. After a few seconds (during which insemination presumably takes place under water) the female extends her neck,

(Right) Black Swans are quite vocal and utter a range of calls.

JEAN-PAUL FERRERO/AUSCAPE



JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

A pair of Black Swans feeding. Pairs tend to stay together all year, and in most cases also between breeding seasons.

Mutual Admiration Societies

Ornamental feathers are usually gaudily coloured or exaggerated in size and shape, and appear to have evolved through sexual selection, increasing the attractiveness of their bearer to members of the opposite sex. Such feathers are typically found in males, and modest plumage elaboration in their female counterparts (such as the faint wash of breast colour displayed by some female robins) has been dismissed as a genetic 'side effect' of sexual selection for ornamentation in males. Because males and females share many of the same genes—so the argument goes—intense selection for ornamentation in males leads to females accidentally inheriting some of this genetic 'baggage'.

This theory fails to explain why in many species, such as parrots, the plumage of the two sexes is similarly elaborate. One obvious explanation for such sexually matched ornamentation is that sexual selection simultaneously favours ornaments in both sexes, not just one. Yet, biologists have been puzzlingly reluctant to consider this possibility. Darwin favoured the idea of genetic correlation, and 'mutual sexual selection' was not explicitly considered until 1914, when Julian Huxley suggested it explained the synchronised displays and identical plumage of male and female Great Crested Grebes (*Podiceps cristatus*).

Seventy-five years passed before the phenomenon of mutual sexual selection attracted any further research interest. In the early 1990s, Ian Jones (Memorial University of Newfoundland) and Fiona Hunter (University of Cambridge) provided the first experimental evidence for mutual sexual selection. They studied a small seabird, the Crested Auklet (*Aethia cristatella*), in which both sexes sport jaunty crests (see Nature Strips, this issue). When model birds with experimentally elongated crests were presented to live auklets, these elicited more sexual displays from both sexes than those with smaller crests.

calls loudly and struggles to the surface, leaving the male to slide ingloriously back into the water.

The female then stretches her neck upwards, raises her wings, and resumes her loud calling. The male soon chimes in as the two birds noisily broadcast their achievement to the other occupants of the lake. Facing each other with necks stretched out and bills pointed downward, the two birds then circle each other for a short while, before preening the feathers that have just been on display.

ALTHOUGH THE CURLY FEATHERS appear to play some role in mate choice, their signalling function is not necessarily limited to the context of choosing a life partner. Black Swan pairs tend to stay together between seasons, suggesting that most pair bonds are long-term. Divorce among established pairs is rare (about five per cent of all pairs), so each individual will only rarely have to choose a new partner during its lifetime. We wondered, therefore, whether the feathers might also function as a signal to birds *outside* the pair bond, either in the context of adulterous matings, or in competition over resources.

A raft of recent studies has shown that infidelity is rife among birds, even in species where males and females form lifelong pair bonds. By taking small blood samples from swans as part of the routine capture procedure, we have been able to assess patterns of paternity by analysing their DNA. It turns out that about 15 per cent of all cygnets are not sired by their social 'father', but by another cob in the population. When we compared the number of curly feathers of cuckolded males with those displayed by successful 'extra-pair' males, we found there to be no difference. Curly feathers therefore do not appear to play a significant role in choosing mating partners outside the pair bond.

It seems very likely, however, that the curled feathers also have a non-sexual function, because they are prominently displayed in a range of contexts, many of which appear to have little to do with mating. For example, swans often resolve conflict over resources such as

H. & J. BESTE/LOCHMAN TRANSPARENCIES

Two male Black Swans beating each other with the callous knob on the front of their wings. Such escalated fights are rare, with disputes usually being settled in ritualised threat displays.

food by means of threat displays, the most common of which is 'wing lifting'. One individual will approach another with its neck curved and bill pointing downwards while its wings are lifted vertically, displaying the curled feathers to maximum effect.

If the curled feathers function as a signal of dominance, it should be possible to predict the outcomes of standoffs and fights over resources from an individual's curly feather count. We carefully recorded the outcomes of interactions involving individuals of matched sex, age and pairing status. As expected, individuals that won aggressive encounters typically had more curly feathers than their opponents.

MICHELLE HALL

Researchers at Lake Wendouree measuring a Black Swan. While the swans can be fiercely aggressive, they become surprisingly placid after being captured.

JOHN CANCALOSI/AUSCAPE

Black Swan nests are big heaps of plant material, often floating, that are continuously expanded by the incubating birds. At the time of hatching, nests of particularly industrious pairs can be up to half a metre high.

Dominance is clearly important for an individual's day-to-day access to food and other resources, but it is also vital for cooperative defence of cygnets during the breeding season. Because partners cooperate closely in raising offspring, the individual success of each partner is to a large extent dependent on the input of the other. A united pair of dominant swans is a formidable unit, and how effectively this unit asserts itself against others in battles over resources has a significant bearing on the survival prospects of the offspring. Immediately after hatching, the precocial cygnets are led to shore by the parents, where the family competes with other swans for access to aquatic plants near the water's edge. Judging by their movements, not all swan families are equally well able to hold their own in this competition. Whereas some 'resident' pairs and their cygnets could be predictably located in the same 500-metre-stretch of lake foreshore from one week to the next, other 'itinerant' pairs appeared to be continually shunted from one patch to another. Presumably, frequent movements to new locations are both disruptive and energetically demanding for the cygnets of such subordinate pairs. As a consequence, survival of cygnets with dominant 'resident' parents is significantly higher.

FOR THE CURLY FEATHERS TO BE A reliable signal, there must be costs associated with their expression, such that the largest ruffles can only be afforded by the highest-quality birds. If the feathers are costly to grow, or impede flight by generating drag, they could function as 'handicap' signals of their bearer's quality. However, if the energetic costs of the feathers are trivial (as seems more likely), this raises the question of why the system would not be open to cheating by lower-quality individuals. What would prevent such lower-quality individuals from producing a crop of feathers out of proportion to their status and quality? The answer is probably related to the significant social costs of exaggerating one's competitive abilities. Any cheating individual is likely to be found out if challenged by a genuinely high-quality individual, with potentially serious consequences in terms of injury.

Our finding that the curled wing feathers play such an important signalling function in Black Swans also begs the question of why such feathers are absent in all other swan species. The explanation may lie in some of the ecological singularities of the Australian species. Signalling traits are expected to be particularly strongly selected for in species that gather in large numbers and where individuals must assess many other unfamiliar birds. The Black Swan is unique among swans in that it commonly congregates in large colonies of many hundreds, and sometimes thousands of individuals.

If our hunch about the role of the curled feathers is correct, our feather-manipulation experiment should be revealing. By enhancing the comple-

ment of curled feathers on some (randomly chosen) unpaired individuals, and conducting a sham manipulation on others (where the same feathers are removed and replaced unchanged), we expect to have improved the pairing prospects only of the former group. Scientifically, this is the only convincing way to demonstrate that the curled feathers, and not some other, closely correlated trait, are a functionally important signal. In a few months, the swans will form pairs and start breeding. And when the breeding season is over, we hope to know exactly how Z-23's brief visit to our research salon has influenced his eligibility. □

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While Black Swans do not feed their young directly, sometimes they pull up weeds from the bottom for the cygnets to eat.

JOHN CANN

A well-fed adult Northern Long-necked Turtle. The large fat reserves allow these turtles to survive long periods of aestivation and make them a favoured food of Aborigines.

MODERN TECHNOLOGY AND ANCIENT LORE LED TO THE DISCOVERY OF A FRESHWATER TURTLE THAT DEFIED CONVENTIONAL WISDOM.

TURNING TURTLE

BY ROD KENNETT

THE METALLIC BEEP IN my headphones grew louder as I moved the receiving antenna slowly through the shallow water of the swamp and across the muddy bottom. Under the water at my feet, its position now pinpointed by the signal from the radio-transmitter, was a nest of turtle eggs that was to cause considerable excitement among reptile workers. The reason was simple: these eggs and the remarkable turtle that laid them contradicted one of the axioms of biology—that all turtles, indeed all egg-laying reptiles, lay their eggs on land. It is well known that eggs left in water will swell and rupture, drowning the embryo, hence the need for animals to find dry nest sites. However, a novel blend of modern technology and ancient lore had led to the discovery of a freshwater turtle that defied conventional wisdom and nested under water.

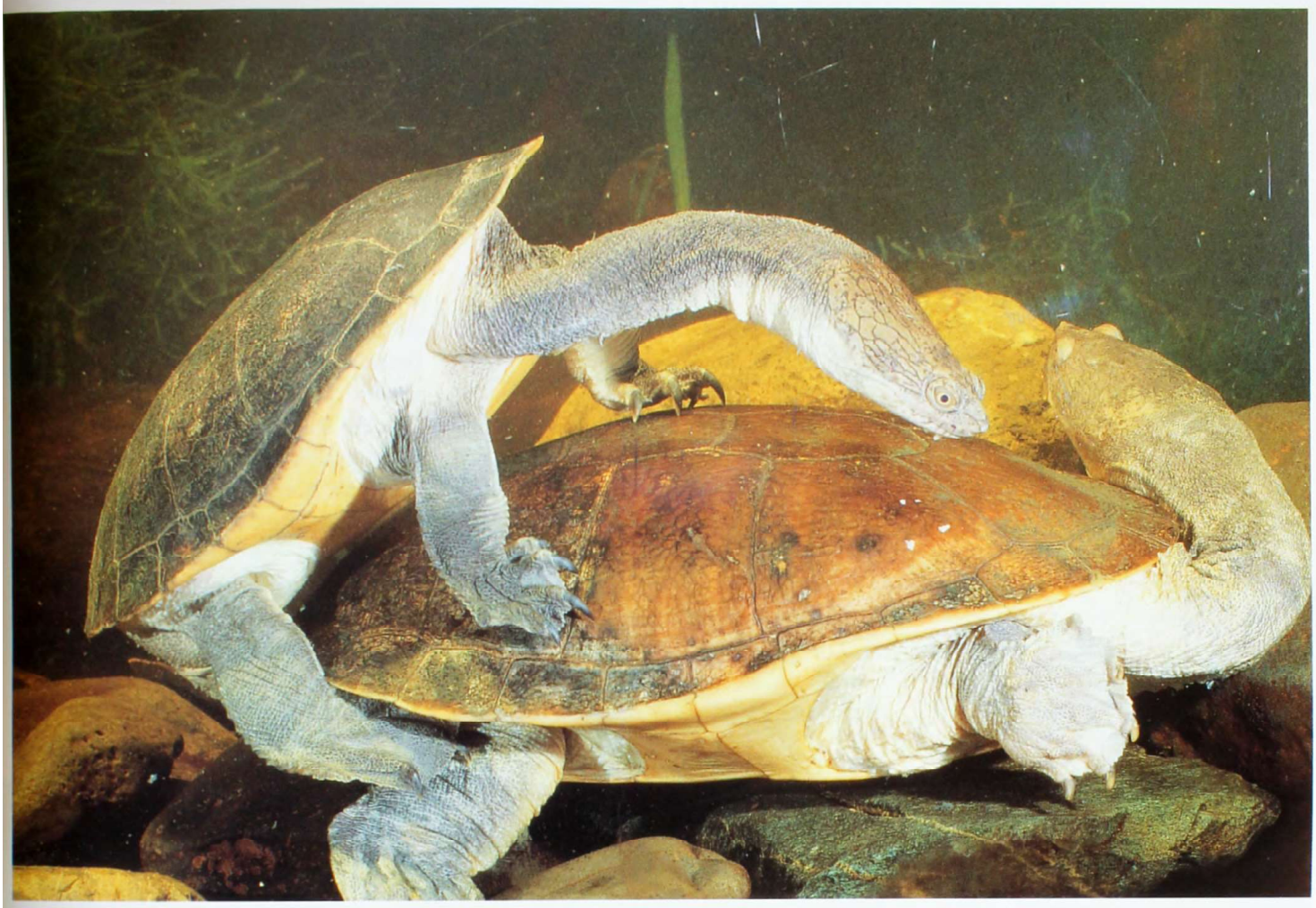
THE NORTHERN SNAKE- OR LONG-necked Turtle (*Chelodina rugosa*) is a large freshwater turtle that lives in the wet–dry tropical region of northern Australia. As its name suggests, it is endowed with an extremely long neck that enables it to strike swiftly at fish and fast-moving invertebrates. Shallow coastal floodplains are the stronghold of Northern Long-necks, and include extensive tracts of paperbark forest, grass and sedge swamps, and lily-covered channels of meandering rivers. During the wet season, turtles and other floodplain-dwellers thrive, but as the dry season progresses they must employ a variety of strategies to survive.

Despite being primarily aquatic, Northern Long-necked Turtles are quite mobile on land and are often found crossing roads several kilometres from water. This mobility enables them to escape from drying waterholes and move to remaining water. However, such journeys are hazardous, as shown by the large numbers of turtles that perish each year. Many die from dehydration or overheating. Others are captured on land or plucked from shallow water by raptors such as the White-bellied Sea-Eagle (*Haliaeetus leucogaster*).

Northern Long-necked Turtles also survive the annual drought by aestivating (the summer equivalent of hibernating). They bury themselves into the drying mud and remain there until the wet season returns. Ground-surface temperatures during the dry often exceed 60° C but just five to six centimetres of mud is enough to insulate the turtles and keep their body temperature at about 30–32° C. Even at these high temperatures the turtles are able to slow down their metabolic rate to as low as one-quarter that of resting. Prior to digging in, the turtles feed up on the fish and aquatic insects that are trapped in the drying swamps. They accumulate large amounts of fat and store water in their main and two accessory bladders. Their slow metabolic rate enables them to survive on these stored reserves for

This Northern Long-necked Turtle regurgitated a large Macleay's Water Snake (*Enhydris polylepis*) when she was captured.

R. MULDER & R. KENNETT



JOHN CANN

Mating Northern Long-necked Turtles. In the wild, mating occurs in the mid to late wet season.

what could be a long dry season.

The turtles' habit of aestivating underground, coupled with their large fat reserves and flavoursome meat, make them a favoured food of Aboriginal people in northern Australia. Aborigines are adept at locating buried turtles and collect large numbers for food every year. These meal-sized turtles, complete with their own casserole dish, have been on the bush-tucker menu for tens of thousands of years, and probably represent one of the world's longest-running and ecologically sustainable wildlife harvests.

