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SUMMER 2002-2003

Dinosaur Titans

Origin of Art

Coorong Wetlands

Purple Wallabies

TUNING IN TO CICADAS

ISSN 1324-2598

AM AUSTRALIAN MUSEUM

NatureAustralia

SUMMER 2002–2003 Volume 27 Number 7

Published by the Australian Museum Trust
6 College Street,
Sydney, NSW 2010.
Phone: (02) 9320 6000
Fax: (02) 9320 6073
Web: www.natureaustraliamagazine.com.au
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WATCH THIS! DESIGN

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Subscriptions
Phone: (02) 9320 6119
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Fax: (02) 9320 6073
email: subscribe@austmus.gov.au

Annual subscription (4 issues)
Within Australia $A36.30 Other countries $A45
Two-year subscription (8 issues)
Within Australia $A69.30 Other countries $A83
Three-year subscription (12 issues)
Within Australia $A97.90 Other countries $A116
Prices include GST where applicable

Proudly printed in Australia by Penfold Buscombe

New subscriptions can be made by credit card on the *Nature Australia* toll-free hotline (1800) 028 558 or use the form in this magazine. If it has been removed, send cheque, money order or credit card authorisation to the address above, made payable to the 'Australian Museum' in Australian currency.

NATURE AUSTRALIA welcomes articles on the natural and cultural heritage of the Australasian Region. Opinions expressed by the authors are their own and do not necessarily represent the policies or views of the Australian Museum. All articles in *NATURE AUSTRALIA* are peer-reviewed. *NATURE AUSTRALIA* is printed on archival-quality paper suitable for library collections.

Published 2002 ISSN–1324–2598

NATURE AUSTRALIA is proud winner of the 1987, '88, '89, '90, '91, '92, '93, '99, 2000 and **2002 Whitley Awards** for Best Zoological Periodical, and the 1988 & '90 Australian Heritage Awards.

FRONT COVER
Cicadas, such as this Greengrocer (*Cyclochila australasiae*), are responsible for one of the most familiar sounds of summer. Photo by Carl Bento/Nature Focus.

up front

The song of the male cicada heralds the arrival of one of my favourite things—the long hot Australian summer day. And one of my favourite pastimes in summer has always been locating well-camouflaged Greengrocer cicadas. Even better if you could find one that was in the process of emerging from its dull brown larval form to become a bright green, winged adult. But little did I realise just how fascinating these insects really are. For the past 25 years, Dr David Young has devoted himself to discovering just how such a small insect is capable of producing an ear-splitting 150 decibels of noise and without making itself deaf in the process. After reading his article on page 28, I couldn't help but marvel at the amazing sound-producing capabilities of these bugs.

What makes us human? Why do we do the things we do? When and how did modern human behaviour evolve? Beginning with this issue, we will explore these questions in "Being Human"—our new regular feature by archaeologist Dr Richard Fullagar. In this issue Richard investigates the origin of art. Archaeological works of art are clear indicators of language and the ability to construct symbols, but where, when and how did humans start creating art?

A Greengrocer makes an impressive sight.

Also in this issue we take a look at the potential fate of the Coorong, an internationally significant wetland in South Australia that is suffering from poor management decisions. We explore why male and female Magpie-larks duet, investigate the existence of a purple mammal, and examine how well Australia's sauropods measure up against the rest of the world's giant dinosaurs.

Jennifer

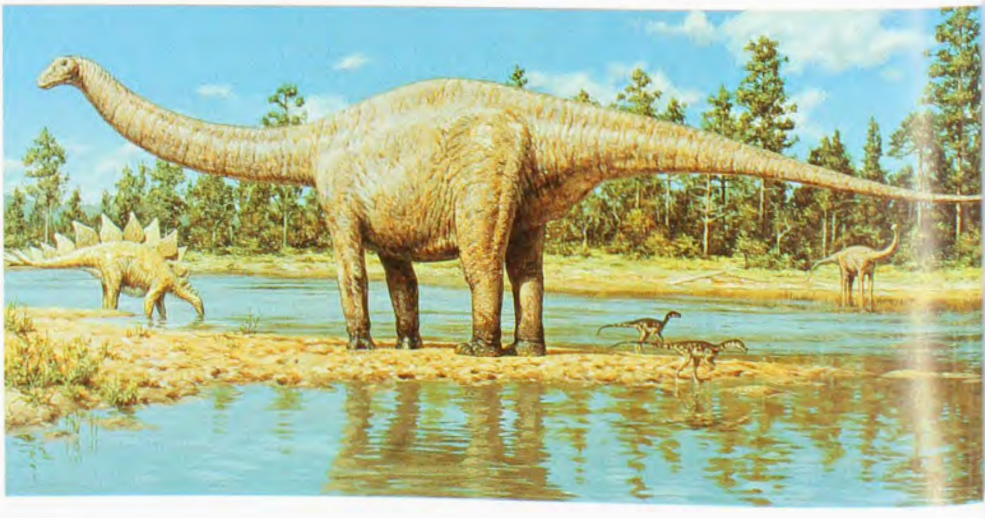
— JENNIFER SAUNDERS
Publishing Manager

Trees on Hillside II painted by Fred Williams in 1964.

contents

ARTICLES

REGULAR FEATURES



RARE & ENDANGERED

Princess Parrot

It's an odd situation when the number of birds in captivity exceeds that in the wild.

BY ALLAN BURBIDGE

24

WILD THINGS

Where Are All the Succulents?

Why do Australia's deserts have so few fleshy plants?

BY TIM LOW

26

PHOTOART

Beyond the Reef: Plankton

Stunning images of the creatures that spend their lives suspended in the blue waters surrounding the Great Barrier Reef.

BY IMAGE QUEST 3-D

70

BEING HUMAN

The Start of Art?

The ability to construct symbols is one of the things that make us human. But when, where and how did art evolve?

BY RICHARD FULLAGAR

74

THE SECRET LIFE OF PLANTS

First to Flower

What did the first flowering plants look like? The 'ape men' of the plant world give us a clue.

BY TIM ENTWISLE

76

THE LAST WORD

Living with Fire

How to manage this flammable continent will always lead to heated debate.

BY DAVID BOWMAN

84

COLUMNS

letters

Feline Soothe-sayer?

I entirely admire *Nature Australia* magazine, which is regularly sent to me by an Australian friend. But I do not agree with the fact that Cats purr to strengthen their bones ("The power of purring", *Nature Aust.* Winter 2002). I believe a helpless or even dying Cat purrs to soothe or tranquilise its enemy (which can be pain itself). A cat in pain or need will purr, telling the world "I am a small, friendly, innocent being; please be the same to me."

—Ingeborg Vetter
Richelbach,
Germany

Coiling Nags

As an old hag-fancier who has worked around the world on these highly specialised survivors, I was a little upset by Douglas Fudge's article in the Spring 2001 issue of *Nature Australia*. While he knows a lot about slime, his knowledge of what hagfishes do seems less authoritative. The comment by my old colleague Bo Fernholm (*Nature Aust.* Winter 2002) prompted me to take the issue further.

Yes, the Atlantic hags burrow and, when forced onto the surface of the substrate, lie straight. Yes, the Pacific hags (at least those that have been studied) coil into a tight spiral when put into an aquarium with a muddy or sandy substrate. *But this is unnatural.*

Pacific hags tend to live on rocky or otherwise complex substrates, intertwining themselves among solid objects. They are 'positively thigmotactic', that is, they bend their body towards an object to maximise contact. This is adaptive in their normal habitat but not on the coarse sandy substrate on which Fudge keeps his animals. In this environment, thigmotaxis leads to coiling: the only way to obtain appropriate stimulation on the flanks is to hug oneself. I wrote a paper on this about 30 years ago.

—Ronald Strahan
Neutral Bay, NSW

Ecological Triage

Most experienced conservationists would disagree with Hugh Possingham's opinion piece on ecological triage (*Nature Aust.* Winter 2002). Ecological triage is a fundamentally flawed approach to threatened species conservation. It makes extinction acceptable, devalues the notion of biodiversity, and lets politicians off the hook when they do not allocate sufficient resources to conservation. Our most endangered species have become flagships for the protection of ecosystems, yet these are the species that would be denied funding under triage proposals. Triage is a medical process applied over a timeframe of hours, with the decisions reflecting availability of medical resources at the time. Even for our most threatened species, we are not faced with this degree of immediacy. Australia has the time and ability to save most endangered species...if we want to.

