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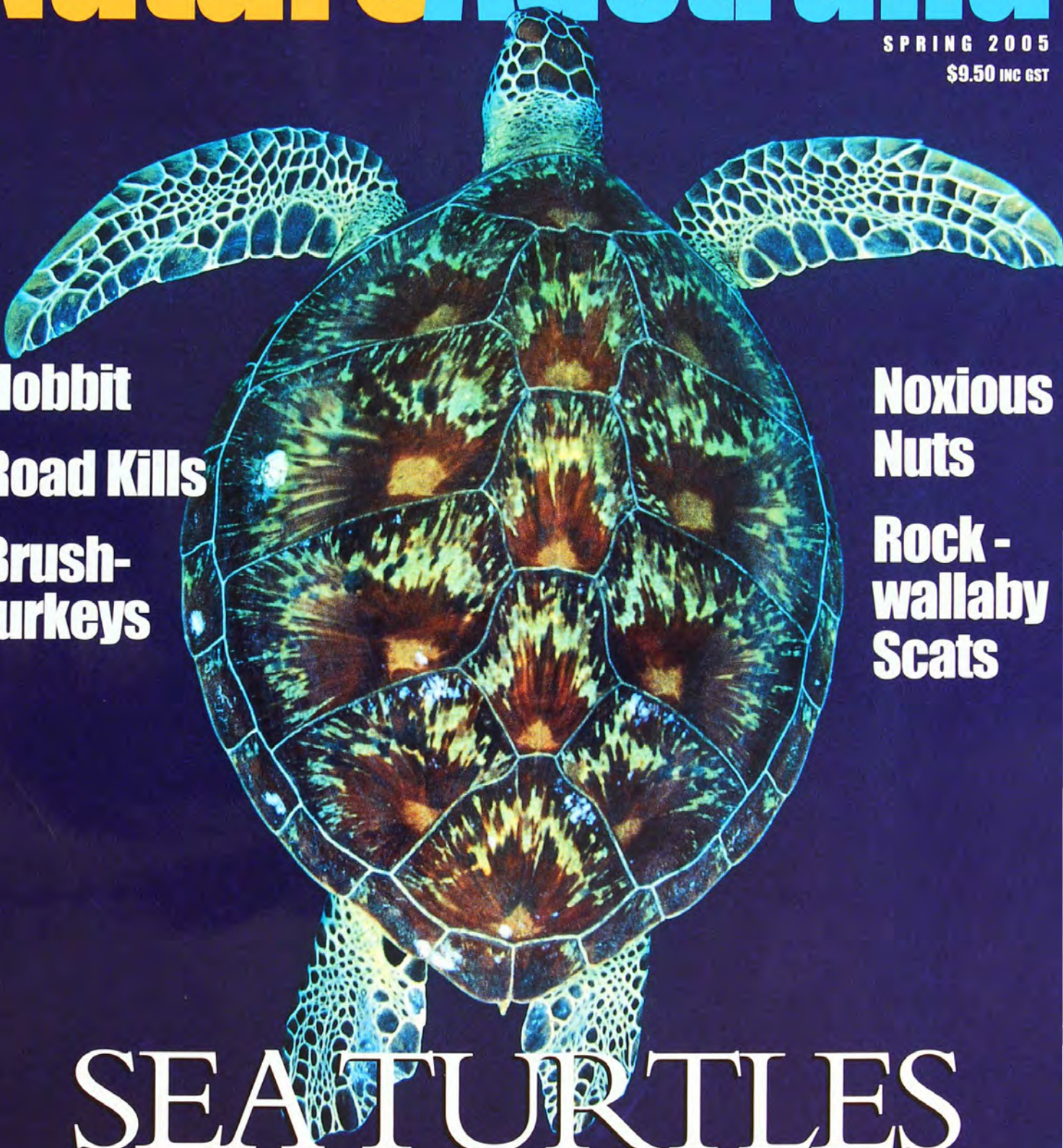

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SEA TURTLES

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nsw arts

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FRONT COVER
Sea turtles like this Green Turtle (*Chelonia mydas*) will put up with just about anything to lay their eggs.
PHOTO BY BECCA SAUNDERS/ AUSCAPE

up front

The Royal Zoological Society of NSW has just awarded *Nature Australia* its 13th Whitley Award for Best Periodical. This is a wonderful achievement for the magazine and its publisher, the Australian Museum. The award was presented by Dan Lunney, Editor of *Australian Zoologist*, and I thought it would be fitting for you to read what he had to say about a magazine that we are devoted to and that you support through your subscription.

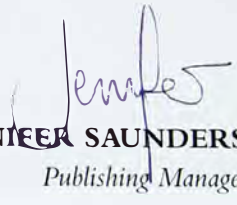
"At a recent meeting of the Royal Zoological Society of NSW (RZS), the Convenor of the Whitley awards, Noel Tait, asked Councillors for their opinions on the award for Best Periodical. He was concerned that *Nature Australia* was once again voted the best entry. That would leave other good periodicals in the shade yet again. His fellow RZS Councillors spoke with one voice: if it was the best periodical submitted in 2005, then it should win the prize. Noel Tait was much relieved. He was justified in his decision, and that of the Whitley Committee, in selecting *Nature Australia*.

"Turn to any item in any edition of *Nature Australia* to give you a glimpse of the quality and fascination of its material. In the Autumn 2005 issue, consider Allen Greer's Last Word piece on "Taxonomy: biology's infrastructure". As Greer points out, roads, ports, law courts, sewers and weather reports constitute the basic infrastructure of a society, and are the physical and conceptual structures that allow it to function smoothly. There is also, he argues, a basic infrastructure in biology, and it is called taxonomy. Greer's case for supporting this infrastructure should be compulsory reading for anyone calling for increased funding in taxonomy. In Winter 2005, under the heading "Trapped", Tom Grant and Mick Lowry ask: "how often do we think about the by-catch?" The authors present their careful research on the impact of traps used to catch fish in rivers and how the traps could be modified to prevent iconic animals like the Platypus from drowning in them. In David Lindenmayer's stimulating article on "Experiments with fire" (Summer 2004–2005), the wonderful photos of Esther Beaton, Jiri Lochman and Kathie Atkinson bring a great story into immediate focus.

"Sustained support of a periodical is the vital factor in encouraging a creative and bold approach to the material. The continuity of a high standard of production, editorial decision-making and photographic choice is a major element in *Nature Australia*'s unparalleled success. The editorial team of Jennifer Saunders, Georgina Hickey and Kate Lowe can proudly accept all the plaudits that this publication so richly deserves.

"The Australian Museum is one of the best known of Australia's scientific institutions, and has an excellent international reputation because of its scientific collections and research staff. However, the Museum is known mostly for its magnificent sandstone building, its fascinating exhibitions and, of course, its publications, most notably, *Nature Australia*. As the Australian Museum continues to provide a safe home for this innovative and zoologically exciting journal, so the reputation of *Nature Australia* continues to reflect well on the institution that nurtures it—the Australian Museum.

"Nature Australia is a national treasure. Each issue provides invaluable resource materials for scholars, while its general readers are brilliantly served with the fascinating content of each new edition. Its recognition is richly deserved, and so it is a great pleasure to present this award to the editorial team of this outstanding periodical."



—**JENNIFER SAUNDERS**
Publishing Manager

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letters

Baby's Doily

Arachnophiles might be interested to know that the spider in the lead photo of the article "Come to My Parlour" (*Nature Aust.* Winter 2005) was a juvenile female St Andrew's Cross Spider (*Argiope keyserlingi*). It was nearly 40 years ago that I first recorded the fact that the young St Andrew's Cross Spider makes a discoid stabilimentum (a 'doily web') and only at a later stage does it change the pattern to the well-known St Andrew's cross. But why a stabilimentum anyway? As Mark Elgar explains in his article, there are some interesting theories, but it's still anybody's guess.

It was probably this common garden spider with its striking adult colours, interesting web-making and complex courtship—so hazardous for the tiny male—that first inspired me to become a spider watcher many years ago.

—Densey Clyne
Warchope, NSW

Death by Hair

On looking back through old copies of *Nature Australia*, I was surprised and dismayed to find a Nature Strips story about the Tasmanian Yellow-throated Honeyeater (*Lichenostomus flavicollis*) and its habit of collecting human and domestic animal hair for nest-building purposes ("Balding Birdos from Tasmania?", *Nature Aust.* Spring 1995). The story was written in a light-hearted tone, about a cutesy habit of a native wild animal communing with humans, and with a suggestion that any tourist might enjoy a similar experience if they visit Tasmania.

This was ten years ago, and I am sincerely hoping that the concept of wild birds collecting long hairs of any variety, human or otherwise, for nest building is no longer considered cute, but in fact quite possibly a key threatening process.

I live on a property in Grafton where I keep Horses. Not long after moving here I learned that Willie Wagtails (*Rhipidura leucophrys*) are avid gatherers of the long mane and tail hairs groomed from the Horses each day. So, keen to help, I collected balls of hair and, at the start of the nesting season, spread them over fences and bushes to make the work of gathering nesting material easier for the birds.

That same year the wagtails built their nests in our shed, and the resultant hatchlings were a source of great joy to us, until one day we found three baby birds, on the verge of fledging, hanging from the nest, entangled in horsehair. They were all dead.

Since then it has been an ongoing battle to prevent the wagtails from collecting the hair, but tragically one that often fails. Just last year what appears to be the last remaining pair of wagtails around the property managed to source more hair and subsequently not just one but three nesting attempts ended tragically.

Not knowing the Tasmanian honeyeaters, I can only suppose that their legs are as fragile as most small birds. Quite possibly even very fine human hair, if used as nest lining in any quantities, could tangle the baby birds in the same way. I am wondering now if the honeyeaters are seen quite as frequently as they were in 1995.

—Patricia Edwards
South Grafton, NSW

Yellow-throated Honeyeaters in Tasmania are holding their own, despite their habit of collecting hair and fur, as are White-eared Honeyeaters, which have a similar habit, on the mainland. In fact, many bird species regularly incorporate hair, even long Horse hair, into their nests. There may well be some casualties, but most likely not enough to cause the demise of whole populations (otherwise the habit would not persist). A more plausible explanation for the decline in wagtails on your property is competition with other native birds (such as Noisy Miners) or predation by Cats.

—G.H.

Wattle War Over

In the Spring 2002 issue of *Nature Australia* I wrote about the likelihood that most of Australia's wattles will be shifted from *Acacia* into a different genus, *Racosperma*. This change seemed inevitable because *Acacia*, as presently defined, includes Africa's thorn trees as well as Australia's wattles, which recent DNA evidence shows are not closely related. The name *Acacia* was first applied to an African tree, which means that Australia's wattles, under the rules of nomenclatural priority, would lose this name. But in July 2005 the Nomenclature Section of the XVII International Botanical Congress in Vienna, Austria, voted to overrule tradition by retaining the name *Acacia* for Australia. This ruling was adopted because Australian botanists argued convincingly that a shift to *Racosperma* here would be very disruptive and confusing, given that Australia has more than 900 '*Acacia*' species, far more than the rest of the world combined. Australians can now heave a sigh of relief. Our wattles will remain 'acacias', and *Racosperma* will vanish into obscurity.

—Tim Low
Brisbane, Qld

Winter Wattles

It was interesting to read in your Winter column that up to a third of wattles flower at this time of year (*Nature Aust.* Winter 2005). However I cannot totally agree with the suggestion that the primary reason is because the "few insects that are still active at this time of the year have fewer flowers to visit", giving the wattles' advantage over other species. I live in a coastal heath area and I have always timed my wildflower walks in this locality for the month of August as this is when there appears to be a greater profusion and variety than at any other time of the year. August 2005 was no exception, with a wonderful carpet of ground bloomers, and local acacias not being at all more dominant among other similar-sized flowering bushes such as *Dillwynia*, *Grevillea* and *Banksia*. I have always assumed that these

plants race to flower and fruit before the appearance of bushfires that are far more likely in late spring or early summer. Since most of these species have evolved requiring heat for seed dissemination, wouldn't this be a more likely reason for winter flowering?

—Jan Ritchie
Balgowlah Heights, NSW

For the Record

The butterfly and larva on page 37 of the Winter 2005 issue of *Nature Australia* were not Imperial Blues, but Purple Oak-blues (*Arhopala centaurus*).

—G.H.

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

JAIME PLAZA VAN ROON/AUSCAPE

Why do up to a third of wattle species flower in winter?

Spring

Compiled by Geordie Torr and Martyn Robinson

ANDREW HENLEY/AUSCAPE

Common Spotted Ladybird (*Harmonia conformis*) eating an aphid.

NOT LIKE A LADY

They look so cute with their little, round, brightly coloured, polka-dotted bodies. Who'd have thought that most of them were voracious predators? There are about 300 species of ladybirds in Australia, and they're pretty much all over the continent. They can be seen year-round, although they're most visible in spring when the warmer weather makes them more active and they're on the prowl for a mate.

Soon after mating, the females lay clusters of 20–50 yellow or orange eggs on the undersides of leaves, often near aphids—these plump little sap-suckers will become the baby ladybirds' first food. A ladybird larva can gorge on as many as 350 aphids during the three weeks it takes to become a pupa. Then, about 7–10 days later, it becomes an adult.

Ladybirds' habit of eating pests has endeared them to farmers and gardeners alike. If you're keen to get a few of these insect enforcers into your garden to deal with some persistent offenders, you can attract some species using a mixture of honey, water and brewer's yeast.

More about ladybirds can be found at **www.abc.net.au/science/scribblygum/september2002/default.htm**

FIGHT CLUB

Around this time of year, lucky bushwalkers in eastern Australia may become the audience for what at first looks like a reptilian rumba—a pair of Lace Monitors (*Varanus varius*) standing on their hind legs and embracing like amorous dancers. In truth, however, the two lizards are both males and this pairing is more akin to a World Wrestling Federation bout.

These altercations can be pretty abrasive, although not anywhere near as disfiguring as they could be, considering the combatants' powerful jaws and claws. When the battle is joined, the two lizards rear up and grapple at each others' backs, which can result in some impressive scratches. However, they rarely put their armoury of razor-sharp, bacteria-infested teeth to full use.

The contest can be over in minutes if the pair is mismatched, or it can go on for an hour or more. Eventually, the weaker animal breaks away and may 'submit defeat', lying flat on the ground with its limbs spread, or it may simply flee the scene.

For more about these reptile wrestlers, check out *Goanna: the biology of varanid lizards* (1993) by Dennis King and Brian Green.

A PLAGUE ON BOTH YOUR MOUSES

Although summer is when plagues of House Mice (*Mus domesticus*) hit their teeming, squeaking peak, spring is when they have

S WILSON

Male Lace Monitors fighting.

MARIE LOCHMAN/LOCHMAN TRANSPARENCIES

House Mice.

their origins.

The House Mouse is an introduced pest that's found throughout Australia—you may well have a family living under your floorboards. Generally, they are a minor nuisance, but every now and then, when food is especially abundant and weather conditions are conducive, their breeding season is extended and numbers grow rapidly. They then become a ravenous horde, causing substantial damage to pretty much anything in the vicinity—crops, stock feed, farm equipment, electrical wiring—you name it, they'll gnaw on it.

It's the incredible reproductive turnover time of the females that enables House Mouse populations to grow as rapidly as they do. They become sexually mature at about six weeks of age and, once they are pregnant, it takes less than three weeks for their babies to develop. And as soon as a female has popped out one load of little pink babies, she's ready to go again.

Under normal conditions, high densities would suppress reproduction, limiting litter sizes. However, during plague years, the increase in abundance is so rapid that this suppression fails to kick in and numbers spiral out of control.

In Queensland, the Department of Natural Resources and Mines conducts trapping surveys in June, September, October and November, checking the breeding status of populations. The earlier they start to breed, the more likely it is that a plague will occur. These surveys allow plagues to be predicted up to six months in advance and warnings are then placed in the local media.

The plagues typically end around July/August, when food becomes scarcer and the harsh winter conditions place the populations under stress. Diseases spread more rapidly and the mice fight, which leads to wounds that quickly become infected. When the population crashes, it usually does so very rapidly—sometimes in just a few days.

To learn more about mouse plagues, visit **www.dpi.qld.gov.au/fieldcrops/7942.html**

FROM THE COLLECTION

STUART HUMPHREYS/AUSTRALIAN MUSEUM

Thylacine pickled pup.

*Well, here it is—the famous alcohol-pickled Thylacine (*Thylacinus cynocephalus*) pup that it was hoped would provide enough DNA to resurrect this extinct species through cloning. Estimated to be about four months old, this unique specimen was obtained from Hobart in 1866 by George Masters, an Australian Museum collector. However, it may well have been collected much earlier, as Masters swapped it from another museum for some other specimens.*

From a variety of early reports and bounty records, it appears that the Thylacine was probably mainly a late autumn/winter breeder (May to August). Hence, if this pup had survived, it may well have been weaned in spring—timed so that conditions were milder and food more abundant.

It would probably have been one of three in the litter. Although females had four teats, it seems that they rarely fulfilled their complete reproductive potential. Once it left the pouch, it would have stayed hidden in a rocky cave, a well-concealed nest or perhaps a hollow log, while its mother went out to hunt.

For more about this icon of extinction, visit **www.amonline.net.au/thylacine**

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 and Geordie Torr are regular contributors to **NATURE STRIPS**.

Evolution Before Our Eyes

Since Cane Toads (*Bufo marinus*) were introduced to Australia in 1935, their impact on native wildlife has been catastrophic. Now Ben Phillips and Richard Shine (University of Sydney) say the toxic toad's relentless march across northern Australia has caused some snakes to adapt their body shape in response to the threat (*Proc. Natl Acad. Sci. USA* 101: 17150).

Previous research had shown that not all snakes are affected to the same degree by Cane Toad toxins: larger snakes have relatively smaller heads, and since the size of a snake's head limits the size of its prey, a bigger snake is less likely to consume a toad large enough to poison it.

To examine whether snakes in Queensland might have responded to the evolutionary pressure caused by the toads, the researchers compared the morphology of hundreds of museum specimens collected before and after Cane Toads reach a geographic area.

They found that two of the four study species, the Red-bellied Black Snake (*Pseudechis porphyriacus*) and the Green Tree Snake (*Dendrelaphis punctulatus*), are highly sensitive to toad toxin, and were found to have increased in length by three to five per cent in the time since toads were introduced. No change was observed in the other two species, the Swamp Snake (*Hemiaspis signata*), which has an unusually small head and so cannot consume toads large enough to kill it, and the Keelback Snake (*Tropidonophis mairii*), which has a very high natural resistance to Cane Toad toxin.

The researchers say that, although it is unusual to see such rapid evolutionary change, the impact of toads has been slightly mitigated over time by the snakes' evolutionary response, and suggest that accurately assessing a species' ability to adapt is an important tool in predicting long-term environmental impacts.

—R.S.

Red-bellied Black Snakes adapt relatively quickly to Cane Toads.

GUNTHER SCHMIDA/LOOKPHOTOS TRANSPARENCIES

Who's a Clever Boy Then?

The ability of some parrots to mimic human speech can be so good that it seems as if you could just ask them how they do it and they would tell you. But of course speaking and understanding are two very different things, so it's taken a team of scientists, led by Gabriel Beckers (Indiana University), to uncover the birds' secret.

In human speech, sounds are created in the larynx and then modulated by rapid movements of the tongue. Parrots also move their tongue when they 'speak', so the researchers wondered if this played a role in their vocal abilities.

In order to test this hypothesis, they took five Monk Parakeets (*Myiopsitta monachus*) that had been caught and killed as part of a government pest-control program, and removed their sound source—an organ known as a syrinx. They then replaced it with a small speaker that produced a broad-band sound and measured the way in which tongue placement affected the sounds that the speaker produced.

They found that even tiny movements of the tongue could alter both the frequency and amplitude of the sounds (*Curr. Biol.* 14: 1592). Moving it less than a millimetre could make a larger difference to the sound than that between an 'a' and an 'o' in human speech. This is the first time such an ability has been seen outside humans.

—G.T.

An Eyeful Helps a Mouthful

When frogs swallow, they blink and retract their eyeballs back into their head. Does this disappearing-eye trick actually help the frog gulp its food, or is it simply a by-product of swallowing? Robert Levine (University of Massachusetts) and colleagues decided to investigate whether an eyeful helps push down a mouthful.

The team employed X-ray cameras to film Northern Leopard Frogs (*Rana pipiens*) swallowing their food. Barium-marked crickets could be seen moving through each frog's digestive tract as its eyeballs pushed against the roof of the mouth, forcing the cricket down the hatch (*J. Exp. Biol.* 207: 1361). Because no bone exists between the eyes and the throat, the eyeballs have easy access into the mouth cavity. However, the researchers found that eye retraction was not essential for consuming food and in 42 per cent of observations swallowing was recorded without the eyes retracting. This was confirmed with denervation of the eyes' associated musculature, proving that a frog can swallow without the help of its eyes. But instead of taking just two gulps to swallow food, it needed an average of four gulps to devour its meal.

While frogs' make good use of their tongues to swallow food, large meals seems to benefit from that extra push from the eyeballs.

—K.H.

COURTESY ROBB LEVINE

Going, going, gone...a Northern Leopard Frog swallows with the help of its eyes.

Bison Boom and Bust

At the end of the last ice age, roughly 12,000 years ago, many North American animals became extinct, including 'megafauna' like mammoths, mastodons, horses, short-faced bears and

lions. Most explanations for the extinctions have blamed human hunting, but increasing numbers of studies point to climate as at least a significant culprit.

The latest in such studies is by Beth Shapiro (Oxford University) and colleagues (*Science* 306: 1561). They obtained mitochondrial DNA and radiocarbon dates from hundreds of bison fossils collected from Beringia (Siberia, Alaska and Canada), North America and China, and showed that the genetic diversity of bison populations skyrocketed from about 75,000 years ago and then dramatically collapsed 37,000 years ago (although bison did not, technically, become extinct).

This period pre-dates the height of the last ice age (21,000–18,000 years ago) when climate was at its harshest, but is also much earlier than archaeological evidence of significant human presence in North America (the last 13,000 years). The authors suggest that environmental changes in the run-up to the coldest part of the ice age were probably responsible.

The project was directed by Alan Cooper, who has taken up a Federation Fellowship at the University of Adelaide, where he is applying similar approaches to the study of Australian extinct and living biota.

Like the recent study on horses (see "Shrinking Horses", *Nature Aust.* Spring 2004), the bison study establishes climate as a key factor affecting Beringian faunal population declines—even if humans, once they reached significant numbers, might have delivered the coup de grâce to reduced populations already doomed.

—R.F.

Home Delivery for Hungry Crabs

Conditions around the shallow-water hydrothermal vents in the seas off the coast of Taiwan are brutal. Temperatures soar up to 116° C, the water is extremely acidic, and a toxic cocktail of chemicals makes life impossible for most organisms. Worse still there's nothing to eat.

Yet the vents are home to the crab *Xenograpsus testudinatus*, which emerges at certain times of the day from crevasses to swarm across the ocean floor at densities of up to 364 animals per square metre.

How these crabs find food is something that puzzled biologists until Ming-Shiou Jeng (Academic Sinica in Taipei) and colleagues dissected the crustaceans' guts to see what they were eating.