The annual drought also has a marked effect on the reproduction of Northern Long-necked Turtles. Other turtles that live in the area, such as short-necked turtles *(Emydura* spp.) and the enigmatic Pig-nosed Turtle (*Carettochelys insculpta*), occupy permanent waterholes and nest in the mid-to-late dry season so that their eggs will hatch at the beginning of the wet. This nesting time is not an option for Northern Long-necked Turtles, because this is when they are flat out storing up fat for their own survival

THESE MEAL-SIZED *turtles, complete with their own casserole dish, have been on the bush-tucker menu for tens of thousands of years.*

or already buried under several centimetres of dried mud. Instead, Northern Long-necks nest in the wet season and this presents its own set of problems—primarily those of finding dry ground, if they had to, in thousands of square kilometres of inundated floodplain where water levels can rise several metres overnight. Nesting under water is therefore a neat but tricky solution to these problems.

THE DISCOVERY OF MY FIRST Northern Long-necked Turtle nest was entirely serendipitous. In late July 1988, while walking through a paperbark swamp from which the water had recently receded, I found a hole that had just been dug and then abandoned by a goanna. Not expecting to find much, I poked my stick down the hole, felt a crunch, and withdrew the stick to find it covered with liquid mud and egg yolk. Closer inspection revealed a nest hole containing one smashed and two intact eggs. Although the surface mud was dry, the bottom of the nest was liquid mud and obviously (I presumed) the eggs would have drowned had the goanna not eaten most of them anyway. Dismissing the nest as aberrant, I took the intact eggs home, stuck them on my shelf as curios, and forgot about them until one hatched about four months later. The second contained a dead but fully formed hatchling that had obviously developed but failed to hatch. My curiosity was certainly aroused but all I could assume was that the eggs hadn't

been in the mud long enough to kill them. It wasn't until later that I realised the significance of the discovery.

My first real suspicion that something unusual was happening came in late 1989 (about a year into my Ph.D. study on the biology of tropical freshwater turtles). Despite having caught many gravid (egg-bearing) Northern Long-necks in my shallow swamp study sites, and having regularly searched all the possible nesting areas around the waterholes, I never found any nests. To add to my frustration, goannas (particularly Merten's Water Monitor, *Varanus mertensi*) were clearly very good at finding nests. Goanna scats containing eggshells were very common around the edge of the swamp and, in many of the scats, the shells were mixed with the remains of large, black water beetles.

THE MESSAGE *was clear these eggs could survive waterlogged conditions that killed other turtle eggs.*

Perhaps the goannas were feeding on the eggs and water beetles at the same time. Perhaps the turtles weren't bothering to leave the water to nest.

The people who would know most about the natural history of Northern Long-necked Turtles are the local Aborigines, especially the women who are the best turtle hunters. So I asked around, and several women described nest sites in mud under shallow water around the base of paperbark trees. This would explain a lot, but I didn't think the scientific world would be convinced unless we found an underground nest to prove it.

Faced with a complete lack of success in locating nests, despite many long hours on my hands and knees groping around in the mud, I undertook some 'bucket and spade' biology at home. In March 1990 I injected gravid females with the hormone oxytocin, thus causing them to release their eggs. This is similar to inducing labour in humans, and in turtle research it is a tried and tested technique that does not harm the animal. Some of the eggs I placed immediately in a takeaway food container and left them to incubate on a

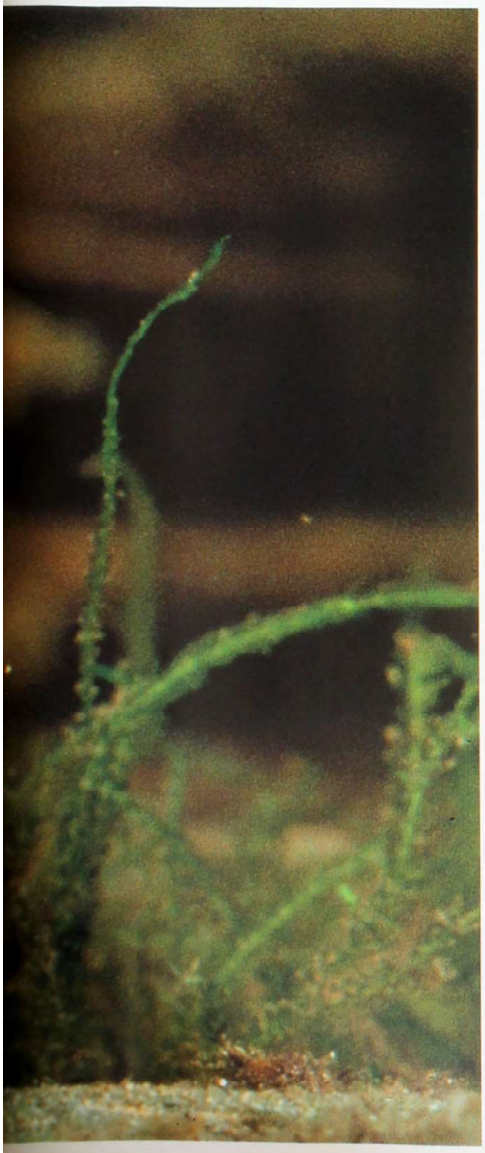
The enigmatic smile of the Northern Long-necked Turtle.

JOHN CANN

A hatchling Northern Long-necked Turtle peers out of its egg. Within a clutch of 12 eggs, incubation times may vary from 70 to 120 days.

JOHN CANN

shelf. After about ten days I could tell that the embryos had started developing because an opaque patch appeared on the uppermost surface of the egg and slowly expanded to cover most of the egg surface. I had buried the remaining eggs in buckets of mud and water from the waterhole, and after two and then four weeks I removed groups of eggs and set them to incubate like the first (control) group of eggs. Sure enough, within a week or so, all of the eggs that had been held in wet mud started to develop, and after several months most of them had hatched. The message was clear: these eggs could survive water-logged conditions that killed other turtle eggs, and those sorts of conditions are exactly what they would experience



Northern Snake-necked Turtle

Chelodina rugosa

Classification
Family Chelidae. Also known as Northern Long-necked Turtle.

Identification
Carapace (upper shell) dark brown to black, plastron (under shell) creamy but often stained brown. Neck and head nearly as long as shell, neck retracted sideways. Adults up to 4 kg and shell length 35–40 cm; females larger than males.

Habitat and Distribution
Most slow-flowing rivers and wetlands through northern Aust. Highest densities on seasonally ephemeral, coastal, freshwater floodplains where it is often the only turtle present.

Biology
Carnivorous, feeding on fish, shrimp, water beetles and other aquatic invertebrates. Matures at 4–7 years, nests 3–4 times annually during wet to early dry season, laying about 12 eggs. Aestivates under ground during dry season.

COURTESY R. KENNETT

Baited hoop traps used to catch turtles are checked by the author.

COURTESY ROD KENNETT

The author measures aestivating turtles caught in a drying waterhole in the Finniss River, Northern Territory.

if they were laid under water like the Aboriginal women had described.

The next step was to refine the experiment and learn a little more about the capabilities of these eggs. To cut a long story short, these more detailed experiments, conducted with the help of Arthur Georges and Mike Palmer-Allen from the University of Canberra, told us four things. First, eggs could survive at least 12 weeks under water (at which point we had run out of eggs). Unlike other turtle eggs, a particularly thick shell membrane that lines the insides of the Northern Long-neck's egg resists the inflow of water. Second, while eggs were immersed, the embryos did not develop (called embryonic developmental arrest) and only started once the eggs were exposed to air. Third, if eggs were re-immersed after the embryos had started developing, the embryos would die. Lastly, we found that embryonic development was also arrested if eggs were held in an atmosphere of pure nitrogen. This meant that the arrest was probably a response to a lack of oxygen (anoxia) rather than the presence of water. Ordinarily, embryos of other turtle species grow to only a very small stage (called late gastrula) and then development stops until the eggs are laid. This is believed to be a response to anoxic conditions within the female's oviducts, so the developmental arrest we observed in immersed Northern Long-neck eggs is probably an 'extension' of this type of strategy.

A likely scenario for underwater nesting was beginning to emerge. Northern Long-necked Turtles start nesting in the wet season when their swamps are full, food is abundant and long before they must direct their resources to their own survival. Because there is little dry ground available, they dig their nests and lay their eggs under shallow water. Under these flooded, anoxic conditions, the development of the embryos remains halted and does not commence until water levels fall and oxygen enters the nest. Turtles probably avoid nesting in dry ground because water levels can continue to rise and eggs that are flooded after they start to develop will drown. Warmed yet protected from the intense tropical heat in their underground nest, the developing embryos will be ready to hatch by the time the next wet-season rains begin. As the rains soften the mud and flood the swamps and billabongs, the hatchlings will emerge into their land of plenty.

THE STORY WAS CERTAINLY SOUNDING more plausible, but the problem of how to actually find a nest remained. Radio-telemetry, the technique of attaching a radio-transmitter to an animal so it can be tracked closely with a radio-receiver, offered a possible solution to finding Northern Long-necked Turtle nests but it required a novel twist.

Northern Long-necks live in swamps that have a heavy growth of aquatic vegetation and often muddy water. Following one 24 hours a day for several weeks, waiting for her to nest when I couldn't see her anyway, would be a sure waste of time. Instead I needed to track the eggs.

Together with veterinary surgeon David Pritchard (Department of Primary Industries and Fisheries) and Keith Christian (Charles Darwin University), we surgically implanted specially designed egg-shaped radio-transmitters inside one oviduct of several gravid turtles. The idea was that the transmitter would be dropped into the nest along with the eggs and so allow me to 'radio-track' the nest. As far as I could tell, nobody had tried this kind of technique before and I couldn't be entirely sure how the turtles would respond. (Two years after this work I recaught most of these operated turtles. All were in good health and at least two of them had since laid eggs.) After they had recovered from surgery, the turtles were released at their waterhole and checked every day until the radio-signal did not change location and I was sure the transmitter was no longer in a turtle. If the transmitter was not in a turtle, was it in a nest?

The answer to this question was a resounding yes! Although there was dry ground around the waterhole, two turtles had laid their eggs at the edge of the waterhole under shallow water. Northern Long-necked Turtles do indeed lay their eggs under water! If the rest of the scenario were correct then the eggs would start to develop only when water levels had subsided and the ground had begun to dry out. Within a month the mud surrounding the eggs was dry and the embryos had started developing. By the start of the following wet season they were ready to emerge from the nest. Unfortunately I wasn't there to see the hatchling turtles make their way to the surface and into their newly replenished waterhole. But clearly they have been doing just that, and will continue to do so, for many thousands of years. □

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JOHN CANN

A hatchling Northern Long-necked Turtle. The average length for hatchlings is 32 millimetres.

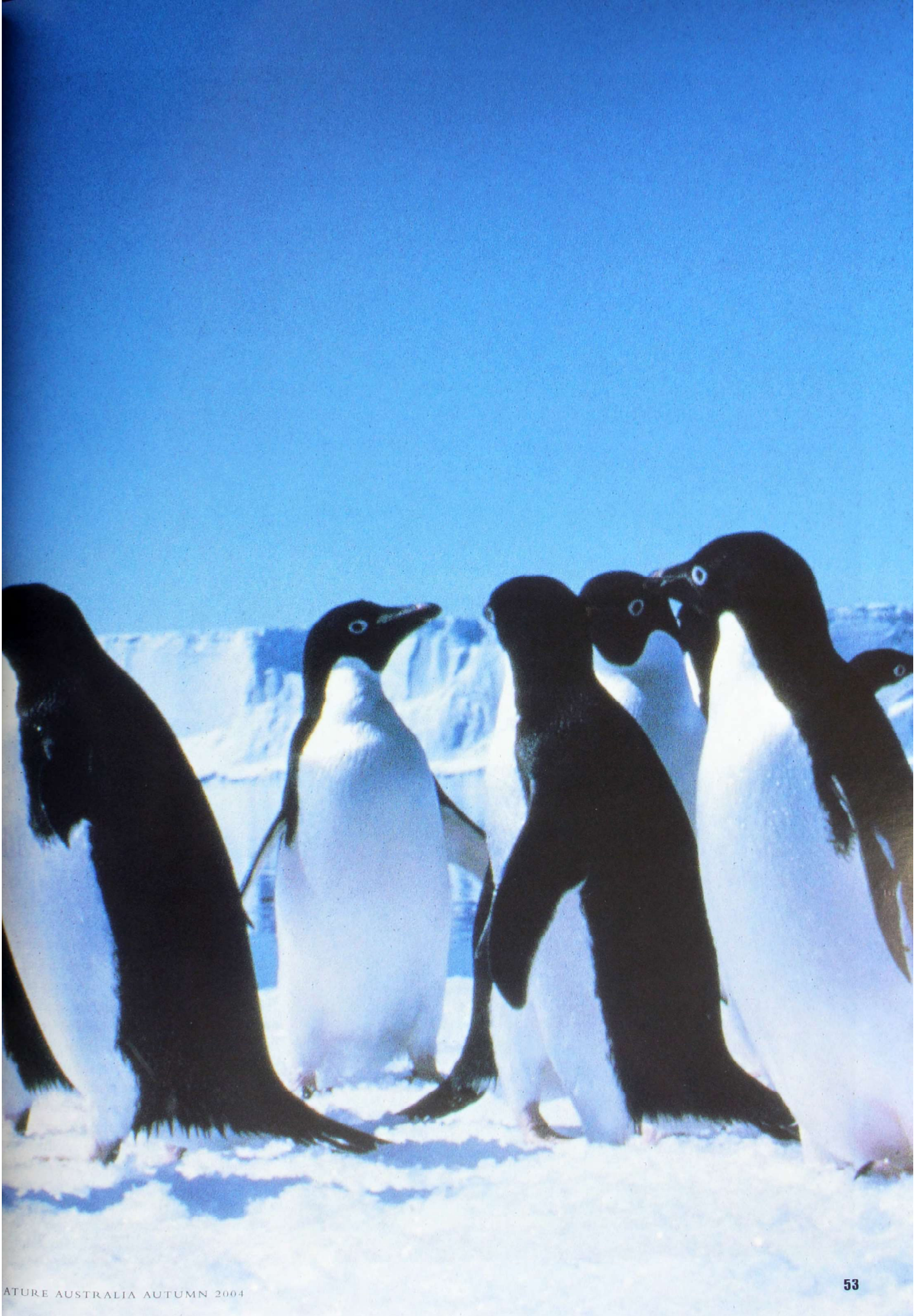
RESEARCH IS SUGGESTING THAT HOMOSEXUAL BEHAVIOURS ARE A NATURAL SUBSET OF OTHER SEXUAL BEHAVIOURS.