—Matt Cameron
& Todd Soderquist
Dubbo, NSW

Just how does Pussy's purring help?

Lost Cause for Lost Giants?

Whilst I agree "Lost Giants" (*Nature Aust.* Winter 2002) does a good job of refuting the 'blitzkrieg' theory of megafaunal extinctions in Australia, I am not ready to totally acquit *Homo sapiens* of all charges just yet.

The blitzkrieg theory assumes colonising humans were ecological vandals that would not have imposed self-regulation with respect to hunting of favoured prey species. But there is cultural evidence, in the form of conservation systems practised by Aboriginal societies, that would indicate an understanding of the concept of extinction and the role of potential human overhunting in it. Measures in place at the time of white settlement, such as totem animals, food taboos and sacred story places, allowed Indigenous tribes to conserve their prey species.

So, if rules were in place to conserve prey species, why did the megafauna disappear? I believe for the same reasons that may eventually undo *our* best conservation efforts—political instability and shortage of resources. During wars and famines all bets were off!

—Peter Williams
Branxton, NSW

Peter Williams raises a salient point, but before I address it, I must point out that our article didn't let Homo sapiens *off the hook. We accept that humans may have played a significant, possibly even decisive, role in megafaunal extinction on this continent—but if they did, it was likely through a combination of influences over a longer period and against a backdrop of climatic disintegration. That is, it wasn't instantaneous obliteration through hunting alone, aka 'blitzkrieg' or 'overkill'.*

Self-imposed conservation systems are commonplace among subsistence societies and Australian hunter-gatherers are by no means unique in this respect. But just because such practices have been widespread in historic times does not mean they were widespread 40,000 or so years ago. We can neither assume that the first Australians had self-imposed conservation systems, nor that they didn't. Advocates of blitzkrieg in Australia unreasonably assume that they didn't—just one more among many undefended assumptions underpinning the simple concept of overkill.

—Stephen Wroe
University of Sydney

Benign Algae?

In his article "Flesh-eating Algae" (*Nature Aust.* Winter 2002), Tim Entwisle draws attention to the dangers of a complacent attitude in Australia towards potentially harmful algae. Harmful algae are widespread throughout Australian coastlines and pose a real threat to our aquaculture industry and to recreational fishers. He refers to *Pfiesteria*, which has caused widespread public concern in the US, because of the purported capability of producing toxins. The approach in the media has often been sensationalised. Yet, since its first report, and with increasing frequency, other scientists have questioned the original claims. Recent articles (published in 2002) conclude that *P. shumwayae* does not produce toxins and that the original description of the *P. piscicida* life cycle was in error. The growing consensus is to question the quality of the research on which much of this alarm was based. It is to the detriment of the reputation of the scientific community that it has taken ten years, very considerable expense, and public alarm before the original research was properly verified. We need to understand why the normal quality-control processes in science (peer review) failed to work in this case; but given the potential disruption to aquaculture that premature actions might cause, this case also underlines the necessity to maintain research into the biology of toxic algae.

—Shauna Murray
& David Patterson
University of Sydney

Murray and Patterson correctly convey that there is a need to understand why "normal quality-control processes in science" failed. However, their writing is misdirected.

Pfiesteria *comes in both toxic and nontoxic strains. Three recent dissenting papers focused on two nontoxic strains, yet extrapolated far beyond their data to "all"* Pfiesteria *strains. Toxic* Pfiesteria *has been verified by multiple laboratories, based on more than 400 toxic strains, published in more than 50 peer-reviewed science articles. Colleagues have purified a potent* Pfiesteria *toxin and published about its impacts on finfish, shellfish and human health.*

The conduct of the dissenting scientists is to be deplored. They took credit for "their new, original" work on Pfiesteria*'s ability to kill fish by physical attack, findings that had been published several years earlier by others. They also ignored published data, in papers they cited, on death to fish in minutes from toxin without physical contact with* Pfiesteria*. The three papers, which were merely 'reviewed', not peer-reviewed by scientists with an appropriate knowledge base, are now being formally corrected by toxic* Pfiesteria *researchers.*

Murray and Patterson correctly state that harmful algae are widespread and pose a genuine threat to Australia's aquaculture and fisheries. It would therefore be foolhardy to base research needs on non-corroborated science about nontoxic Pfiesteria *strains.*

—JoAnn M. Burkholder
North Carolina
State University

Erratum

Three captions in the Spring 2002 issue of Nature Australia *were incorrect. The pair of Longman's Beaked Whales on pages 64–65 showed an adult male (top) and female, not female and juvenile. The illustration on pages 70–71 was not Frank Knight's Southern Bottlenose Whale, but an adult male Longman's Beaked Whale by Pieter Folkens. And the image on page 75 of Photoart was of salt-ridden, waterlogged pasture near Onyen in Victoria, not the King River in Tasmania, which was reproduced in the Contents pages.* Nature Australia *apologises for these errors.*

—G.H.

Nature Australia **requests letters be limited to 250 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 *Killers in Eden*. The winner this issue is Peter Williams.**

Summer

Compiled by Geordie Torr and Martyn Robinson

A freshwater Long-finned Eel.

Slippery Summer Swimmers

Whenever you see an eel in a creek, it's easy to get the impression that all it does is swim languidly around in the cool water. But over the course of the average freshwater eel's life it undertakes long-distance migrations, undergoes more bodily transformations than Michael Jackson and goes through more names than your average con man.

In Australia, Long-finned Eels (*Anguilla reinhardtii*) are found mostly along the east coast. They are diadromous, which means they move from marine to fresh water as juveniles and then, when mature, return to the sea to spawn and die. These migrations usually take place during summer.

The exact location of the eels' spawning ground is a mystery, but it's thought to be somewhere around Fiji. Each female produces millions of eggs, which hatch within a few days into larvae called leptocephali. Ocean currents sweep these larvae onto the continental shelf, where they develop into toothless, unpigmented glass eels.

The glass eels move into estuaries where, over the next 12–18 months, they develop pigmentation and teeth. Once they move upstream, they settle down, enter a feeding stage, and become known as yellow eels.

As they mature, the eels' pectoral fins, eyes and gonads enlarge, their skin thickens and turns grey-green on top and silvery white underneath, their stomach degenerates and their anus constricts to reduce water loss. Landlocked eels will often put off maturing as long as they can, and females can be as old as 96 years and reach two metres in length and over 20 kilograms in weight, before they finally make the change.

With maturity comes the final long journey back to the sea to spawn, at which time they take on their final name—silver eels. All up, their reproductive round trip can be as long as 4,000 kilometres.

Check out **www.amonline.net.au/fishes/fishfacts/fish/areinhard.htm** for more on this slippery subject.

A colony of Little Red Flying-foxes.

Things that Go Crash in the Night

All four mainland species of flying-foxes (*Pteropus*) form dense aggregations, known as camps, where they mate and raise the young of the previous year's matings. During summer, camp sizes reach their riotous peak. If you live in Melbourne or Sydney, pay a visit to your botanic gardens, both of which host large flying-fox camps.

Residents of these cities may complain of being kept awake by the raucous shrieks of squabbling flying-foxes. But spare a thought for inhabitants of the tropics where many wily flying-foxes grab a take-away mango on which to munch back at the camp. If the mango's too ripe, it'll slip from the animal's jaws and drop 100 metres or more with a thud on a corrugated-iron roof.

A great book on flying-foxes and their kin is *Flying foxes, fruit and*

blossom bats of Australia by Les Hall and Greg Richards.

Home is Where the Gecko is

Warmth to reptiles is like a caffeine hit to coffee-addicts—without it, they just can't seem to get moving. Being mostly nocturnal, geckos have managed to overcome their thermal cravings somewhat, and are often active at quite low temperatures, but the delicious heat of summer is still bliss for them and it's then that their activity reaches a peak.

Geckos are found in all mainland Australian States, but it's in the north that they're at their most visible. House geckos—a vague term used for any of the pinkish geckos that cohabit with humans—are a common sight in and around buildings throughout the tropics, as they dart across walls and congregate around outdoor lights, waiting to ambush moths and other insects.

While we have several native house geckos (*Gehyra*), at least two of these live-in pest-control agents are actually foreign interlopers: the House Gecko (*Hemidactylus frenatus*) is from Asia, and the Mourning Gecko (*Lepidodactylus lugubris*) most likely hitchhiked aboard the canoes of Pacific traders well before Europeans arrived.

All geckos lay one or two eggs, usually in late spring or early summer. Next time you catch sight of a gecko, look closely and you may be able to see eggs through the lizard's thin body wall.