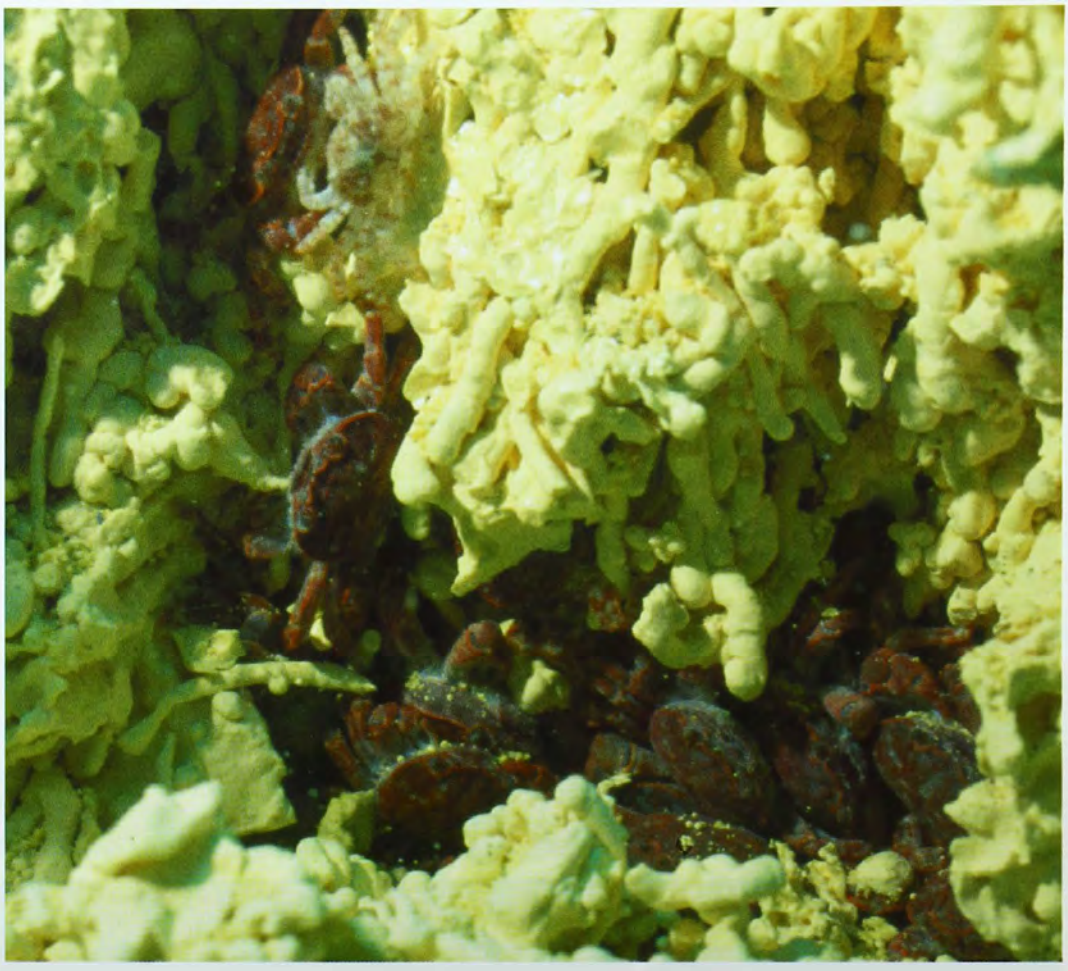
They found their stomachs crammed full of zooplankton—tiny animals that normally float near the surface of the ocean (*Nature* 432: 969). How did the crabs get hold of the plankton? Diving down to investigate, the researchers discovered that, when conditions are calm, the boiling, poisonous water pouring from the hydrothermal vents goes straight upwards, killing anything above it.

Cooked by the hot water, millions of zooplankton at the surface sink down and provide a feast for the crabs, which scurry about picking up the dead plankton off the ocean floor. The researchers noted that the falling zooplankton had the appearance of falling snow.

Crabs have learnt that when the current stops running, it's tucker time—emerging from their crevasses twice a day to take

ROBIN SMITH

Bison were once much more genetically diverse than today.



COURTESY NG NGAN KEE

Hydrothermal-vent crabs seek shelter in crevasses until their next meal of cooked plankton rains down.

advantage of the brief banquet in this otherwise spartan world. Then as the current picks up again, the plume veers sideways and the crabs resume their vigil in amongst the rocks, waiting for their next home-delivered meal.

—A.T.

Dolphins Swim in Circles

It is well known that when dolphins sleep, they swim in lazy circles, resting half their brain at a time. However, most research on dolphin sleep behaviour has been done in the northern hemisphere, where they generally swim in an anti-clockwise direction. So when Guinevere Stafne and Paul Manger (University of Witwatersrand, South

Africa) studied a local captive population, they were intrigued to discover that south of the equator, dolphins tend to swim clockwise.

Using a low-light-sensitive camera, Stafne and Manger observed eight adult bottlenose dolphins (*Tursiops truncatus, T. aduncus* and hybrids) on several consecutive nights, and measured the time each sleeping dolphin spent swimming or simply 'hanging' (no motion) in a clockwise or counter-clockwise direction.

They found that collectively, the dolphins spent 86 per cent of their time engaged in clockwise behaviours (swimming 49 per cent, hanging 37 per cent), with only 14 per cent in counter-clockwise behaviours (*Physiol. Behav.* 82: 919).

The researchers say it is still unclear why southern hemisphere dolphins prefer to swim in the opposite direction; dolphins' brains are the same wherever they live, so it is unlikely that differing brain anatomy or chemistry accounts for directional preference. Rather, it appears that dolphins may be capable of sensing magnetic fields, and that differences in the Earth's magnetic field between northern and southern hemispheres may cause them to swim in different directions. The Coriolis Effect (which causes ocean currents to spiral in opposite directions either side of the equator) may also be a factor, but more research needs to be done, particularly on the swimming patterns of dolphins that have been relocated from one hemisphere to the other. However, anecdotal evidence suggests that the direction of swimming of hemispherically translocated dolphins doesn't change, adding more mystery to the observations made so far.

—R.S.

Well-timed Trysts

Tardiness seems to be grounds for 'divorce' among Icelandic Black-tailed Godwits (*Limosa limosa islandica*).

Like many other migratory shorebirds, this species is long-lived (up to 25 years) and usually mates for life. After raising each clutch of chicks, however, breeding pairs separate to fly to different winter feeding grounds on coastal mudflats and grasslands across northern Europe, between Britain and Iberia. Breeding pairs reunite each spring at breeding grounds in Iceland, with flocks arriving over a period of about a month from mid-April.

Recent research by Tómas Gunnarsson (University of East Anglia, UK) and others has found that even though breeding partners over-winter at separate locations—some more than 1,000 kilometres apart—and don't travel together during migration, they usually arrive at their breeding grounds within three days of each other (*Nature* 431: 646).

This extraordinary synchronicity is probably important in maintaining the pair bond, and the consequences when it breaks down were observed on two occasions by the researchers. Two males that arrived more than eight days out-of-sync with mates found their impatient former partners had already hitched up with other birds.

The researchers can't yet explain how most pairs manage to time their arrivals at the breeding grounds so precisely. The separated birds might exploit winter feeding grounds of a similar quality so that they respond physiologically to the onset of the breeding season, and the call to migrate, at the same time. Genetics might be important too. Or the

COURTESY OLEG LYAMIN

The bottlenose dolphin *Tursiops truncatus*. Does the geographic hemisphere affect the direction of swimming during sleep?

COURTESY DANIEL BERGMANN

Black-tailed Godwit pairs synchronise their arrival at their breeding grounds.

pairs may be responding to some sort of environmental cues from the breeding grounds.

—K.McG.

Old *Homos* from Omo

In 1967, two human skulls (Omo I and Omo II) were found in the Kibish Formation, Ethiopia, but how old were they? Ian McDougall (Australian National University) and colleagues have recently determined that both fossils are almost 196,000 years old (*Nature* 433: 733). This is more than 35,000 years older than the next oldest known skulls (*Homo sapiens idaltu*) from Herto, Ethiopia (see "Earliest Modern Funerals", *Nature Aust.* Autumn 2004).

McDougall calculated the maximum age (196,000 years) by measuring the accumulation of radiogenic argon-40 within volcanically derived rocks (tuffs), found below the skulls. Distinct beds of tuff are buried in layers of sandstone, siltstone and claystone, which were originally deposited by the Omo River. These accumulations of sediment can be correlated with periods of river flooding, and are also reflected in black mud layers called 'sapropels' found in drill cores from the Mediterranean Sea. A 195,000-year-old sapropel closely matches that of the 196,000-year-old tuff, providing further confidence that the Omo *Homos* are close to this age.

Should we expect older *Homo sapiens* discoveries? Probably not. About 200,000 years ago seems to be a watershed, and accords with other evidence of origins for anatomically modern humans. Earlier indicators (stone points, grindstones and pigment) of modern behaviour 250,000–300,000 years ago are associated with another species of *Homo*.

—R.F.

DIY Dung Renovations

When it comes to home improvements, the

COURTESY JOHN FLEAGLE

Oldest *Homo sapiens* skulls from Omo, Ethiopia.

Common Waxbills plaster their nests with the poo of carnivores.

Common Waxbill (*Estrilda astrild*) of Sub-Saharan Africa has rather unusual tastes. These tiny finches collect the manure of carnivores to plaster on the outside of their nesting chambers. The spherical nests are hidden amongst the grass close to the ground, so the use of carnivore dung has been suggested as a way of safeguarding the nest from predators, such as rodents and snakes.

To test this theory, Justin Schuetz (Cornell University) spent several seasons studying Common Waxbill nests in South Africa. By creating artificial nests using bamboo baskets, Schuetz plastered half the fake nests with manure from Servals (*Felis serval*) and African Wild Cats (*F. sylvestris lybica*), while leaving the other half untreated. Using unfertilised finch eggs that were obtained from captivity, nests were placed in the wild and observed over 16 days. Schuetz found that nests treated with cat scats survived significantly better. On average the nests covered in poop lasted 14.8 days, whereas untreated nests lasted 12.4 days (*Behav. Ecol.* 16: 133).

While the stench of carnivore scat may help mask the scent of nestlings, it most likely deters rodents from approaching an area that stinks of their own predators. Living in a whiffy house might not be pleasant for the chicks, but at least it's a home-security system that's been proven to work.

—K.H.

Ear, Ear!

The bones of the mammalian middle (or internal) ear, which convey sound from the eardrum to the auditory nerves, are a striking example of evolutionary opportunism. Mammals are unique among animals in having three such bones—the incus, malleus and stapes. In mammalian ancestors, the incus and malleus, along with the tympanic bone (which supports the eardrum), were large bones that formed part of the jaw. During the evolution of mammals, they detached from the jaw, shrank in size, and were co-opted for hearing. One might assume that such a complex and bizarre event must have occurred only once—in the common ancestor of monotremes, marsupials and placentals—but a tiny new fossil suggests otherwise.

Tom Rich (Museum Victoria) and colleagues describe a new lower jaw of the oldest known monotreme, the 115-million-year-old Platypus-like *Teinolophos trusleri* from Flat Rocks, Victoria (*Science* 307: 910). Its anatomy suggests that the incus, malleus and tympanic bone were all still integral parts of the jaw in this primitive monotreme. This in turn implies that separation of the bones (to form the distinctive mammalian middle ear) evolved independently in advanced monotremes, and in therians (marsupials and placentals).

While the parallel evolution of such a distinctive ear morphology seems surprising, there are similar, albeit slightly simpler, precedents elsewhere in the animal kingdom. Frogs, lizards and archosaurs (crocodiles and birds) all hear very well, using a middle ear that has only a single sound-conducting bone. For a long time, this type of middle ear was also thought to have evolved only once. However, fossils of primitive

A fossilised jaw of the oldest known monotreme *Teinolophos trusleri*.

relatives of all these animals reveal that a single-bone middle ear, and good hearing, evolved convergently in each of these groups as well.

—M.L.

Honeycomb Hexagons Explained

How do honey bees (*Apis* spp.) manage to create those perfectly arranged hexagonal honeycomb cells in which they raise their brood? It turns out that the answer is not nearly as clever or complex as was once widely thought. There's certainly no evidence that bees deliberately work the wax using sophisticated angles and measurements. Rather, it's simply a matter of physics.

Christian Pirk (now at University of Pretoria, South Africa) and colleagues made their discovery by mimicking what bees do when they construct each honeycomb cell, which is to secrete wax flakes around themselves (*Naturwissenschaften* 91: 350). Packed closely together, each honey bee's body acts as a self-warming cylinder so that metabolic heat from the bees raises the temperature of the surrounding wax to 40° C. The wax melts, and flows around the bees' bodies. As the wax then cools and hardens, the six points of contact between the adjacent bees change into lines of surface contact, and the familiar hexagonal cells we call honeycomb. To prevent the cells from melting again, the bees add silk for reinforcement.

—K.McG.

Octopus Twinkle Toes

Do you remember those classic scenes from "The Flintstones", where Fred manages to sneak across an open space without being seen? He does this by holding a leafy branch over his face and doing a 'twinkle-toe' walk. Amazingly, Fred is not alone. Two octopus species have been found to do the same thing.

Christine Huffard (University of California, Berkeley) and colleagues video-taped the fist-sized *Octopus marginatus* as it moved along the seafloor (*Science* 307: 1927). Striding out on the tips of just two of its limbs, with the other six wrapped around its body, it bore a remarkable resemblance to a rolling coconut—a common sight in the tropical Indonesian waters where this octopus lives. Another tropical species, the walnut-sized *O. aculeatus* from Australia, was filmed walking with a similar two-armed gait along the bottom of a three-metre-long aquarium. But rather than wrapping its other arms around its body, it held them loosely above its head, giving it the appearance of a drifting piece of seaweed.

The researchers explain that this bipedal stealth mode of locomotion not only provides excellent

ANDREW HENLEY/AUSCAPE

How do honey bees create such perfectly hexagonal honeycomb cells?

This Heat's the Pits

Everyone's always assumed that the heat-sensing pits from which pitvipers get their name evolved to help them catch prey. And it makes a great story—snakes striking unerringly at some poor quivering mouse in the pitch dark thanks to their bizarre sensory organs. But Aaron Krochmal (currently at University of Houston - Downtown) and colleagues wondered if these remarkable organs might have other uses.

The researchers decided to test whether or not the snakes could use their pits to find somewhere cool to escape the heat. All up, they collected 13 different pitviper species, ranging from primitive to advanced and from a variety of habitats, and one species of true viper (which doesn't have pits), and placed them, one at a time, in a Y-shaped maze made from PVC tubes. The maze was situated in a room kept at 40° C—hot enough to stress but not kill the snakes—and at the ends of its two diagonal arms were refuges, one at the same temperature as the room, the other cooled to 30° C.

In half of the trials, the researchers temporarily disabled the snakes' pits by plugging them with a small polystyrene ball and then gluing some aluminium foil over them. They found that in the pitvipers, the snakes with functional pits preferentially chose the cool refuge, while those with disabled pits showed no preference (*J. Exp. Biol.* 207: 4231). The true viper also showed no preference.

Because the ability to use the pits to choose the cooler refuge was present in all of the pitvipers but not in the true viper, the scientists suggest that this is probably an ancestral trait among the former. They also speculate that it may well be this function, rather than the ability to deal death in the dark, for which the pits first evolved.

—G.T.

COURTESY TONY LEE CAMPBELL

Close-up of the pits of a Western Diamondback Rattlesnake (*Crotalus atrox*).

COURTESY XIAOMING XU & INST. VERT. PALEONT. PALEOANTHROP. CHINESE ACADEMY OF SCIENCES

Reconstruction of the Mesozoic mammal *Repenomamus giganticus* eating a juvenile dinosaur *(Psittacosaurus)*.

camouflage from predators (by freeing up the other arms for a disguise), but is actually faster than walking on all limbs. And, just as Fred Flintstone isn't the only cartoon character to adopt the camouflaged, twinkle-toe gait, there are likely to be other octopus species that do it too.

—G.H.

Mesozoic Mammals on the Rise

Early mammals are typically viewed as tiny shrew-like creatures eking out a marginalised existence, until the mass extinction of the dinosaurs gave them their big evolutionary break. However, spectacular new mammal fossils from China challenge this scenario.

Yaoming Hu (Chinese Academy of Sciences) and colleagues describe a new mammal, *Repenomamus giganticus*, which lived during the peak of the dinosaurs' reign (*Nature* 433: 149). At over a metre long and weighing 12–14 kilograms (about as large as a Tassie Devil), this is by far the largest Mesozoic (250–65 million years ago) mammal, overlapping in size with small contemporaneous dinosaurs. The Chinese team also describes a fossil of a smaller

related mammal with a juvenile dinosaur in its stomach, and suggests that mammals might have actively competed with and predated upon small dinosaurs during the latter stages of dinosaurian history.

Consistent with this view, David Penny and Matt Phillips (Massey University) showed that small dinosaurs declined in diversity towards the end of the Mesozoic, perhaps due to competition from mammals and birds. If this new view of the success of early mammals is true, the meteorite impact that killed the dinosaurs and paved the way for the mammalian radiation might have simply accelerated a trend that was already underway, instead of radically changing the course of evolution.

—M.L.

Snoozing Jellies Caught in the Act

Many jellyfishes have superb eyesight and awesome defences, but could they be complex enough creatures to need sleep?

Jamie Seymour (James Cook University) and colleagues believe so. They have discovered that the Box Jellyfish (*Chironex fleckeri*)—a deadly marine creature found in northern Australia—appears to 'sleep' during the night (*Medical J. Aust.* 181: 707).

The researchers used superglue to attach a tracking device to the bell of several individuals, then followed their travels through the tropical seas. They found that, during the day, the jellyfishes moved at about 200 metres per hour. But in the late afternoon they dropped to the bottom and lay at rest with their tentacles spread about them. The jellyfishes remained this way until the following morning when they resumed swimming at about 6 am.

It is thought that sleep serves a variety of functions for humans, particularly so our brains can sift and order the thoughts and experiences we have had during our waking hours. It's unlikely jellyfishes sleep for the same reasons, but sleep may serve a different function.

For one thing, sleeping saves energy. The Box Jellyfish is an active hunter of fish and relies on its excellent eyesight to do this (Box Jellies possess four sets of six eyes). But there's no point hunting at night if you can't see your quarry. It makes more sense to save your energy for growth—which these jellyfishes do at a rate of two to three millimetres per day. Resting on the bottom when it's dark also helps jellyfishes avoid hungry marine turtles, their main predators.

—A.T.

FURTHER READING

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

QUICK QUIZ

1. *What is the name of Jared Diamond's latest book about factors that lead to the downfall of societies?*
2. *Where else are magnetic (meridional) termite mounds found besides Australia?*
3. *What type of animals are Imperial Blue Butterflies closely associated with?*
4. *Name the new geological period (620–542 million years ago) that was formally recognised last year.*
5. *What is an 'opera house' style trap used to collect?*
6. *Name the world's tallest plant.*
7. *What are the two most prominent colours of the male Mistletoebird?*
8. *How many toes does an Ostrich have on each foot?*
9. *What term is given to the rotational effect of the Earth's spin?*
10. *What type of plant is a halophyte?*

(Answers on page 79)

COURTESY JAMIE SEYMOUR

A tagged Box Jellyfish having 40 winks.

...And a Koel in a fig tree

I was going insane. I'd raised teenagers, I'd attended speech nights and I'd endured violin practice, but in the Common Koel I'd met my match!

LAST DECEMBER I HAD A CLOSE brush with alcoholism induced by my mother-in-law. She'd invited us to stay with her at Stradbroke Island for two weeks over Christmas, a prodigious period of engagement I'd thought. And solid grounds to open the rum meant for the cake.

My problem was not so much with her; as mother-in-laws go she's a living legend. It had more to do with her oh-so-dreary tenant whom I'd got on the phone just about every time I'd rung her in the last three months. Always droning on in the background. To me he was nothing more than a boring, fly-by-night who came to the island to cat around for the summer and then leave. Yet Ellie, my wife's mum, seemed to hang on his every word.

And the things she said she'd seen him doing lately, you wouldn't read about; feeding cherries to one of the island girls then copulating with her under the fig tree, beating up the local skin-heads that were attacking his mate, even swallowing whole stone fruits then showing off by vomiting up the dry pits.

Arriving on the island late at night, we found everyone but Ellie asleep, but she warned me that by 3.30 a.m. 'you-know-who' would be up. Solid grounds to justify a toddy or two with a slice of the Christmas cake we'd just unpacked!

True to her word, around three the next morning, just outside the bedroom window, he started "coooo-eee, cooo-eee, coooo-eeee" in that piercing, excruciatingly monotonous way that had me anticipating every next phrase and then getting a rush of hot rage when it arrived. By 6.30 a.m., I was uncorking the *vino collapso* for a morning of cerebral paralysis on the back verandah that looked into the crown of a big fig tree.

By the end of the first week the fluid in my veins could have pickled a mammoth. It was OK for Ellie; her husband's snoring over the last 50 years had primed her to sleep through a nuclear strike. I, however, was going insane. I'd raised teenagers, I'd attended interminable speech nights and I'd endured four years of their violin practice, but in the Common Koel (*Eudynamys scolopacea*) I'd met my match!

Whether Ellie could see I was no longer fit to provide for her daughter and grandchildren I'm not sure, but very subtly she began drawing my attention away from the lead sinkers and other missiles I had reloaded onto the verandah railing and onto the dynamics of the fig tree. There, at eye level, and no more than five metres away she told me to just watch what happened when I heard the "wark-wark-wark-wark" of enraged Leatherheads (Noisy Friarbirds, *Philemon corniculatus*) chasing the female Koel back into the fig.

When it finally happened I looked up from my glass and saw a big brown spotted bird (the female Koel) screaming "dit-dit-dit-dit-dit-dit" while the Leatherheads attacked and chased her down through the branches to the very base of the tree.

This brought the fiery-eyed male who flung himself into the fracas sending the mobsters packing while he screamed out a call that sounded like a rising "wood-oo, wood-oo, wood-oo". Almost immediately, as if to provide her with some sort of comfort (after all, being a cuckoo, she'd probably been out on a sortie, appraising friarbird nests for an egg drop), he made a gently "hick-hick-hick-hick" and approached her with a fat, red Brazilian Cherry (*Eugenia brasiliensis*) in his mouth. Then, having gained her attention with the cherry, he casually climbed onto her back and copulated with her. Mind you he didn't actually feed her the fruit until he'd had his way and dismounted!

Mmmm, this is pretty interesting, I'd thought; I never realised cuckoos had much of a love life.

Sensing a fleck of interest beyond the bottle, Ellie said to me, "Now see how he deals with the local fruit". So I watched him eat.

Common Koel

Eudynamys scolopacea

Classification
Order Cuculiformes (cuckoos), family Cuculidae (true cuckoos and koels).

Identification
Length of a thin Magpie, 40 cm. Male shiny black with ruby eye; female's back brownish black with white spots, underparts pale with barring.

Habitat and Distribution
Woodland to rainforest with fruiting trees from Kimberley to Vic. Also from Iran through India and Indonesia to PNG.

Biology
Eats native and introduced fruits, but mostly figs. Arrives in Aust. from Indonesia and PNG in Sept. to breed. Adults and young leave in Mar. Parasitises nests of Magpie-larks, Figbirds, and large honeyeaters like Noisy Friarbirds and Red Wattlebirds. Lays many eggs in one season but not in same nest. Male calls day and night "coo-ee", female less often with "dit-dit-dit-dit".

BY STEVE VAN DYCK

REG MORRISON/AUSCAPE

A female Koel sings her 'dit-dit-dit-dit' call, which is much easier on the human ear than the male's monotonous 'coo-ee'.

First I saw him picking cherries. These he simply pulled off the branch, but to get the great fat things down his throat he had to pump his neck like a constipated concertina. That was pretty funny. With the smaller marble-sized native figs, however, he'd pick them, but then give them four or five sharp flicks before swallowing them. Why the big flick?

I picked some of the figs myself and when the sticky white milk oozed out of the severed stems onto my fingers it was pretty clear that this cuckoo was no klutz. If that stuff was almost impossible to wash off my long glass tumbler, how bad would it be on the roof of your mouth?

Then I heard a high-pitched wheeze like the sound of someone deflating a pinched balloon. It was the male coughing and jerking his head from side to side like he had something stuck in his throat. Next thing he opened his mouth and out fell a ball the size and shape of a sucked Jaffa. I scrambled around down in the ferns until I found it, perfectly clean, dry and white. A quick nibble on a ripe Brazilian Cherry on the way back confirmed what it was—not as clean and bright as the Koel's, but a white cherry stone just the same. Instead of sending that great plunger through his digestive system then facing the heavy music at the rear end, he was dealing with it all up front. This cuckoo was very cool.

By the end of the holiday his record regurgitation rate stood at three stones coughed up in as many minutes! And by that time I'd seen him feed his mate so many cherries that she was often either too sick or full of them to do more than take the treat but then unapologetically drop it to the ground!

To his credit, his offer of fruit did not always come with strings attached! They had an understanding. Sometimes she didn't swallow; sometimes he didn't score. But the bond was undeniably close; they were mates that worked together and relaxed together.

If I'd had more time to drink and less time to gawk in that second week, I wouldn't be looking forward so much to next Christmas...my mother-in-law, the verandah, and the extraordinary lodger who'll be back in the same fig tree, filling Point Lookout with his magic call! □

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

Black Rockcod

This magnificent fish can grow to two metres in length and weigh over 80 kilograms.