HOMOSEXUALS, NATURALLY

BY GEOFF MacFARLANE & KEVIN MARKWELL

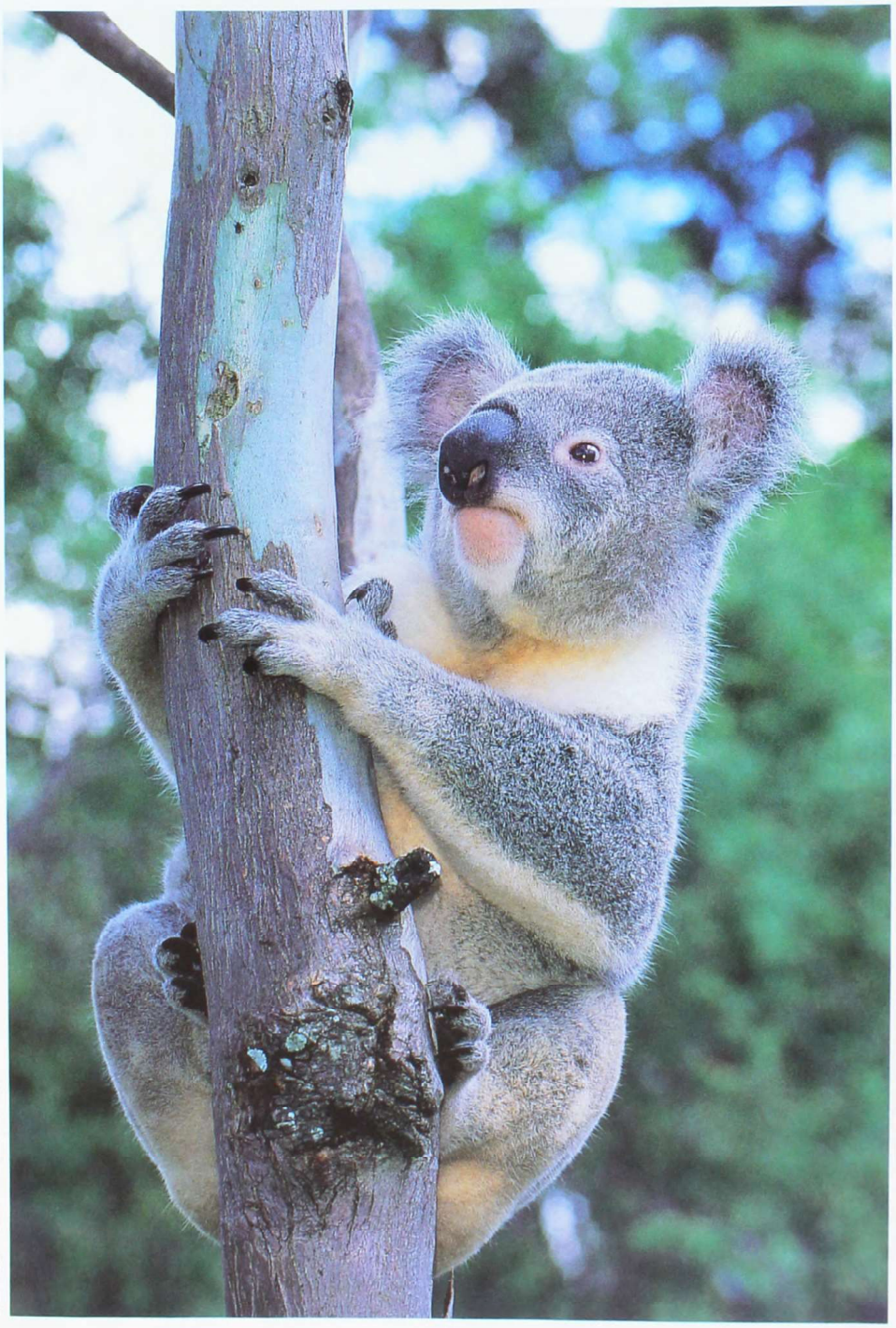
R. WATERHOUSE

Male–male mounting is known to occur in Adelie Penguins.



One of the arguments people use to oppose the acceptance of homosexual behaviour is that it is not 'natural'. Proponents of this argument tend to claim that homosexual behaviour is clearly against the 'laws of nature', that evolution has no place for homosexual activity, and that animals do not engage in same-sex sexual behaviour, at least not in the wild. If homosexual behaviour does exist among animals, it is aberrant, unusual and deviant.

What is only now emerging is scientific evidence that forcefully demolishes these assumptions and beliefs. A growing body of research is quietly accumulating in the scientific literature, suggesting that homosexual behaviours are a natural subset of other sexual behaviours, and that they occur in a wide range of mammal, bird and even reptile, amphibian, fish and invertebrate species. Homosexual behaviour is most frequently observed in highly social animals, the Bonobo or Pygmy Chimpanzee (*Pan paniscus*) being the 'flagship' species, with a staggering 50 per cent of all sexual interactions between same-sex individuals. Remarkably, more than 450 species of animals worldwide have been reported as engaging in homosexual activity.



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In the past, homosexual behaviour in non-human animals was rarely discussed. A notable exception was the famous sexologist Havelock Ellis who recognised the extent to which homosexual behaviour occurred in animal species. In his book *Psychology of sex* published in 1933, he wrote "The fundamental and what may be called 'natural' basis of homosexuality is manifested by its prevalence among animals. It is common among various mammals, and as we should expect, is especially found among the primates most nearly below Man."

In the main, though, it seems that instances of homosexual behaviour

Female Koalas may mount other females.

ERWIN & PEGGY BAUER/AUSCAPE

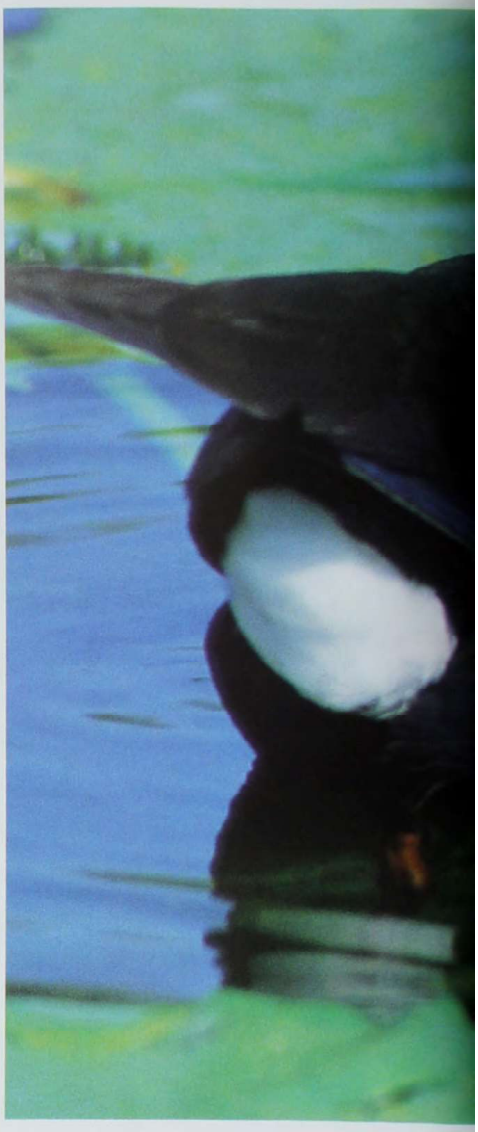
Homosexual behaviour is most frequently observed in highly social animals such as the Bonobo.

were underreported in the literature. They may have been ignored, dismissed or misinterpreted by scientists due to a moral, religious or biological bias, or a lack of appreciation of their importance. When homosexual acts are described in the literature, they are often anecdotal in nature or passed off as being 'abnormal'. Indeed, historically there has been a tendency to 'explain away' homosexual behaviours with other more socially acceptable explanations such as mistaken identities, play, or practising for later heterosexual encounters. At worst, homosexual behaviours have been viewed as dysfunctional and maladaptive. Even today, some researchers are hesitant to admit that such encounters are a normal component of many animals' sexual repertoires. It is now clear though that animals are 'doing it' with their same-sex peers across the animal kingdom, not withstanding our own Australian fauna.

THERE IS MUCH SUBJECTIVITY regarding what types of behaviour constitute homosexual activity. Indeed, in the context of human sexuality, the term 'homosexual' is loaded with social and cultural significance and other connotations such as preference or orientation. However, by defining and categorising on the basis of observable motor patterns alone, homosexual behaviour in animals refers conservatively to any interaction among individuals of the same sex (male–male or female–female) within a sexual context. Thus homosexual behaviour in animals may be defined as any behaviour usually inferred as being related to mating in heterosexual situations but exhibited by individuals of the same sex towards each other. Homosexual courtship behaviour, for example, refers to behavioural patterns that may lead to mounting or copulation, where the same or similar form has also been reported for heterosexual encounters within the same species and the behaviours were precopulatory in nature. Homosexual mounting or copulatory behaviour describes attempted and/or achieved

WITHIN AUSTRALIA,

New Zealand and Antarctica, homosexual behaviour has been documented in 25 mammal and 45 bird species to date.



intercourse.

There are also many reports in the literature of same-sex affiliative behaviours, which broadly include pair-bonding, parenting activities, and allopreening and allogrooming (where two individuals mutually preen/groom each other). All of these interrelated behavioural categories are applied loosely and viewed as integral components of heterosexual interactions of a sexual nature within the behavioural literature. Their context is rarely questioned for heterosexual interactions, even though established links to sexual behaviour often remain unclear. When these behavioural categories are applied to observations of same-sex interactions and termed 'homosexual', it becomes more problematic. Despite this, many authors have defined these associations as homosexual. Silver Gulls (*Larus novaehollandiae*), for example, may form female–female pairs, build nests and lay eggs, often forming 'supernormal' clutches of greater than four eggs. Whether these parenting and bonding arrangements are homosexual in nature is unclear. It is important for future research to establish whether such same-sex associations are homo-'affiliative' only, or also homo-'sexual', by ascertaining if sexual behaviour between individuals forms part of these associations and also examining the mechanisms of preference and mate choice in the formation and maintenance of these bonds.

Within Australia, New Zealand and Antarctica, homosexual behaviour has been documented in 25 mammal and 45 bird species to date. These include a number of notable examples of same-

Female–female mounting in Northern Quolls.

JIRIR LOCHMAN/LOCHMAN TRANSPARENCIES

T. & P. GARDNER/NATURE FOCUS

Some male and female Purple Swamphens may court and mount the same sex.

sex courtship and/or mounting, and thus may be described as truly homo-'sexual' in nature.

Several marsupials have been observed to engage in homosexual behaviour in captivity. Female homosexual behaviour occurs in Red-necked Wallabies (*Macropus rufogriseus*) and includes mounting. Female Rufous Bettongs (*Aepyprymnus rufescens*) also often mount other females, while male Agile Wallabies (*M. agilis*) may mount other males. Female–female mounting in Koalas (*Phascolarctos cinereus*) is sometimes accompanied by other distinct signs of sexual activity, such as holding the nape of the neck in the jaws, and performing pelvic thrusts. Among marine mammals, wild Bottlenose Dolphins (*Tursiops truncatus*) can form long-lasting male–male pair bonds including mounting, alternating with heterosexual activity.

Homosexual behaviour in birds is more widely documented. Wild male Superb Lyrebirds (*Menura novaehollandiae*) direct elaborate courtship displays and songs to immature males. Such male–male courtship is common, having been recorded in over 90 per cent of encounters between adult and immature males. In the Purple Swamphen (*Porphyrio porphyrio*), male–male and female–female activities, including courtship postures, the pre-copulatory hunch and mounting, have been documented in the wild.

Galahs (*Cacatua rosei*) of the same sex may engage in synchronised courtship displays, which are characteristic of long-term male–male and female–female pair bonds, both in captivity and the wild. These bonds are resistant to changes in group composition, size and organisation. Some individual's same-sex preferences remain even when their mate dies and is replaced by a new one.

Reciprocal male–male mounting has been observed in Adelie Penguins (*Pygoscelis adeliae*) under field conditions, where two males reverse their respective positions during mounting (see " 'Fairy' Penguins?", *Nature Aust.* Summer 1999–2000). Cattle Egrets (*Ardea ibis*) are also known to participate in extra-pair male–male copulations in the wild. However, rather than swap roles, the dominant-ranking male tends to stay 'on top'.

About five per cent of adult male Black Swans (*Cygnus atratus*), both in captivity and the wild, form exclusive pair bonds with other males. These bonds are long lasting, with some spanning over many years. Males engage in greeting ceremonies, pre-copulatory displays and mountings. They may temporarily associate with a female, later driving her away from the nest and

clutch, or they may steal the nest and clutch of others. Male pairs may perform all parenting duties including incubation and caring for cygnets. These male pairings are aggressive, dominant, and hence superior in terms of maintaining larger territories.

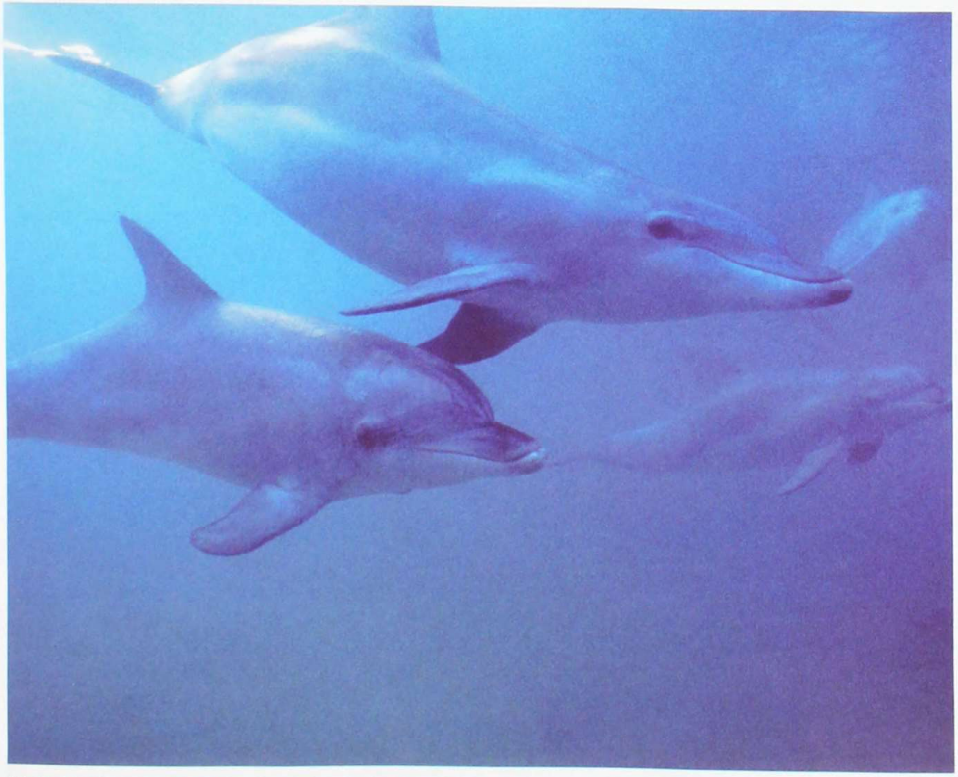
ONE OF THE CRITICISMS LEVELLED at some examples of homosexual behaviour is that they have been observed under captive conditions, and so may be the direct result of the potentially stressful conditions captivity may impose, or the absence of opposite-sex partners (the so-called 'prisoner-effect'). Although homosexual interactions can occur as the result of captive arrangements, there are also examples where homosexual interactions are preferred. For Galahs, same-sex preferences occur in captivity despite the availability of sufficient opposite-sex individuals. Homosexual behaviour may also be observed more often under captive conditions simply because infrequent behaviours such as sexual interactions are more likely to be observed under the close and continuous access that captivity affords. Perhaps most importantly, there are numerous species where homosexual behaviour has been observed with equal frequencies in both captive and wild populations, with Australian examples including the Eastern Grey Kangaroo (*Macropus giganteus*) and the Black Swan.