If you're interested in identifying the geckos in your area, grab a copy of Harold Cogger's *Reptiles and amphibians of Australia*.

A Mourning Gecko.

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

FROM THE COLLECTION

*This specimen of an Australian Plague Locust (*Chortoicetes terminifera*) was collected in 1890 on the Darling River floodplain. This species is Australia's most serious grasshopper pest. The earliest locust plague recorded by Europeans took place around Adelaide in 1844. Plagues can occur almost anywhere on the mainland, usually during summer.*

During warm, wet years, the previously solitary, sedentary, 'normal' grasshoppers build up in huge numbers, change colour and set about devouring everything vegetable in their path. Interestingly, the trigger to transform comes from a rub on the hind legs. When numbers swell, the locusts jostle against each other, stimulating touch-sensitive hairs on the femurs and signalling that it's time to take to the skies and begin pillaging the countryside. When swarming, individual locusts can travel as far as 400 kilometres in a night, riding on the warm winds associated with fronts and low-pressure systems. To learn more about locusts, and the clever techniques used to predict swarms, visit the Australian Plague Locust Commission's website at www.affa.gov.au/aplc.

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**.

Picking Thorns

Lions wandering in the wilds of Africa will no longer need help from St Jerome. The compassionate saint who pulled the thorn from the Lion's paw would be glad to know that one Lion (*Panthera leo*) has been discovered performing its own surgery, and using a tool to do so.

Hans Bauer (Leiden University) reported seeing a Lioness in Waza National Park, Cameroon, that, having stepped on a thorn, tried to remove it using another thorn. After attempting to get it out with her teeth, she picked up another thorn in her mouth, manoeuvered it into position between her teeth, then scraped the infected paw for at least half an hour. Six days later, she appeared free of pain and, presumably, the thorn.

Many animals have been reported to use tools, but most have features that make tool-use easier. For example, elephants use their prehensile trunk to hold a leafy branch to swish flies, and Chimpanzees use their opposable thumb to grasp sticks to winkle out termites. What makes the Lioness's thorn-picking observation so remarkable is that she was apparently able to use a tool to extract a thorn, using only her mouth. For us, it would be like trying to remove a splinter with our hands tied behind our back.

—A.T.

Leaving Warning Signs

The brilliant colours of autumn leaves are often explained away as pretty, but incidental, by-products of biochemical reactions. But Sam Brown and the late Bill Hamilton (Oxford University) have recently proposed that they act as a 'handicap signal'—one that flaunts fitness and wellbeing to would-be predators. "Look at me", such a signal is thought to say, "I'm too strong and healthy for you to even bother with". It's an idea that's often used to explain what would seem to be otherwise evocative and

Licking his wounds? The Lion can now be added to the list of animals that use tools.

JOHN SHAW/AUSCAPE

Red alert: vivid autumn colours may signal extreme fitness to would-be insect attackers.

foolhardy displays towards predators by prey in the animal kingdom. But, until now, no-one has attempted to apply it to plants.

Brown and Hamilton's view of striking autumn colours works something like this. The pigments required for vivid pre-winter displays are energetically expensive to produce. By investing in these a tree can send out the message that, if it's healthy enough to bother with such an exhibition (the 'handicap'), then it's more than capable of defending itself against attack by autumn-colonising insects.

To test their theory, the researchers investigated the extent of autumn colouration in more than 260 temperate, northern hemisphere tree species and compared this with the number of aphid species that attacked each of them. Sure enough, they found that autumn colouration is most spectacular in those species facing the prospect of attack from the highest diversity of aphids, insects that rely on visual colour cues to select their hosts.

—K.McG.

In-flight Meal

Every year millions of small songbirds fly from Siberia to Africa to escape winter and find food. They travel mainly at night, leading to the belief that they rarely attract predators. But researchers have now discovered that a silent and lethal murderer dogs the birds' path, catching them mid-flight and crunching them up on the wing.

Carlos Ibáñez (Estación Biológica de Doñana in Spain) and colleagues have found that the culprit is the Greater Noctule (*Nyctalus lasiopterus*)—one of the rarest mammals in Europe and the continent's largest known bat. While no bats were caught red-handed with bird in mouth, the smoking gun came in the form of 14,000 fecal pellets collected in Spain.

The researchers netted the bats and then kept them in a bag overnight until their bowels were well and truly empty. Prising the poo apart revealed insects and hair, but also plenty of bird feathers, especially during the

JOHN CANCALOSI/AUSCAPE

One of the earliest birds in the Australian dawn chorus: the Eastern Yellow Robin (*Eopsaltria australis*).

Early Birds

Have you ever noticed that it's always the same birds that start singing well before sunrise, while other species start later? The order in the dawn chorus, it seems, is no coincidence.

Robert Thomas (University of Bristol) and colleagues noted the times that different species started to sing and also their eye size, and found that early birds had larger eyes for their body size than their late-starting counterparts. Large eyes capture more light and so are better to see with at lower light levels. As the researchers explain, singing at dawn can be a risky business because it alerts predators to a bird's presence. Only those birds with big enough eyes to spot (and avoid) these predators can afford to get a head start on the day.

—Craig Barnett
University of Canterbury, NZ

KATHIE ATKINSON

Eucalypts have an extraordinary ability to resprout after fire.

migration months of March–May and August–November. It seems the normally insect-loving bats switch over to a bird-based diet when the birds fly over their territory. With 45-centimetre wingspans, the bats approach the birds swiftly and silently. They have low-frequency calls of long duration, making it easier to detect prey at a distance.

What is remarkable for biologists is how bats and birds—which have quite different behaviours and ecologies—have come to interact so specifically. Obviously the airborne banquet that migrating birds offer has made 'bird-watching' an irresistible pastime for the Greater Noctule.

—A.T.

Budding Talents

The regenerative powers of the Australian bush are the stuff of legend. Just weeks after fire has reduced the landscape to a barren wasteland, the charred and blackened bodies of gum trees sprout clumps of healthy foliage. But how do the trees achieve this miraculous resurrection?

The trunks and branches of most trees have dormant buds on the bark surface. When the tree is damaged, perhaps by a storm or by insects, these buds sprout and the tree begins to grow anew. But because the buds are close to the surface, they are extremely vulnerable to fire.

Most eucalypts have small bumps on their bark that were assumed to house dormant buds similar to those found in other trees. However, when Geoff Burrows (Charles Sturt University, Wagga Wagga) examined these structures, he didn't find buds, but strands of specialised tissue that ran from the bark surface into the woody part of the tree. Called epicormic strands, they had the remarkable ability to form buds all along their length, which means they can resprout even when most of the bark is destroyed by fire.

This budding mechanism is unlike that seen in any other trees in the world and gives eucalypts a head start after fire.

—G.T.

Lilliputian Lizard

Jonathan Swift must have known about the extremes of size found on islands when he wrote about Gulliver's encounters on the island of Lilliput. Now Blair Hedges (Pennsylvania State University) and Richard Thomas (University of Puerto Rico) have discovered a truly Lilliputian lizard that has an average snout–vent length of just 16 millimetres. With the exception of fishes, it's about as small as a vertebrate can get.

The diminutive brown gecko, *Sphaerodactylus ariasae*, was found in leaf litter in the coastal forests of two islands in the Dominican Republic. Only one other lizard is known to get down to this size—the related *Sphaerodactylus parthenopion* from the British Virgin Islands.

Such small size comes with several physiological limitations, including high rates of water loss through large surface-area to volume ratios. To survive, these geckos must seek out humid microhabitats, such as leaf litter.

Size extremes often occur on islands because species that do happen to reach islands evolve to fill niches that would normally be

S. BLAIR HEDGES, PENNSYLVANIA STATE UNIVERSITY

This newly discovered gecko from the Dominican Republic is about as small as a vertebrate can get.

YOU'D INVENT GUN-POWDER TOO IF YOU THOUGHT THEY MIGHT COME BACK.