LURKING BENEATH A ROCKY overhang, the cavernous mouth of a Black Rockcod hides its large canine teeth. Generally solitary and sometimes docile by nature, this magnificent fish can grow to two metres in length and weigh over 80 kilograms. However, specimens of these dimensions are now rare.

The Black Rockcod (*Epinephelus daemelii*) is a large teleost (bony) fish belonging to the family Serranidae. This large family includes rockcods, groupers and coral trouts, and comprises around 450 species worldwide. Related species of *Epinephelus* that occur in New South Wales waters include the Estuary (or Goldspotted) Rockcod, the Banded (or Bar) Rockcod, the Malabar Grouper and the Queensland Groper, all of which grow to over one metre in length and can be confused with the Black Rockcod. Many rockcods and groupers are known to form spawning aggregations and anecdotal evidence suggests that Black Rockcods do the same. Also, like many other rockcods and groupers studied to date, the Black Rockcod is a protogynous hermaphrodite, meaning that all juvenile fish are females and a proportion of the females eventually change sex to become males. Preliminary research in New Zealand waters indicates that sex change occurs at lengths between 100 and 110 centimetres.

The Black Rockcod occurs in warm temperate and subtropical waters of the south-western Pacific. Its coastal distribution extends from southern Queensland to southern New South Wales and New Zealand. Once common along the New South Wales coastline, its strongholds are now around island localities of northern New South Wales (between South West Rocks and the Queensland border). It is also found around more remote islands and reefs such as Lord Howe Island, Norfolk Island, the Kermadec Islands, islands off northern New Zealand, and Elizabeth and Middleton Reefs. In New South Wales waters, juveniles usually inhabit coastal and estuarine rock pools, while subadults and adults move farther offshore to rocky reef habitats such as caves, gutters and bommies to depths of at least 50 metres. Most observations of large Black Rockcods are associated with caves, where they are commonly found, especially during daylight hours. Individual Black Rockcods can inhabit a particular cave for many years if left undisturbed. Most groupers and rockcods are ambush feeders, dining on fishes and crustaceans.

Individual Black Rockcods can inhabit a particular cave for many years if left undisturbed.

Concerns about diminishing numbers of Black Rockcods date back to 1916 when scientist Theodore Roughley commented on their decline around the Sydney region. In 1922, ichthyologist Allan McCulloch reported it to be "a valuable food fish in NSW", highlighting its abundance and culinary qualities. The increased popularity of spearfishing in the 1960s and 1970s also took advantage of the curious and territorial nature of the Black Rockcod. Numbers speared in New South Wales competitions in 1976 alone totalled 137 fish averaging 2.4 kilograms in weight. In 1983 the Black Rockcod was listed as a protected species in New South Wales

BY JOHN POGONOSKI

waters. Unfortunately, specimens still turn up at the Sydney Fish Markets, where they are usually confiscated on the market floor. Their sale in New South Wales is banned, regardless of the location of capture.

In recent years, anecdotal evidence suggests that the Black Rockcod has made a slow recovery in some areas, with sightings of small to medium-sized fish (less than about one metre) being relatively common. Preliminary scientific studies point to it being a slow-growing, late-maturing, long-lived fish. Most organisms with such traits are easily over-harvested and take many decades to recover from exploitation.

Scientific research to date has barely scratched the surface of the secret life of the Black Rockcod. A planned joint research project between the University of Technology (Sydney) and New South Wales Department of Primary Industries (Fisheries) aims to address some of the many information gaps for this species. The focus of this research revolves around understanding the spawning behaviour, home range and movements, population parameters (sex ratios, size and age at maturity, fecundity and genetics) and recruitment of juveniles to populations in New South Wales. The spearfishing and SCUBA-diving fraternity may play a role in assisting scientists in their quest for knowledge.

The obvious challenge to researchers lies in accumulating scientific information without exerting further pressure on Black Rockcod populations. Embracing 21st-century technological advances, such as tagging and tracking devices and underwater video systems, will no doubt contribute to the success of the research. □

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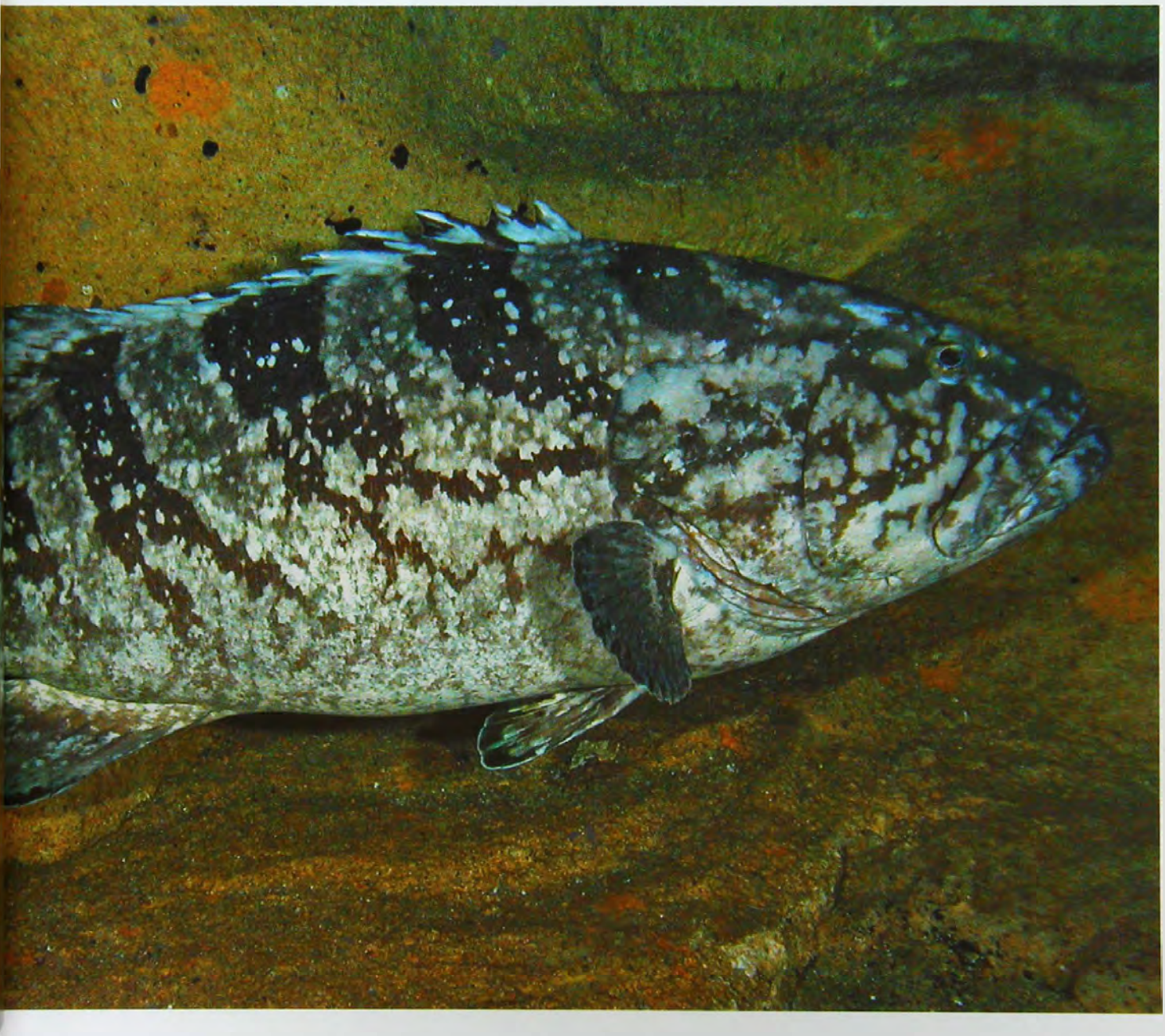


DAVID HARASTI

Creeping and climbing

Climbing and creeping habits have evolved many times among plants, with vines occurring in close to half of all seed-plant families.

Bower Vine (*Pandorea jasminoides*) is a vigorous rainforest vine that has become popular in gardens for its attractive flowers and for its value in blanketing unsightly structures.

BY TIM LOW

SEVERAL YEARS AGO I INSTALLED A native grassland in my garden by transplanting clumps of native grass from a development site. For several seasons my little grassland brought me much joy, then everything went awry. A little native creeper in my lawn, Wandering Jew (*Commelina diffusa*), began invading the spaces between the clumps. A few native vines planted among the grasses became too assertive, then the ornamental jasmine on a nearby fence joined the fray. I found myself locked into a backyard battle against creepers and twiners.

Now, ten years on, I have lost. All the grasses are long dead and a tangle of jasmine has taken their place. While I am sad about my grassland, I am very impressed that it was swamped so comprehensively by vines. Why should this be?

Vines are plants with elongated stems, which either creep along the ground (creepers), or climb upwards by gripping other plants, sometimes developing a woody stem and becoming what are called 'lianas'. Compared to shrubs and trees, vines skimp on structural supports, diverting more of their resources to leaves and roots. Because leaves and roots power growth, vines can grow very quickly, often becoming the first plants to claim newly bared ground, and often smothering taller foliage. Some of them sprout roots from their stems to take advantage of newly encountered soil.

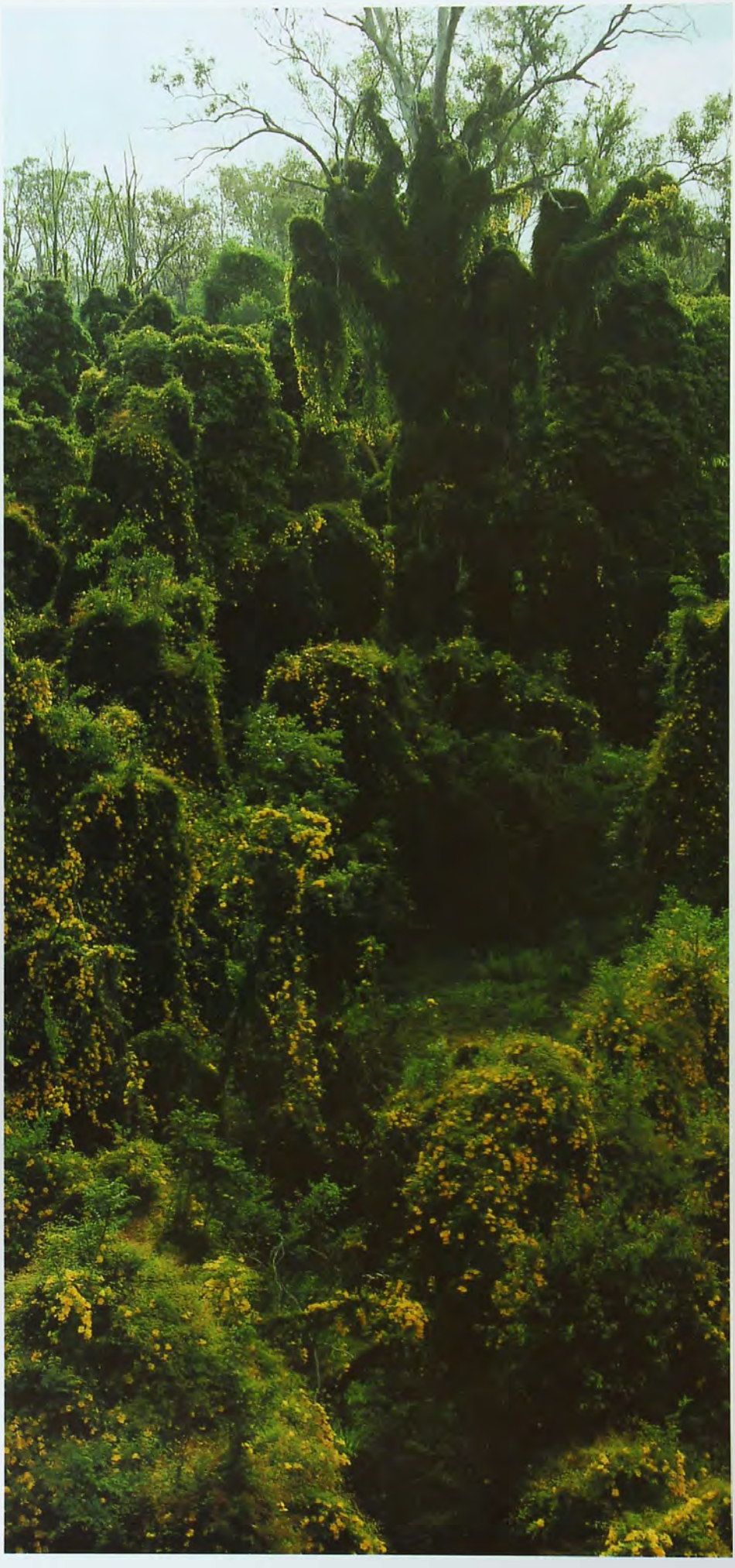
By growing quickly these plants can capitalise on change. When a rainforest tree falls, or riverine forest is felled by floods, vines are often first to fill the space, although trees eventually overtop them. On changeable coastal dunes creepers often dominate, their runners keeping pace with shifting sands. In monsoon woodlands, vines resprouting from tubers quickly exploit rains falling after a long dry.

Vines do best in tropical rainforests, as any Tarzan fan would know. The larger ones reach the canopy where they compete seriously with trees for light, as well as competing underground for nutrients. When a liana-clad tree falls the tree dies but the flexible lianas survive, often going on to form leafy tangles that inhibit growth of new trees. Vines do best along rainforest edges where they encounter more young vegetation to climb over and more sunshine to fuel their growth.

Climbing and creeping habits have evolved many times among plants, with vines occurring in close to half of all seed-plant families. There are climbing palms, ferns, figs, orchids, wattles and peas, climbing via devices such as tendrils, hooks, spines, aerial roots and stems that twine and lean. The diversity of lineages shows that evolution has often favoured a climbing habit.

But the advantage of being a vine—a cost saving in structural support—can also prove a weakness. Vine stems, as thin-walled tubes servicing large numbers of leaves, are poorly insulated against fires and cold, and vines are least successful where there are cold winters or unpredictable fires.

People depend a lot upon vines. Major crops include yams, Sweet Potato, Pepper, Pumpkin, peas, beans, cucumbers, melons, Passionfruit, Hops, Kiwi Fruit and of course Grapes, the original 'vine'. Cane furniture comes from climbing palms called rattans (*Calamus* species). Vines also make handy garden plants because they can quickly cover shabby fences, trellises and bare ground. But because they can grow fast and favour disturbed sites vines also do well as weeds. Rubbervine



PHOTOS TIM LOW

Vines such as Cat's Claw Creeper (*Macfadyena unguis-cati*) are counted among Australia's worst weeds because they smother native vegetation, sometimes including trees.

(*Cryptostegia grandiflora*) and Bridal Creeper (*Asparagus asparagoides*) rate as two of Australia's 20 worst weeds, and many others cause problems. At Wingham Scrub near Taree, New South Wales, garden vines nearly ruined a valued rainforest fragment, with 560 stems choking one tall tree. The National Trust sprayed up to 160 litres of herbicide a year over several years to break their lock.

But if weedy vines are proliferating today, so too are their native counterparts. All over the world, damage to tropical forests by logging, road-building, piecemeal clearing and fragmentation is proving very helpful to vines, which contribute to the kind of regrowth once called 'jungle'. Damaging floods made worse by climate change and upstream deforestation also aid vines. So too, it seems, do greenhouse gases—or at least carbon dioxide. Deep inside the Amazon rainforest the mass of lianas is increasing relative to trees by 1.7 to 4.6 per cent each year, a change attributed speculatively to high carbon dioxide levels.

Put simply, vines like disturbance, and people are disturbing the world more than ever before. My vine-choked garden is a microcosm of the wider world—or at least the warmer and wetter parts of it. I'm not sure we can do much about all this, apart from noting the change underway. Maybe someone should make a movie: "Invasion of the Vigorous Vines". They could film it in my backyard. □

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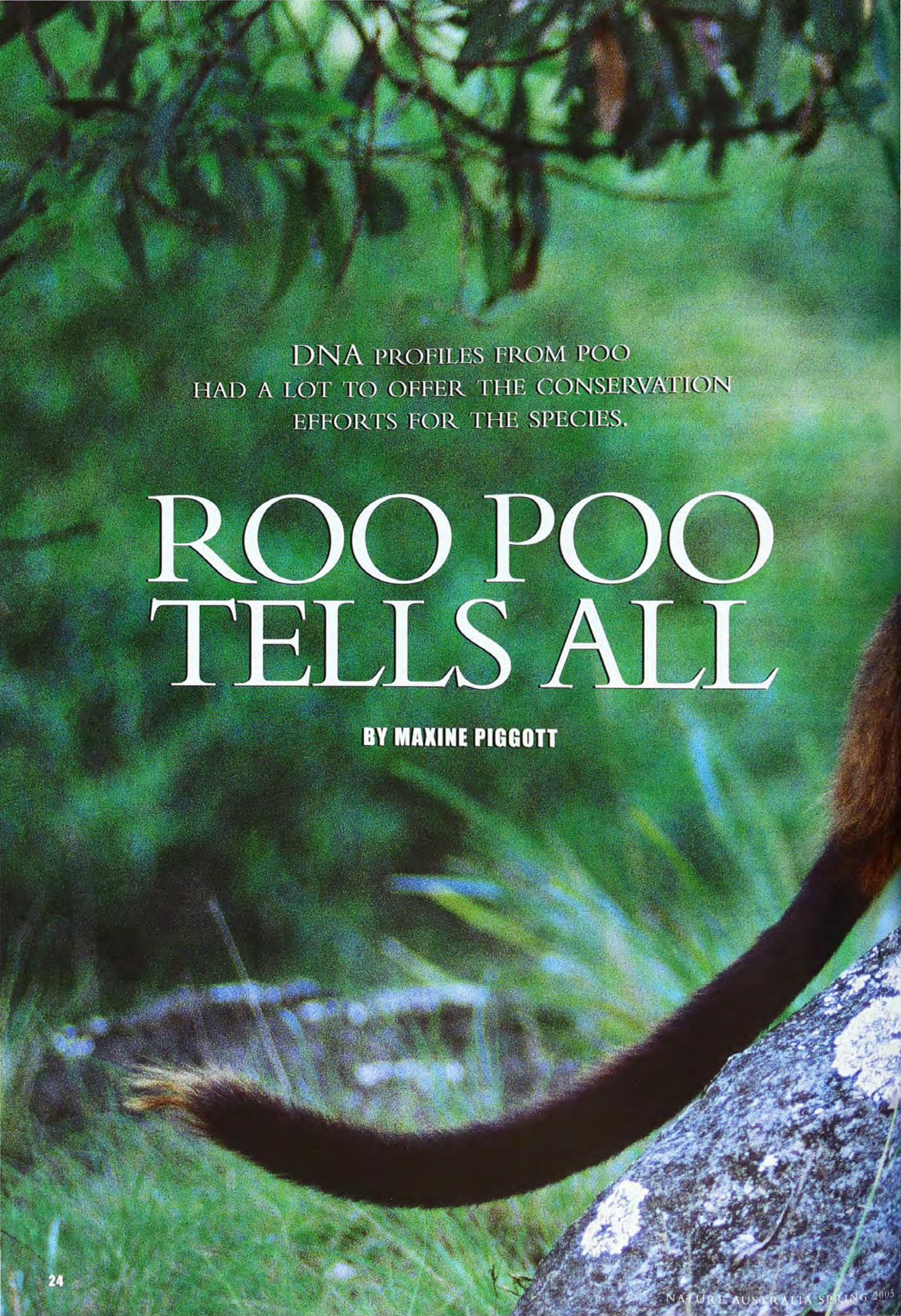
TIM LOW IS A BIOLOGIST AND NATURE WRITER LIVING IN A VINE-CLAD CORNER OF BRISBANE. HIS MOST RECENT BOOKS ARE *FERAL FUTURE* AND *THE NEW NATURE*.



DNA PROFILES FROM POO HAD A LOT TO OFFER THE CONSERVATION EFFORTS FOR THE SPECIES.

ROO POO TELLS ALL

BY MAXINE PIGGOTT

Brush-tailed Rock-wallabies move down to the bottom of the cliffs to graze in the evenings on native grasses.

DAVE WATTS/OCEAN PLANS/RARE SPECIES

HAVE YOU EVER WISHED you could identify which neighbour's Dog left the steaming pile on your front lawn? This is now possible, since every time an offending mutt leaves a deposit, it also leaves behind its unique DNA profile. In fact, a DNA 'fingerprint' can be taken from a wide range of animal sources, including scats (faeces), hair, feathers and even urine, and used to determine the species, identity and gender of the individual animal from which it came. This has been an important breakthrough in the conservation of rare or endangered species that are difficult to trap and study.

In 2000 I started a Ph.D. project on DNA extraction from poo. At the time, researchers overseas were developing techniques for bears, coyotes, wolves and even whales, but this was a very new field in Australia. I spent the first year of my research trying different ways of collecting, storing and washing scats from a range of Australian animals—as diverse as quolls, Foxes and rock-wallabies—to develop the most effective way of extracting DNA to assist in the conservation of Australian mammals. It was around this time that I met Neil Stone and Chris Banffy from the New South Wales Department of Environment and Conservation (DEC). Neil and Chris were keen for me to apply my newly gained poo expertise to help them monitor and conserve Brush-tailed Rock-wallaby colonies in the Wolgan Valley in Wollemi National Park, New South Wales.

BRUSH-TAILED ROCK-WALLABIES (*Petrogale penicillata*) are found in south-eastern Australia and have declined seriously throughout their range. Although monitoring changes in abundance is an important aspect of endangered-species management, Brush-tailed Rock-wallabies aren't easy to observe or trap, and it had so far proved extremely difficult to estimate the size of the Wolgan Valley colonies. Since it is much easier to pick up a scat than catch a rock-wallaby, DNA profiles from poo had a lot to offer the conservation efforts for the species.

Wollemi National Park is a fantastic place to do fieldwork, but the terrain makes accessing many of the colonies extremely difficult. Indeed, the rock-wallabies were only discovered there in the late 1990s, when a ranger spotted some from a helicopter during fire-fighting operations. Further investigations on foot and by air showed that the animals sheltered in rock crevices and caves at the base of sheer cliffs and fed on the leaves of the native fig trees that grow on the boulders. Although their living arrangements seemed idyllic, rangers soon discovered a Fox den nearby, complete with several rock-wallaby carcasses. Predation by Foxes has probably been one of the major causes of the decline of the species, and since the discovery, Chris Banffy has been coordinating a Fox-control program to minimise the risk from these feral predators.

After the first colony was found, rangers soon found Brush-tailed Rock-wallabies at three other locations in the valley—Rocky Creek, Crocodile Rock and Little Tower. Although there was no method to accurately count the number of wallabies at these sites, they appeared to be smaller populations than the first (Main) colony. Crocodile Rock was named after the distinctive shape of the major rocky outcrop at this site, which resembles a crocodile's head with its jaws slightly open. Accessing the top of the rocks requires clambering through the crocodile's 'jaws'. Other appropriately named locations braved by myself and the other intrepid poo

Wolgan River, Wollemi National Park. Brush-tailed Rock-wallabies in the Wolgan Valley prefer not to cross this river when dispersing between colonies.

BRUCE LOCHMAN/LOCHMAN TRANSPARENCIES

KATHIE ATKINSON

Brush-tailed Rock-wallabies use their tails for support when jumping around rocks and boulders.

collectors included Scary Cave, Killer Ant Rock and Xena Rock.

Neil Stone has been monitoring the four colonies by counting scats in designated 1 x 2- metre 'scat plots' located 25 metres apart, twice each year, to identify trends in abundance. However, since nobody knows just how much poo a rock-wallaby can do, it is very difficult to work out population size from the number of scats collected. DNA analysis could solve this problem, because if individuals can be identified from their faecal DNA profiles, then a 'mark and recapture' analysis can be applied to the DNA profiles.

I first carried out a pilot study to find out whether DNA analysis of scats was a feasible approach to identifying individual rock-wallabies. I found that I could obtain good-quality DNA and reliably identify individuals from scats that were less than one week old. I could easily determine which scats were fresh by their appearance (particularly colour) and smell. Smelling rock-wallaby scats was not that popular so it was left to me to become the scat-aroma connoisseur. At least rock-wallaby scats don't smell too bad, unlike the scats of some of the carnivorous animals I have worked on!