IT IS IMPORTANT

not to equate same-sex behaviour in animals with homosexual identities in humans.

The main argument against the 'naturalness' of homosexual behaviour relies on traditional Darwinian views of evolution, which suggest that an animal's sole purpose is to reproduce in order to pass on its genes to the next generation. If this is the case, and homosexual behaviour has a biological basis, why has it not been 'bred out' over time by individuals engaging in non-reproductive behaviours?

Despite the fact that few individuals engage exclusively in homosexual behaviour, it seems there are many possible genetic scenarios where genes may be passed on indirectly through others of the same species, such as siblings or parents. Homosexual behaviour may even confer other reproductive advantages, such as linked traits for greater sexual activity. Alternatively, homosexual behaviour may simply be selectively neutral. These hypotheses remain to be tested systematically. Homosexual behaviour may also be employed by animals in numerous social contexts, in an attempt to reduce tension, competition, aggression and conflict among individuals, or to enhance bonds and form alliances. Many of these hypotheses may hold simultaneously. Sexual activity has a whole host of functions that may be social and/or sexual in nature, and only one of which is reproduction. Perhaps in some species, sexual gratification and the attainment of



STEVEN DAVID MILLER/NATURE FOCUS

Male Bottlenose Dolphins have been observed engaging in homosexual activity.

C.A. HENLEY/NATURE FOCUS

Eastern Grey Kangaroos exhibit homosexual behaviour in both captive and wild populations.

pleasure could be among the primary motivating forces for homosexual behaviour in particular individuals. This too may apply equally to heterosexual encounters. In other words, homosexual acts may have no evolutionary or reproductive benefits, but rather are maintained because they 'feel good'.

Being aware of same-sex behaviour in animals can have practical implications for behavioural studies. In many species of birds, there are often little, if any, easily distinguishable features that discriminate the sexes. Numerous studies rely on behaviour during copulation to determine the sex of individuals. The potential occurrence of same-sex sexual interactions may confuse sex identification in some instances, and thus determining sex based on behaviour during mounting alone may prove to be inaccurate and bias interpretations from such studies. Alternative techniques using DNA, for example, should be employed when the sex of individuals is important.

On the whole, homosexual behaviour is not a single, uniform behavioural phenomenon in animals. It exists in diverse forms and the possible functional significance may differ among and within species. However it must be remembered that, just as those who interpret same-sex behaviour as being deviant or aberrant are guilty of imposing their own values on their data, there are also those who are guilty of interpreting the behaviour with a humanistic agenda. It is important not to equate same-sex behaviour in animals with homosexual identities in humans and *vice versa*. Nevertheless, same-sex interactions are very much a 'natural' component of the sexual and social repertoires of many and varied animal species, making humans much less 'queer' than many might otherwise like to think. □

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For a more comprehensive list of scientific papers, see **www.natureaustralia.net**

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We studied two unrelated groups of Australian and New Guinean rainforest birds that appear to have evolved identical leapfrog distributions.

LEAPFROG BIRDS

BY LEO JOSEPH, JANETTE A. NORMAN & LESLIE CHRISTIDIS

ESTHER BEATON

The Greater Sooty Owl (*Tyto t. tenebricosa*) from central and south-estern Australia.

HAVE YOU EVER FLICKED through a species field guide and noticed how many species are often restricted to the same area? Ever wondered how this came about? Biogeographers, who study the distributions of organisms, certainly have, and they have probably had more than their fair share of headaches trying to work it out.

One particularly tricky pattern to explain is known as the 'leapfrog' distribution. This describes a situation where three closely related species or populations are each endemic to (found only in) one of three different regions, usually along a simple north–south or east–west axis. Members of the two groups most widely separated from each other (the 'terminals') are similar in overall appearance, whereas members of the third group in the middle are most distinctive.

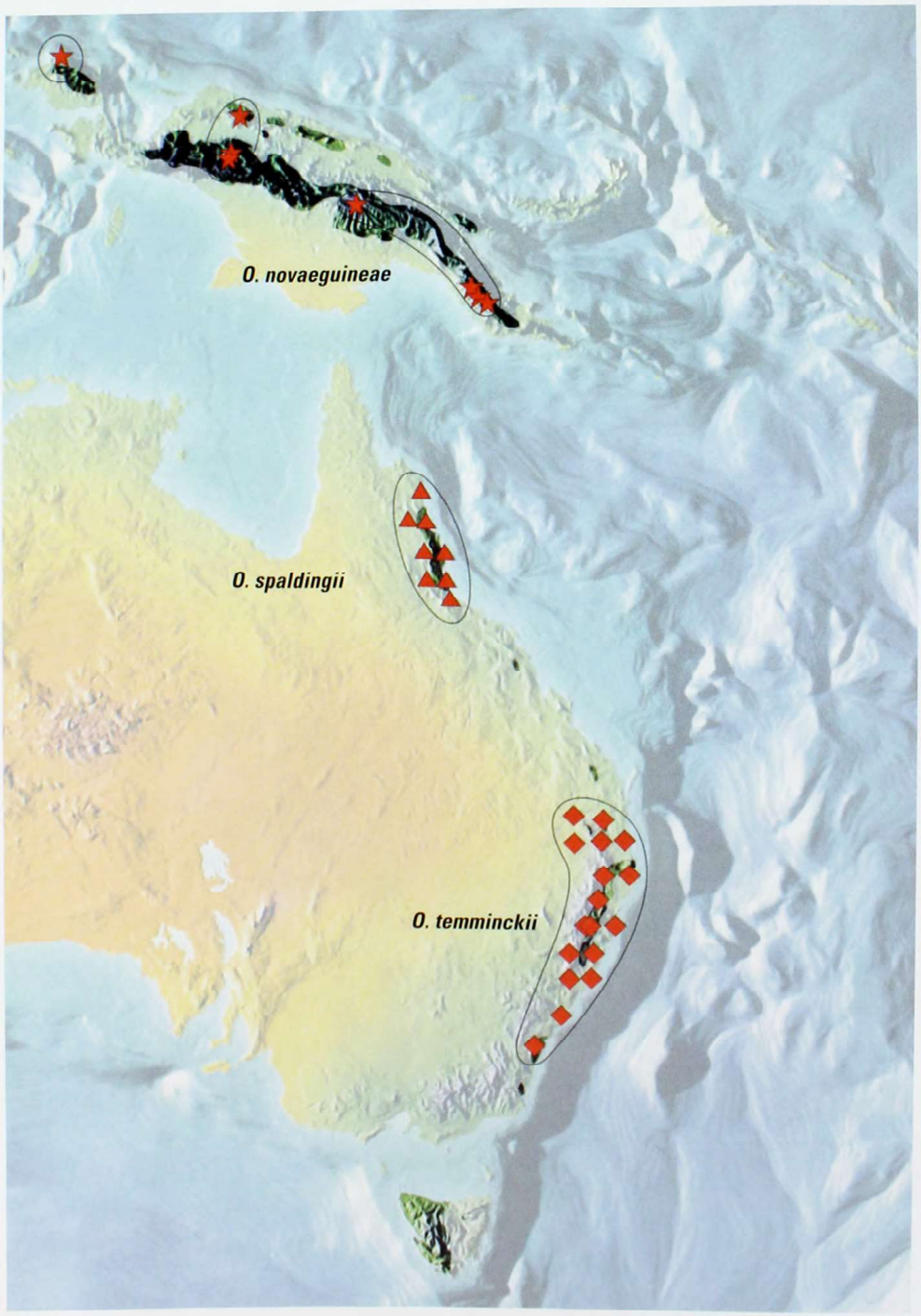
How do these leapfrog patterns come about? Do shared patterns of endemism in different groups of organisms mean that the same processes have shaped their distribution and evolutionary paths?

Evolutionary biologists can now address these questions using genetic data—in particular DNA sequences, which provide a record of a species' evolutionary history and evidence for how closely related different species and populations are.

WE STUDIED SOOTY OWLS AND logrunners—two unrelated groups of Australian and New Guinean rainforest birds that appear to have evolved more or less identical leapfrog distributions. Conventional taxonomy holds that one species of sooty owl (Sooty Owl *Tyto tenebricosa*) and one species of logrunner (Logrunner *Orthonyx temminckii*) occur in New Guinea *and* in south-eastern Australia, whereas a second species of sooty owl (Lesser Sooty Owl *T. multipunctata*) and a second species of logrunner (Chowchilla *O. spaldingii*) occur in the intervening Wet Tropics of northern Queensland. (Sooty owls are part of the tytonid group of owls, which also includes the Barn Owl *Tyto alba*. Logrunners are ground-dwelling Australo-Papuan songbirds whose closest relatives are yet to be determined.)

HOW DO THESE *leapfrog patterns come about?*

There are two possible explanations for the leapfrog distributions. According to the 'terminals related' model, morphological similarity of the most geographically widely separated populations is thought to arise because they are more closely related to each other



COURTESY THOMAS WILKE & LEO JOSEPH

Map showing the distribution of logrunners (*Orthonyx* spp.). Even though the northern and southern species look superficially similar, they are not closely related.

GLEN THRELFO/AUSCAPE

A female Southern Logrunner (*Orthonyx temminckii*) feeding chicks. Found in central eastern Australia, this species resembles the New Guinean Logrunner (*O. novaeguineae*).

C. & D. FRITH/FRITHFOTO

A female Chowchilla (*Orthonyx spaldingii*), the very distinctive logrunner species of Queensland's Wet Tropics. Unlike white-chested males, females of all logrunner species have rufous chests.

than either is to the population in the middle. This could come about either through long-distance dispersal, or if the terminal populations had once been connected by a now-broken habitat corridor that bypassed the central population. In the 'terminals unrelated' model, the terminals are not each other's closest relatives even though they resemble each other, and one of them is in fact more closely related to the central population. This model argues for unequal rates of morphological change among the populations and this could come about in various ways. Natural selection could slow the rate at which the two terminal populations diverged from the appearance of the entire group's common ancestor, such that they retain characters present in the ancestor. Conversely, the central popu-

lation could adapt to its environment by diverging at a disproportionately faster rate, thus taking on a very different appearance.

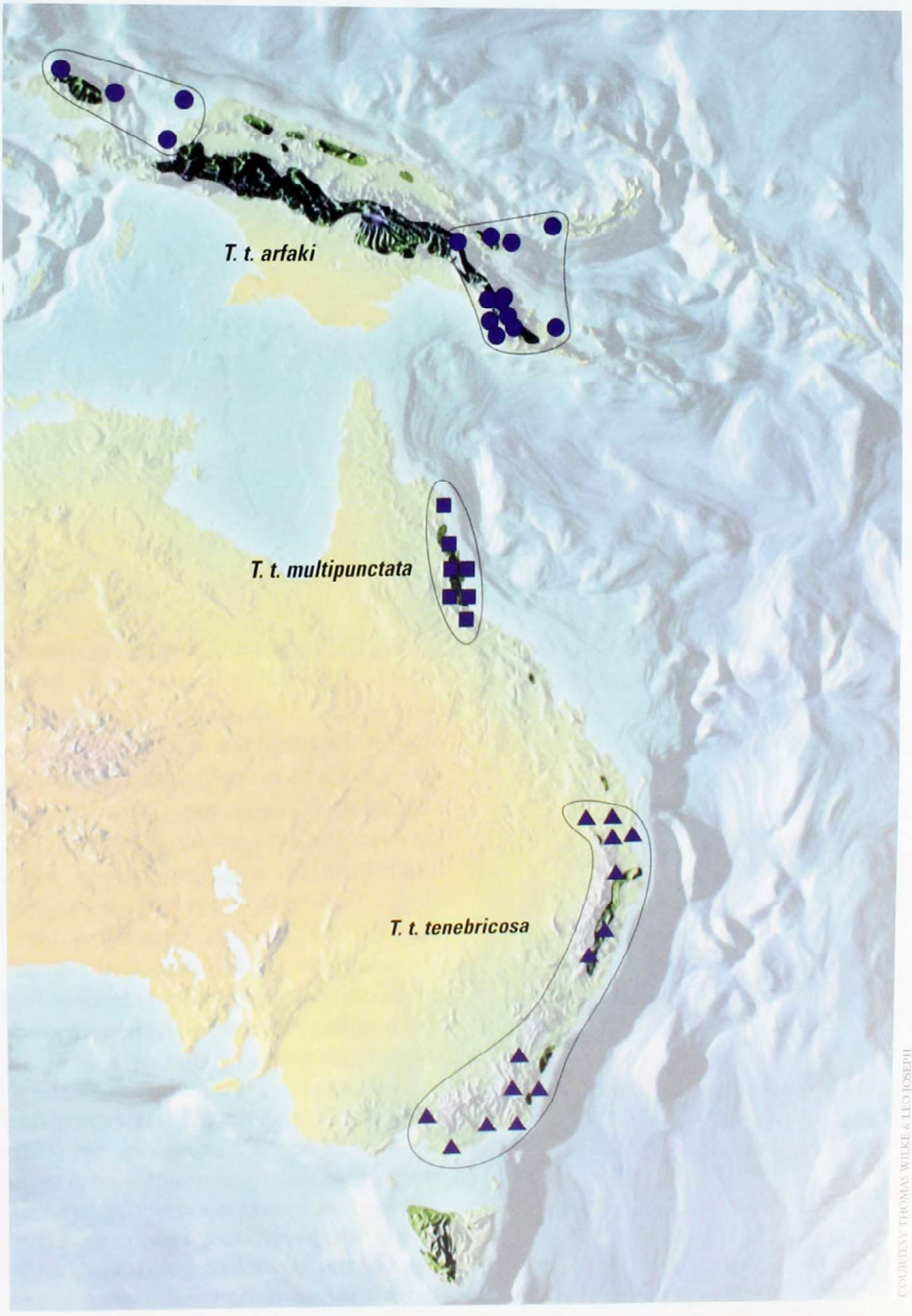
Under the 'terminals related' model, New Guinean and south-eastern Australian populations of sooty owls and logrunners should be genetically more similar than either is to their respective Wet Tropics counterpart. However, if one of the terminal populations were more closely related to the central population then we would have to favour the other model.