CHINESE DINOSAURS

中國的恐龍

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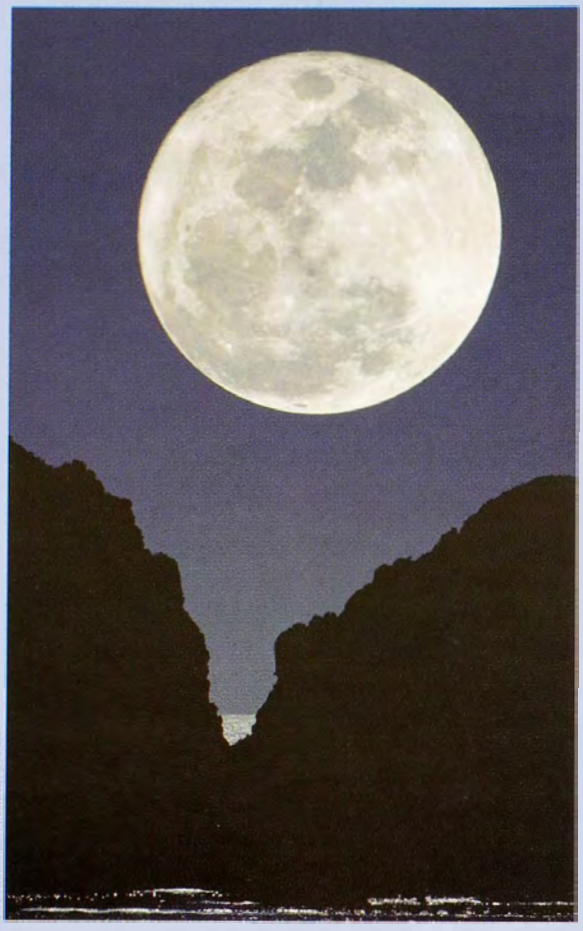


COURTESY AUSTRAL PHOTO

Lunar Myths

There's a widespread belief that more babies are born during the full Moon than at other times. But a painstaking study of 70 million US births over 20 years has knocked this idea on its head. Daniel Caton (Appalachian State University) found no correlation between births and phases of the Moon, and suggests people who give birth or deliver babies on a night with a full Moon just tend to notice the Moon more than if it was only partially lit up or not at all.

The same goes for Dog bites. People are not more likely to be bitten by Dogs on Moon-lit nights, according to a recent study of 2,642 hospital records in Greece over a 3.5-year period. After controlling for factors such as increased exposure to Dogs on weekends and in the warmer months, the researchers found no link between risk of Dog bites and Moon periods.

The full Moon has been blamed for many things, including increased crime rates, car accidents, poisonings and epileptic fits, but as far as Dog bites and birth rates go, it is now officially off the hook.

—G.H.

taken up by other groups. In the case of the Lilliputian lizards, they probably 'shrank' over time to fill the niches occupied by invertebrates on the mainland.

—R.S.

High Pitch for Neanderthal IQ

In 1963, Dietrich Mania (Friedrich-Schiller-Universität) discovered two lumps of resin or pitch in a German archaeological site in the Harz Mountains, one of them complete with a human fingerprint. Pitch-processing, for use in attaching handles on stone tools, is an ancient skill of modern humans, so what makes these pieces of pitch so special?

First, their dates have been estimated at 80,000 years. Previously, pitch-processing to make adhesives was thought to be associated only with fully modern humans in the last 40,000 years. Second, one of the pieces was found with distinctively shaped 'Mousterian' stone tools typical of Neanderthals, thus suggesting Neanderthals, rather than modern humans, made the pitch. And third, the pitch has recently been found to come from European White Birch (*Betula verrucosa*), a particularly difficult wood to process.

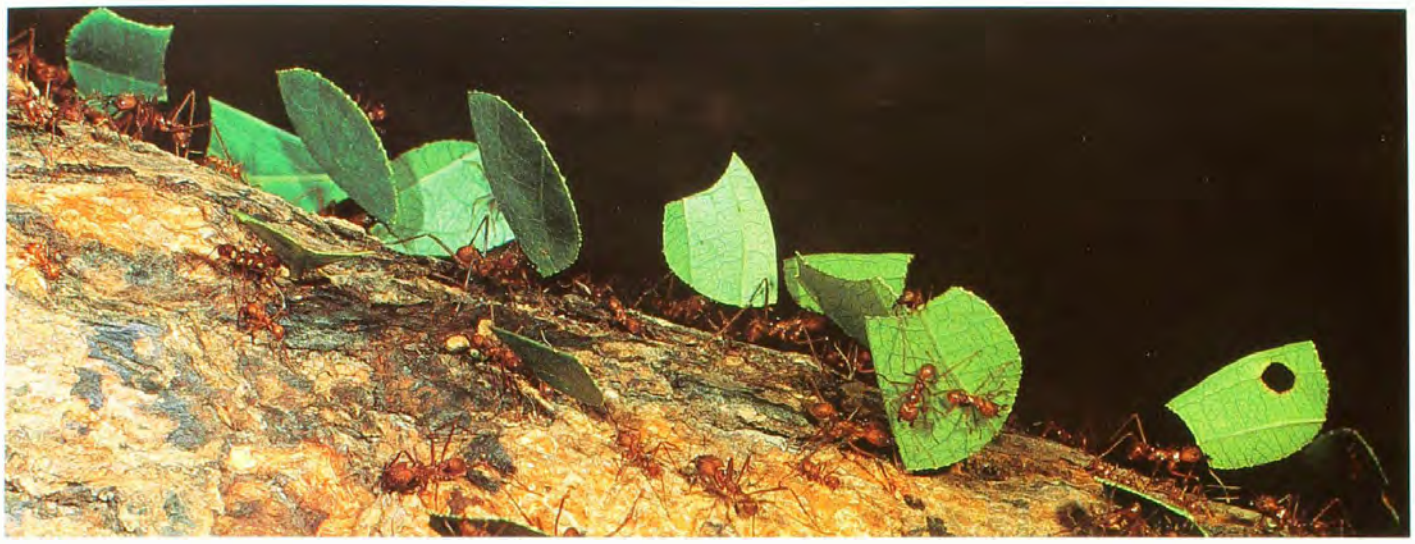
Johann Koller and Ursula Baumer (Doerner-Institut in München) carefully analysed the pitch of birch trees, and described the conditions necessary for the sticky tar to be produced. Using modern techniques, this involves smouldering in an airtight flask at a controlled temperature of between 340 and 400° C. Any lower, and no tar is produced; any higher and the tar burns.

That the Neanderthals had the technical knowledge and skills to produce the prehistoric glue, let alone handles for their tools, once again shows that they were no nincompoops. And it seems less and less likely that they disappeared because of any inferior intelligence.

—R.F.

ROB ALDRICH

Neanderthal glue? A piece of birch pitch preserves a human fingerprint, estimated to be 80,000 years old.



Head-on collisions in leaf-cutting ants (*Atta cephalotes*) are the norm.

Ant Traffic Snarls

Spend a few minutes on the observation deck of any tall building, and you'll probably overhear someone remark that the people below look like ants. Colonies of the leaf-cutting ant *Atta cephalotes* can indeed resemble large human cities, with several million individuals and networks of permanent, cleared foraging trails.

Martin Burd (Monash University) and colleagues decided to examine the behaviour of this ant traffic by artificially increasing congestion along the trails. Using moveable plastic walls to constrict the pathways, the researchers found that ant traffic slowed more abruptly compared with human pedestrian traffic. This was due at least partly to a sharp increase in the number of head-on collisions in ants. Such altercations between ants are (apparently) not as damaging as those between humans, and might even facilitate information exchange through 'antennation'; ants thus devote less effort to

Sexy Budgies glow in the eye of the beholder.

avoiding such collisions. Furthermore, dense human pedestrian traffic spontaneously segregates into streams travelling in opposite directions, but the leaf-cutter ants in the study never showed this behaviour.

The researchers believe there might actually be an advantage to mixing outbound and inbound traffic. Outbound ants are fast and manoeuvrable, while inbound ants are slow and ponderous, each burdened with a chunk of leaf like a removalist struggling with a queen mattress. If traffic was segregated, the inbound lane would be prone to gridlock, consisting entirely of heavily laden individuals all unable to easily avoid each other. In mixed lanes, however, inbound ants do not have to avoid each other as often, since they are separated from each other by a fluid matrix of fast and agile ants, which can readily swerve to avoid each other and their cumbersome colleagues.

—M.L.

Australian Budgerigars are turned on, sexually speaking, by fluorescent feathers.

Fluoro Budgies

Budgies prefer mates in glowing good health…literally.

Research carried out by Kathryn Arnold (University of Glasgow) and colleagues has found that Australian Budgerigars (*Melopsittacus undulatus*) are turned on, sexually speaking, by fluorescent feathers.

Such plumage is common in the parrot family but, until now, no-one has been sure whether it has an explicit function or whether it is simply an expensive and useless by-product of the biochemical processes that give feathers their colour.