I then teamed up with Neil and Chris during the scat-plot surveys and, with the help of numerous volunteers, we collected about 500 scats from the four rock-wallaby colonies over a two-year period. By the end of a field trip, even 'poo virgins' who started off disgusted at having to collect scats for a week ended up as enthusiastic as I was when locating a 'steamer'. The excitement of finding a fresh one was also of course related to the chance of seeing the animal that recently deposited the sample. The rock-wallabies in this area are wary but curious, and were relaxed enough to sit or lie around, often nodding off to sleep, while we took photos.

MY PROJECT WAS NOT JUST ABOUT frolicking around the Wolgan Valley collecting rock-wallaby scats and watching these lovely animals when the opportunity arose. After a field trip I would return to Monash University and analyse all the samples I had collected. The first step for isolating the DNA involves massaging the scats in plastic bags containing a cocktail of chemicals to remove as many intestinal cells as possible from the surface. This also splits the cells open and releases their DNA. Massaging scats is certainly one way to strengthen the muscles in your hands and fingers, but not something I would recommend trying at home.

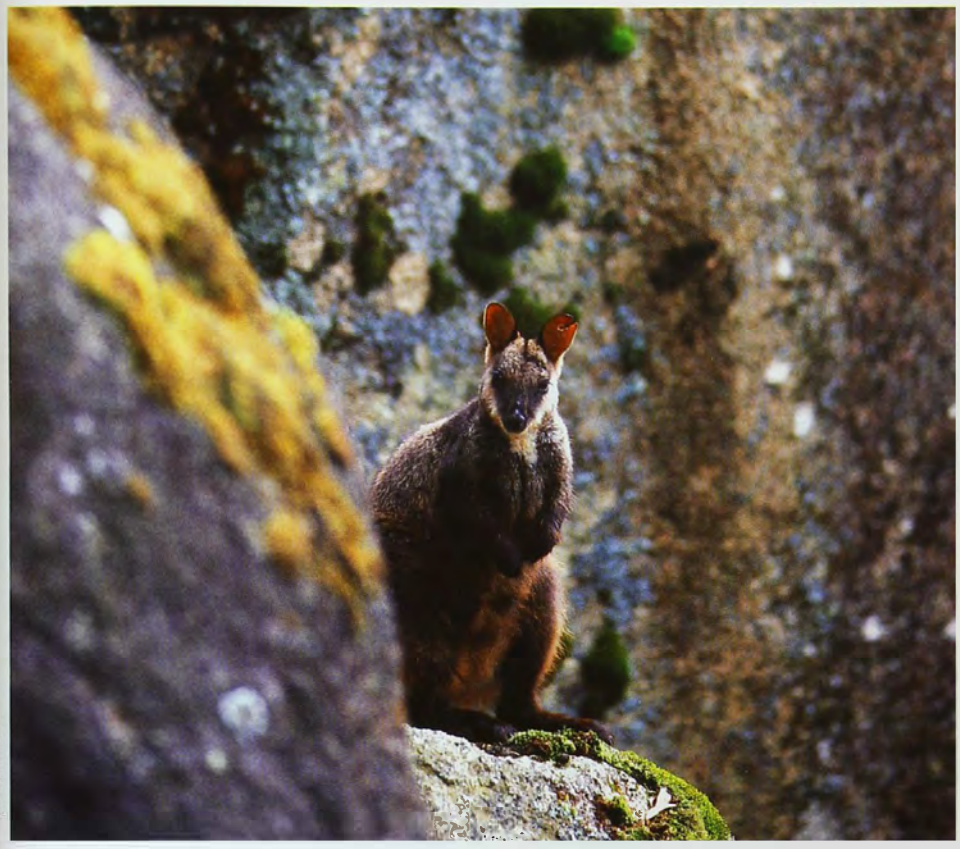
After a purification step to separate the rock-wallaby DNA from the poo, I used a set of genetic markers (sequences of DNA that can differ between individuals) to distinguish individuals based on their DNA fingerprint. Because close relatives are genetically similar, I had to ensure that I used a sufficient number of genetic markers to minimise the risk of a match between two rock-wallabies. I also determined the sex of the individual by using a genetic marker found only on the Y (male) chromosome.

After many months working in the laboratory, I finally started to identify scats that came from the same rock-wallaby. Using scats collected between 2001 and 2003 from all four colonies in the Wolgan Valley, I confirmed the Main colony was the largest in the valley, containing between 60 and 80 animals, while Crocodile Rock and Rocky Creek each had a population size of 15–20 animals. Little Tower had only a few animals but, during the two years of scat collection and analysis, this colony appeared to have increased in size. This increase in size could be due to immigration or birth of new rock-wallabies. There was genetic evidence that a female detected in the first year of sampling in this colony was likely to be the mother of a rock-wallaby sampled two years later.

A benefit of using DNA fingerprints to count rock-wallabies is that the information can be used to infer patterns of movement between the colonies (based on the patterns of genetic similarity between individuals). From this I learnt that each colony in the Wolgan Valley is like an island and that rock-wallabies rarely move

SAM HANKS

The author selecting some 'steamers' from a rock surface.



KATHIE ATKINSON

When disturbed, Brush-tailed Rock-wallabies like this female are sometimes as curious about us as we are of them.

between them. They also didn't seem to like getting their feet wet, as there was evidence of less movement between colonies across the Wolgan River than between colonies on the same side of the river. A low rate of dispersal between the colonies results in each colony being genetically distinct from the others.

The rock-wallabies living within each colony are closely related. However, there were individuals in each of the colonies whose DNA was sufficiently different to suggest they were recent immigrants. These immigrants also appeared to have come from unknown colonies, indicating there were probably more undiscovered colonies of Brush-tailed Rock-wallabies in the area. Neil has since discovered another colony and it is likely there are others scattered throughout the valley.

The results of my study suggest that, to conserve the maximum amount of genetic biodiversity in the Wolgan Valley Brush-tailed Rock-wallaby populations, we must maintain all colonies if possible. Since the colonies are genetically distinct, each is an important component of the overall genetic composition of the entire valley population. The major threat to these colonies is Foxes. Although the Main colony was the only one protected from Fox predation when I started my study, the results showed that the smaller colonies weren't simply 'satellite' colonies or outposts of the Main colony and so they all require independent management and conservation.

The novel DNA methods I developed and used in this study will hopefully assist in reversing the extensive decline and extinction of Brush-tailed Rock-wallaby colonies in south-eastern Australia and offer great opportunities for studying other endangered and rare Australian species in the future. □

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DR MAXINE PIGGOTT COMPLETED HER PH.D. AT MONASH UNIVERSITY AND IS APPLYING NON-INVASIVE TECHNIQUES TO OTHER BRUSH-TAILED ROCK-WALLABY COLONIES AND TO OTHER SPECIES SUCH AS FOXES. SHE IS CURRENTLY IN THE SCHOOL OF BIOLOGICAL SCIENCES, MACQUARIE UNIVERSITY.

Brush-tailed Rock-wallaby

Petrogale penicillata

Classification
Family Macropodidae.

Identification
One of the larger species of rock-wallaby, 4.9–10.9 kg. Coat colour brown above, rufous on rump and grey on shoulders, with chest and belly paler. White to buff cheek stripe. Prominent brush on tail.

Habitat and Distribution
Once abundant in rocky areas in a wide range of habitat. Ranges from south-eastern Qld to Vic. The only rock-wallaby species found in Vic. Has suffered a significant decline in its former range.

Biology
Largely nocturnal during summer, more crepuscular in winter. Prefers rocky outcrops with rock crevices, caves and ledges for shelter during the day. Feeds on grasses and forbs. Colonies comprised of social groups, often a single male and 1 to 3 females. Females produce a single pouch young and breeding may be continuous.

Status
'Endangered' in NSW, 'critically endangered' in Vic.

CYRIL ALBERTS

HOW DO THESE YOUNG BIRDS RECOGNISE PREDATORS, FOOD AND THEIR OWN KIND, GIVEN THAT THEY HAVE NO PARENTS AROUND TO TEACH THEM?

LIFE WITHOUT PARENTS

BY ANN GÖTH

VIGOROUSLY, THE YOUNG BIRD DIGS UPWARDS. A METRE OF SOIL AND leaf litter need to be conquered before it can reach the surface. Rocks and branches are in its way. Only one day ago, it had hatched from an egg that was buried deep in the soil. Now it pushes its head and back against the ceiling of the small cavity it has formed, before scratching and trampling down the loosened soil with its large feet. The hatchling is a megapode, a bird that faces unusual challenges after hatching.

DAVID LOWTHER (INSET)

(Above) A brush-turkey chick emerges from its incubation mound. When reaching the surface, the chicks scan their surroundings carefully and hardly move, to avoid attracting predators. They then quickly run into the nearest thicket to hide. (Right) During the breeding season, adult male brush-turkeys carry a yellow wattle around their neck, which they can either retract, as seen in this picture, or inflate during social interaction.

It was on a remote volcanic island in the South Pacific that I came across my first megapode chick, in a nesting burrow more than a metre deep. It had taken me several hours to remove all the soil to reach that depth, and I could not help but admire the little Polynesian megapode that was about to dig its way up the surface, through all that soil and gravel. Since then, my admiration for these young birds has not ceased.

Megapodes (meaning 'big-feet') leave the incubation of their eggs to external heat sources, such as geothermal heat on volcanic islands, or the heat produced by microbial decomposition of leaf litter in self-made incubation mounds. All three Australian megapodes use the latter strategy. Megapodes are also exceptional because they provide no parental care: their chicks are left to fend for themselves. The only contribution mothers make to the survival of their offspring is by depositing large amounts of yolk into the egg—so much that the chicks can still feed on it after hatching.

When I started my studies on megapode chicks more than ten years ago, I had many questions, such as how long do the chicks remain in the soil after hatching? The books say that megapode chicks can fly "soon after hatching". But how soon is soon—hours or days? Flying obviously isn't possible when you are stuck in the soil. Little was also known about how many chicks survive, where they live and how far they disperse. In addition, there was the question of how these young birds recognise predators, food and their own kind, given that they have no parents around to teach them. There were lots of mysteries to be solved, and I feel fortunate that I have had the opportunity to unravel some of them.

The Australian Brush-turkey (*Alectura lathami*) is an ideal megapode species to study. In many areas along the east coast, brush-turkeys build their large incubation mounds from moist mulch in private gardens. The owners of such gardens sometimes find this unacceptable, especially if the birds incorporate plants, top soil and even sprinklers into their mounds. For me, these suburban mounds are a welcome source of eggs, which I then incubate artificially to obtain chicks. Finding the eggs requires digging through tonnes of soil by hand, which takes a couple of hours per mound.

One of my first studies was to observe how the chicks dug themselves out of a Perspex 'digging box' that was heated from the bottom and filled with mulch material from an incubation mound. I found that, for the first 16 hours or so after hatching, the chicks hardly move, except when they preen their feathers. During this time, while they continue to absorb nutrients from their internal yolk reserve, their plumage dries and their lungs fill with air. Also, the soft inner egg membrane, to which the chicks are still attached, dries and falls off. After that, however, they dig their way straight up, and only rocks or branches force them to take detours. While digging, they are often completely surrounded by soil, but they stop frequently and, when they do, they fashion a small air cavity around them-

GLEN THRELFO/AUSCAPE

An adult male brush-turkey on his incubation mound. This mound is in its early stage of construction. When completed, mounds can be up to three metres high and four to five metres in diametre.

selves, which helps them to breathe.

All 31 chicks in the digging box reached the surface, but the smaller and lighter ones took much longer than the heavier ones. The fastest chick emerged after 26 hours, the slowest after 55 hours, and the average time was 40 hours. No chick ever emerged after dark. This makes sense, because at dusk, brush-turkey chicks climb up a tree to roost. Emerging after dark would leave these hatchlings, which are so dependent on their eyesight, vulnerable to predation by owls and carnivorous marsupials. Numerous predators also await emerging chicks during the day. But the chicks make a dash for the nearest thicket as soon as they exit the mound. Sometimes they are wobbly at first, which is not surprising since they have never run before, but they nevertheless move at an amazingly fast speed for a bird that only weighs around 150 grams.

Many people who live with brush-turkeys remark that they never see the

ROGER BROWN/AUSCAPE

A male brush-turkey covers an egg that has been deposited in his mound by one of the several visiting females. This egg was laid in an unusually shallow location; normally the eggs are buried much deeper.

Australian Brush-turkey

Alectura lathami

Classification

Order Galliformes, family Megapodiidae (megapodes).

Identification

Adults 2.1–2.6 kg with black laterally flattened tail. Wings black, feathers on chest and side of breast brownish-black with paler fringes. Head and neck mostly bare and red, neck bare and yellow. During breeding season, males carry a wattle around the neck. Chicks weigh 100–170 g, have no tail feathers or bare head, and are brown all over.

Habitat and Distribution

East coast of Aust. from Cape York to Illawarra region south of Sydney. In wet and dry rainforests and gullies, but also drier areas with lots of undergrowth. Recently also suburban gardens.

Biology

Does not incubate eggs or look after chicks (typical of megapodes). Males build incubation mounds of leaf litter in which eggs are incubated by heat produced by microbial decomposition of organic material. Several females lay eggs into one mound, from July/Aug. to Jan./Feb.

chicks, while the older birds are so conspicuous. A radio-tracking study provided more insights into the reasons for this. Radio-transmitters glued to the back of the chicks allowed my co-worker Uwe Vogel and me (then at Griffith University) to follow them once they had been released in rainforest near natural brush-turkey mounds. Tracking was an emotional ordeal because mostly all we found were their remains—feathers and the transmitter. Some feathers were bitten off one by one, signs that the culprit had been a Cat. Others had been plucked out without being damaged at the base, indicative of a bird of prey, and sometimes I found whole parts of a wing bitten off and discarded, as Dingoes, Foxes and Dogs tend to do. A snake was only identified as the predator once, when the signal came from inside a large Carpet Python. Cats were by far the worst predators, and more than once did I receive a signal from inside houses at the edge of the rainforest. The house-

owners insisted that their Cats never kill birds, but the freshly dead chicks in the corners of their living rooms always proved them wrong.

One factor, however, did enable some chicks to survive: the presence of large patches of thickets, such as lantana, raspberry and blackberry. This demonstrates once more how important such thickets are for the survival of many small ground-living birds (and also mammals), even though they are regarded as weeds. In my study, I released chicks at two sites, one a rather intact old-growth rainforest without much ground over, the other a more disturbed site with more patches of lantana and other thickets. Survival was significantly higher at the second site. Some chicks travelled up to 800 metres a day to find suitable thickets to hide in, even though they had been released near an incubation mound.

In summary, radio-tracking revealed three reasons why brush-turkey chicks are not often seen. First, because most of them are killed; second, because those that survive prefer to live secretly in dense thickets; and third, because they often disperse large distances. A fourth reason became obvious when chicks were raised in captivity: their rapid growth rate. At hatching, they weigh between 100 and 170 grams, and within nine to ten months, they weigh ten times as much. The chicks have fluffy brown feathers at hatching, but start exchanging these for black feathers at the age of three weeks. When two months old, they look like miniature adults, except that they lack the bright red head and yellow wattle around the neck. By the age of eight months, they are nearly fully grown and have almost reached the adult body weight of approximately 2.2 kilograms for females and 2.5 kilograms for males.

WHILE CHICKS MAY *encounter their parents after emerging, they never form any bonds with them.*

RAISING CHICKS IN CAPTIVITY ALSO allowed me to study how they recognise predators, food and fellow brush-turkeys without the opportunity of learning from adults. While chicks may encounter their parents after emerging from the incubation mound, they never form any bonds with them and live completely on their own. To observe their response to predators, I moved two-day-old chicks into a large outdoor aviary and presented them with predators, including a live Dog

ANN GOTH

One-week-old brush-turkey chick. With their brown plumage, these young birds blend in with their surroundings and can hardly be seen when motionless.

Two one-week-old brush-turkey chicks encounter one another in an outdoor aviary. Most of the social behaviour found in adults is already present in freshly hatched chicks.

and Cat that had been trained to walk through the aviary, a rubber snake that was pulled along the floor, and a silhouette of a goshawk that 'flew' overhead. The youngsters crouched when they saw the bird of prey, and they ran away when the Cat and Dog approached. The snake evoked the least response, as if the chicks knew that they could outrun it easily.

Following the latter study, I felt a lot more confident about releasing the chicks back into thickets in the wild after observing them. In addition, I found that chicks also have no difficulty recognising food. Brush-turkeys feed on whatever invertebrates, seeds and fruit they can find. When I presented two-day-old chicks with the choice of various potential food and non-food items (such as pebbles) they soon learned to direct their pecks at the palatable food only. Food that moved, such as earthworms, was their favourite, which is not surprising given that such fast growth needs to be supported by a high-protein diet.

Recognising predators and food is clearly not difficult for chicks. But how about recognising their own kind? In captivity, they form groups with other chicks from an early age, and even in the wild two chicks are occasionally seen together. The usual process by which birds learn to recognise conspecifics is called imprinting and describes how hatchlings form bonds to the first conspicuous object encountered, usually a parent. Brush-turkey chicks, however, do not imprint, as shown by Sharon Wong at Griffith University. They must therefore respond innately to certain cues in conspecifics. To identify those cues, Christopher Evans (Macquarie University) and I presented chicks with a choice between a stuffed static chick and a robotic chick that pecked at the ground (see "Turkey Tactics", *Nature Aust.* Autumn 2005). The robot was made of the skin of a chick that had died naturally, built around a servo engine for remote-controlled cars. Chicks approached the pecking robot much more that the static chick. In addition, we changed the colour of the robots by mounting coloured filters above them, and found that chicks approached them significantly less if the UV or short-wave colour component was removed from their plumage. These studies show that brush-turkey chicks use certain visual cues, such as

A male brush-turkey showing the typical identification features of the adult birds: a vertical tail, red head and yellow wattle.

body colour and pecking movements, to identify members of their own species. They might also use acoustic cues, such as the one short call that brush-turkey chicks utter, and I plan to investigate this in the future.

Megapodes are also affected by factors long before hatching, such as the amount of hormones and yolk that mothers deposit into their eggs, and by the temperature in their incubation mounds. David Booth (University of Queensland) and I have recently shown that the incubation temperature strongly affects the hatchling's sex. This study was triggered by reports from an Aboriginal elder that the numbers of male and female adult brush-turkeys differ after hot or cold nesting seasons. We incubated eggs at 31° C, 34° C, or 36° C—temperatures found in natural incubation mounds. At 34° C equal numbers of females and males hatched, but significantly more females hatched at 36° C, and more males at 31° C. Many readers will immediately think of similarities with some reptiles, such as crocodiles and turtles. These also bury their eggs, and their sex is determined by the incubation temperature. However, in birds, including brush-turkeys, sex is determined by sex chromosomes long before incubation, whereas the reptiles' sex is determined during incubation.

We do not yet know what causes the sex bias in brush-turkeys. It may be that male embryos are more likely to die at higher temperatures, and females at lower, but it could also be that temperature somehow overrides the influence of sex chromosomes. Another mystery to be solved in the fascinating life history of megapodes! □

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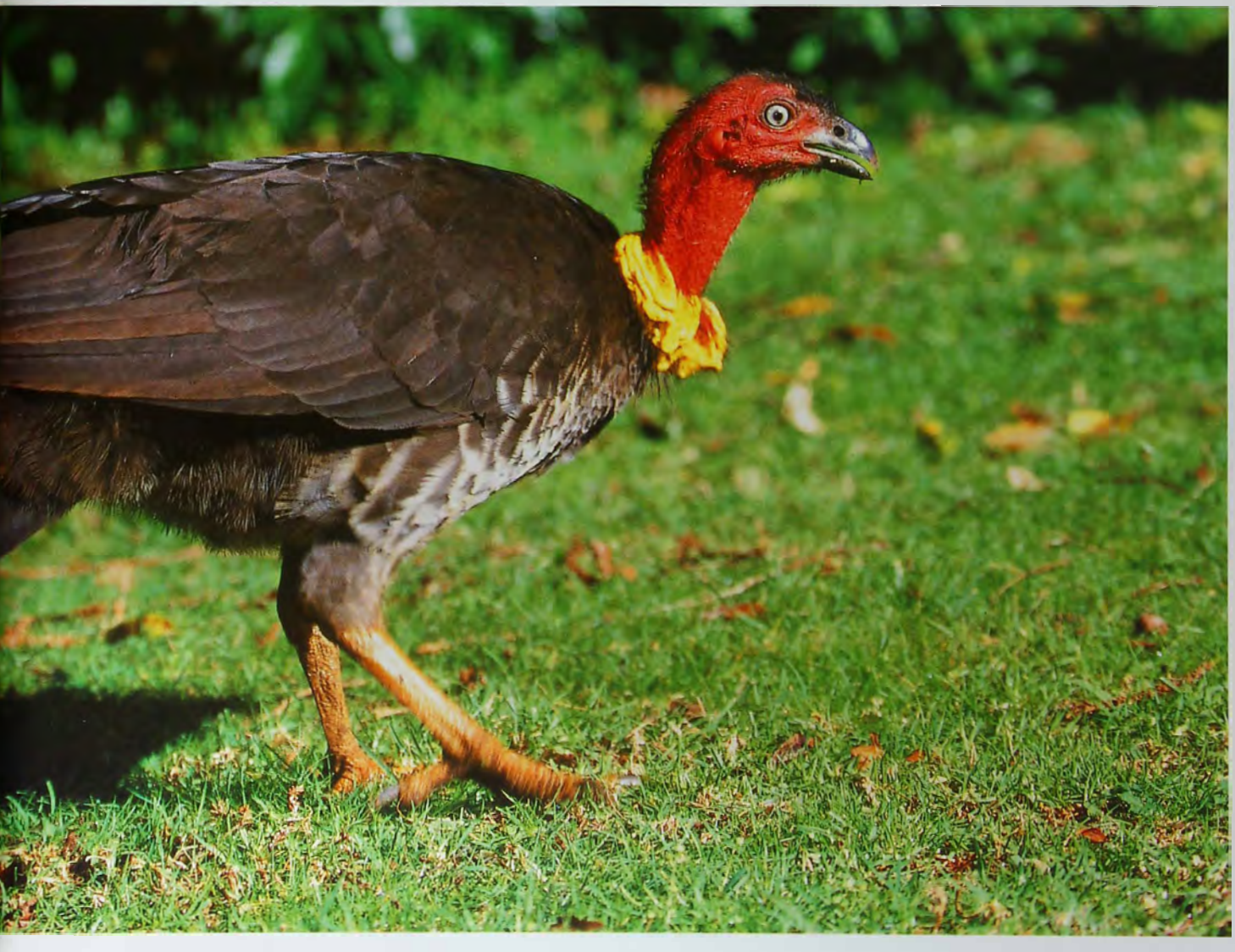
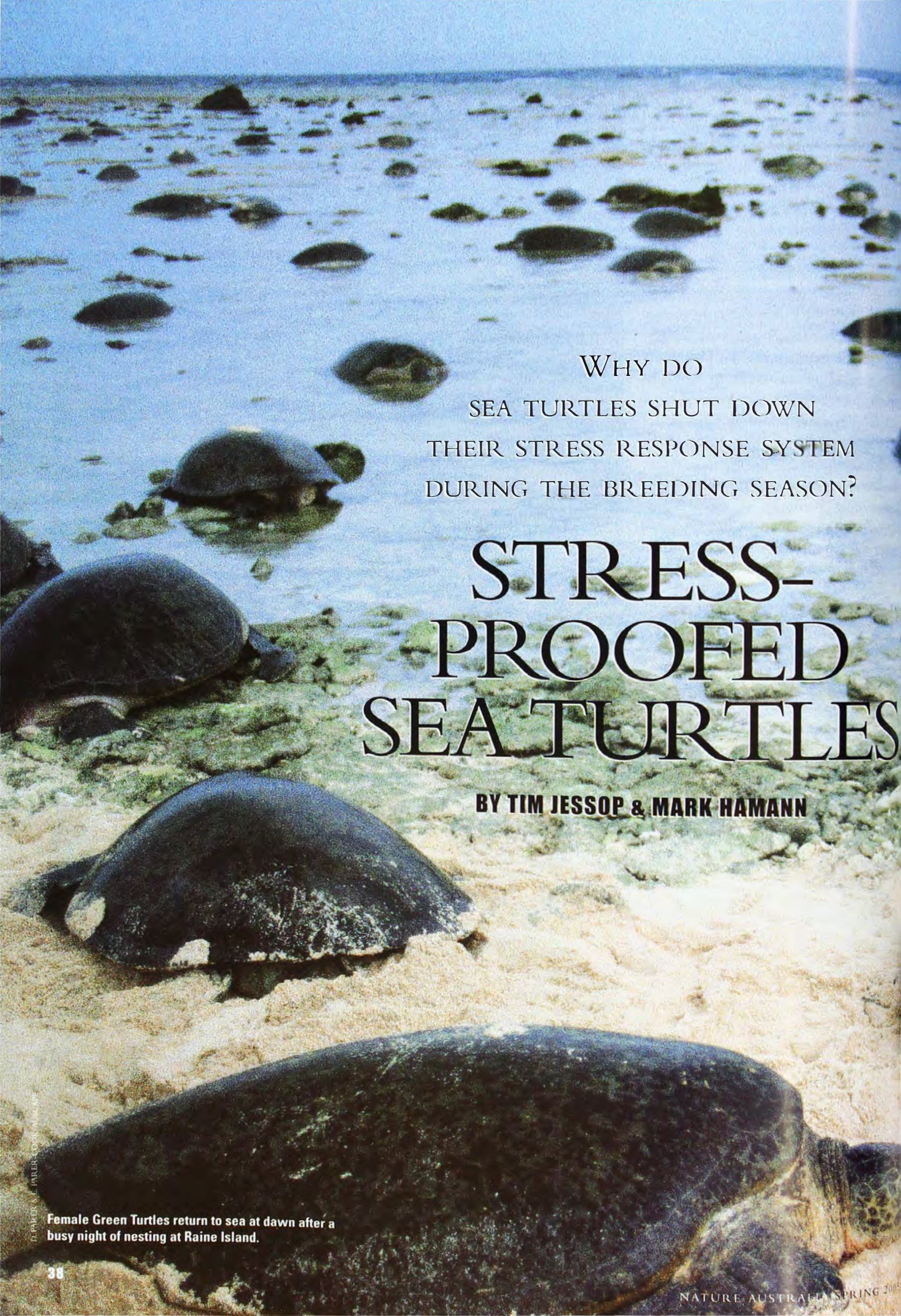
DR ANN GÖTH IS A POSTDOCTORAL RESEARCHER AT MACQUARIE UNIVERSITY IN SYDNEY. SHE WOULD LIKE TO THANK DARRYL JONES AND CHRIS EVANS FOR THEIR SUPPORT DURING HER STUDIES. FURTHER INFORMATION ON HER WORK CAN BE FOUND AT ***http://galliform.bhs.mq.edu.au/megapode_project/main.html***



KEN GRIFFITHS



WHY DO SEA TURTLES SHUT DOWN THEIR STRESS RESPONSE SYSTEM DURING THE BREEDING SEASON?