We obtained DNA sequences from the same two independently evolving stretches of DNA in sooty owls and in logrunners—DNA from the cell's mitochondria (mtDNA) and DNA from the cell nucleus (nDNA). Surprisingly, we found that the patterns in DNA sequences of logrunners were vastly different from those of sooty owls.

FOR LOGRUNNERS,
we found enormous genetic differences between the three populations.

For logrunners, we found enormous genetic differences between the three populations, so much so that we believe they should be treated as separate species (Southern Logrunner *Orthonyx temminckii*, Chowchilla *O. spaldingii* and New Guinean Logrunner *O. novaeguineae*) that diverged from each other a long time ago. This agrees with the fossil record. Logrunners have been around since at least the Miocene, which ended 5.3 million years ago. Perhaps more unexpected was our finding that the New Guinean Logrunner is more closely related to the distinctive Wet Tropics bird, the Chowchilla, than to the south-eastern Australian birds that they more closely resemble. Clearly we could reject the 'terminals related' model to explain the leapfrog pattern in logrunners. Instead, unequal rates of morphological change must have been operating in the logrunners. Either the Chowchilla has undergone a rapid morphological divergence, or the morphological similarity between the New Guinean and Southern Logrunners is due to retention of characters that were

The New Guinean Sooty Owl (*Tyto t. arfaki*). This form more closely resembles the southern Greater Sooty Owl (*T. t. tenebricosa*) in its plumage and size rather than the geographically closer Lesser Sooty Owl (*T. t. multipunctata*) of the Wet Tropics.



Map showing the distribution of Sooty Owls (*Tyto tenebricosa*). Although the intermediate (Wet Tropics) form (*T. t. multipunctata*) is most distinctive in its plumage and size, it shows little genetic differentiation from the other populations.

COURTESY THOMAS WILKE & LEO JOSEPH

AT A GLANCE

SOOTY OWLS (*Tyto tenebricosa*)

Greater Sooty Owl
(*T. t. tenebricosa*)
SE Aust. 34.5–40 cm, 490–890g, female larger. Compared to *T. t. multipunctata*, bigger and darker from above (finer, sparser dorsal spotting), with unbanded primary feathers and dark grey underbelly.

Lesser Sooty Owl
(*T. t. multipunctata*)
NE Aust. 33–36.5 cm, 370–560 g, female larger. Compared to *T. t. tenebricosa*, smaller and lighter (more densely spotted), with banded primaries and pale underbelly.

New Guinean Sooty Owl
(*T. t. arfaki*)
NG. Similar to *T. t. tenebricosa*, but slightly smaller and white spots slightly larger.

LOGRUNNERS & CHOWCHILLA (*Orthonyx*)

Southern Logrunner
(*O. temminckii*)
SE Aust. 18–20 cm, 55.5–62.5 g, male larger. Upper body and wing surface rufous brown with black scalloping and double white wing stripes.

Chowchilla
(*O. spaldingii*)
NE Aust. 24–28 cm, 135–180 g, male larger. Upper body and wings black with no stripes or scalloping, prominent blue eye ring.

New Guinean Logrunner
(*O. novaeguineae*)
NG. 18.5 cm, 81–95 g, male larger. Similar colouring to O. temminckii, but generally darker all over.

found in the ancestral logrunners. These scenarios will be difficult to tease apart but at this stage we suspect the latter.

More surprises came from the DNA data of sooty owls. Unlike the logrunners, the three populations of sooty owls shared almost identical DNA sequences. We have therefore proposed the three populations of sooty owls be treated as the one species *Tyto tenebricosa* but with three subspecies (Greater Sooty Owl *T. t. tenebricosa*, Lesser Sooty Owl *T. t. multipunctata* and New Guinean Sooty Owl *T. t. arfaki*). In fact, the data suggest that sooty owls as a group must be little more than dark Barn Owls that evolved very recently

UNLIKE
the logrunners, the three populations of sooty owls shared almost identical DNA.

(within the last one or two million years) in Australia and New Guinea. Again, this agrees with the fossil record. Tytonid owls have only been recorded in Australia since the beginning of the Pleistocene, about 1.8 million years ago. Nonetheless, the lack of evidence of a closer relationship between the two terminal yet similar-looking sooty owl populations precludes finding any preference at this stage for the 'terminals related' model. Unequal rates of morphological change are again our preferred explanation for the leapfrog distribution pattern found in sooty owls.

HABITAT ADDS AN IMPORTANT ecological dimension to this story. The distributions of sooty owls and logrunners are certainly centred in the Australo-Papuan rainforests. But throughout their range, sooty owls extend into eucalypt-dominated habi-

tats adjacent to rainforest, whereas logrunners are strict rainforest specialists. The wider habitat tolerance of sooty owls has probably helped them maintain greater habitat and genetic connectivity in the face of long-term retraction of the whole region's rainforests. Also, sooty owls may have only recently colonised, dispersed and diverged in plumage and size within the Australo-Papuan region. Logrunners, on the other hand, are old Australo-Papuan rainforest endemics. They appear to have evolved their present distributions through a combination of long-term range retraction, isolation and extinction of interconnecting populations.

Our study highlights an important warning for biogeographical studies of

C. & D. FRITH/FRITHFOTO

The Lesser Sooty Owl (*Tyto t. multipunctata*) from the Wet Tropics. Note the broad, wide spots on the wings and back.

endemism. General conclusions should not be formed about why unrelated species share the same distribution patterns without supporting molecular data on the species' evolutionary histories and relationships. Just because two species are endemic to the same area doesn't mean that they have been quietly evolving there together over the same period of time. We look forward to further DNA-based insights into the shaping of the Australo-Papuan rainforest biota. □

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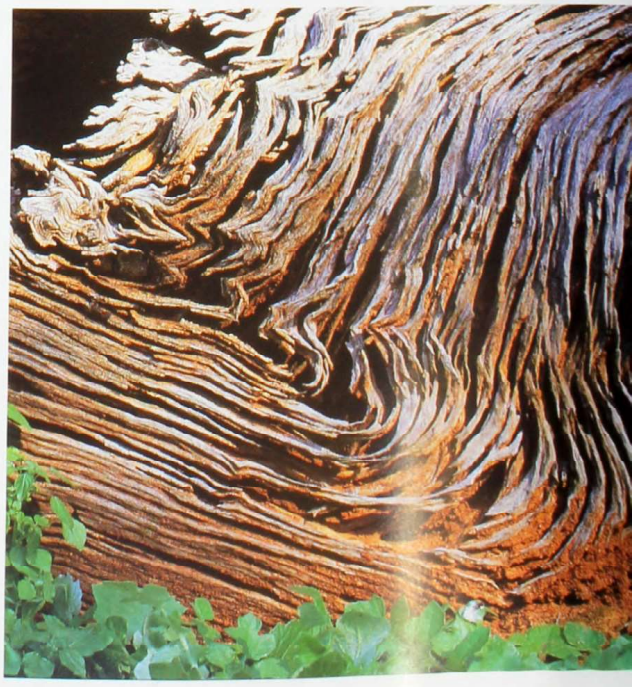
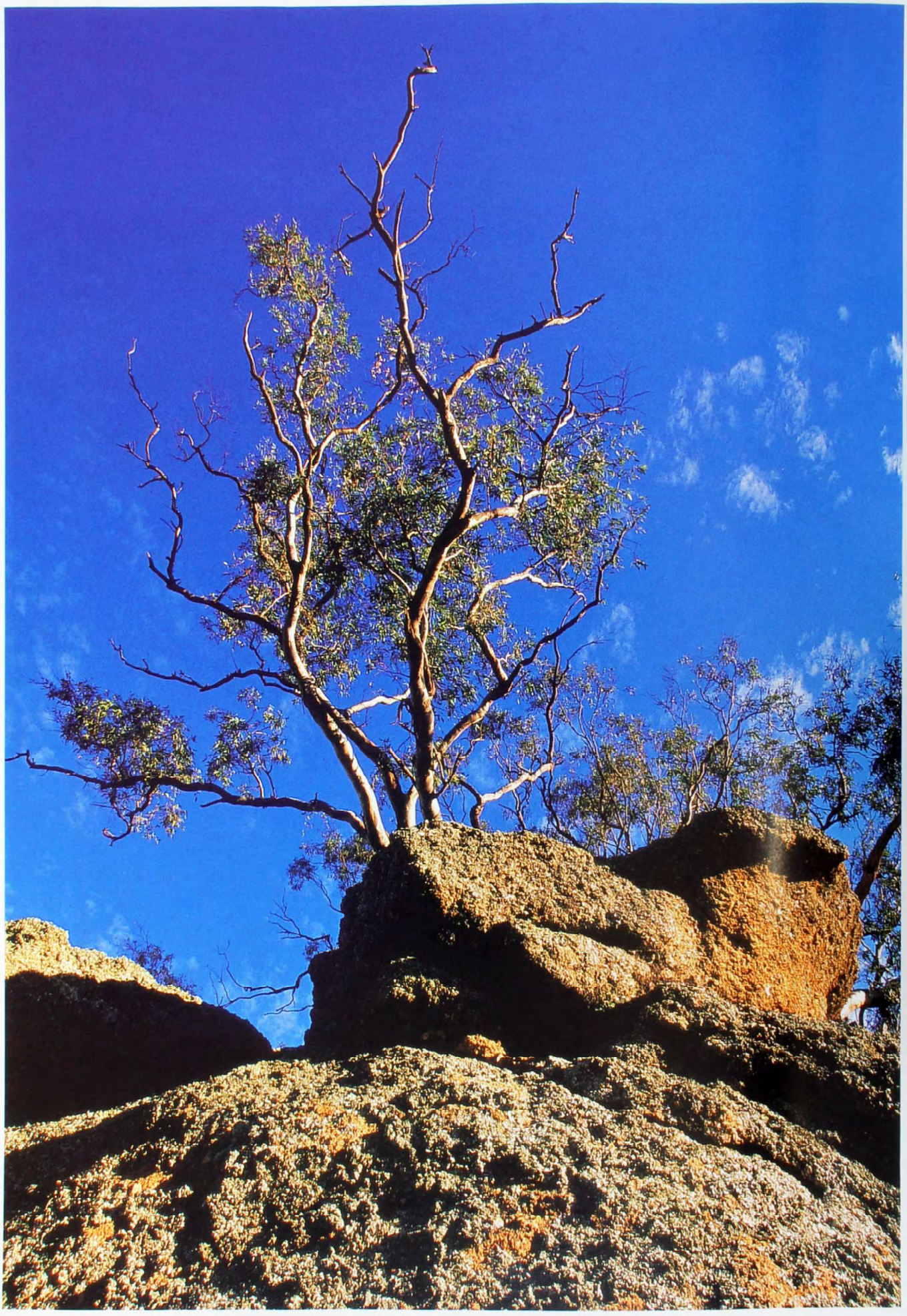
Early morning as seen from Riegals Rock in the 3,850-hectare national park.



Nature's patterns in Terrick Terrick National Park.

Terrick Terrick

BY KEVIN HONE



Granite outcrops, Riegals Rock, Terrick Terrick National Park.
The park is the only national park in Victoria's Riverina bioregion.

Old White Cypress Pines at Bennetts Rock in Terrick Terrick National Park (north central Victoria). Victoria's most significant stand of the slow-growing trees is found within the park.

Striped ghosts of the twilight

Zebras will stand next to a piece of wood with black and white vertical stripes, rather than stand alone.

Zebras

'Zebras' are a loose taxonomic group of striped equids (family Equidae), with Plains and Mountain Zebras being more closely related to asses than either is to Grevy's Zebra. There are 3 species, each with several subspecies.

Plains Zebra
(Equus burchelli)
East African grasslands and savanna. Broad vertical B&W stripes, becoming horizontal on haunches. The extinct Quagga (*E. b. quagga*) is considered a subspecies on the basis of genetic data.

Mountain Zebra
(Equus zebra)
South-west African mountain grasslands. Narrow vertical B&W stripes, white belly, dewlap under neck.

Grevy's Zebra
(Equus grevyi)
Ethiopian, Somalian, north Kenyan subdesert steppes and arid grasslands. Narrow vertical B&W stripes, curving upwards on haunches, belly white, prominent ears.

SO THEY WAITED TILL DARK AND then the Leopard heard something breathing sniffily in the starlight that fell all stripy through the branches, and he jumped at the noise, and it smelt like Zebra, and it felt like Zebra, and when he knocked it down it kicked like Zebra, but he couldn't see it. So he said, 'Be quiet, O you person without any form. I am going to sit on your head till morning, because there is something about you that I don't understand.' (From "How the Leopard Got his Spots" in Rudyard Kipling's *Just So Stories*, 1902.)

And in the morning sun, the Zebra became stripy shadows behind a bush and could not be seen by the Leopard. If Rudyard Kipling had read a recent review by Graeme Ruxton (University of Glasgow) on why zebras have stripes, his short story may have had a few other characters, including other zebras, tsetse flies and the Quagga.

The three living species of zebras are all nomadic grazers of grasses in Africa and all have a striking pattern of dark and light stripes over their bodies. The extinct Quagga is a subspecies of the Plains Zebra, a relationship only recently established through analysis of DNA samples from Quagga skins in museums, taken almost 100 years after the animal's demise. Strangely, only the front half of the Quagga had stripes, making it look like a painting whose artist had run out of white.