The bodies of wild Budgies are mostly non-glowing green but, in both sexes, crown and cheek feathers are imbued with fluorescent yellow pigment. Because this absorbs ultraviolet light and then re-emits it at longer wavelengths, it makes the feathers appear to glow in the eyes of other Budgies.

To test whether fluorescent feathers act as a sexual signal in Budgies, Arnold and her team exposed both male and female birds to two types of prospective partners. Some had their fluorescence toned down by the application of UV-absorbing sunscreen, while others were smeared in petroleum jelly, which does not affect fluorescence.

Both sexes showed a strong preference for brightly glowing partners, suggesting that fluorescence evolved as a sexual signal. The researchers believe that Budgies with a 'healthy glow' to their cheeks (and crown) advertise their fitness and ability to produce healthy young.

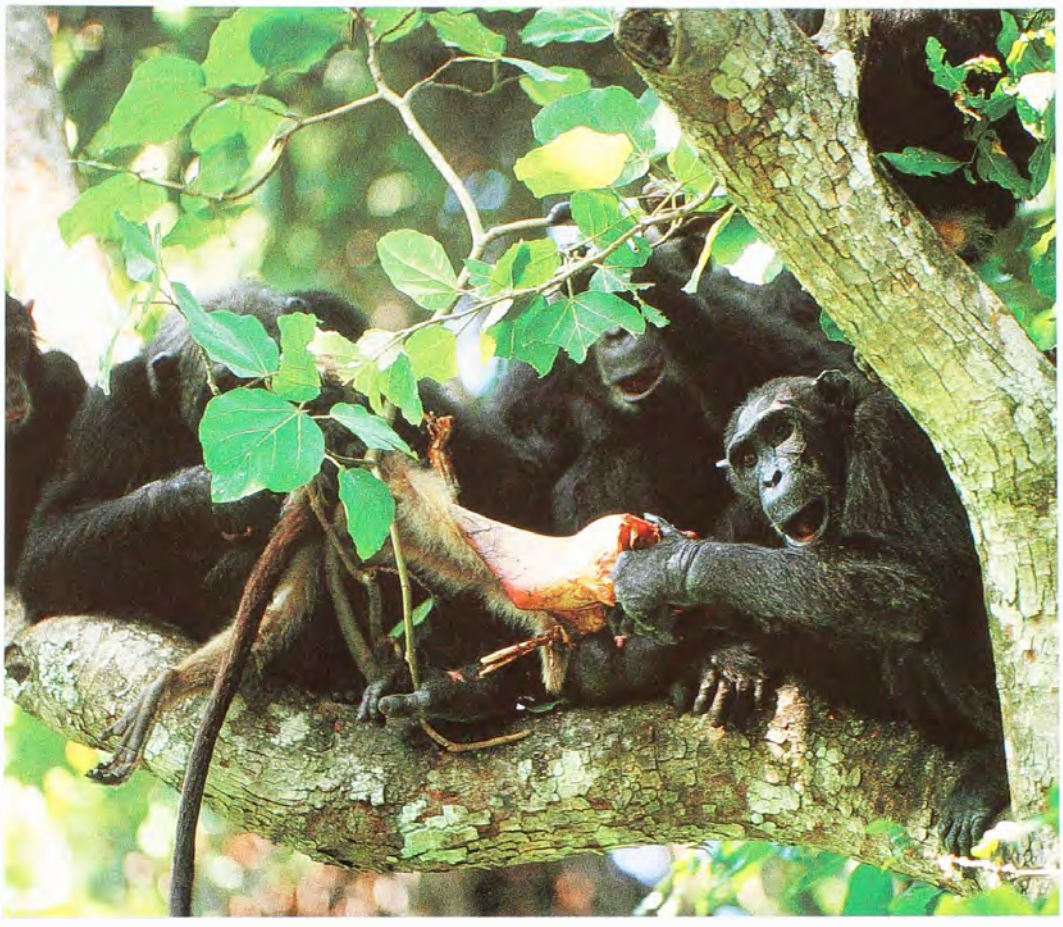
—K.McG.

Men and their Meat

When it was first revealed that male Chimpanzees (*Pan troglodytes*) hunt and kill monkeys for meat, our illusions of these gentle creatures were shattered. At the time it was assumed Chimps must be driven to this aggressive behaviour as a result of food shortages. However, a recent study has shown the hunt's a stunt.

Over a period of 16 months, John Mitani (University of Michigan) and David Watts (Yale University) watched male Chimpanzees hunting Red Colobus Monkeys (*Procolobus badius*) in Kibale National Park, Uganda. Sometimes the Chimps would ignore the monkeys and continue foraging for fruits instead. But at other times Chimps

Male Chimpanzees share their monkey meat—it's a bonding thing.



appeared to 'plan' their hunts, assembling together to patrol their territory in search of potential prey. Oddly, these hunts usually occurred at times of food abundance rather than scarcity.

The idea that Chimps may lure mates by providing them with meat-for-sex was also investigated, yet the presence of oestrous females in the group did not predict the tendency for Chimps to hunt. Instead, males were most likely to hunt when accompanied by other males. The Chimps divvyed up the meat only with their allies, who reciprocated during subsequent hunts.

Mitani and Watts concluded that hunting is a form of male bonding, in which alliances and 'friendship networks' are formed. In a way, it's similar to that great Australian tradition where blokes gather round the barbie, sharing meat and swapping stories.

—K.H.

Resurrecting the Dodo

The origins of the Dodo (*Raphus cucullatus*) have puzzled scientists ever since the peculiar bird was discovered on the island of Mauritius in the 16th century. Its large size, bulbous beak and aerodynamically useless wings have had scientists bamboozled as to its evolutionary history. Over the years, the Dodo has been grouped with anything from the birds of prey to the flightless ratites, such as the Emu and Ostrich, and even the parrots. Since the mid

Honeydew on Tap

Feeding on fluid from the bottoms of insects sounds pretty gross, but for some animals it's all in a day's work.

In the forests of Madagascar, Markus Fölling (University of Bielefeld, Germany) and colleagues observed diurnal geckoes (*Phelsuma* and *Lygodactylus* spp.) inducing sap-sucking planthoppers to excrete honeydew—a sugar-rich substance. Even a nocturnal species, *Homopholis sakalava*, interrupted its sleep to come out during the day for a sugar hit.

Similar behaviour is well known in ants, and some vertebrates, including humming birds and lemurs, lick the secretions from branches and leaves. However, this is the first known case of a vertebrate going straight to the source.

The researchers watched as the geckoes slowly approached planthoppers, bouncing their heads rapidly up and down against the tree trunk. In response to the vibrations, the planthoppers raised their rear ends a few times and exuded a drop of honeydew. The geckoes then delicately pushed their snouts into the drop, pulled back, and licked it off with their fleshy pink tongues.

From the geckoes' point of view, the benefit of this odd relationship is obvious—the honeydew is a high-energy food source and may help them get through lean periods. The benefit to the planthoppers is less clear, but it could be that the geckoes are acting as their garbage collectors. The volume of honeydew the insects produce is large, and when population densities are high it could restrict their movements or they could even drown in it. The fact that geckoes treat the planthoppers as food producers, rather than just food, must also help.

—G.T.

As dead as a...big flightless pigeon.

1800s, the Dodo has been linked with the pigeons and doves (order Columbiformes) but its exact position within this group has been much debated.

Recent molecular analysis carried out by Beth Shapiro (Oxford University) and colleagues has finally resolved the issue. DNA extracted from the Dodo has revealed the bird belongs firmly in the middle of the pigeon family tree (Columbidae). Its closest relative was the flightless Solitaire (*Pezophaps solitaria*) from nearby Rodrigues Island, a species that died out a century after the Dodo. The data indicate the species diverged from one another around 25 million years ago.

Mauritius, the only locality where the Dodo was ever found, is relatively young, having formed around seven million years ago through volcanic activity. Rodrigues is even younger still, being only 1.5 million years old. Therefore, the two flightless species couldn't have diverged because of isolation on the two islands.

Genetic evidence shows that the Dodo and the Solitaire descended from the pigeons of eastern Asia, where their closest living relative, the Nicobar Pigeon (*Caloenas nicobarica*), remains. The researchers suggest that ridges of the Mascarene Plateau, now submerged under the Indian Ocean, must have provided stepping stones for the Dodo and the Solitaire. Through their island hopping, the two species became physically and genetically separated before reaching the separate islands of Mauritius and Rodrigues. Yet at what point the species became flightless is still unsolved. Whether they flew, swam or floated between island stepping stones remains unknown.