STRESS-PROOFED SEA TURTLES

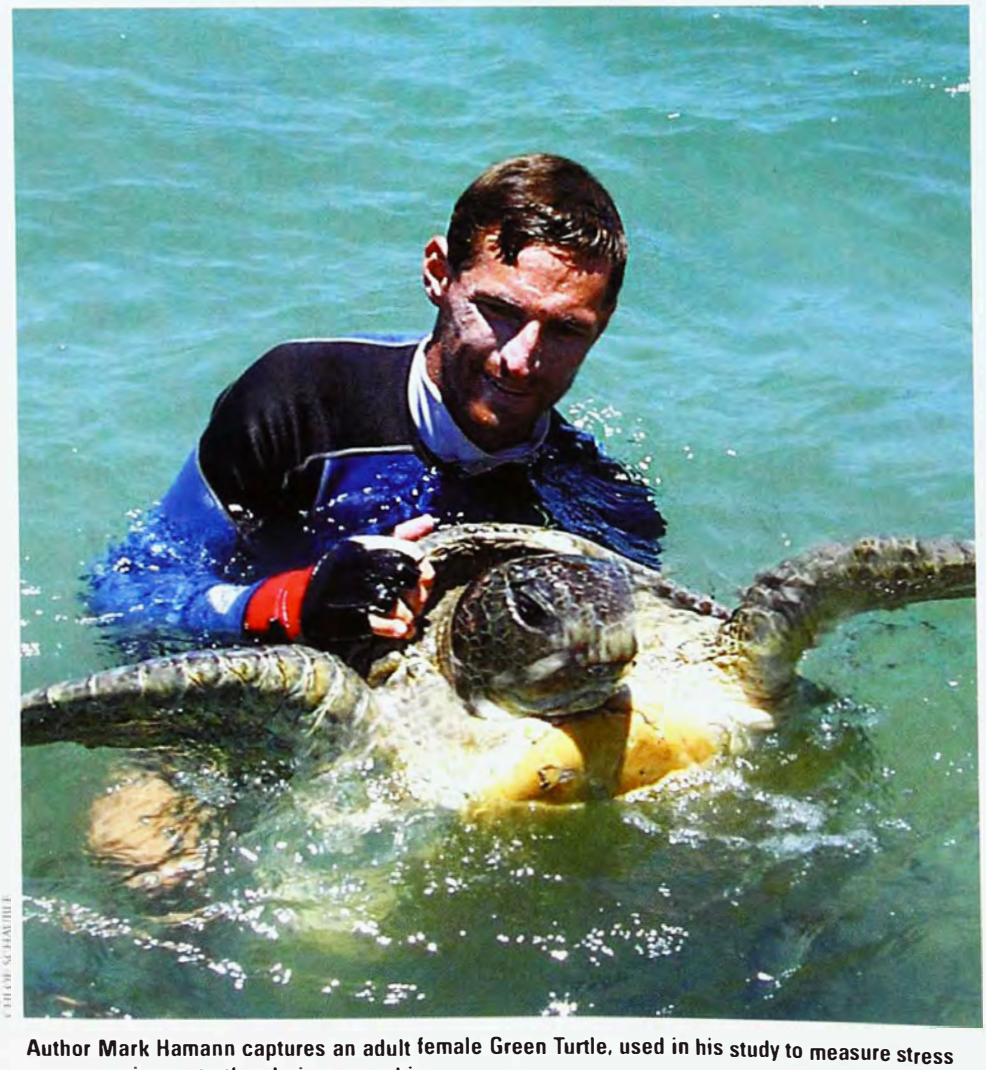
BY TIM JESSOP & MARK HAMANN

Female Green Turtles return to sea at dawn after a busy night of nesting at Raine Island.

IN THE EARLY EVENING, THE BULKY silhouette of a barnacle-clad turtle lurched up the white coral sand onto the fore-dune of Bell Cay in the Swains Reefs—a Loggerhead Turtle rookery in the southern corner of the Great Barrier Reef. In itself this was an unremarkable feat, because female Loggerhead Turtles (*Caretta caretta*) have been going ashore to lay eggs for the last 200 million years. However, this female had recently been severely attacked by a Tiger Shark and was bearing a horrendous injury. The shark's teeth had punctured and removed a dinner-plate-sized portion of her hind carapace (top shell), a piece so large that loops of her intestine now dragged up the beach behind her. Unfazed, this female continued on her way, successfully laying her eggs before returning back, perhaps for the last time, to the ocean.

Was this an amazing individual feat of pain tolerance? Yes and no. There is now considerable evidence, both anecdotal and from recent research, that females of all seven species of sea turtles exhibit a great ability to endure a host of injuries and other disturbances to make the most of their reproductive opportunities. In essence, during nesting, sea turtles appear to be stress-proofed.

DESPITE THE HUGE *amount of natural disturbance facing these females during nesting, we were never able to detect 'stressed' turtles.*



CHRIS SCHAUBLE

Author Mark Hamann captures an adult female Green Turtle, used in his study to measure stress responses in sea turtles during courtship.

IN NATURE, ALL ANIMALS ARE FACED with adverse disturbances or 'stressors'. For example, during their lives most animals will confront harsh weather events (storms, floods, drought), social pressures such as competition and hierarchies, and the ever-present reality of predation and disease. Consequently, animals have evolved complex physiological systems that attempt to reduce the impact of stressors on their survival. These stress-response systems generally involve hormones that regulate the physiological and behavioural responses that occur when changes in the immediate environment threaten an animal's wellbeing or survival.

The most commonly known of these are the flight-or-fight responses, primarily governed by two rapidly acting hormones called adrenaline and noradrenaline. When faced with a sudden threat such as a predator, these hormones almost instantly prepare an animal to either stand up for itself and confront the aggressor or situation, or to flee. However, not all stressful encounters can be managed by this short-term response. More pervasive stressors may last for hours or days, and to deal with these types of stressful situations animals use a different set of stress hormones, a class of steroid hormones called glucocorticoids.

The main glucocorticoid hormone found in sea turtles is corticosterone and it is generally involved with a suite of discrete and often long-term behavioural and physiological responses that are geared towards helping survival. For example, reproductive activities are energetically expensive and consequently are often one aspect of an animal's life history compromised when adult animals are exposed to pervasive stressors. Indeed several studies have shown that stressed animals—those with high levels of corticosterone in their blood—will often shut down reproductive activities and transfer energy reserves towards survival, recovery and/or repair.

While the mechanics of the way animals deal with stress are well understood, until relatively recently there was little knowledge of the way stress was involved in the ecology of free-ranging

ALBY ZIEBELL/AUSCAPE

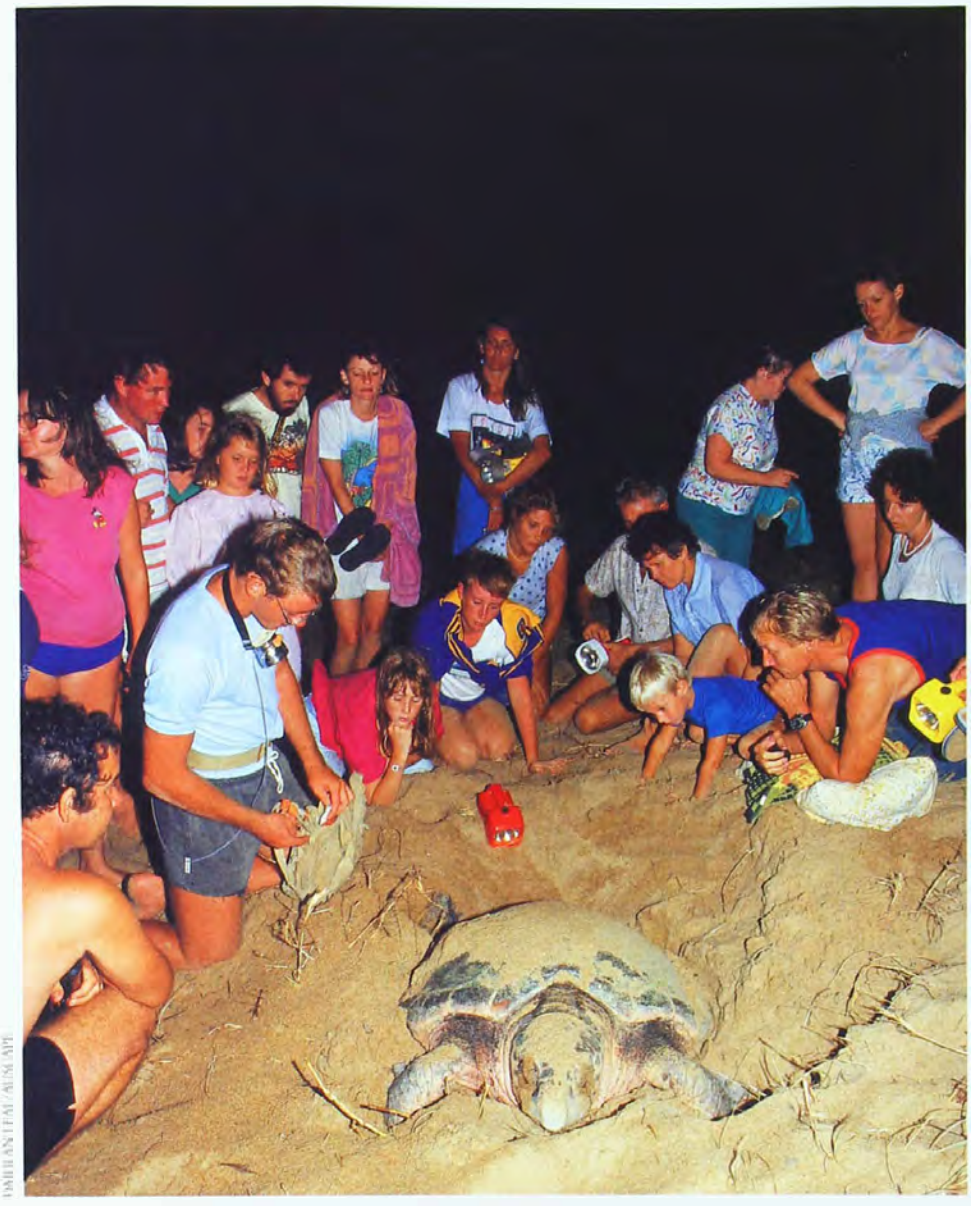
Green Turtles are promiscuous and any one female may mate with several males in a courtship season. The females then store the sperm in their oviducts so they can fertilise each of the five or so clutches per season, without having to find another male.

animals. Now scientists have begun to learn ways in which animals modify their stress response to facilitate or promote particular stages or events of their lives. Put simply, sometimes it is beneficial for an individual to mount a stress response, but in other stages in the life cycle it may not be. Now we come to the puzzle. Why do sea turtles shut down their stress response system during the breeding season?

How and why sea turtles 'stress-proof' themselves during breeding were aspects investigated during our Ph.D. studies at the University of Queensland. Working with Queensland Environmental Protection Agency's (QEPA) turtle research project, we were able to collect several thousand blood samples to measure hormonal responses to various stressful situations in breeding and non-breeding sea turtles. In doing so, we documented some very impressive physiological accounts of how female sea turtles could withstand formidable naturally occurring stressors to carry out reproduction.

THE SITE OF MOST OF OUR WORK on nesting Green Turtles was Raine Island, a small coral cay in the northern Great Barrier Reef. Raine Island is arguably the largest Green Turtle rookery in the world and in the 'really big' years of nesting on this island, as many as 15,000 Green Turtles (*Chelonia mydas*) may emerge in a single night to lay their eggs. In the ensuing melee, females inadvertently jostle, hinder and clamber over one another in attempts to find a small piece of unoccupied sand to dig their nest and lay a clutch of eggs. Not surprisingly, in such extreme high-density situations natural disturbance to nesting activities is great, and Green Turtles often have to repeat the process over many nights before they are able to successfully lay their eggs. Following analysis of corticosterone levels in blood samples taken from turtles on our first trip to Raine Island, what surprised us was that, despite the huge amount of natural disturbance facing these females during nesting, we were never able to detect 'stressed' turtles (that is, those with high corticosterone levels). This made us curious, so we looked for females stressed by other factors.

Apart from crowds, Raine Island presents Green Turtles with another problem—heat stress. Generally, post-nesting sea turtles return directly to the ocean. However on the south side of



A Loggerhead Turtle completes her nesting cycle at Mon Repos, under the watchful eyes of tourists and staff from the Queensland Environmental Protection Agency. This is the best time to observe the turtles and to collect information (size, tag numbers etc.).

Green Turtle

Chelonia mydas

Classification
Family Chelonidae.

Identification
Olive-green above, cream below. Moderate-sized head. Shell almost circular to heart-shaped. Adult females and males approx. 105 and 95 cm shell length, respectively.

Biology
Breeds every 4–6 years and each breeding season lays av. 5–6 clutches of approx. 115 eggs. Sexual maturity at 30–40 years old. Eats mainly seagrasses or algae. Pan-tropical distribution.

Status
Vulnerable.

Raine Island many females returning to the ocean have to cross a shallow depression running lengthways along the beach. For some females this depression delays their return to the ocean because, once at the bottom of it, they cannot easily see the seaward horizon that normally guides their path back to the water. Consequently, some turtles that enter this depression become disorientated and wander along the beach, often until after dawn. On days that were clear, hot and with little wind, female sea turtles that were still on the beach after dawn endured body temperatures well above their comfort zone. In some instances females actually overheated and died as body temperatures rose above 40° C, some 10° hotter than when they emerged from the ocean. Surely heat stress would elicit a hormonal stress response. However, amazingly, we found that irrespective of the potentially lethal nature of this overheating, female Green Turtles did not produce a significant hormone stress response. Moreover, by measuring sex hormones in these same heat-exposed females, it was evident that they were still capable of ovulating to produce the subsequent clutch of eggs.

After looking at our Raine Island findings we decided to go to even more extremes. We began investigating stress response in nesting Loggerhead Turtles that had been recently attacked by sharks. To do this, we travelled to a small rookery in the Swains Reefs and collected blood samples from nesting females that had signs of recent shark attack and those that were injury free. Incredibly, we found no indication that severe and recent shark damage to Loggerhead Turtles during the nesting season triggered a stress response that might lead these females to abandon reproduction. Furthermore, even when exposed to the short-term stresses of capture (by us) and blood collection, shark-attacked female Loggerhead Turtles exhibited no greater hormone stress response than uninjured females.

It was becoming very clear that, during the nesting phase of their reproductive cycle, female sea turtles showed a robust ability to shut down their stress response to both social and environmen-

A young Green Turtle swimming mid ocean.

tal stressors. However, at this stage of our research, we were still unclear if female sea turtles were permanently stress-proofed or if it was just a phase coinciding with their nesting activities. Building upon data collected from nesting turtles exposed to natural stressors, we then tested the capacity for female sea turtles to modulate or change their stress response in different phases of their reproductive cycle. To do this we subjected four groups of healthy, uninjured female sea turtles—non-breeding turtles, those in the early stages of the reproductive cycle (beginning to deposit yolk into their ovarian follicles), those in the late stages of the reproductive cycle (pre-migratory), and nesting turtles—to artificial stress through a 'capture-stress protocol'. This is a research technique widely used in animals to measure their stress responsiveness. It involved collecting blood samples from turtles immediately following capture and then at hourly intervals for up to eight hours. Turtles that showed a stress response were those whose corticosterone levels increased with time.

As we expected, female turtles that were not preparing to breed or those in the early stages of the reproductive cycle were not stress-proofed and they increased the levels of stress hormones when exposed to capture and handling. This led us to believe that, if turtles suffered severe injuries in these stages, it may result in changes to the reproductive cycle, including the cessation of existing reproductive development (yolk production) or an increase in the interval between breeding seasons. This theory is now supported by capture-mark-recapture data collected by the QEPA's turtle project.

ONCE EGG-LAYING *begins, they enter a 'trance-like' state and nothing, it seems, will stop them.*

Interestingly, these experiments also showed that female sea turtles began to shut down their stress response as they entered the later stages of the reproductive cycle, which occurs shortly before they migrate (final stages of yolk deposition), and by the time they had arrived at their courtship areas/nesting beach they had completely decreased their stress response. This suggests that a physiological threshold is reached around the time of migration departure whereby female sea turtles rank current reproduction higher than immediate survival or future reproduction. The next piece of the puzzle was to determine how long turtles remained in this stress-proofed state.

FEMALE GREEN AND LOGGERHEAD Turtles lay multiple clutches of eggs per season, approximately every two weeks, hence a nesting season for an individual may last for two to three months. What we did not know was whether this stress-proofed state lasted for the entire nesting season, or whether, as a female laid more clutches and hence got closer to expending her total seasonal reproductive output, she would start to show signs of a stress response. Continuing our capture-stress protocol, this time on Green Turtles at various stages of the nesting season, we found that females remained stress-proofed for the entire two-to-three-month period. This indicated that the relative amount of reproductive investment remaining was not influencing the capacity for stress proofing. In essence, nesting turtles were shutting down their stress response to maximise reproduction in the current season.

This is particularly important because female turtles invest substantial energy in preparation for a nesting season (for example, developing eggs). In a separate study we found that, if female Green Turtles at Raine Island are forced by disturbance to undertake several unsuccessful nesting attempts throughout the course of the season, they stand to waste valuable energy. This may ultimately mean that they are able to lay fewer clutches of eggs than expected. Although it is emerging as a complicated system, our studies suggest that female turtles are stress-proofing themselves to safeguard against natural disturbances that may otherwise cause them to transfer energy away from their eggs to other activities.

While it may seem intuitive that decreasing their stress response may enable nesting sea turtles to successfully nest and in turn produce more offspring carrying their genes, shutting down the stress response is likely to have costs.

Loggerhead Turtle

Caretta caretta

Classification
Family Chelonidae.

Identification
Dark brown above, cream below. Head of adults large and massive. Shell elongate and heart-shaped. Adults of both sexes approx. 95 cm shell length.

Biology
Breeds every 3–5 years and each breeding season lays av. 3 clutches of approx. 120 eggs. Sexual maturity at 30–40 years old. Eats marine molluscs, crustaceans, sponges, jellyfishes and fishes. Pan-tropical distribution.

Status
Endangered.

KATHIE ATKINSON

An adult female Green Turtle has come ashore to nest despite recent damage to her right front flipper, possibly caused by a shark. Injuries such as this are relatively frequent among nesting sea turtles.

Females that do not respond to their injuries or to their adverse environment are more likely to forsake their own survival for reproduction. Throughout nature a trade-off between survival and reproduction is widely observed in plants and animals, and our data indicate that the ability of sea turtles to shut down the stress response could provide a physiological basis for producing this trade-off.

It is important to note that, despite their apparent stress-proofing, sea turtles do not deliberately go looking for trouble; indeed, they will use a repertoire of behaviours to avoid stressful situations. For example, if circled by a Tiger Shark, a Loggerhead Turtle, given the chance, will position itself vertically in the water and pivot, perhaps in an effort to prevent or reduce the severity of the attack. Further, sea turtles in the early stages of nesting are extremely wary, and will readily abort a nesting attempt and return to the water if disturbed by moving people and/or artificial lights. However, once egg-laying begins, they enter a 'trance-like' state and nothing, it seems, will stop them. This is the ideal time for people to view this amazing spectacle.

While a female sea turtle will never have the chance to meet and care for her offspring, she draws on many evolved strategies designed to increase the odds her offspring will survive. By effectively turning a blind eye to natural disturbances during the breeding season, stress-proofed turtles are indirectly giving a maternal hand to the next generation. □

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CAIRNS HISTORICAL SOCIETY

RAINFORESTS ARE OFTEN PERCEIVED AS A 'GARDEN OF EDEN'. SO WHY DID IT TAKE SO LONG FOR HUMANS IN AUSTRALIA TO COLONISE THEM?

COPING *with* NOXIOUS NUTS

BY RICHARD COSGROVE

(Above) People from the Russell River area in the 1880s preparing for a ceremonial gathering. Often decorated with cockatoo feathers and armed with large hardwood swords and shields, the people would hold ceremonies for up to two weeks, dancing, trading and settling disputes, all the while being sustained by huge quantities of processed nut meal together with other rainforest plants and animals. (Left) The Wet Tropics World Heritage area in north-east Queensland is home to a huge variety of animal and plant life. It also contains a remarkable Aboriginal history of rainforest occupation extending back at least 7,500 years.

PAUL ZBOROWSKI

Ironically rainforests have been considered the cradle of human evolution, rich and luxuriant, providing the classical notion of a paradise untouched for millennia. They are often perceived as a 'Garden of Eden', where there is an abundance of food and the living is easy. So why did it take so long for humans in Australia to colonise them?

Until recently archaeologists had also shunned these forests; they were viewed as unhealthy, wet, dark and impenetrable places to work in, and preservation of organic and inorganic remains was thought to be poor in the acidic soils. However, archaeological work by Nicky Horsfall (James Cook University) in the early 1980s, and my research team between 1997 and 2005, has dispelled much of these views. Our separate studies at Jiyer Cave in the wet tropics of north-east Queensland showed surprisingly good preservation of organic remains, principally the nutshells of rainforest fruits that people had eaten. The research indicated that Aboriginal people had indeed occupied these forests for at least 5,000 years, but only intensively for the last 2,000 years.

ABOUT 10 PER CENT
of the exploited plant foods were toxic and required complex processing of up to 48 hours or more to make them edible.

Historical records indicated that rainforest people relied on different species of fruit trees to provide substantial quantities of protein and carbohydrates. The problem was that many were highly toxic and, in the case of *Macrozamia* species like cycads, also carcinogenic.