One theory for the evolution of zebra stripes is that they are actually exaggerated wrinkles. Zebras are social mammals that groom each other around the mane and neck, and when the neck is bent into a grooming position, wrinkles appear. These wrinkles may have directed the groomer to the right spot and stripes may have evolved to enhance social cohesion in the group. Zebras are certainly attracted to stripes, especially when they are on another zebra, and they will even stand next to a piece of wood with black and white vertical stripes, rather than stand alone. But, as Ruxton points out, there are relatives of zebras, like the Horse, that are also social but do not have stripes.

Other theories suggest that the stripes evolved as camouflage from predators such as Kipling's talking Leopard and, of course, Lions. However, while one zebra may disappear into the stripy shadows of sunlight through a bush, most zebras prefer the company of other zebras, making it difficult to imagine them hiding *en masse*. And, unlike other ungulates, zebras are not only loud in their fashion sense, but they also make a lot of noise. In fact, their call has been described as a semi-hysterical whinny, which combined with the dazzle of a herd of moving stripes, is a far cry from blending in with the background. Another suggestion is that the stripes of a bolting herd of zebras create an optical illusion that makes it difficult for a predator to single out an individual to attack. However, Lions are under no illusion at their ability to kill zebras and do so with the same confidence that they kill other similar-sized non-striped prey.

A more compelling idea is that stripes make zebras blend into their surroundings in the low light conditions of dusk and dawn. This makes them less visible to predators like Lions and Spotted Hyenas hunting at these times. And to our eyes, and apparently those of a talking Leopard, zebras also fade away at these times. Although zebras flee from people during the day, as striped ghosts of the twilight, they will let people approach close enough to hear them breathing (sniffily). Since all zebras have excellent hearing it is very unlikely that they are not aware of people next to them. And it is also unlikely that the zebras do not flee for want of night vision (because we know they see as well as cats and owls).

Another suggestion is that stripes evolved as a defence against insects rather than big cats. The idea that zebra stripes protect against tsetse flies was

BY SIMON D. POLLARD

The purpose of these Plains Zebras' stripes remains a mystery.

made in 1930 and followed up with experiments over 50 years later that showed tsetse flies prefer solid black or white model animals over striped ones (see "The Zebra and the Tsetse Fly", *Nature Aust.* Spring 1993). Since zebras are often in close proximity to other mammals, it was argued that, even if zebra odour attracted tsetse flies from a distance, once they were there they would avoid the stripes and choose other more visually attractive targets nearby. One problem with this theory is that it has not been established whether tsetse flies actually pose any risk to zebras; two zebra species, for example, live in areas where tsetse flies are rare or absent.

Of course, evolution of the zebras' stripes may have been the result of more than one factor. What may have started as a marker for social grooming could have spread to cover the body as camouflage in low light. As Ruxton concludes in his review, a lot more research beyond 'just so' stories is needed to understand why zebras are so instantly recognisable. And why does the body of the Quagga look like an unfinished canvas? Another mystery, but I'm sure Rudyard Kipling could have made a wonderful story out of it. □

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First words: let's stick together

There are over 6,000 different languages today, but how did language evolve in the first place?

PINPOINTING THE ORIGIN OF language might seem like idle speculation, because sound does not fossilise. However, music, chit-chat and even humour may have been driving forces in the evolution of language, and gossip possibly freed our ancestors from sitting around scratching heads, and wondering what to say next.

There are over 6,000 different languages today, and the main language families are thought to have arisen as modern humans wandered about the globe in four great migrations beginning 100,000 years ago. But, apart from modern linguistics, what is the evidence, and how did language evolve in the first place? Potential indicators of early language are written in our genetic code, animal behaviour, material culture and our bones.

The genetic evidence is a gene called FOXP2, in which mutations appear to be responsible for speech defects. FOXP2 in humans differs only slightly from the gene in Chimpanzees, and may be about 200,000 years old, slightly older than the earliest modern humans (see "Earliest Modern Funerals", Nature Strips, this issue). Such a recent origin for language seems at first rather silly. How could our speechless *Homo* ancestors colonise the ancient world, spreading from Africa to Asia, and perhaps making a short sea-crossing in Indonesia, without language? Well, language can have two meanings: the infinite variety of sentences that we string together, and the pointing and grunting communication that we share with other animals.

Marc Hauser (Harvard University) and colleagues argue that study of animal behaviour and communication can teach us how the faculty of language in the narrow human sense evolved. Other animals don't come close to understanding thought processes captured in sentences like "I think that you think that I think that you understand what I am saying". Nevertheless, this complexity of human expression may have started off as simple stages in animal 'thinking' or problem-solving, as in number processing (how many Lions are we up against?), navigation (time to fly south for the winter), or social relations (we need teamwork to access that alpha male's harem). In other words, we can potentially track language by looking at the behaviour of other animals.

William Noble and Iain Davidson (University of New England) look for the origin of language in early symbolic behaviour and the evolutionary selection in fine motor control. For example, throwing and making stone tools could have developed into simple gestures like pointing that eventually entailed a sense of self-awareness. They argue that language is a form of symbolic communication that has its roots in behavioural evolution, rather than biological determinism. Even if archaic humans were *physically* capable of speech (a hyoid bone for supporting the larynx and tongue has been found in a Neanderthal skeleton), we cannot assume symbolic communication. They conclude that language is a feature of anatomically modern humans, and an essential precursor of the earliest symbolic pictures in rock art, ritual burial, major sea-crossings, structured shelters and hearths—all dating, they argue, to the last 100,000 years.

But the archaeological debate of *when* does not really help us with what was going down in those first chats. Robin Dunbar (University of Liverpool) reckons they were probably talking about each other—gossiping. He discovered a relationship between an animal's group size and its neocortex (the thinking part of the brain), and tried to reconstruct grooming times and group sizes for early humans based on overall size of fossil skulls. Dunbar argues that gossip provides the social glue permitting humans to live in cohesive groups up to the size of about 150, found in population studies among hunter-gatherers, personal networks and corporate organisations. Other apes are reliant on grooming to stick together, and that basically constrains their social complexity to groups of 50. Gelada Baboons, grooming champions of the primate world, stroke and fondle each other for several hours per day. If humans had no speech faculty, we would need to devote 40 per cent of the day to physical grooming, just to make our social ends meet.

Humans manage large social networks by 'verbal grooming' or gossiping—chatting over coffee and chatting up mates—so the 'audience' can be much bigger than for one-on-one massage. Giselle Bastion, who recently completed her Ph.D. at Flinders University, argues that gossip has acquired a bad name, being particularly associated with women and opposed by men who are defending their supposedly objective world. Yet it's no secret that men gossip too. We are all bent on keeping track of other people and maintaining alliances. But how did we graduate from grooming to gossip? Dunbar notes that just as grooming releases opiates that make monkeys and apes feel good, so do the smiles and laughter associated with human banter.

Dean Falk (Florida State University) suggests that, before the first smattering of language, there was 'motherese'—that musical gurgling between a mother and her baby, along with a lot of eye contact and touching. Early female hominids found it hard to bear children, because bipedalism was transforming

BY RICHARD FULLAGAR

JEAN-PAUL FERRERO/AUSCAPE

Grooming in Japanese Macaques (*Macaca fuscata*) is the tactile equivalent of gossiping in humans.

the pelvis, narrowing the birth canal and selecting for less-developed babies. Human babies could not even cling on to mum, so motherese evolved to soothe and control infants. Motherese is a small social step up from the contact calls of primates, but at this stage grooming probably still did most of the bonding.

So when did archaic human groups get too big to massage? Dunbar suggests that nomadic expansion out of Africa, maybe 500,000 years ago, demanded larger group sizes and language sophistication to form the various alliances necessary for survival. Davidson, who rejects Dunbar's gossip theory, suggests that there was a significant increase in brain size from about 400,000 years ago, and this may correlate with increasing infant dependence. Still, it probably took a long time before someone's mother delivered humanity's maiden speech.

But once the words were out, and eventually put on paper, they acquired an existence of their own. Reading gossip magazines and newspapers today is essentially one-way communication with total strangers—a far cry from the roots of language. □

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Froth and bubble

To see plants cry you need to rise early on a humid morning after good soaking rains.

ESTHER BEATON

Plants manufacture a range of surfactants or detergents. This person is washing his hands with the green pods of Cole's Wattle (*Acacia colei*).

LIKE ALL LIVING THINGS, A PLANT can be viewed as a complex chemical factory. The main business is that fundamental process of life—photosynthesis—where water and carbon dioxide are converted into sugar and oxygen. This keeps the plant alive and growing. But away from sunlight, production lines are devoted to backroom concerns like biosecurity and waste management. It's only when plants bleed, cry, or froth at the bough, that we are reminded of some of these more obscure chemical processes.

There are plenty of 'bleeding gums' along the east coast of mainland Australia. Take the characteristic rosy resin exuded from the rough bark of the Red Bloodwood (*Corymbia gummifera*). This resin contains terpenes, the same chemical group that colours the Blue Mountains blue when volatile oils escape from the fallen leaves of eucalypts. The bloodwood resin is a response to wounds, particularly from borers (beetle and other insect larvae), and seeps to the surface through a series of ducts in the wood. The sticky resin physically inhibits the borers, and the terpenes may act as an insecticide (there are reports of bloodwood resin being used as an antiseptic). A balance is eventually reached, where the borers keep boring and the resin keeps running.

To see plants cry you need to rise early on a humid morning after good soaking rains. Increased pressure from sap build-up in the roots forces liquid through the vascular system, forming droplets on the tips of leaves. Some plants appear to 'guttate', as it is called, to rid the plant of unwelcome or over-abundant chemicals such as calcium. A few trees, including eucalypts, appear to do this by excreting calcium-rich water into airspaces in their leaves and then releasing it along the leaf margins.

It is more unusual to see plants foaming, but after the drought-breaking rains in metropolitan Sydney last April, radio talkback was flooded with questions about foaming trees. Callers wanted to know what the foam was, why the trees were producing it now, and whether it was bad for the trees or them. To answer these questions we need to know a little about 'saponin', or natural soap.

Plants manufacture a range of surfactants or detergents that go under the general name of saponin. This term comes from the generic name of soapworts, *Saponaria*, which is in turn derived from the Latin word for soap, *sapo*. There is also Soapbark (*Quillaja saponaria*), soapberry (various species of *Sapindus*), Soap (or Broad-leaf) Aloe (*Aloe maculata*, but previously *A. saponaria*) and so on. But many plants, and plant parts, have been used to produce soap for washing clothes or even polishing metals.

Saponin is another terpene, a secondary plant compound not involved primarily in photosynthesis or growth. That's not to say it doesn't have its uses. Why else would it occur in hundreds of plants, from cabbages to chenopods (saltbushes), and of course in eucalypts? Many secondary compounds are used to protect plants from pests and diseases, particularly in the tropics, and saponin is what is known in polite botanical circles

BY TIM ENTWISLE

as a 'defaunating' agent. It's a soap that kills.

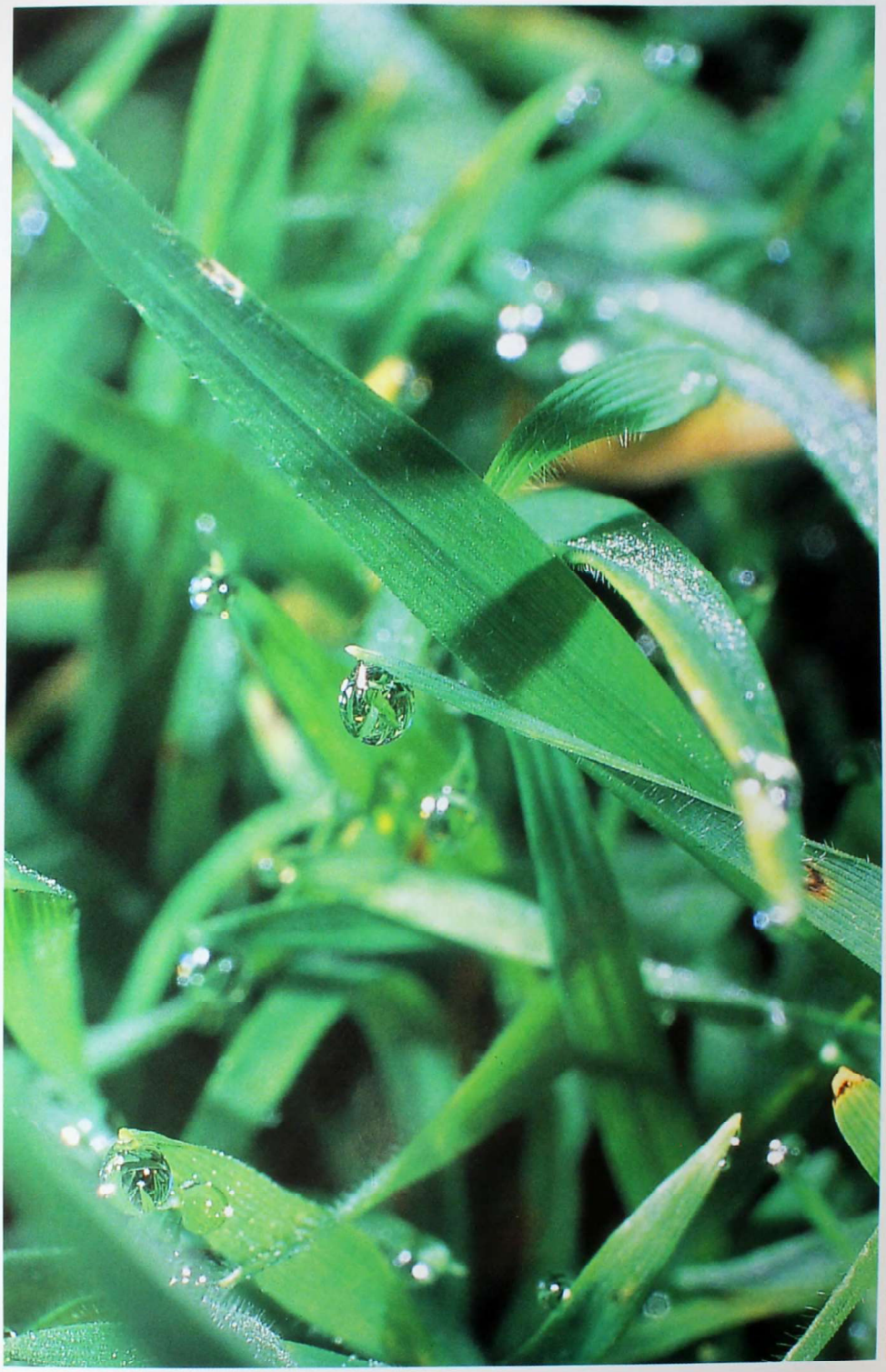
A good example is Western or Florida Soapberry (*Sapindus saponaria*), a dryland tree native to tropical America but widely cultivated in Asia and occasionally Australia. Its berries are poisonous to humans and some other animals but useful as a soap substitute. However, when fed to Sheep in small doses, the seeds of Western Soapberry blitz the protozoa living in their gut, allowing beneficial bacteria and fungi to thrive. A nice example of defaunation, and apparently good for the digestion of Sheep foraging in tropical regions.