—K.H.

Snake Blankets

Each spring in Manitoba, Canada, Red-sided Garter Snakes (*Thamnophis sirtalis parietalis*) emerge in their tens of thousands from the dens in which they've spent the winter. The males appear first and loiter around the den entrances waiting for the females to arrive. Then it's on for

QUICK QUIZ

1. *How many body segments does a spider have?*
2. *What is the name of the artificial lake formed by the damming of the Ord River in Western Australia?*
3. *Where would you look to find a stabilimentum?*
4. *Do whales see blue?*
5. *How many species of brushtail possums are there?*
6. *Which animal is best associated with Joy Adamson?*
7. *What does the Latin word sapiens, as in* Homo sapiens, *mean?*
8. *When do animals aestivate?*
9. *How many seasons do local Aboriginal people recognise in the wet–dry tropics?*
10. *What type of whales were seen frolicking in Sydney Harbour last winter (2002)?*

(Answers on page 83.)

young and old, with each female being set upon by a horde of horny males, in some cases more than 100 of them.

Just to confuse the issue, some of the emerging snakes are imposters—reptilian cross-dressers that smell like females but are actually males. For the first day or two after emergence, these 'she-males' produce female-like pheromones and it was long thought that they gained a mating advantage by confusing the other males.

But Rick Shine (University of Sydney) and colleagues have come up with an alternative hypothesis. When the snakes first emerge, they are extremely cold, and a cold snake is a slow-moving snake. These sluggish serpents face death at the

DAVID CONNOR

Things can get pretty hot under this writhing mass of horny garter snakes.

beaks of hungry crows, and Shine suggests that, by cloaking themselves in a writhing mass of sex-crazed suitors, the she-males may gain vital protection from predators. But this is only half the story.

In contrast to the newly emergent males, those that've been out for some time have had a chance to warm up in the sun. The researchers hypothesised that perhaps the she-males were using their suitors as an electric blanket. They therefore compared the temperatures of courted with uncourted females and found that, sure enough, the courted snakes warmed up significantly faster. They also found that warmer she-males reverted to he-male status more quickly.

—G.T.

Sweet and Sour Elephants

Imagine the stench of an old Billy Goat. Multiply it a thousand-fold and that, according to pachyderm experts, is what a male Asian Elephant (*Elephas maximus*) smells like when looking for a mate.

Bull Asian Elephants achieve this pongy state for about four weeks a year, when in musth—a time of intense sexual interest, activity and aggression. Musth is driven by surging male hormones and characterised by the production of odorous secretions from temporal glands, located between the eyes and ears.

However, only fully mature males have truly pongy secretions. Adolescent males, which experience a kind of teenage version of musth known as 'moda', smell just like honey. Bets Rasmussen (Oregon Health and Science University) and colleagues analysed the secretions from young bulls aged between eight and 13 years and found that they shared key chemical components with honey, including several sweet-smelling acetates. The secretions change chemically as elephants mature, such that in mature bulls they have little in common with honey and include an array of putrid compounds instead.

The researchers noted that moda males in captivity tended to avoid the temporal-gland secretions collected from mature bulls, while secretions from moda males evoked no response in older males. Observations of wild animals confirm these findings.

Like a white flag, the moda aroma appears to signal to older, more dominant males that the younger males are no threat, thus helping to quell unnecessary male conflict during musth.

—K.McG.

JEAN-MICHEL FERRERO/AUSCAPE

A mature Asian Elephant in musth.

Delicious or Malicious?

The excruciating, burning pain inflicted by chilli peppers is so notorious that chilli seeds have been used as a crude torture device in many Eastern countries for centuries. The body-sweating, eye-watering, mouth-on-fire pain is caused by the chemical

capsaicin, which binds to a receptor called 'VR1' on sensory nerve endings, triggering the scorching sensation. But why do chilli plants punish consumers so painfully?

Sven-Eric Jordt and David Julius from the University of California have recently shown that not all animals experience the discomfort mammals go through after coming into contact with capsaicin. Birds, for example, can chow down on chilli without ruffling a feather. This, the researchers demonstrated, is due to subtle differences at the VR1 receptor sites, making them insensitive to the fiery chemical. The molecular basis of sensitivity to spiciness also explains the findings of a recent study on seed dispersal of Chiltepine Chillies (*Capsicum annum*) in

GERRY WHITMONT

Red hot chilli peppers: there are some animals that just can't stand the heat.

KATHIE ATKINSON

Water striders clash spines with claspers in violent pre-mating tussles on the water surface.

Arizona.

Joshua Tewksbury (University of Florida) and Gary Nabhan (Northern Arizona University) trained video cameras on wild-growing chilli plants to determine which creatures ate and dispersed the seeds. They found that birds, especially the Curve-billed Thrasher (*Toxostoma curvirostre*), were the only animals eating the red peppers, confirming them to be invincible when it comes to fiery fruit. Back in the lab, Packrats (*Neotoma lepida*) and Cactus Mice (*Peromyscus eremicus*) could be convinced to eat modest amounts of a capsaicin-free chilli, but they steered well clear of the zesty wild peppers.

Because birds pass seeds through the gut without crunching, they provide the best start in life for a germinating seedling; mammals, however, crunch the seeds up, rendering them infertile. By using capsaicin as a chemical deterrent, chilli plants fend off hungry mammals and instead attract birds as beneficial seed dispersers.

—K.H.

Battle of the Sexes

It's official. Love is a battlefield, and Göran Arnqvist (University of Uppsala, Sweden) and Locke Rowe (University of Toronto) have just found the first empirical evidence of the lengths to which some bugs will go to fend off unwanted advances.

The idea of an evolutionary 'arms race' between sexes is not new. This occurs when advantages gained by one sex from an exaggeration of sexual weaponry are balanced by a counter-adaptation in the other sex. But because each sex is continually evolving weapons and counter-measures, such sexually antagonistic coevolution is difficult to observe in nature.

To demonstrate sexually antagonistic coevolution in progress, the researchers studied 15 species of water striders. These insects engage in violent pre-copulatory struggles on the water surface, during which males use claspers on their hind legs to hold down the females, and females use spines on their back to dislodge mounting males. Arnqvist and Rowe found that, within some species, one sex had evolved a relative advantage over the others, while in most cases male and female adaptations were balanced.

It was previously thought that female water striders developed their own weapons because they wanted to choose the most genetically

fit male. But the reason is much simpler, say the researchers: when it comes to mating, each sex has a different agenda. Males want to mate with as many females as possible, while females, vulnerable to attack from below during mating, want to mate only a few times. And when females gain the upper hand and evolve a relative advantage over their suitors, the mating rate falls dramatically.

Basically, say the researchers, most females just don't want to mate, and do everything they can to avoid it.

—R.S.

Guppies Mimic Fruit

The way to a man's heart, they say, is through his stomach. But for Guppies, it seems, the girls fall for the boys that remind them most of their favourite food.

Female Guppies (*Poecilia reticulata*) in some populations show a strong preference for males with the biggest, brightest orange spots. Curiously, one of the Guppies' favourite foods is the bright orange fruit of the rare Cabrehash Tree (*Sloanea laurifolia*), which grows in north-eastern South America, Trinidad and Tobago. Is this mere coincidence, or is there a connection?

Helen Rodd (University of Toronto) and colleagues have suggested that Guppies may have genes that make them particularly sensitive to orange, and that enable them to find rare food sources. They suggest that female preference for big-orange-spotted mates may have arisen as a side-effect of this.

To test whether there was any genetic basis for colour preference, the researchers presented different coloured discs to both wild and captive Guppies. They found that, regardless of gender or age, most Guppies went for orange or red discs.

Guppies vary geographically in their sexual characteristics and mate preferences. So the researchers looked at populations where females were most attracted to non-orange males. They found that even in these populations, if the fish were presented with different coloured discs, they still chose orange most frequently, suggesting an innate colour preference not based on environment or learning.

Orange spots, it seems, are built into the Guppy's search image for both food and mates.

—A.T.

FURTHER READING

References for the stories that have appeared in this edition of Nature Strips are available online:

www.natureaustraliamagazine.com.au

True blue heeler?

Is the Dingo a continental gatecrasher, or is it as native as Blinky Bill?

AUSTRALIAN PUB PROTOCOL HAS never demanded too much of the average male. Basically, all he should have is the filling capacity of a Two-humped Camel and the ability to pull facts and figures from the air to participate in those perennial pub arguments that make the bar such a stimulating alternative to home. Sports results, the GST, and Brown Snakes crossing with pythons usually prevail, but the issue of the Dingo's right to true-blue Aussie status can always be counted on to turn florid faces purple.