Transforming toxic plants into edible food is a process known in many societies. For example almonds, cycads, mangroves and acorns were all carefully prepared to remove noxious substances by Anatolian, Oceanic, South Pacific people and Californian Indians, respectively. Helen Pedley (James Cook University) studied the ways in which contemporary Aborigines in the north-east Queensland rainforests detoxified the various nuts and tubers, including Black Bean (*Castanospermum australe*), Yellow Walnut (*Beilschmiedia bancroftii*), Hope's Cycad (*Lepidozamia hopei*), Black Pine (*Sundacarpus amara*), Rainforest Bowenia (*Bowenia spectabilis*) and Black Walnut (*Endiandra palmerstonii*). Her study revealed that the procedures used by Indigenous people today, like steaming, slicing, grinding and leaching nuts in streams, are very close to early historical accounts. She also found that about 10 per cent (compared with 2.4 per cent Australia-wide) of the exploited plant foods were toxic and required complex processing of up to 48 hours or more to make them edible.

From his research in the Carnarvon Gorge, central Queensland, John Beaton (Australian National University) argued that the development of processing techniques occurred outside Australia and diffused into this country

R. COSGROVE

Jiyer Cave is in the Russell River gorge and was first inhabited by Aborigines 5,000 years ago. The most intense period of occupation began 2,000 years ago.

R. COSGROVE

Aboriginal peoples of the rainforest consumed nuts and fruits, many of which were high in protein and carbohydrates but also toxic. Lengthy preparation was required to rid the kernels of alkaloids and carcinogens to render them edible. All were leached in running water or steamed in fire pits. Some of the common varieties included these Hairy Walnuts (*Endiandra insignis*).

about 4,000 to 3,000 years ago. Moya Smith (Western Australian Museum), on the other hand, suggested a much earlier date, 14,000 years, for *Macrozamia*-processing in Western Australia. Given that Australia has been occupied for at least 40,000 years and that people were already present in tropical rainforests about 35,000 years ago on Melanesian islands to our north, Judith Field (University of Sydney) and I began to explore the possibility of occupation before 5,000 years and the part played by toxic plant foods in the development of rainforest societies. In particular we wanted to learn just when the rainforests came back after the ice age, when people began to live in rainforests on a sustained basis, and what role climate and toxic foods played in permanent settlement.

WE FOCUSED OUR STUDY ON THE Atherton Tableland in far north Queensland and more particularly in areas around Lake Koombooloomba. The area is very remote and we had to use boats and helicopters to survey for sites. The Jirrbal people were involved in all fieldwork, helping us identify suitable sites and assisting in excavations. Maise Barlow, a Jirrbal elder, has an intimate knowledge of plants and animals used by rainforest Aboriginal people. This was invaluable to our research and in reconstructing the ways of life of past rainforest Aboriginal society.

Our work has provided us with some surprising results. First, extremely low levels of human activity were recorded at one site beginning 7,500 years ago. Three other sites were initially occupied 5,000 years ago, with intensive use only

R. FRANK

The Ooyurka is one of the most distinctive stone tools associated with rainforest subsistence. Found only in a small region of upland and lowland rainforest, they are made of slate and have a highly polished flat working surface. On some specimens organic residue survives, identified by chemical analysis as a mixture of wax and resin.

Pollen cores taken from a number of swamps on the Atherton Tableland preserve the vegetation history of the region extending back some 150,000 years. Each plant has pollen with a distinctive shape. Identifying and counting the pollen types in the peaty core and dating the layers by radiocarbon show the different plants that existed at different times and climatic conditions.

within the last 1,800 years. Second, we have recorded well over 20,000 fragments of charred nutshells, almost all the remains of nut processing. Charred remains of toxic varieties are present, particularly the Yellow Walnut in the upper levels from all sites. It seems that people started using these noxious nuts intensively about 1,800 years ago, which is similar to the evidence found at Jiyer Cave 50 kilometres to the north. Very small amounts of nutshell are also present in the lower layers of these sites but none can be identified unequivocally as toxic. Analysis of nearly 100,000 artefacts from all our sites suggests that Aboriginal people imported raw material for stone-tool manufacture from up to 60 kilometres away and had developed specialised tools for the processing of toxic foods.

The main archaeological indicators of toxic nut preparation in the rainforest zone are the large slate grinding slabs (many of which have parallel surface striations cut across the soft slate), indented stone anvils and stone mortars. Many hundreds have been ploughed up in cane fields between Cardwell, Cairns and the Atherton Tableland. Only a few have been directly dated to less than 1,000 years old from open sites where they, together with axe heads, are the most common tools. The Ooyurka or T-shaped stone is another specialised and distinctive artefact associated with rainforest subsistence. It has a handle and a flat working edge and, although we carried out a functional study of these tools, their use is still unclear. Of the 104 we examined, 22.6 per cent had traces of resin and waxes and a lustrous edge-polish consistent with the processing of grass or soft organic matter. The axes were used to access the fruits of the forest as well as cut trees to make swords and shields. When and how this forest appeared in its present form is a matter of great importance to our understanding for human settlement.

Recent research on the Atherton Tableland on long pollen cores from volcanic lakes shows a very detailed vegetation record, which is a key to understanding the late occupation of Australian rainforests. All cores show that before 7,500 years ago eucalypts were the most common trees, suggesting drier climate conditions. Old buried tree stumps that we studied near the coastal township of Babinda, just south of Cairns, confirm this pattern. The wood was identified as River Red Gum (*Eucalyptus camaldulensis*) and dated to about 9,300 years old. Today, by contrast, Babinda has one of the highest rainfall averages in Australia with up to 4–5 metres per annum.

R. COSGROVE

Many stone tools have been identified from the coastal lowlands and the Atherton Tableland, including incised grinding stones made on soft slate. These are unique to the region and were probably used to process plant foods. Starch grains left on the surface give clues to their use.

R. COSGROVE

Many of the charred seeds and nutshells found within the archaeological deposits can be identified to species. The most common include these Yellow Walnut seeds.

Chris Turney (University of Wollongong) and others have found substantial increases in charcoal beginning about 45,000 years ago, which they argue is indicative of human presence. However, there is no archaeological evidence on the Atherton Tableland for humans at this early time and the charcoal may have come from other non-human sources like lightning. More convincing are recent studies by Simon Haberle (ANU) that show strong increases in firing from 5,000 years ago, particularly between 2,700 and 1,200 years ago. Evidence for humans is unequivocal at this time with 33 of our 41 radiocarbon dates falling within this period.

To determine the extent of late glacial rainforest, Mike Hopkins (CSIRO) and John Ash (ANU) studied the type and age of charcoal found on high mountains within Queensland's humid wet tropics. They identified that most of the charcoal was from eucalypt species and that fire had an influence on this ecosystem between about 25,000 and 6,000 years ago, with frequencies peaking between 12,000 and 8,000 years ago. This appears to be a particularly dry period with increased sedimentation of rivers. John Nott (James Cook University) has dated many of the sediments that lie along the lowland rivers to this drier period. Our work on the Tully

River terraces on the Atherton Tableland also shows rapid sand accumulations between 12,000 and 10,000 years ago, then a wetter period when these sediments were cut into by increased water flows after 8,000 years ago. At the height of the glacial period (about 28,000–15,000 years ago), rainforest retreated into refugia, which were highly fragmented but protected from fire, probably along the deeply incised river valleys. The dominance of eucalypts at this time was due to the dry climate and enhanced through lightning strikes and/or Aboriginal burning. The endemic fauna and flora appear to have survived in a series of smaller rainforest pockets that persisted throughout the late ice age. As the Earth warmed up after 15,000 years ago and became much wetter, particularly between 8,000 and 7,000 years ago, rainforest invaded the eucalypt vegetation on the Atherton Tableland.

It appears that fire also played a role in forest biodiversity right up until the recent past. Dates we obtained on charcoal collected from the forest floor near Lake Eacham on the Atherton Tableland suggest fire occurred there within rainforest in the last 400–300 years. These may have been low-intensity fires that cleared the thick understorey while promoting economically important Aboriginal plants. Other radiocarbon dates from our Urumbal Pocket site on Lake Koombooloomba show firing pulses about 250, 650 and 1,000 years ago. The charcoal came from 30-centimetre soil pits that we dug in a eucalypt forest patch where grass trees (*Xanthorrhoea australis*), she-oaks (*Casuarina* sp.) and Long-fruited Red Mahogany (*Eucalyptus pellita*) grew surrounded by lush tropical rainforest. Hopkins has also demonstrated that eucalypts and fire were present at least 1,300 years ago at Cape Tribulation, right in the heart of what is now tropical rainforest. The palaeoenvironmental evidence shows that rainforests are not the stable and untouched systems that we were once led to believe. They are dynamic systems that respond to both climatic and human influences.

What emerges from these studies is that the rainforest expanded after 8,000 years ago in conditions much wetter than the preceding period, yet humans only began to permanently settle them 1,800 years ago. An explanation for this pattern perhaps lies in the highly variable climate driven by El Nino–Southern Oscillation (ENSO) events, which cause damaging droughts across Australia. Recent studies of corals from the Great Barrier Reef by Michael Gagan (ANU) show that the severity and frequency of ENSO events have changed through time. The last strong increases in ENSO events started 5,000 years ago and increased further after 3,000 years ago. The most intense period of ENSO activity occurred from 2,500 to 1,700 years ago, coincident with increased levels of Aboriginal activity in the region. Rainfall appears to have not only been 20–40 per cent lower but highly seasonal. These fluctuations may have had a profound effect on the surrounding semi-arid regions, forcing people to permanently occupy rainforest only used occasionally on a seasonal basis before 1,800 years ago. Making a

The Moreton Bay Chestnut or Black Bean is a favoured rainforest Aboriginal food. It grows in vast quantities on mature trees. When the pods fall to the ground they are harvested, the seeds removed and their poisonous qualities neutralised before consumption. The beans are available all year round.

R. COSGROVE

Bush tucker is still prepared today by the Jirrbal people who enjoy detoxified Black Bean and Black Pine nuts. Fred Barlow, a Jirrbal elder, boils the Black Beans over a 48-hour period before grating them into meal. They are then leached in water for a further 24 hours and eaten. The seed pods in which the beans form can be seen on the ground.

living may have become increasingly risky and unpredictable, encouraging people to find alternative sources of subsistence such as the abundant but bitter-tasting toxic nuts and fruits of the rainforest previously ignored as too time-consuming to process.

THUS A FACTOR IN THE ABILITY OF Aboriginal peoples to successfully settle the rainforest in the face of climatic perturbations was the exploitation of the wide array of highly toxic nuts and fruits by cooking and complex processing. This appears to be based upon the recent development of a very specialised and elaborate material culture like the Ooyurka and incised grinding stones found nowhere else in Australia. They were also attractive because of their abundant production, their durability and high food value. The elaboration of leaching technology probably increased the amounts of starch and protein that could be processed, which could have been a catalyst for the increase in the intensity of occupation and population growth 1,800 years ago.

Our work on the Atherton Tableland has shown that toxic plants were incorporated quite late into the rainforest economy probably as a result of climatic instability with the onset of ENSO events 5,000 years ago. Since it is costly and time-consuming to process such resources, the pay-off must have been significant in terms of higher food quality and subsequent population increases. Although speculative at present, the rise of the large and regular ceremonial gatherings at the beginning of the wet season in north-east Queensland rainforests, as witnessed by European settlers, may have been a consequence of this development. The widespread processing of toxic species appears significant in Aboriginal people's adaptation to rainforest settlement and may be central to notions about how humans adapt to rainforest ecosystems worldwide. □

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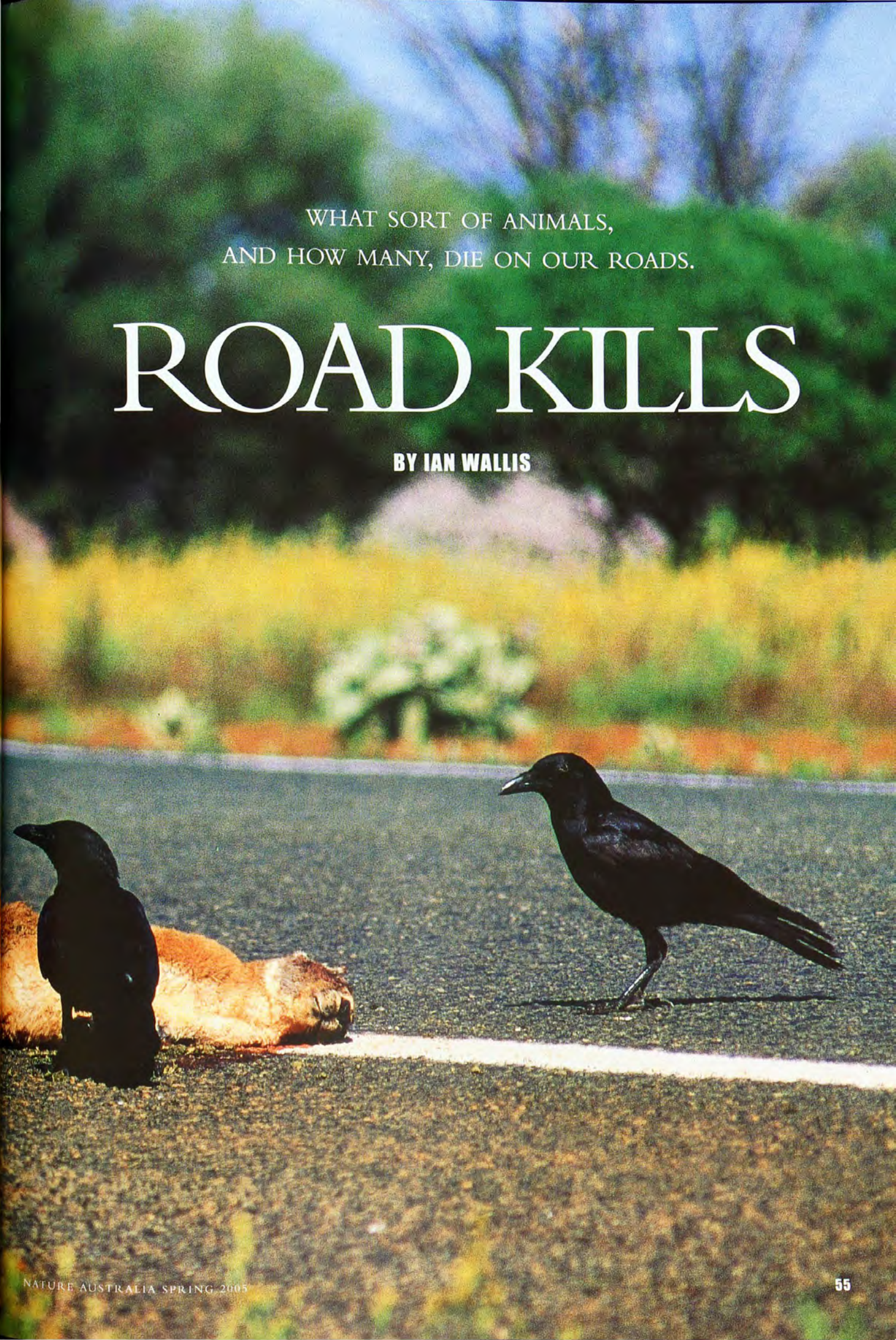
DENNIS & JASON COLEMAN / FLPA IMAGES OF NATURE

Corvids, like crows and ravens, are the master scavengers of road kills and only rarely are they hit by motor vehicles.



WHAT SORT OF ANIMALS,
AND HOW MANY, DIE ON OUR ROADS.

ROAD KILLS

BY IAN WALLIS

COLLISIONS *with motor vehicles leave many small animals, particularly birds, intact—seemingly undamaged but shattered within.*

YOU MISS A LOT WHEN travelling by car through the seemingly uniform environment of arid Australia. At speeds of 100 kilometres per hour or more, what chance is there of seeing the Thorny Devil (*Moloch horridus*), dressed in its mediaeval armour, robotically devouring ants, or of catching a glimpse of Australia's largest lizard, the Perentie (*Varanus giganteus*), clothed to melt into the central Australian landscape? This is why my partner and I decided to cycle from Uluru to our home in Canberra.

We saw our first Thorny Devil just a kilometre from Yulara airport, clearly identifiable, armour intact but squashed indelibly onto the hot tarmac. Did the driver see it? Probably not. And, despite it being one of the most recognisable of Australian reptiles, no doubt through its innumerable media appearances, few people have ever seen one. Indeed, it was a lot smaller than I'd imagined.

It was the sight of this unfortunate Thorny Devil that made me wonder what sort of animals, and how many, die on our roads. Mangled macropods litter our highways, but what else falls victim to the motor vehicle? Of course, it is difficult to record this information. Scientific studies require replication—repeated measurements suitable for statistical analysis. Moreover, a serious study of road kills would describe exact locations and information about sex, age, body condition and numbers. However, precise counts are difficult partly because animals may succumb in many ways. Large animals, like kangaroos, may die instantly and then be hit again by other passing vehicles and finally picked at by scavengers. Their remains may be reduced to sun-bleached bone chips, and may mix with other victims and be scattered around the accident scene. Without enlisting forensic biology, one would have no idea of how many dead animals there are at a site. Other animals are mortally wounded and struggle away to a lonely death. Collisions with motor vehicles leave many small animals, particularly birds, intact—seemingly undamaged but shattered within. They become an easy meal for scavengers and simply vanish. Indeed, 40 per cent of wildlife bodies disappear in a week.

Our cycling trip was for pleasure so I

The Shingleback (*Tiliqua rugosa*) is the perfect design for a road kill—a non-descript dark blob that loves sunning itself by the roadside.

D. PARER & E. PARER-COOK/AUSCAPE

The Thorny Devil often wanders from its sandy habitat onto the road, where it may fall victim to cars.

was not about to spoil it with an arduous study of road kills. Instead the aim was to take a snapshot of carnage by identifying the species of fresh vertebrate road kills—those that had died in the preceding 24 hours. Often I took photographs, both to aid identification but also to document this largely ignored result of motor vehicles—big, fast, relentless marauders capable of killing anything from insects to large mammals.

DRIVING SLOWLY

and stopping randomly is a particularly dangerous activity that may increase road-kill diversity and numbers!

WHAT IS THE BEST WAY TO CATALOGUE road kills? Although walking is effective, cycling enables an accurate survey of road kills over much larger distances. Like walking, it is easy to stop and inspect specimens and the vigilant cyclist will see tiny organisms—even invertebrates. Unfortunately, most scientists use cars for these surveys, which imposes considerable bias on both the number and composition of species recorded, because most small animals remain unseen. In addition, driving slowly and stopping randomly is a particularly dangerous activity that may increase road-kill diversity and numbers!

So what animals died on the roads between Uluru and Canberra in the autumn of 2001? In 32 days of cycling I recorded 93 fresh vertebrate road kills, or one every 35 kilometres. This might not seem that many, but I'll get to that later. The victims comprised 32 birds (18 species), 15 reptiles (10 species) and 46 mammals (nine species). They were big (Red Kangaroo, *Macropus rufus*) and small (Spinifex Hopping-mouse, *Notomys alexis*), colourful (Major Mitchell's Cockatoo, *Cacatua*

KATHIE ATKINSON

Some species carry more political clout than others. The prevalence of road-killed Koalas, for example, has spawned measures like protective fences along highways and Koala hospitals.

KATHIE ATKINSON

Being big, obvious and active by day, like the Perentie, does not guarantee protection against cars.

leadbeateri) and pallid (Apostlebird, *Struthidea cinerea*), fast (Pygmy Mulga Monitor, *Varanus gilleni*) and slow (Central Bearded Dragon, *Pogona vitticeps*). Eleven were nocturnal, 42 were diurnal (active by day) and 40, the macropods, were crepuscular (most active at twilight). The largest number of fresh road kills we saw on one day was nine, and there were only two days when we saw none. One of these was from Yass to Canberra along the busy Barton Highway, where one sees dead animals on most days. How do these data compare with those from other studies?

An international literature survey revealed a similar picture—astonishing diversity with almost no animal safe. This is borne out by the finding in 1994 of a road-killed Night Parrot (*Pezoporus occidentalis*) near Boulia in south-western Queensland. Then, the Night Parrot was presumed extinct; known from just 22 specimens with all but one collected in the 19th century. Not even animals with a largely aquatic existence are safe. Every year scores of European River Otters (*Lutra lutra*) die through collisions with vehicles. National parks also offer little protection from vehicles. A survey of dead animals on a highway traversing Mikumi National Park, Tanzania, revealed 52 species, including the endangered African Savanna Elephant (*Loxidonta africana*) and the African Wild Dog (*Lycaon pictus*). A French road-kill survey in 1995 along a newly opened motorway passing through a rural landscape reported four endangered species among 97 species found dead.

The farther we cycled in a day, the more road kills we saw. This may seem intuitive but I found it surprising because we travelled on a wide variety of roads that crossed a broad range of habitats. Many animals died even on quiet roads. It seems that contacts between animals and cars is not just a matter of chance collision. The effects of roads extend far beyond the strip meandering through the landscape. Stephen Trombulak (Middlebury College, Vermont) and Christopher Frissell (University of Montana) identified seven major influences of roads. Apart from direct hits from cars, these include the increased spread of exotic species, alteration of the physical and chemical environment, and changes in animal behaviour. There are countless interactions between these effects that influence both the numbers and species of animals killed on roads. Our records of dead Spotted Nightjars (*Eurostopodus argus*) provide an excellent introduction to this ecological complexity.

Even though Uluru is an enormously popular tourist attraction, the Lasseter Highway, which links it to the Stuart Highway, is not particularly busy. It is certainly not the expected place to find three dead nightjars. But roads, particularly sealed roads, provide both a comfortable ride for vehicles and an enormous heat pad for animals. Their conductive power means they warm early each day, which explains why reptiles find roads attractive on cool mornings.

G. HARGED

Three Spotted Nightjars were seen on the ride from Uluru to Canberra, unfortunately all road kills.

Roads also catch water and distribute above-average precipitation to the adjoining land—one of many reasons that road edges support high plant and animal diversity. This landscape begins to look particularly appealing for a Spotted Nightjar. What better place to wait for insects at night than the heat sink of black tarmac where the occasional vehicle traps insects in its lights? Camping within 100 metres of the road and not hearing a vehicle for an hour, I found it difficult to envisage a tragedy, other than of a moth in a nightjar's mouth. The series of events that leaves nightjars crushed is unclear. Perhaps they hawk insects caught in the headlights and are then hit. Or perhaps, like the insects, the lights dazzle them and they never move from their heat pad. Clearly, the interaction between roads and animals is complex.

Carrion-feeders, such as crows and ravens, various raptors and the Tasmanian Devil (*Sarcophilus harrisii*), benefit from roads. Hundreds of Wedge-tailed Eagles (*Aquila audax*) congregate along the Stuart Highway, which offers a smorgasbord of meat. However, in another bizarre twist, these scavengers frequently fall victim. Unlike the nimble corvids, Wedgetails have difficulty escaping vehicles thundering down on them. Their task is particularly hard in much of the Northern Territory because there are no speed limits. But coming to their rescue are the owners of Cadney Homestead roadhouse in northern South Australia, who have adopted the Wedgetail as their emblem and appeal to motorists to take extra care in avoiding these majestic creatures.

Not only scavengers fall victim. There was a report from northern Greece, where road-killed Sand Martins (*Riparia riparia*)—swallow-like birds—were seen to attract other Sand Martins, which took turns in copulating with the victim, eliciting a chain reaction of death and fornication.

I COMMENTED EARLIER ABOUT SEEING far fewer fresh road kills than expected. This is impossible to explain without planned experiments but the likely explanation concerns rainfall. For much of our journey, especially in the Northern Territory and South Australia, lush vegetation surrounded us but particularly on the roadside. Exceptionally high rainfall fell in this region for the six months prior to our trip, while other areas we passed through had experienced at least average rainfall. The widespread food resources meant that animals did not need to seek food near the road, where it is common to find the first food after rain and the last food as drought takes its grip.