A native Australian saponin-producing plant is the Foam Bark Tree (*Jagera pseudorhus*). This near-coastal species of northern New South Wales and Queensland is the source of a fish poison used by Aborigines. Swish any part of the plant in water and you get a soapy, but toxic, foam. In a similar way, saponin can be flushed out of many plants after a heavy downpour, particularly if a prolonged dry period has allowed the chemical to build up on its outer surface. So the drought-breaking rain in Sydney whipped up a nice foam of saponin in a few local eucalypts.

Saponins are sometimes described as the plant's immune system, harmful to unwanted visitors but safe to the tree itself. Structurally saponin is an organic chemical with a sugar side-chain. It is the insoluble, non-sugar part of the molecule that causes the foaming response—and the toxicity, by altering the permeability of membranes and gills. Non-toxic levels of certain saponins are part of our day-to-day life, turning up in cough medicines, diuretics, toothpastes, and even beer (to improve the head). Outside the human body saponins appear in photographic emulsions, the foam of some fire extinguishers, an ore-separating process in the mining industry, and of course, in some soap substitutes.

One of the most famous saponins is digitalis, a heart medicine extracted from the common garden plant Foxglove (*Digitalis purpurea*). In low doses digitalis strengthens contractions of the heart muscle by increasing the local calcium levels (calcium stimulates the heart beat); in higher doses it is used as a deadly arrow and spear poison in Africa and South America. There are recent reports of saponins inhibiting or killing human cancer cells, and of a possible application for fungal infections. So whether or not saponins are toxic depends upon what you are.

If you're a Sydneysider, you needn't worry about being poisoned by your frothing boughs. The lathering of saponin is an opportunity to see one of the great chemical laboratories in action. □



H. EHMANN

Some plants form droplets on the ends of their leaves (guttate) to rid themselves of unwelcome or overabundant chemicals such as calcium.

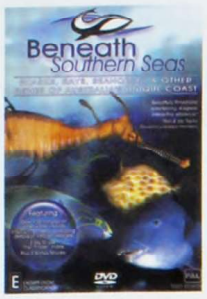
FURTHER READING

Cameron, P.M., 1994. Toxicology of Australian native plants. Aust. Biol. *7: 120–128.*

Reynolds, S.T., 1985. Sapindaceae [excluding Dodonea *and* Diplopeltis*].* Flora of Aust. *25: 4–164.*

DR TIM ENTWISLE IS DIRECTOR OF PLANT SCIENCES AT THE ROYAL BOTANIC GARDENS AND DOMAIN TRUST, SYDNEY.

reviews



Beneath Southern Seas: Sharks, Rays, Seahorses & Other Fishes of Australia's Unique Coast

DVD by Coral Sea Television Pty Ltd & Unlimited Realities, 2002, $34.95 rrp.

THIS DVD BY A TEAM OF AUSTRALIAN UNDERWATER PHOTOGRAPHERS IS A BEAUTIFUL AND impressive reference work on the fishes of temperate Australian marine waters. It consists of short movies of 180 fish species, each backed up with a 'fact page' consisting of still photos, information on habits, distribution and the scientific name. Each selection can be accessed through several menus, or watched as a movie. Extras include a tour of the Australian Museum's Fish Collection. It is designed to be played on a DVD player through a TV, and does not require a computer. As a result, the navigation is a bit awkward, but the producers have done well within the limitations imposed.

"Beneath Southern Seas" is suitable for divers, fishers, and those with an interest in our highly endemic marine fishes. The quality of the images is very high, and the musical background usually suitable. However, some of the voice-over is not terribly informative (many of the species, for example, are said to have a "distinctive shape", without elaboration), some of the natural-history information is of the 'just so story' variety, and I was irritated by the near-constant bubble noise in the background. On the positive side, the quality of the more than 100 minutes of underwater photography is justification alone for purchasing this DVD. A companion DVD on marine invertebrates is under production.

—JEFF LEIS
AUSTRALIAN MUSEUM

Red Sand Green Heart: Ecological Adventures in the Outback

By John L. Read. Lothian Books, Melbourne, 2003, 320 pp. $29.95 rrp.

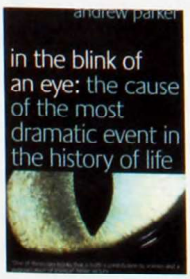
SCIENCE IS A LOT OF FUN, AND YET YOU'D BARELY KNOW IT FROM MOST OF THE MEDIA REPORTS on the topic. Of course scientists do tend to be earnest about their work—and indeed science has significant import in the world, so frequently it is a serious business. Yet there's not enough writing about the very human pleasure of doing science.

John Read's book is a lovely step in this direction. Perhaps ecologists are fortunate among their scientific peers because a great deal of ecology is done in the bush, where adventures large and small take place almost as a matter of course. John makes full use of this advantage. His story of ecological investigations across the arid heart of the Lake Eyre Basin, from Coober Pedy to the Strzelecki Track, contains an entertaining and illuminating variety of anecdotes. He shares his love of the country effortlessly, and populates the landscape with pen pictures of adventures that range from personal epiphany to life-threatening accident. Animals and plants share the story, particularly the reptiles that John so evidently admires.

Human beings are not displaced by the animals, though. John writes of the companions who travel with him, of anti-nuclear activists, of pastoralists, of boffins, and of many more human types. His eye is sympathetic and understanding of different perspectives, yet the reader also comes away with a strong sense of John's values and beliefs.

John Read loves the dry country and its plant, animal and human inhabitants. Read his book and you'll understand why he does so, and you'll have fun along the way too.

—STEVE MORTON
CSIRO, CANBERRA



In the Blink of an Eye: The Cause of the Most Dramatic Event in the History of Life

By Andrew Parker. Simon & Schuster (Australia), NSW, 2003, 336 pp. $29.95 rrp.

ANDREW PARKER PRESENTS A NOVEL APPROACH TO UNDERSTANDING THE EVOLUTION OF LIFE. HE regards the development of light-sensitive organs, which range from the simple pigment spots of jellyfish to the complex eyes of vertebrates, as the driving force behind the evolution and diversification of organisms on Earth. The perception of light, what he terms the 'Light Switch Theory', is seen as the trigger for the Cambrian 'explosion' of life, the sudden appearance of diverse hard-bodied organisms, as exemplified by the famous Burgess Shale fossils. Being able to see, especially being able to see other organisms, provided selection pressure for both predation and predation avoidance, and resulted in rapid diversification of body plans and external structure.

This book covers many topics: the structure of eyes and lenses, structural colour and refraction, Precambrian environments, the evolution of trilobite eyes, mimicry and protective colouration, light perception in dark nocturnal and abyssal environments, and evidence for colour in fossils.

There is a lot of new and stimulating information here, and Parker is not afraid to push his 'Light Switch Theory' to the

The Waterhole

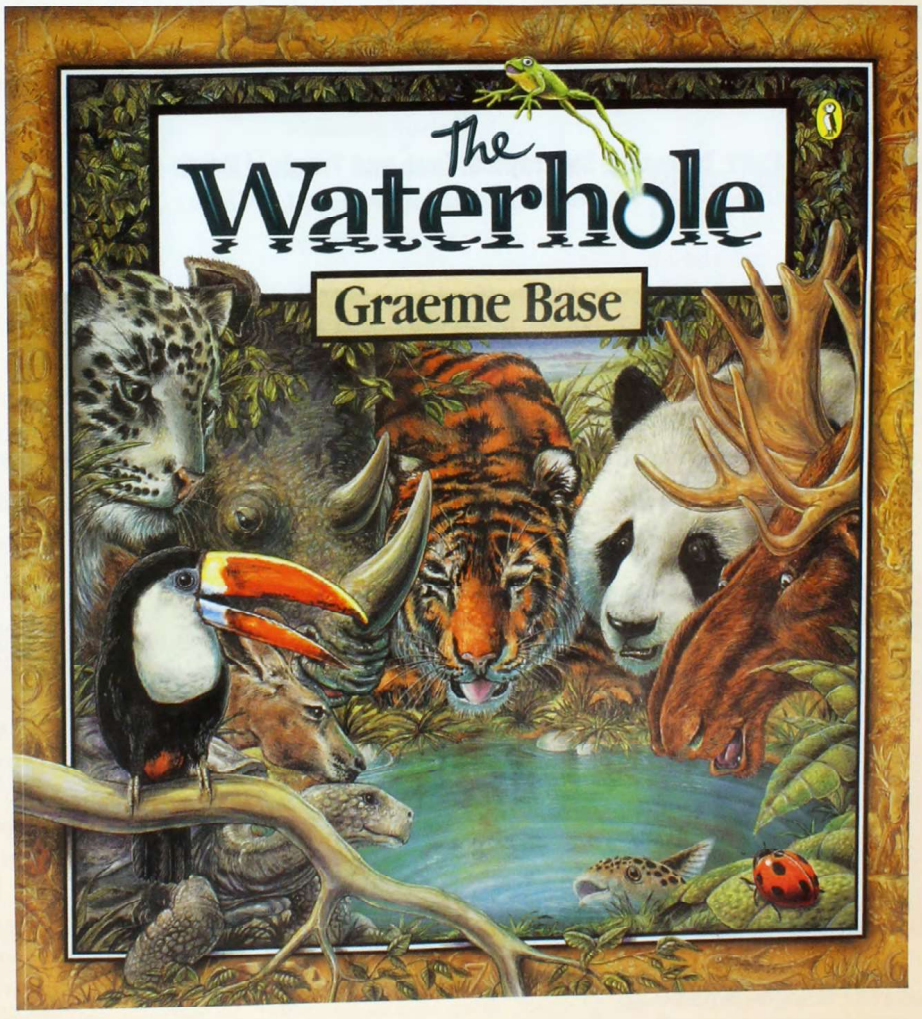
from the highly acclaimed book - to an inspiring exhibition

From the internationally highly acclaimed book *The Waterhole*, springs the beautiful exhibition of the same name at the Australian Museum. *The Waterhole* showcases the inspiring and imaginative work of renowned award-winning children's author and illustrator, Graeme Base.

Featuring original artworks and friezes from his latest picture book, *The Waterhole* exhibition covers each continent across the globe, telling the story of a diminishing waterhole and how this affects the animals on which it depends.

The exhibition includes colourful displays, as well as the author's original worksheets, together with his explanation of how he created the book. Many animals from the Australian Museum's own collection have been included in the exhibition to help illustrate the themes.

Graeme Base's lavish visual treatment of the exhibition is deliciously rich in colour and detail. It takes the book's message of drought and dwindling water supply to another exciting visual dimension.



The Waterhole is showing at the Australian Museum from 14 February until 18 July 2004. Entry is free with general admission.

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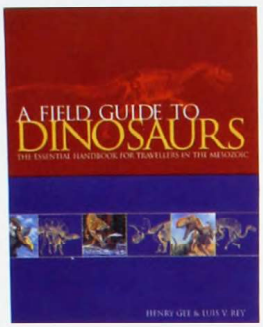
limit. As highly visual primates, we are naturally receptive to such ideas. However, life is complex and many forces drive evolution. I could imagine a highly intelligent Dog (such as described in Olaf Stapledon's classic SF novel, *Sirius*) writing a history of life based on olfaction, the sense of smell. *In the blink of an eye* is certainly worth a look. But a major fault in this book is the total absence of any references, essential in such a work, whether 'popular' or not.

—Daniel Bickel
Australian Museum



A Field Guide to Dinosaurs

By Henry Gee and Luis V. Rey. Allen & Unwin, NSW, 2003, 144 pp. $39.95 rrp.

The last decade has seen a surge of amazing dinosaur discoveries that have radically changed the way we view prehistoric (more specifically, Mesozoic) life. In a potent blend of science and fantasy, palaeontologist Henry Gee and artist Luis Rey have produced an engaging book that vividly portrays our new understanding of dinosaurs and the world they inhabited.

As its name implies, the book is set out like a modern-day field guide. Selected dinosaurs are illustrated and described as if they were living animals, with details on their appearance, habits, distribution and classification.

One of the major shortcomings of this book is that, by its very nature, it is very hard for even the most avid enthusiast to distinguish fact from fiction. As the producers of "Walking with Dinosaurs" found, the public like to know how and why palaeontologists know what they do. This qualm aside, the standout feature is the richness and the quality of the illustrations. In addition to over 20 full-page colour plates, there are numerous pencil sketches, highlighting aspects of each animal's anatomy and likely behaviour. While not all of them may be backed by scientific findings, the style is always thought-provoking and inspiring. A definite 'must have' for any dinophile.

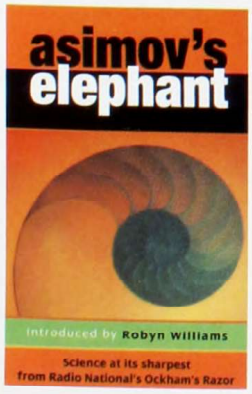
—Steve Salisbury
University of Queensland

Australian Bird Calls: Tasmania; Subtropical East; and Tropical North-east

CDs recorded 2001 and 2002 by David Stewart, Nature Sound, PO Box 256, Mullumbimby, NSW 2482. Each approx. 73 mins, $25 rrp.

Listening to Australian bird-call recordings has become easier. These avoid the problems that plague cassettes when trying to quickly find a particular species. For Australian birds, among the best choices are those by David Stewart of Nature Sound. Stewart is one of Australia's best wild-sound recordists, which is evident on these three CDs. The CDs cover the birds of some of the most commonly visited regions of Australia. The Subtropical East, in particular, will be popular because its coverage includes Sydney and Brisbane, while the Tasmanian disc includes all the island's endemic species. Each CD is over 70 minutes long and presents the calls of more than 80 species. Stewart has produced several frog recordings and environmental sound scapes, which are also well worth listening to.

—Walter E. Boles
Australian Museum



Asimov's Elephant

Edited by Robyn Williams. ABC Books, NSW, 2003, 248 pp. $24.95 rrp.