Is the Dingo (*Canis lupus dingo*) a continental gate crasher along with Swamp Buffaloes and feral Pigs, or is it as native as kangaroos and Blinky Bill? A ticklish wager that could send your last $20 into the publican's till and see you off with a dry throat.

Across the mainland the Dingo is officially regarded as vermin. In Queensland where I live, the *Rural Lands Protection Act* 1985 classifies the Dingo as a 'Declared (Pest) Species', making its eradication the lawful *duty* of landholders. Its threat to the jumbucks of Queensland, New South Wales and South Australia led to the erection of the world's longest fence designed to keep it out once it was expunged from within. At 5,580 kilometres long, the 'Dingo Fence' is over twice the length of the Great Wall of China.

Eradication seems a gruesome way to treat the animal that for so long has been known as our 'Native Dog', unofficial faunal icon of Australia, unchallenged totem on my mother's tea towels. But stand the Dingo in an illegal immigrant identification line-up alongside wallabies, bandicoots, the Koala and the Thylacine, and it doesn't take long to pick the odd bod. There is no pouch under the yellow pooch's paunch, and the Dingo's teeth are unlike any of the others. A discreet glance at the pup-producing bits under Mr and Mrs Dingo will also leave you in a state of vertigo. For a start, the Dingo's donger is in front of his scrotum, while that of the others is behind. And a Dingo's nipples are spread out along the belly, while the others cram theirs into a pouch.

"Hang on", you scream. "You've stacked the line-up with marsupials and left out Australia's native bats and rodents, all of them placentals with wedding tackle laid out the same way as the Dingo's." That's true, but Australia's placentals, like its marsupials, also have a fossil history that goes back millions of years. Even the last rodents (*Rattus* spp.) to arrive here via natural land bridges can be dated back 2–3.5 million years in Australian deposits. By contrast, Dingo fossils in Australia have been reliably dated to only around 3,500 years old. In a birthright dispute the Dingo would be hard-pressed getting a hearing.

If you insist that any animal automatically qualifies as 'native' after 3,500 years then the same logic must allow you to embrace camels, Cane Toads, Foxes, Cats and House Sparrows as native Australians too. After all, compared with the multi-million-year histories of dinky-di natives, whether you arrived 3,500 years ago or within the last 200 years (with Europeans) hardly makes a difference.

In his book *The dingo*, Laurie Corbett, one of Australia's best-known canid researchers, concludes that the Dingo originated in Thailand (where it is still common) and was brought to northern Australia around 5,000 years ago by seafaring Asians. Not by Aborigines.

The bitter pill for champions of the 'Native Dog' to swallow is the concept that the Dingo is most accurately described as a feral Asian canid that represents the first foreign predator to be successfully introduced by humans into Australia. It is now an entrenched part of the Australian fauna.

The issue of whether it's a 'good' part of the Australian fauna or a 'bad' part will always polarise opinion and often result in management decisions that are resolved along political lines. Many Australians simply love the Dingo—it has high icon status, it eats Rabbits, Pigs and, in places, excludes Cats and Foxes. Many others, however, are frustrated by

Dingo

Canis lupus dingo

Classification
Family Canidae.

Identification
Kelpie-sized, usually sandy-ginger, sometimes black-and-tan or white. Head–body length 100 cm, tail 30 cm, weight up to 24 kg.

Distribution
Originally from Thailand, now widespread in southern Asia. Introduced into Aust. Common from coast to desert throughout mainland Aust. and on some islands, Tas. being a notable exception.

Biology
Unlike domestic Dogs, breeds only once yearly. Mates in autumn, up to 10 pups born in winter. Females reproductively mature at 2 years. Eats almost anything, from insects to cattle to carrion.

BY STEVE VAN DYCK

it—it kills stock and is implicated as a threat to many rare native species, the mainland Thylacine being a notable early terminal victim and the Queensland Hairy-nosed Wombat a later case in point.

Complicating all this is the Dingo's eagerness to breed with domestic Dogs. The extraordinary difficulty in picking the pure Dingo, the Dingo-cross and the drover's Dog was beautifully epitomised in a story told by Francis Ratcliffe in his book *Flying fox and drifting sand*.

George Jacques had spent his childhood living in a horse-drawn wagon that his father trundled around the country following up rumours of work. The family's yellow, spotty Dog not only helped round up hens when it came time to shift camp, but it was also gainfully employed when the Coolgardie got low on mutton.

One day the Dog got among a flock of Sheep and dispatched about a dozen jumbucks. George and his dad were just selecting the choicest mutton when they noticed two men riding towards them. Instinctively, Jacques Snr pulled out his rifle, shot the Dog, and whipped off its collar before the poor family pet hit the ground.

"We found this Dog playing hell with your Sheep, so I shot him", George's father said.

The men looked at each other then at the Dog, and one said, "That's the bugger we've been after for three years...the worst Dingo in the district. The boss's got 20 quid on his scalp, you'd better take him over to the homestead."

Never short of gall, Jacques Snr asked if he could take a carcass as they were a bit short of meat.

"Take what you like, they aren't no good to us lyin' there", one of them replied.

So George and his dad took a couple of lambs and went over with the Dog's scalp to collect their bounty. They then cleared off as fast as they could in case the real Dingo showed up! □

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

A male Dingo and pup. Unlike domestic Dogs, Dingoes breed only once a year.

Princess Parrot

A third of the observations of Princess Parrots in the wild have been made in the last 10–15 years.

PERHAPS ONE OF THE MOST beautiful parrots, with its pastel-coloured plumage and long wings and tail, the Princess Parrot (*Polytelis alexandrae*) is also one of the most enigmatic. The species was named by John Gould in 1863 in honour of the then Princess of Wales. For years, it was regarded as a rare nomad, inhabiting the vast sandy deserts of central and western Australia, and feeding mainly on spinifex seeds. However, our understanding of its biology has changed.

The bird appears always to have been rare and, until recently, most of its range was remote and little visited. Increased ownership of four-wheel-drive vehicles and the popularity of nature-based tours has changed this—about a third of the observations of Princess Parrots in the wild have been made in the last 10–15 years. And with these observations have come some interesting findings. For example, in good seasons on the Canning Stock Route, Princess Parrots have been reported to feed avidly on blossom, and to prefer various native grasses over spinifex. Other people have reported them feeding on nectar and fruit. Clearly, Princess Parrots are more opportunistic in their feeding habits than previously thought.

Unfortunately the increase in rate of sightings has not been matched with an increase in breeding records. Most reports of their breeding are historical, not recent. The reason for this is unknown, but may be related to the bird's unpredictable movement patterns. A.J. North, in 1911, noted that Princess Parrots would visit a locality where they had never been seen before, and breed in considerable numbers. Once the young were able to fly, they assembled in flocks and suddenly departed. This behaviour makes it hard to predict where breeding might occur. Still, given the increased accessibility of much of the desert areas, and increased visitation, it is surprising that more breeding attempts have not been recorded. It may be that massed breeding events are less common now than in the past, perhaps due to a decline in population numbers, or perhaps they have simply gone unrecorded.

The true status of this beautiful parrot is unknown, and will remain so unless we obtain more information.

Like the closely related Regent Parrot (*Polytelis anthopeplus*) and Superb Parrot (*P. swainsonii*), the Princess Parrot often nests in loose colonies. Up to ten nests have been reported in one tree, although solitary nesting also occurs. Breeding occurs at various times of the year, and it has been said that the birds breed when seeds of spinifex are ripening.

Based on the movement patterns noted by early ornithologists, the species was thought to be nomadic—wandering throughout the central and western deserts in search of suitable conditions. Examination of more recent records, however, indicates that the birds are reliably found in the north-eastern part of the Great Sandy Desert, in the vicinity of the Canning Stock Route. This has led to suggestions that this is their core range, and birds seen away from here may be the result of irruptive movements, rather than nomadic wanderings through a larger range. Whether such irruptive movements result from birds escaping drought in the Great Sandy Desert, or whether they occur as

BY ALLAN BURBIDGE

dispersive movements following highly productive breeding seasons, is unknown.

All this may seem a bit academic, yet it has important implications not only for how we might go about studying the species, but how we might go about conserving it. If the north-eastern Great Sandy Desert is the core part of the parrot's range, then conservation efforts may need to be concentrated there.