This finding of relatively few road kills contradicts most studies. Typically, the sheer volume of road kills is extraordinary, whether expressed as numbers or as a proportion of populations. About 500,000 deer, representing several species, die annually on American roads, 10–15 per cent of the Eurasian Badger (*Meles meles*) population of Denmark succumb to motor vehicles, and 500–600 Milos Vipers (*Macrovipera schweizeri*)—a staggering 25 per cent of the entire population—die on the roads each year. Recently, in 20 weekly surveys near Byron Bay, Brendan Taylor and Ross Goldingay (Southern Cross University) counted 529 carcasses of 53 species along 100 kilometres of roads. Of 23 radio-tracked Common Brushtail Possums (*Vulpecula trichosurus*) in Launceston, nine died and two were injured on roads. Farther south, Menna Jones (University of Tasmania) showed that the increase in the number of road-kills following the upgrading of the road into Cradle Mountain eliminated the local Eastern Quoll (*Dasyurus viverrinus*)

population and halved the Tasmanian Devil population. In April 2004, the first Koala (*Phascolarctos cinereus*) seen in Canberra's suburbs for years was an otherwise healthy female—dead on the road. In many places scores of WIRES volunteers care for injured animals while Port Macquarie has a Koala hospital. Cars explain most of the casualties.

Reducing this toll requires a change of attitude. How often have we heard "A bloody roo ran into my car" rather than the other way round? Perhaps this change is coming. There is now a Road Ecology Research Group at the University of New South Wales, led by David Croft and Daniel Ramp, that studies the environmental effects of roads in an Australian context. One of their key areas of study is wildlife mortality, which aims at collating information on road kills and then describing it spatially and temporally with a view to better road design. This research is still in its infancy and research results are just starting to appear. For example, they estimate that 15–20 million vertebrates die on the 810,000 kilometres of Australia's roads each year.

Another sign of change is that in November 2003, the Wildlife Preservation Society of Australia and the Linnaean Society of New South Wales held a joint seminar on reducing road kills. The clearest thing to come out of this discussion was that any attempt to reduce road kills requires approaches aimed both at animals and at drivers, such as culverts under roads, night-time speed limits and reliance on alternative transport. Unfortunately, there seems to be little effort to increase driver awareness, other than from insurance companies miffed at their losses. There are dual benefits to introducing awareness campaigns into driver education: not only would they protect animals, but also the more vulnerable road users, like pedestrians, cyclists and children. □

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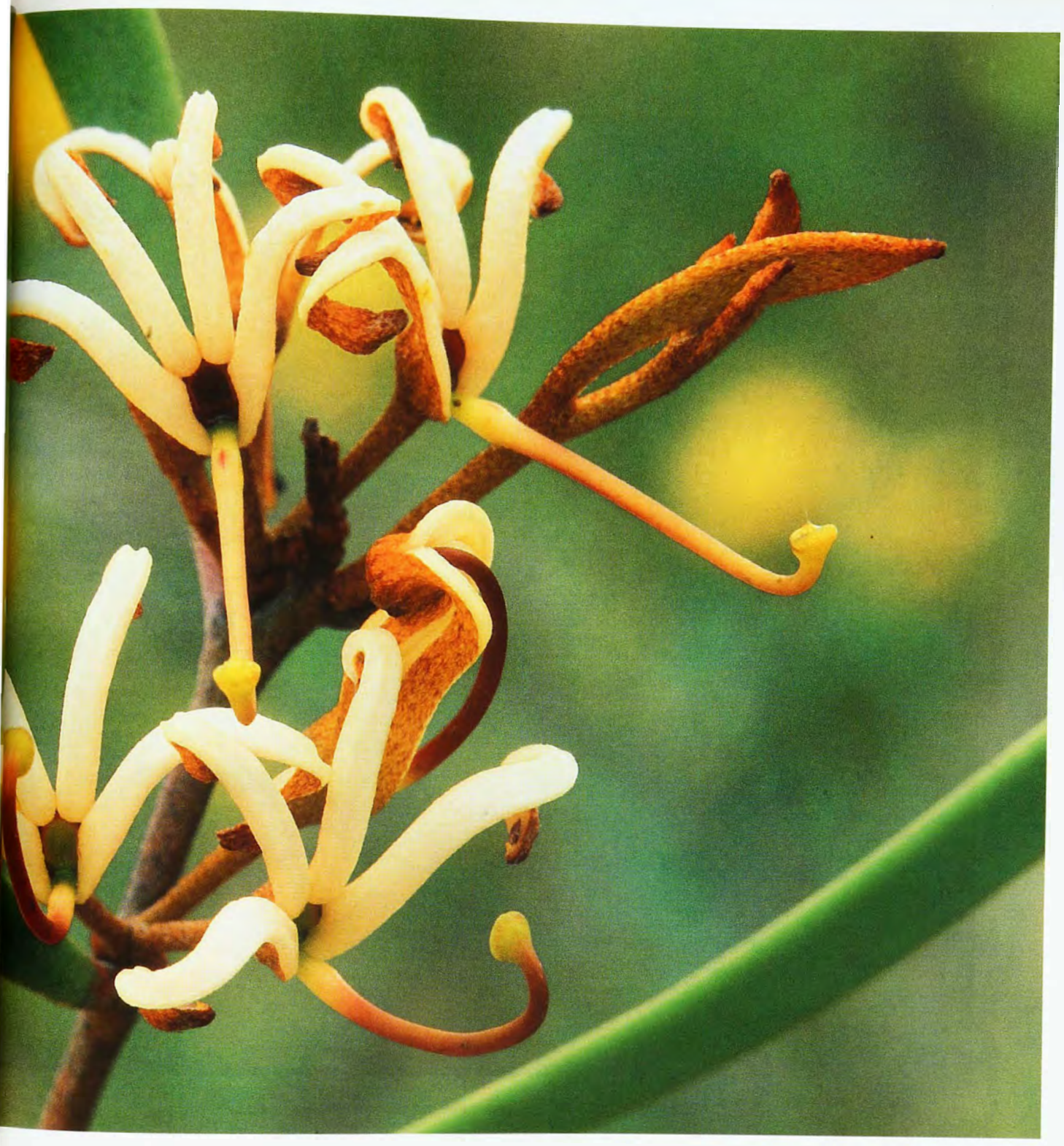
IAN WALLIS

In a bizarre twist of fate, a Wedge-tailed Eagle lies dead after being hit by a vehicle while scavenging a road-killed kangaroo.

Hakea *Hakea pandanicarpa*.

Sand Bottlebrush (*Beaufortia squarossa*).



Wild Flowers of the West

BY MARIE LOCHMAN
Lochman Transparencies

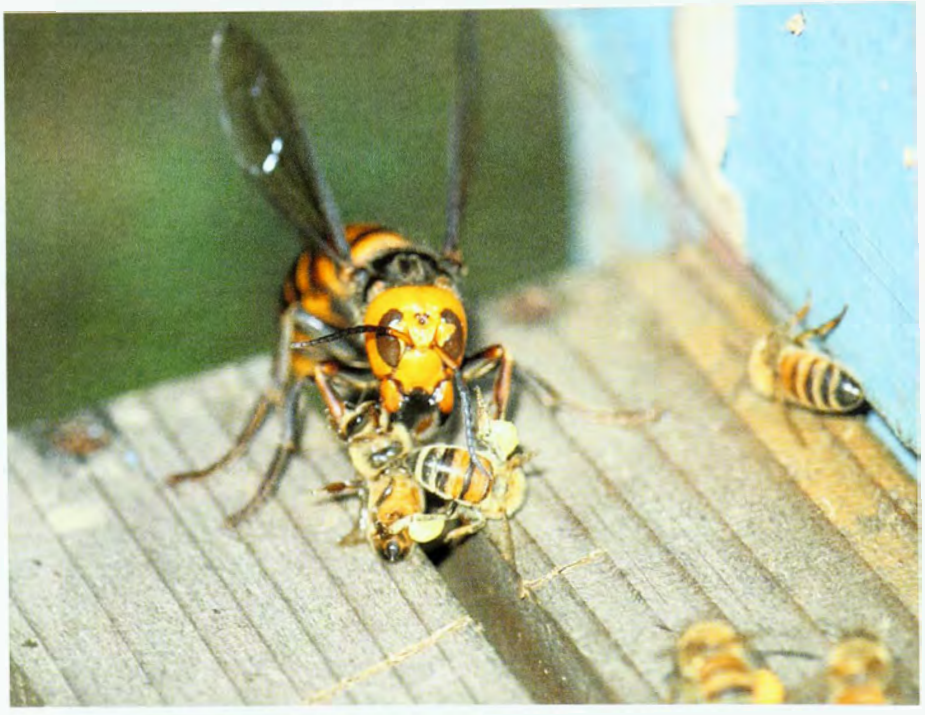
Feather flower (*Verticordia endlicheriana*).

Native rose (*Diplolaena leemaniana*).

Dryandra (*Dryandra arctotidis*).

Quivering balls of death

Japanese Honey Bees have evolved an unusual defence mechanism against such a formidable enemy.



A Giant Japanese Hornet attacks European Honey Bees, which, being introduced, have no defences against this formidable predator.

PHOTOS COURTESY DR MASATO ONO, TAMAGAWA UNIVERSITY

"Listen. And understand. The terminator is out there. It can't be bargained with. It can't be reasoned with. It doesn't feel pity, or remorse, or fear. And it absolutely will not stop, ever, until you are dead."

It may be a line from the 1984 film "The Terminator", in which Arnold Schwarzenegger plays an apparently unstoppable killing machine, but in the imaginary world of Japanese Honey Bee (*Apis cerana*) conversation, it could be a warning of another type of terminator, the Giant Japanese Hornet.

Five times larger than a honey bee, *Vespa mandarinia japonica* is the world's largest hornet and can be 25–45 millimetres long with a wing span of 75 millimetres. Queens can be up to 55 millimetres long. One hornet can kill 40 bees in a minute with its mandibles and 20–30 hornets can kill 30,000 bees in three hours. The honey bee's sting is useless when it comes to penetrating the cuticle of the heavily armoured hornet. However, in the struggle for survival, Japanese Honey Bees have evolved an unusual defence mechanism against such a formidable enemy.

When spring arrives in Japan, the humungous hornet queens emerge from hibernation and begin building nests and laying eggs. Within a month, a new generation of the hive's workers have matured into insect terminators and forage in the surrounding forests, gathering food to carry back to the nest. One queen can lay thousands of eggs, which take only a week to become hungry hornet larvae, so a huge amount of protein is needed to sustain each nest. It is not surprising that the hornets target the nests of social bees since the nutrient payoff is so great.

For European Honey Bees (*Apis mellifera*) imported into Japan, there is little they can do to save themselves from an attack, and often their hives fall silent, littered with the dismembered bodies of slaughtered bees. The hornets may occupy the nest for around ten days, while they move the bee larvae and pupae back to their own nest to be used as baby hornet food. However, Japanese Honey Bees have a very clever trick, which is just the bee's knees when it comes to taking on Giant Japanese Hornets.

When a hornet lands at the entrance of a Japanese Honey Bee hive, it kills a few of the bees that are guarding the entrance and takes the bodies back to the nest. After a few return visits, it leaves a pheromone on or near the bee hive, which alerts the hornet's nest mates flying in the area about the food. But Japanese Honey Bees have evolved an ability to recognise the hornet pheromone as a signal that effectively says, "I'll be back." (European Honey Bees do not respond to the pheromone.)

Once the Japanese Honey Bees have picked up the hornet's scent, about 100 of them crawl around the entrance and, when the next hornet approaches, they lift and shake their abdomens and then run back into the nest. But rather than being an act of cowardice, their retreat draws the pursuing hornet into the nest, where it is met with a stampede of around 1,000 bees that leave the hive's comb and rush towards the hive's entrance to confront the hornet. And it is the nature of the confrontation that is the bees' secret weapon. The hornet is quickly engulfed in a ball of around 500 bees. By quivering and shivering their bodies and wings for about 40 minutes, the bees increase the temperature inside the ball to about 47° C, which they maintain for about 20 minutes. This is high enough to kill the hornet, but not the bees, which have a few degrees up their sleeves (or behind their knees).

BY SIMON D. POLLARD

While 44–46° C is lethal to the hornet, it takes temperatures of 48–50° C to kill the bees.

Masato Ono and his team at the Tamagawa University in Japan have been studying the Japanese Honey Bee's extraordinary defence mechanism for nearly two decades. Using a camera that records differences in temperature as different colours (thermography), they demonstrated how the bee's balling behaviour causes the temperature to rise high enough to be lethal to the hornet. This was the first case of a 'cold-blooded' animal using heat to defend itself from predators. They also wondered how the bees could organise themselves into a defensive ball so quickly and found that isoamyl acetate, which smells like bananas and is a component of the bees' alarm pheromone, was present around the ball and may incite nest mates to join in. Possibly the alarm pheromone was released by all bees in the ball, or just by those that had been damaged by the engulfed hornet.

By quickly killing the initial hornet visitors that are drawn to the nest, the bees may be able to prevent a frenzied attack, which can start if three or more hornets are alive inside the hive. As more of the pack-hunting hornets join in the attack, the demise of the hive becomes inevitable. The pheromone-regulated mass attack by the hornets may have evolved as a counter-adaptation to the bee's defensive behaviour. The hornets are under enormous pressure to supply sufficient food for the nest, and the larvae and pupae from a bee's hive are spoils of war worth fighting for.

When I first read about the hornets being cooked by a convection oven made of bees, I thought of the scene in "The Wizard of Oz", when Dorothy killed the Wicked Witch of the West, who cried out as she turned into a puddle of goo, "I'm melting, melting." While the Giant Japanese Hornets actually expire less dramatically, dead is dead, and in the case of the Hornets from Hell, it's all just a matter of degrees. □

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Japanese Honey Bees have formed a defensive ball around a Giant Japanese Hornet.

Little Lady of Flores

Commonly called hobbits, their discovery is acknowledged as being one of the most important in the last ten years.

ARCHAEOLOGY RARELY HUGS THE headlines like "Lord of the Rings", but announcement of a new species of primitive human in October 2004 caused excitement around the world. Commonly called hobbits*, their discovery is acknowledged as being one of the most important in the last ten years, and it is still making headlines. Why such a fuss over these creatures, whose remains were found not in Africa, but in Liang Bua, a limestone cave on the remote island of Flores, Indonesia?

The now-famous illustration of an adult male *Homo floresiensis* is based on a skull, a few arm and leg bones, partial pelvis, incomplete hands and feet, fragments of vertebrae, ribs and shoulder bones. All up, there are now bits and pieces from at least eight individuals. Look at the picture carefully. The shouldered rat gives some kind of scale, and the hunter barely looks human. But even without a picture, many readers will already know two extraordinary facts:

- hobbits were tiny, the size of a three-year-old human, much smaller than the smallest pygmies alive today, and comparable to J.R.R. Tolkien's Hobbits of the Shire; and
- hobbits shared the same world with modern humans from at least 38,000 to as recently as 13,000 years ago (see box). We were not alone.

Hobbits were tiny, the size of a three-year-old human, much smaller than the smallest pygmies alive today, and comparable to J.R.R. Tolkien's Hobbits of the Shire.

The species was described by Peter Brown (University of New England) and a team of Australian–Indonesian researchers on the basis of a buried skeleton, which they estimate to be that of an adult female about 106 centimetres tall, weighing 16–28.7 kilograms and with a brain capacity of 380 cubic centimetres—about the size of a grape fruit or a small bottle of beer. 'Hobbit' is even smaller than 'Lucy', the best-known australopithecine, who walked around eastern Africa between 3.9 and 2.9 million years ago. Did hobbits take a rather backward biological step in evolutionary time? The researchers propose that such dwarfing resulted from long-term isolation of an ancestral *Homo erectus* population, making the term hobbits, which in Tolkien's words "seldom now reach three feet; but...in ancient days...were taller", even more appropriate. Pygmy stegodont elephants also evolved on Flores at the same time.

Mike Morwood (University of New England), Radien Soejono (Indonesian Centre for Archaeology, Jakarta) and Bert Roberts (University of Wollongong), who co-ordinate the research program, argue that numerous stone artefacts were found in association with 'Hobbit', and were most likely made by hobbits. Although only 32 artefacts were found in the same resting place as the skeleton, other excavation trenches in the cave revealed a large concentration—5,500 artefacts per cubic metre. A remarkable number included sophisticated points, perforators, blades, and microblades, which the researchers claim were probably spear barbs. And these were found exclusively with stegodont bones, from up to 95,000 years ago until stegodonts disappeared around 13,000 years ago. Further study is investigating whether the artefacts were elements in a 'big-game' hunting toolkit, primarily for taking juvenile stegodonts.

Interestingly, remains of the island's macaque monkey, deer, pig and porcupine are not found with bones of *Homo floresiensis*, but only appear above a 13,000-year-old layer of volcanic ash (see box) and were probably brought over by our *H. sapiens* ancestors. A catastrophic eruption could have caused local if not complete extinction of the hobbits, although there are myths and reports of little people surviving in remote bushland and mountains of Indonesia—perhaps a reference to extant populations of modern pygmies (all *H. sapiens*) in the region. While it is plausible that modern humans had a hand in the extinction of such a species (some scientists say it is typical modern human behaviour), there is no evidence they were even there...or is there?

The absence of an early archaeological trace of modern humans on Flores is indeed puzzling, because we know that *Homo sapiens* was around in Africa for nearly 200,000 years and crossed into Australia about 45,000 years ago (plus or minus a few thousand years, depending on whom you believe). Perhaps early modern humans made the sophisticated stone artefacts and made a meal of the

BY RICHARD FULLAGAR

* *The skeleton, on which the species description was based, was nicknamed 'Hobbit' by team leader Mike Morwood. The term 'hobbits' has since been used as a common name for the species.*

Illustration of a male hobbit.

hobbits. Perhaps they lived and dined at Liang Bua but were buried elsewhere. Would this scenario push back modern humans on Flores up to 95,000 years ago, the earliest possible age for 'smart tools'? Such an age for modern humans is currently out of whack with accepted regional archaeology, and poses challenges to the theory of modern humans evolving in Africa. More precise dating and study of the stone tools will help resolve these issues.

For Jared Diamond (University of California, Los Angeles) coexistence, even if islands apart, of modern humans and hobbits is the most astonishing fact of all. He argues that colonising humans have a sinister track record, and are followed by a wake of extinctions around the world. No present-day analogy makes sense to him. A model of peaceful coexistence with today's pygmies based on complementary economies (where pygmy hunter-gatherers trade produce with full-sized farmers) doesn't work on Flores because both humans and hobbits would have had similar hunter-gatherer lifestyles. Coexistence of Chimpanzees and humans in Africa is also based on substantial economic differences (no competition between the species). Moreover, Chimps are just too dangerous to hunt (something the latest generations of humans appear to be overcoming). Could hobbits have survived on their own tiny island simply because they were too dangerous for modern humans to hunt? It's possible; hobbits were probably tough—they somehow coped with Komodo Dragons and stalked stegodonts—and Diamond notes that any idea of 'safe sex' between *H. sapiens* and the feisty *H. floresiensis* (as with Chimps) would have been out of the question! But modern humans have certainly hunted more ferocious beasts. Diamond remains perplexed. I wonder, however, if the Flores evidence does not undermine his starting position. Maybe early modern humans did not typically cause big extinctions wherever they went. Certainly, the role of colonising humans in Pleistocene faunal extinc-

tions is hotly contested.

Also hotly contested are the rights to study the bones. 'Hobbit' was stored at the Centre for Archaeology, Jakarta, until December 2004 when it was temporarily moved to the laboratory of Teuku Jacob, a renowned Indonesian palaeoanthropologist from Gadjah Mada University. Jacob encouraged other scientists to study the specimen, which outraged the international team, and has publicly questioned whether 'Hobbit' represents a new species, asserting it is probably a *Homo sapiens* with microcephaly (a deformity characterised by a small brain and skull). This claim was rejected by Brown and Morwood (*Before Farming* 2004/4), and most recently by Dean Falk (Florida State University) and colleagues who found the shape of Hobbit's brain, as revealed by computer images of inside the skull, to be quite different from that of a European microcephalic, as well as modern humans, pygmies and great apes. 'Hobbit' was returned in February 2005 just before a public airing of the debate on the television program "60 Minutes".

But all this didn't begin yesterday, and certainly won't finish tomorrow. Father Theodor Verhoeven, a Dutch missionary, first started digging at Liang Bua over 40 years ago. Soejono then continued excavations during the 1980s, and the large international team is now down 11 metres, with hobbits at 95,000 years back in time and no sight yet of the bottom. □

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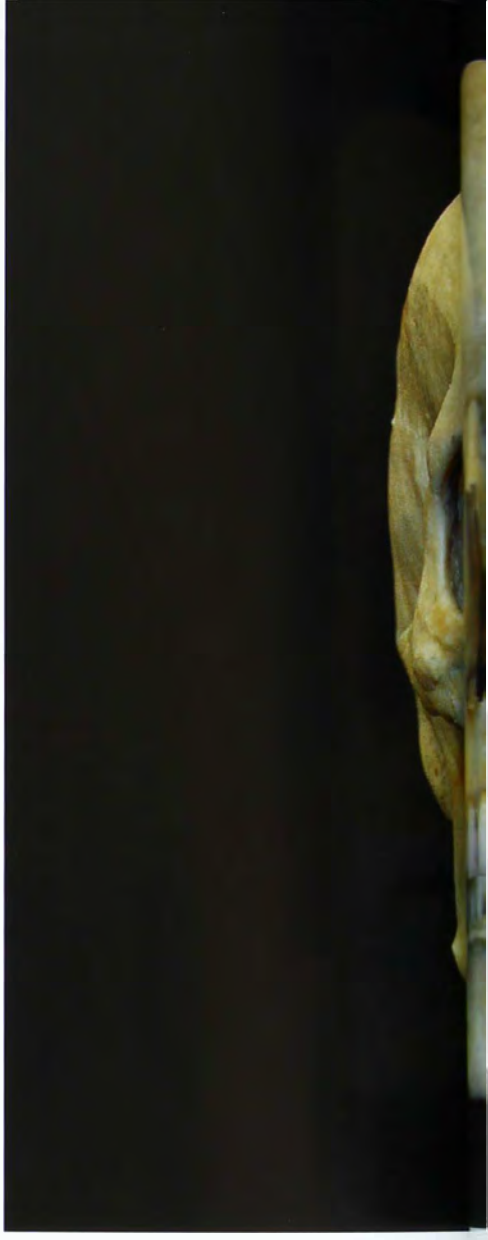


COURTESY P. BROWN

DATING MIDDLE-EARTH

As soon as 'Hobbit' was discovered in Liang Bua, we were desperate to know just when this female last walked on 'Middle-Earth' (the mythological world inhabited by Tolkien's hobbits) and when her species (*Homo floresiensis*) finally became extinct.

The ancient anatomical features of the skeleton shared many similarities with 1.8-million-year-old human remains found at Dmanisi in the Republic of Georgia. So we anticipated it to be at least hundreds of thousands of years old. But because the skeletal remains were the only known examples of an entirely new species, we could not afford to destroy any of it by using direct dating methods that consumed any bones or teeth. Parts of the skeleton were still articulated, indicating 'Hobbit' had died very close to where she was discovered. For this reason we decided to date the associated organic and inorganic materials (charcoal and sand) to provide an age for the skeleton.

We began with luminescence dating (see "Grains of Truth?", *Nature Aust.* Summer 1998–99), which measures the energy stored in the crystal lattices of sand grains since they were last exposed to sunlight. This corresponds to the point in time when the skeleton was entombed by sediments on the cave floor. The energy released from feldspar and quartz grains, using light and heat respectively, showed that the grains of sediment had last seen the sun's rays sometime between 14,000 and 35,000 years ago, which was much more recent than we had expected.

To check these luminescence ages and to better constrain the age of the skeleton, we decided to use the latest generation of radiocarbon-dating techniques. The upper age limit of conventional radiocarbon dating is about 40,000 years. However, by chemically pretreating the charcoal fragments and converting them into pure carbon (graphite), it is possible

Modern human (left) and Hobbit skulls.

to push the limits back to 60,000 years ago. So if the skeletal remains were hundreds of thousands of years old, then this method of radiocarbon dating would only give a minimum age of 60,000 years. As it turned out, however, there was plenty of radiocarbon remaining in the charcoal samples from Liang Bua (that is, it had not all decayed away) and this gave ages for the skeleton of about 18,000 years.

As radiocarbon and luminescence dating methods are based on completely different physical principles, yet yielded ages that agreed beautifully, we were confident that we had reliably dated 'Hobbit' to an age 100 times younger than her closest anatomical equivalent in far western Asia! The youngest known remains of *Homo floresiensis*, recovered the following field season from immediately below a volcanic ash layer, were radiocarbon-dated to just over 13,000 years. This ash is presently being chemically analysed to identify the source of the volcanic eruption, which appears to have sealed the fate of this species and spelt the end of Middle-Earth.