Robyn Williams has been producing a shining gem of a radio program called "Ockham's Razor" on ABC Radio National for almost 20 years, and this book is the fifth collection of talks he's put together from the program. As usual it's an eclectic mix—everything from English physicist Anthony Garrett's brief piece on William of Ockham himself and his descendants in modern mathematics and cosmology, to prize-winning Australian novelist Roger McDonald's elegant explanation of why he became obsessed with the story of Charles Darwin's servant, Syms Covington, and immortalised him in the book *Mr Darwin's shooter*.

The beauties of this book are exactly those of the radio program: here are a bunch of disparate characters who are passionate about a subject and who will take any opportunity to tell you about their passion. But the brevity of the program (and the written pieces) means that none of the writers can assume the luxury of being expansive—it's all short, sharp and to the point. Sometimes you may disagree with the point, but at least you don't have to wade through acres of verbiage to get there.

There are many who think that Robyn Williams is a living national treasure and that anything he touches turns to gold. *Asimov's elephant* is another example of his golden touch: it's provocative, it's serious and it's fun, all at the same time.

—José Borghino
Australian Society of Authors

SOCIETY PAGE

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Membership: $40.00

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Ph: 02 9417 6171
Contact: Hon. Treasurer

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Contact: Kate Cox
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Ph: 03 9877 9860
Web: *www.vicnet.net.au/~fncv*
Contact: Ann Williamson

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Contact: John Love

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EMERTON NSW 2770
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Contact: J.A. Banks

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q&a

Turtle off Track?

Q: *Last January a Green Turtle was found on its back on a beach, just to the north of Bermagui, on the New South Wales south coast. After being put back the right way up, it swam safely out to sea. But wasn't this turtle a long way from home?*

—John Crew
Bermagui, NSW

A: Green Turtles (*Chelonia mydas*) have long been thought to be waifs along the New South Wales coast and in some cases have been transported to Queensland to be released in what was thought to be more appropriate habitat. However, the increased number of sightings of turtles along the New South Wales coast, even on the south coast, suggests that this area is probably part of their natural range, perhaps for feeding, if not nesting. The policy of transporting New South Wales Green Turtles to Queensland was (is) just another example of the 'save-the-individual' mindset paying scant attention to the actual ecology of the population.

—Allen E. Greer
Australian Museum

Raven or Crow?

Q: *My field guide shows there are five big black birds in Australia, three called ravens and two called crows. What's the difference between them and between crows and ravens in other parts of the world?*

—Eliza Connelly
Braddon, ACT

A: There is no clear difference between crows and ravens other than ravens, by tradition, are larger than crows. This size difference sort of holds in Australia: the Australian Raven (*Corvus coronoides*) and Forest Raven (*C. tasmanicus*) are the largest species; the Little Crow (*C. bennetti*) is the smallest; and the Little Raven (*C. mellori*) and Torresian Crow (*C. orru*) are about the same intermediate size. Ravens also have grey bases to the black body feathers (white in crows) and longer feathers (called hackles) on the throat.

This conventional division of ravens and crows derives from the situation in England, where there are four species of these black birds. Two have typical black colouration—the large Common Raven (*Corvus corax*) and medium-sized Carrion Crow (*C. corone*)—while the two smaller species have more distinctive appearances—the Rook (*C. frugilegus*) with its naked face, and the diminutive Jackdaw (*C. monedula*) with its grey head. There are few counterparts of the latter two species elsewhere in the world, and where two or more related birds occur together in other places, they generally resemble the typical English raven and crow.

Like so many English birds, 'crow' and 'raven' were applied to different species that were reminiscent of the original name-bearers. Thus, in a new locality, the larger black bird(s) were called ravens, and the smaller ones crows. This does not imply that various types of ravens are more related to each other than any is to one of the crows. In fact, it appears that the five native Australian species form a natural group whose members are closer to each other than they are to either crows or ravens on other continents. Indeed, our rather moderately sized ravens would probably only rate as crows in some other countries.

—Walter E. Boles
Australian Museum

Spider Ears

Q: *Do spiders have ears?*

—Tom Hickey
Griffith, ACT

A: Although spiders have nothing like the sensitivity and complexity of the human ear, they do have organs that allow them to sense vibrations of the air and substrate. Spiders' bodies are completely covered by an external skeleton called the cuticle. Because of this, spiders must sense the world largely through various types of 'hole and hair' sense organs in the cuticle (remember, most spiders have poor eyesight). These organs relay sensations of touch, taste, humidity, temperature and vibrations via their sensory nerve endings.

Vibration sensing (or 'hearing') relies on a specialised set of 'hairs and holes' on the outer leg segments. Airborne vibrations are detected by long, thin, vertical hairs (called trichobothria) set in open sockets in the cuticle. Deflection of these hairs tells the spider about changes in the direction and intensity of local air currents. This can alert the spider to approaching prey or predators.

Substrate vibrations are detected by 'lyriform slit organs', a series of flexi-

RON & VALERIE TAYLOR/NATURE FOCUS

A Green Turtle on the move.

Huntsman spiders 'listen' with their legs.

ble, transverse slits in the cuticle around the leg joints. Vibrations set up by prey animals struggling in a web or walking on a leaf will result in slight widening or narrowing of these slits, setting off nerve impulses that alert the spider to the presence and direction of its prey.

—MIKE GRAY
AUSTRALIAN MUSEUM

Answers to Quiz in Nature Strips (page 19)

1. *An Orangutan's* **2.** *Red* **3.** *Queensland* **4.** *Global Positioning System* **5.** *Yes* **6.** *Spitfire grubs* **7.** *The red end* **8.** *A meteorite is a meteoroid that has made it to the Earth's surface.* **9.** *Komodo Dragon* **10.** *Puggle*

JOHN FIELDS/NATURE FOCUS

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 the video "Attenborough in paradise". Summer's Pic Teaser was the burrows of Soldier Crabs (*Michyris longicarpus*).

What's your biodiversity identity?

A set of three Australian species—a vertebrate, an invertebrate and a plant—will be allocated to all Australians at birth.

MEETING SOMEONE FOR THE first time and a bit stuck for conversation? Want to choose a special gift for someone? Can't decide where to go on holiday? If the scheme that my colleague Mike Young and I are promoting comes to life, you could find clues in your 'biodiversity identity'. This is a set of three Australian species—a vertebrate, an invertebrate and a plant—that we hope will be allocated to all Australians at birth. Unlike star signs, everyone would have their very own unique group of species to identify with and be helping conservation to boot.

Most Australians now live in cities and their lifestyles offer little opportunity for them to 'connect' to their environment. A loaf of bread, a hamburger, a glass of water from the tap—none comes with a story about the biodiversity that helped produce it, or was displaced in its production.

But as people grow in number and biodiversity declines, things will change. Recreational places in the bush will become less resilient. Cities will have to construct elaborate water-treatment plants to clean the water that was once filtered by natural systems. Farmers will have to buy more fertiliser to replace the nutrients that were once recycled by soil biodiversity; and they'll have to use more pesticides to replace the pest control that was once provided by native birds and insects.

If every Australian had a sense of being connected to, or being guardian for, just a few species each, our collective decisions will be ones that better ensure biodiversity's survival and our own quality of life. The concept is clearly related to the way in which Indigenous people have interwoven biodiversity with their lives for thousands of years. We respectfully acknowledge this and see our proposal as a way of making a small contribution to the conservation challenges caused by European settlers.

Unlike star signs, everyone would have their very own unique group of species to identify with.

We see the scheme working something like this. For newborn Australians, invitations to participate would be issued through the Registrar of Births, Deaths and Marriages in each State when the birth is registered. Other Australians could apply for their allocation at any time. Ideally there would be no charge and we suggest that State governments make the very small investments needed to run the scheme.

The allocation of species would be random and non-negotiable. People have asked if they could choose, but our concern is that this would perpetuate focus on just a few attractive species when the need is to grow an appreciation for the numerous millions of less charismatic species that make our ecosystems work. Democracy for biodiversity! We arrived at the suite of three by recognising the challenge in learning to love something like *Austroblandex bituberculatus*, an obscure hairy earwig that nevertheless fills a particular ecological role.

There are about 6,000 described vertebrate species, 20,000 plants and 80,000 invertebrates, so even if only a small proportion of the Australian population subscribes, many people will share individual species. However, the chances of any two people getting the same combination of three would be miniscule.

While there would be technical issues for taxonomists and Registrars of Births, Deaths and Marriages to sort out, essentially this is a simple, low-cost scheme that could deeply penetrate Australian culture over time. The identities would provide just a starting point for a wide range of imaginative uses. A classroom of Aussie kids would represent a hypothetical biological community that teachers could use to explore many aspects of science and the arts. The concept could inspire stories and art about people searching for or interacting with 'their' species. People looking for information about their identities would create a thirst for knowledge about Australian biodiversity. Families could design holidays to the places where their biodiversity identities live. And Olympic Games participants could wear theirs embroidered on their clothing.

We are now actively promoting our idea about biodiversity identities. Most people catch on quickly, and like it, which gives us confidence that the concept is worth further market testing. We would be interested to know what you think. □

BY SARAH RYAN

DR SARAH RYAN IS A STRATEGIC ADVISER IN CSIRO SUSTAINABLE ECOSYSTEMS, CANBERRA.

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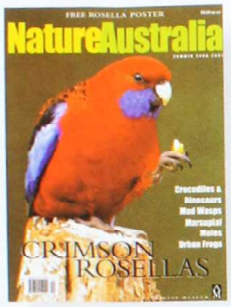

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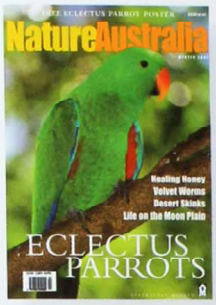

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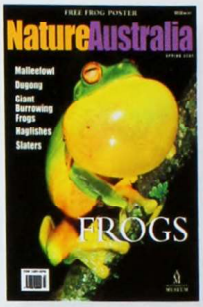

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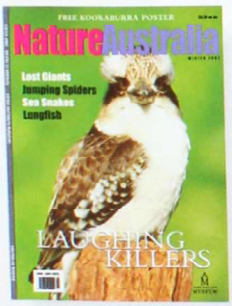

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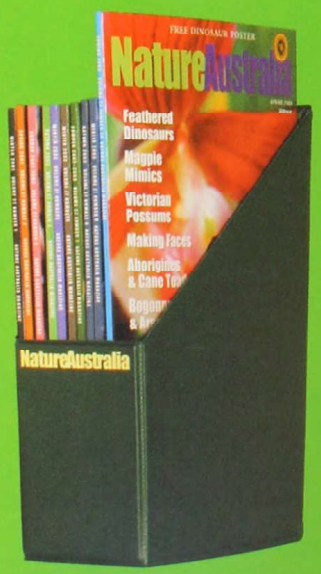

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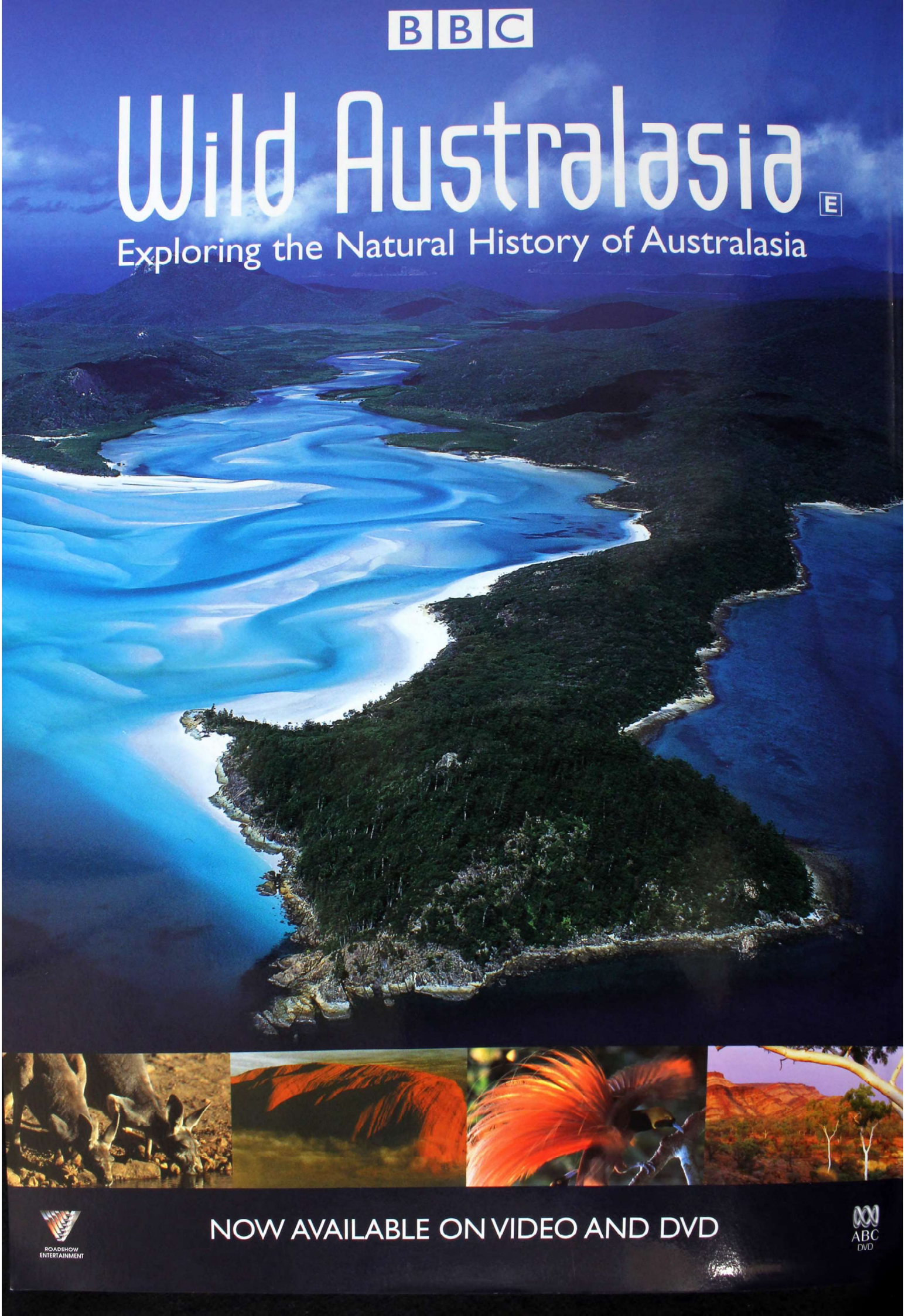
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