—Chris Turney, Richard 'Bert' Roberts & Kira Westaway
GeoQuEST Research Centre,
University of Wollongong

She-oak up in smoke

She-oaks are highly specialised survivors of drought and fire.

KATHIE ATKINSON

Desert She-oak survives even the fiercest of bushfires.

BY TIM ENTWISLE

IT'S BEEN DESCRIBED AS THE BEST firewood in the world: easy to split, burning even when green, and making excellent charcoal. Until the advent of electric ovens it was the fuel of choice for Australian bakeries. Yet she-oaks, or casuarinas, thrive in some of the most fire-prone forests of southern Australia. This is just one of the apparent contradictions of the quintessentially Australian plant family, the Casuarinaceae, that happens to extend through to South-east Asia and the Pacific Islands.

The wood of she-oaks, when not being burnt to bake our bread, has been used to make shingles, tool handles, bullock yokes, boat masts, beer barrels, piano legs and boomerangs. The Thai elephants at Taronga Zoo will shelter under a lofty shingle roof of Forest Oak (*A. torulosa*). Yet just across the harbour the Nielsen Park She-oak (*Allocasuarina portuensis*) is on the brink of extinction (see *Nature Aust.* Summer 2001–2002). While it's not so strange for one species in a genus to be common enough to clad buildings (although she-oak shingles are now unavailable), and another rare, to many people she-oaks all look the same. At best there seem to be two kinds: the pine-like trees scattered across rocky hillsides or beside snaking rivers, and the tangled, dull-grey shrubs that occupy heathy woodlands and heathlands in places like Nielsen Park.

Indeed the 60 species of *Allocasuarina*, six species of *Casuarina*, and one species of *Gymnostoma* that represent the she-oak family in Australia are remarkably similar except to the trained eye. The first thing you notice about all she-oaks is that they don't have broad flat leaves typical of most flowering plants (although the first seedling leaves are 'normal'). Instead they seem to have long, segmented needles, much like a pine tree. In fact, the 'needles' are green stems, or branchlets, and at each of the constrictions in the stem there is a ring of minute, usually shrivelled leaf-tips like little triangular teeth. These leaves are little more than a scrap of dry tissue. If you are a taxonomist, the first thing you'll do is count the number of these 'teeth' in each ring to help you identify the species. For everyone else, the stem is where the action is.

You might need a hand lens to see it, but each branchlet is grooved along its length. The 4–20 or so grooves can be hairy or hairless inside, but they all contain a row of breathing pores called stomata. By having these pores deep in the grooves, the rate of water loss is minimised, allowing she-oaks to grow in some of the most inhospitable places in Australia—belahs (*Casuarina pauper* and *C. cristata*) are the dominant, and often only trees, on loamy rises in semi-arid inland Australia.

She-oaks are highly specialised survivors of drought and fire. Their stem anatomy already makes them one of the stingiest plants in terms of water loss, and during dry periods the stems of some species brown off, springing back to life with the first rains. Under severe water stress the branchlets are shed. And a subterranean clan of fungi, bacteria and various other micro-organisms lives on and in the extensive root system, providing she-oaks with extra water and nutrients such as phosphorus and nitrogen.

Different she-oak species have their own strategies for surviving fire. The Desert She-oak (*Allocasuarina decaisneana*) in central Australia will survive even the fiercest bushfire, and some species will resprout from their base. Most, however, rely on seed released from cones that are prised open by the heat of the fire. The valves open slowly, and the seed is released onto a cool, nutrient-enriched soil. Mature cones are usually common but not always on all individuals—quite a few species have separate male and female plants.

Few other plants grow under she-oaks. This may be due to seeds being unable to germinate in the dry layer of slowly decaying branchlets, or perhaps chemical inhibition by salts leached from the branchlets or antibiotics from the root bacteria. It may simply be competition for water, given the she-oak's extensive root system. However

there is one notable exception. Many Australian terrestrial orchids seem to favour soil covered in she-oak 'needles', whether in the wild or in cultivation. Some of the most spectacular displays of mosquito orchids (*Acianthus*), greenhoods (*Pterostylis*) and spider orchids (*Caladenia*) I've seen have been in she-oak woodlands.

Although successful as a family, there are some precarious species. *Allocasuarina fibrosa* is known from a single population in the Charles Gardner National Park in Western Australia, a park created to conserve the species. *Allocasuarina glareicola* from Castlereagh Nature Reserve, in the western suburbs of Sydney, and the Nielsen Park She-oak mentioned earlier, were only formally named in 1989. Both have been considered endangered since their discovery earlier in the 1980s, with the Nielsen Park She-oak declining to a single 'she-she-oak' (with no 'he-she-oak') in 2002, which died the year after.

The survival of the Nielsen Park She-oak now depends on seed collected and stored in the New South Wales Seedbank at Mount Annan Botanic Garden (part of the Botanic Gardens Trust), and the success of replanted seedlings (both male and female!) in Nielsen Park and neighbouring areas over the last decade or so. With the critical soil organisms also possibly lost or in low numbers, competition from aggressive weeds, and shading from trees with denser canopies, it may be difficult to get this species re-established. The aim of course is to get the transplanted shrubs to reproduce and survive on their own. Carefully controlled burns are part of the recovery plan, but in the middle of a city of four million people, even a tough plant like the she-oak can meet its match. □

FURTHER READING

Keith, D., 2004. Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT. *Department of Environment and Conservation: Hurstville, NSW.*

National Research Council, 1984. Casuarinas: nitrogen-fixing trees for adverse sites. *National Academy Press: Washington, DC.*

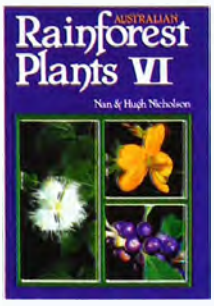
NSW National Parks and Wildlife Service, 2002. Allocasuarina portuensis recovery plan. *NSW National Parks and Wildlife Service: Hurstville, NSW.* ***http://www.nationalparks.nsw.gov.au/PDFs/allocasp.pdf***

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

MARIE LOCHMAN/LOCHMAN TRANSPARENCIES

Seed cones of the Dwarf She-oak (*Allocasuarina humilis*).

reviews



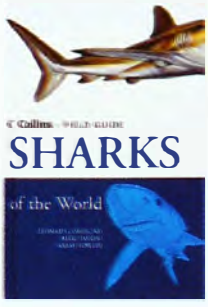
Australian Rainforest Plants VI: In the Forest and in the Garden

By Nan & Hugh Nicholson. Terania Rainforest Publishing, The Channon, NSW, 2004, 72 pp. $16.95 rrp.

Time flies. It's been 20 years since the first book in this series appeared. Now, reading the sixth book in Nan and Hugh Nicholson's Australian Rainforest Plant Series, it feels a bit like I'm visiting an old friend: a lot is comfy and familiar but there are some new things to catch up on.

The format is familiar and still works well. Each of the 120 species dealt with is shown in a colour photo and accompanied by a brief paragraph, covering description, distribution, cultivation and propagation. There is also the usual smattering of interesting snippets of information that make the book a 'good read'. However, what sold me on the continuing relevance of the series was the information contained in the final pages of this volume, where the authors discuss some very contemporary issues which, whilst aimed at growing rainforest plants, are pertinent to any native gardening. Issues such as appropriate site selection, water conservation, using local plant stock, potential for escapees to become weeds, fragmentation and connectivity, genetic diversity, and the case for including less attractive species, are all very relevant and place this book well and truly in the time frame of contemporary ecological thought.

—Greg Gowing
Australian Museum



Collins Field Guide: Sharks of the World

By Leonard Compagno, Marc Dando and Sarah Fowler. HarperCollins, London, 2005, 368 pp. $75 rrp.

This is a thorough treatment of sharks of the world. It contains a brief introduction into fish evolution, life history, biology, fisheries and conservation of sharks, with the remainder of the book covering all the 453 known species. For each species there is a line drawing, a distribution map, and information on identification, size, habitat, biology and conservation status. Colour paintings of the sharks are contained in the 64 plates. There is extensive information comparing species that are particularly difficult to separate. Leonard Compagno has worked on shark taxonomy for several years and has produced numerous scientific publications and guides. He and his co-authors are ideally suited to produce such a guide. The text for each species is limited, but often that reflects the limited knowledge of the biology of individual species. To get so much in such a small volume, it was necessary to use very small fonts, which can make reading the text trying. However, the book is extremely comprehensive and of value to anyone interested in sharks.

—Doug Hoese
Australian Museum

Kookaburra: King of the Bush

By Sarah Legge. CSIRO Publishing, Collingwood, Vic., 2004, 144 pp. $34.95 rrp.

Australian Magpie: Biology and Behaviour of an Unusual Songbird

By Gisela Kaplan. CSIRO Publishing, Collingwood, Vic., 2004, 142 pp. $39.95 rrp.

Herons, Egrets and Bitterns: Their Biology and Conservation in Australia

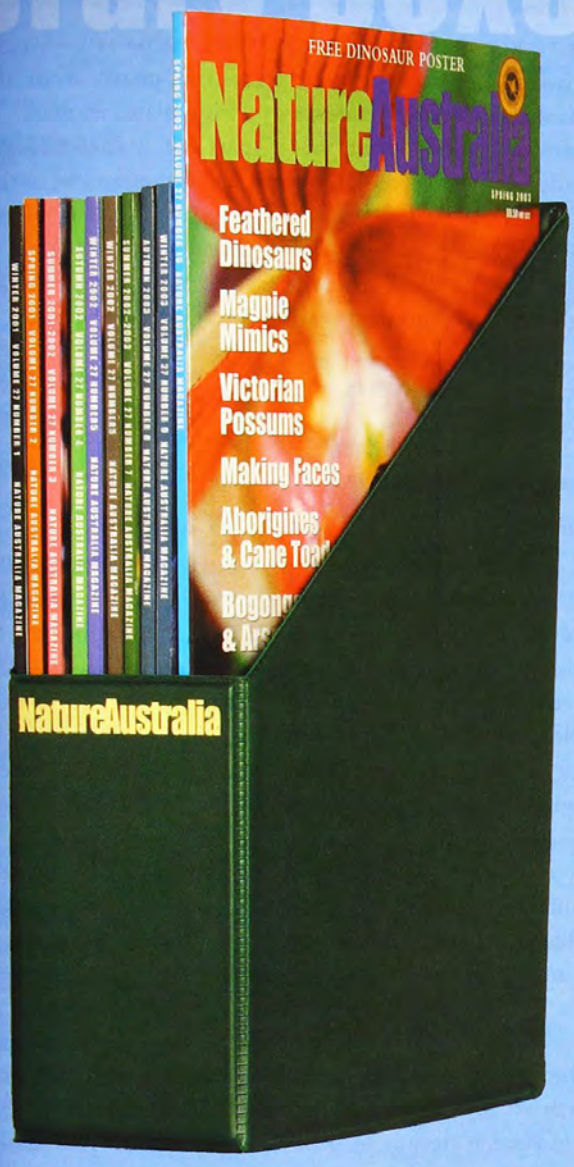
By Neil McKilligan. CSIRO Publishing, Collingwood, Vic., 2005, 134 pp. $34.95 rrp.

These books form part of the growing titles in the well-received Australian Natural History Series. One of the strong points of this series is that each book is written by a scientist who has worked extensively with the animals that are the topic. While each title contains chapters on the main natural-history topics of its subject animals, what sets them apart is the new information from the authors' recent studies and presentation of what makes the species special.

McKilligan deals with a number of Australian heron species, placing a strong emphasis on their importance in this country's ecosystem and the conservation of these birds. This is the first book to exclusively cover this family of Australian birds. Kaplan and Legge offer in-depth looks at two of Australia's most iconic species, the Australian Magpie and Laughing Kookaburra, respectively. These authors' works make important advances on the previous pioneering studies from the 1960s. The study of the social and intellectual development in Magpies is a particularly important contribution to our understanding of this intelligent species.

Well produced and engagingly and accessibly written, these books maintain the high standard of the series. Recommended to anyone with an interest in birds.

—Walter E. Boles
Australian Museum



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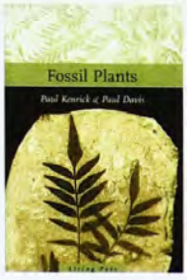

Fossil Plants

By Paul Kenrick and Paul Davis. The Natural History Museum, London, 2004, 216 pp., $59.95 rrp.

FOSSIL PLANTS IS ABOUT MORE THAN JUST FOSSIL FLORAS. KENDRICK AND DAVIES, FROM THE NATURAL History Museum in London, detail the history and evolution of terrestrial plants from their beginnings in the Ordovician to the geographical and climatic contexts in which plants evolved. The result is a very readable, comprehensive and fascinating account of a part of palaeontology—palaeobotany—that often takes a back seat to the study of large vertebrates such as dinosaurs. The authors even manage to make a chapter on the formation of coal a page-turner!

There is an easy authority to the text, no doubt a reflection of the solid expertise of the authors and obvious interest in all things botanical. Illustrations include photographs of fossil plant material as well as reconstructions of what these plants might have looked like in life. This small yet excellent book should be considered essential reading for anyone interested in botany or palaeontology.

—ANNE MUSSER
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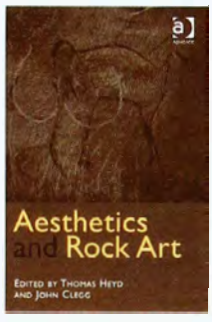

Aesthetics and Rock Art

Edited by Thomas Heyd and John Clegg. Ashgate, Hampshire, UK, 2005, 316 pp. $151.80 rrp.

ROCK ART, WHETHER PAINTING, DRAWING, ENGRAVING, PRINT OR STENCIL, HAS CAPTURED OUR imagination since at least the 1800s but it has only been in recent decades that it has become an area of serious worldwide study. Today new discoveries are trumpeted in academic journals and on the front pages of newspapers, and rigorous methods have been developed to study rock art. Among other things, the power of the imagery, and sometimes its pleasing form, is highlighted. The so-called Bradshaw or *Gwion Gwion* figures of the Kimberley, and the Dynamic or *Mimi* figures of Kakadu and Arnhem Land, are noteworthy in this respect. But detailed studies of other people's rock-art aesthetics have generally been avoided because it was believed we would read too much of our own aesthetic sense into the art.

This book is a bold divergence from this trend. Seventeen brilliantly researched papers covering major rock-art regions of the world demonstrate that for too long we have been ignoring a central feature of rock-art imagery—its aesthetic intent. The introductory paper by co-editor Thomas Heyd explains why this occurred and presents a convincing argument for taking a fresh aesthetic approach to rock art. He and others point out it is demeaning to suppose that only people of European origin are capable of aesthetic appreciation.

The arguments and detailed descriptions are beautifully presented, and the black-and-white illustrations are of high quality and relevance. However, it is a shame cost considerations precluded the use of colour photographs as the colour of rock art in many parts of the world is a key aspect of the aesthetics. Recent x-ray art of northern Australia, San paintings of southern Africa, pictographs of the American south-west and the painted caves of France are just four of many examples where colour is so important.

—PAUL S.C. TAÇON
GRIFFITH UNIVERSITY, QLD

Australia's Four-Billion-Year Diary

By Reg Morrison. Sainty Books, Potts Point, NSW, 2005, 32 pp., $19.90 rrp.

THIS THIN BOOK CONTAINS AN AMAZING SUMMARY OF AUSTRALIA'S ROCKS AND FOSSIL BIOTA AND the way they reached their present position and condition. Reg Morrison is a renowned photographer known for setting his pictures within natural and human contexts. His superb photos, succinct scripts and clear diagrams provide a masterly distillation of Earth's story and how it relates to the evolution of life.

The story is simplified by equating 4.6 billion years of Earth history to the 12 months of a calendar year. Each 'month' includes a timetable showing Australia's past position in time, latitude and relationship to major ice-age events. A separate box in each section relates the developmental stages in evolution to the present complex biology of the readers themselves. Appendices summarise tectonic Australia, the first Australians, how continents move, palaeomagnetism and evolution, and the inside-back cover forms a stylish time chart of events. In a few places the simplifications may go too far. For example, Morrison states that "Earth is a metal planet with an iron core", but it is really a rocky (silicate) planet with a metal iron core. The book, however, is a wonderful eye-opener to our Australian surroundings within a global picture.

—LIN SUTHERLAND
AUSTRALIAN MUSEUM

SOCIETY PAGE

Get involved! Across Australia there is a network of active societies, large and small, local and national, that exist to further the cause of the subject that you hold dear. Whether your special interest is conservation, birds, science, national parks, bushwalking or a particular group of animals, there's a society for you.

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Contact: Hon. Treasurer

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Web: *www.agwine.adelaide.edu.au/industry/RSSA/*
Contact: John Love

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q&a

Turtle Frog (***Myobatrachus gouldii***).

Guardian Ants

Q: *What are these ants in the accompanying photo doing? Most summer evenings, just on dark, for about 30 minutes, they stand quite still outside their nest opening, with most of them facing the same direction. There are two nests and they both exhibit this behaviour.*

—Ian Reeve
Armidale, NSW

A: These sugar ants (*Camponotus* sp.) are undergoing swarming behaviour for reproduction. Near the nest entrance to the left of the image is a pair of winged reproductives, often referred to as 'alates'. They are surrounded by the non-reproductive and wingless females—the small worker and large soldier castes.

Eggs laid by the queen inside a mature nest are normally fertilised and produce wingless workers and soldiers, but when conditions are right alates are produced. The adult alates emerge into the nest and wait until environmental conditions trigger swarming.

Swarming behaviour is linked with weather conditions, the time of year, and the time of day. The worker and soldier ants gather around the emerging alates, acting as guards. In some species swarming is a spectacular once-a-year phenomenon, with hundreds of alates produced. All of the nests in a given area will often swarm at the same time. The male and female alates mate, and the successfully mated females will attempt to establish a new nest. By swarming only in the right conditions, such as on humid warm nights, they maximise their chances of successfully mating and establishing a nest.

—Dave Britton
Australian Museum

Froggie Style

Q: *Do all frogs swim?*

—Robyn Hewitt
Sarsfield, Vic.

A: Certainly all frogs that regularly encounter free water swim. However, some frogs, such as Australia's Turtle Frog (*Myobatrachus gouldi*) and Sandhill Frog (*Arenophryne rotunda*), never encounter water in puddles as they live in sandy soil and any rain that falls quickly drains away. These frogs can float if put in water but I wouldn't call what floundering they do 'swimming'. Both species have extremely well-developed front legs, which they use to burrow like moles through the ground, but their back legs are relatively undeveloped. There are several other species around the world that rarely if ever experience water in puddles or creeks. They might also be non-swimmers, but I don't know if anyone has tested this.

—Martyn Robinson
Australian Museum

A Case of Moths

Q: *For many years I've found cocoon-like objects, made out of small sticks and twigs, attached to walls and fences around my backyard. Please can you tell me what creates them.*

—Carolyn Scibilia
Morley, WA

Wingless worker and soldier ants guard the newly emerged winged reproductives.

A: This is the leftover shelter and cocoon of a case moth (order Lepidoptera, family Psychidae). The larvae (caterpillars) of case moths construct a silken bag around themselves as protection from predators and parasites. The bag is often adorned with fragments of vegetation, such as small sticks, sections of leaves and, in this case, grass stems. Some of the better-known species of case moth can be identified by the structure of the case.

The larvae feed on plants by protruding their head through the top of the

COURTESY CAROLYN SCHULTZ

A cocoon of a case moth.

case. When danger threatens they retreat inside the case and pull the top tightly shut. As they moult and get bigger, they add larger grass stems. They pupate inside the case and the adult moth emerges from the bottom. The tip of the empty pupal skin can just be seen in this photograph. Many species have flightless females that often remain inside the case. They produce a sex pheromone to attract the flighted males for mating, and mate and lay eggs by protruding their abdomen through the bottom of the case.

—Dave Britton
Australian Museum

Answers to Quiz in Nature Strips (page 17)

1. *Collapse*
2. *Nowhere else*
3. *Ants*
4. *Ediacaran Period*
5. *Yabbies*
6. *Californian Redwood* (Sequoia sempervirens)
7. *Red and blue*
8. *Two*
9. *Coriolis Effect*
10. *Salt-tolerant*

G.B.BAKER/AUSTRALIAN MUSEUM

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 *Carnivorous nights*. Winter's Pic Teaser was a terrestrial amphipod, family Talitridae.

Lessons from South Africa

South Africans are well aware of the value of their wildlife.

BY MATT HAYWARD

At last year's Kirkwood wildlife sales in South Africa, six disease-free Buffalo sold for about $AUS210,000. White Rhinos sold for over $50,000 each. Kirkwood is small, yielding about $2 million per year. KwaZulu Natal's game sales, on the other hand, netted $10 million last year.

So what's our Yellow-footed Rock-wallaby worth? What about our Rufous Hare-wallaby? These threatened species should be worth a motza. But they're not. There is no large-scale market for the sale of Australian wildlife.

How can a developing nation like South Africa place a value on its wildlife, while a developed country like Australia cannot? Primarily, this relates to the rapid increase in private game reserves in South Africa arising through the value of ecotourism to its economy. The South African environment has an economic value—higher productivity leads to higher game numbers, which provide more tourist observations. This leads to the conservation of the environment—both the habitat and the species it supports.

Yet Australia receives thousands of tourists each year, many of whom seek our unique wildlife. Why are there not more John Walmsley's creating private conservation reserves throughout Australia? Are tourists content to see our unique wildlife in a zoo? Surely there is a market to see our endangered species in their natural settings? Imagine an afternoon sitting on the back of a four-wheel-drive and spotting Koalas, Red-necked Wallabies, Eastern Grey Kangaroos and dozens of native birds before dining at a table covered with gourmet Australian delights and washed down with a fine red. As your waiter cleans up, you are back out to see nocturnal inhabitants such as Spotted-tailed Quolls, Brush-tailed Phascogales, Greater Gliders and a couple of Powerful Owls. Similar scenarios are played out thousands of times a day in Africa.

"But the chances of seeing a quoll are miniscule," I hear you cry. The chances of seeing Leopards in Africa generally are too. Yet in two hours of game drives in the Shamwari Game Reserve, I have seen four. This is not luck; rather, all creatures that are of high tourist priority become 'familiarised' to vehicles and many are fitted with radio-collars so they can be easily located.

But does it matter that we Aussies have no idea of the worth of a Woylie (Brush-tailed Bettong)? Well, yes. First, it means we have less of an ownership of our biological resources. Government conservation agencies are the only ones charged with owning and conserving our natural heritage. With game-sale information printed in newspapers, South Africans are well aware of the value of their wildlife.

Second, Australia has one of the highest rates of extinction anywhere on Earth, with more species becoming threatened annually. This indicates our current conservation strategies are failing. Processes threatening Australian wildlife are predominantly habitat alteration and predation by introduced species. Virtually the only areas free from these foes are conservation areas where programs are run to eradicate introduced species. Yet these lands are virtual islands of natural habitat surrounded by a sea of land that is inhospitable to most wildlife species and writhing with introduced threats.

Since democracy in South Africa, pastoralism in marginal lands has given way to game farming. In the Eastern Cape there were 18 reserves in 1994 compared with 64 today. This equates to an area of almost a million hectares.

These conservation areas are fenced. Not just the barbed-wire fences that line Australia, but two-metre-high game fences. Predators require 9,000-volt pulsed electric fencing with chicken-wire mesh to keep them inside.

Now, fencing animals inside reserves is important in Africa. If your Lion escapes and starts eating people then you'll be blamed. Australia has different reasons to fence reserves. Currently we merely exclude Cattle and Sheep from our national parks. Yet considering the threat that introduced species pose to our wildlife, it would be extremely valuable to improve the type of fences and use them, in association with an introduced-species eradication program, to keep Cats, Foxes and Rabbits out.

The issue of hunting reserves is another that should be opened to debate. No extant animal is threatened by hunting in Australia and with adequate regulation this industry could provide more money to ensure habitats are protected and introduced species eradicated.

The sad fact about our current economic rationale is that the environment must pay its way. Valuing wildlife is one way to achieve this. □

Dr Matt Hayward is a postdoctoral research fellow at South Africa's Nelson Mandela Metropolitan University researching large-predator reintroductions.

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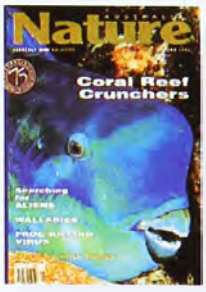

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