Actual threats to the Princess Parrot are unknown. Perhaps it is a desert specialist, and the provision of artificial water supplies in the rangelands may have favoured competing parrot species that rely on these. Furthermore, if temperature-induced climate change increases rainfall across much of arid Australia, then this competition effect may be increasing. For the moment, the species is classified as 'Near Threatened'—it is probably more common in captivity than in the wild—but the true status of this beautiful parrot is unknown, and will remain so unless we obtain more information. Anyone who sees a Princess Parrot in the wild can help by reporting details to Birds Australia (03 9882 2622) or to the relevant State museum or wildlife authority. □

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DR ALLAN BURBIDGE IS A SENIOR RESEARCH SCIENTIST WITH THE WESTERN AUSTRALIAN DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT, SPECIALISING IN THREATENED BIRD RECOVERY.

Where are all the succulents?

Our outback is nearly a succulent-free zone.

MY BEST EXPERIENCES AS A botanist abroad have been encounters with the great succulent floras of the world. I have marvelled at towering cacti and Boojum Trees in the wilds of Arizona and Mexico, and admired the extraordinary 'stone plants' that protrude from South Africa's quartz-pebble downs. Southern Africa has 4,600 succulent species spread across 32 families, while over in Mexico the Cardon Cactus (*Pachycereus pringlei*) can grow 20 metres tall and weigh 25 tonnes. Why can't Australia boast anything like these?

All we have is a mere smattering of succulent plants. There are samphires and other saltmarsh plants, pigfaces (*Carpobrotus*) on beaches, fleshy rainforest epiphytes, small-leaved saltbushes, and tiny arid-zone annuals that sprout after rain (mainly *Parakeelya* and *Portulaca* species). What we lack entirely are plants like the tree euphorbias, cacti and stone plants of dry realms overseas. Our outback is nearly a succulent-free zone.

Succulence might seem the ideal strategy for a desert plant. Water captured from the soil after rare rains can be stored in fleshy leaves or stems for later use. But this strategy comes at a high price. The area of plant surface available for photosynthesis, as a ratio of plant volume, is very low. There are metabolic costs incurred in maintaining so much non-productive tissue. And because plants rely on osmotic pressure to absorb moisture through their roots, succulent plants, being so wet inside, can only absorb water from the dampest of soils. For these reasons succulent plants often grow slowly, and they can be outcompeted by other life forms. They fare best in certain harsh settings where competition is limited.

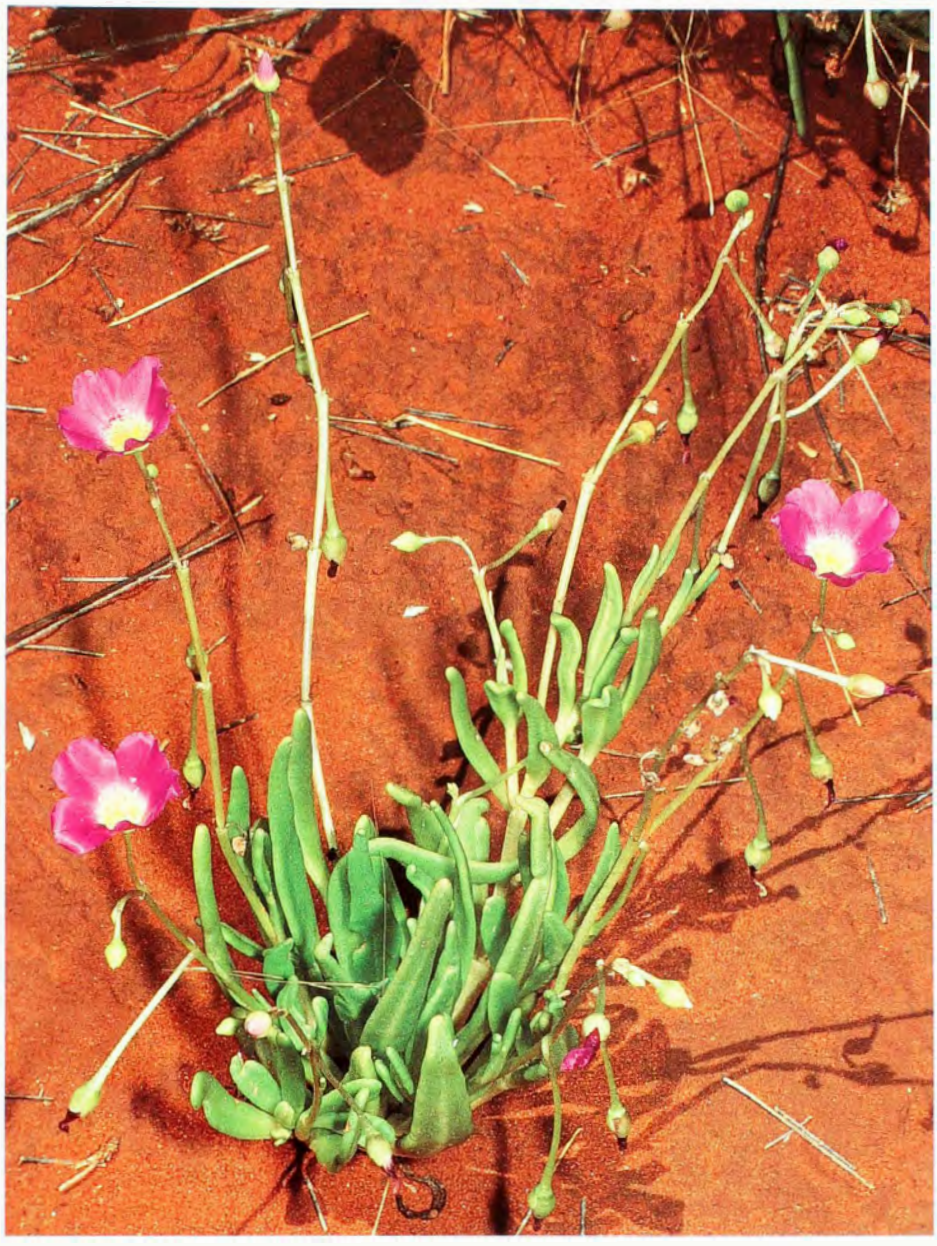
Succulents are very thrifty with water, usually practising what is called 'crassulacean acid metabolism' (CAM). They absorb carbon dioxide through their leaves or stems only at night (not by day like other plants). This is converted into organic acids, which are then stored in the succulent tissues until daylight, when sunlight completes photosynthesis. This two-stage process is less efficient (that is, requires more energy) than other photosynthetic pathways, but by opening their stomata (pores) only at night, fleshy plants limit water loss, and can keep growing when soil is dry. CAM plants are succulent partly because they need tissues in which to store acids. Some non-CAM outback plants, including certain vines, store water in tuberous roots instead of leaves or stems.

Because succulent plants close their stomata by day (to prevent reconverted carbon dioxide from escaping and to reduce water loss), they cannot practise evaporative cooling, and thus cannot survive in very hot deserts. They rarely grow in true deserts at all, thriving mainly in semi-arid zones, often among rocks and pebbles. Their distribution

PHOTOS TIM LOW

Australia's succulent plants are seldom spectacular to behold. Ruby Saltbush (*Enchylaena tomentosa*) is one of several species with small leaves that are only slightly fleshy.

BY TIM LOW



This parakeelya (*Parakeelya stagnensis*) is one of several small succulent plants found in outback areas, all of which die completely during dry periods, or die back to underground tubers.

across the globe is patchy. Dry-zone succulents are rare, not only in Australia, but in North Africa, the Middle East and central Asia.

The extreme appearance of many of these plants implies a long evolutionary response to consistent selection pressures. Tony Burgess (University of Arizona) and Avi Shmida (Hebrew University) argue that certain regions of the world have fostered succulent evolution. These are the coastal 'deserts' on the western sides of continents cooled by cold oceanic currents, and also rain-shadow zones in subtropical montane realms. 'Hot spots' include the western sides of South Africa, Madagascar, Peru and Mexico, especially on stony substrates shunned by other plants. Where rain is unreliable fleshy plants do poorly (they are less drought-resistant than is commonly thought), and where rain is too frequent they are outcompeted by other plants.

Succulents are scarce in Australia because the selective forces that produce them have not operated consistently over a long enough period of time. Rainfall in the outback is too erratic, and there are no high inland ranges to serve as drought refuges. The small succulents that dominate in South Africa are known to receive low but very regular seasonal rains (and often fog as well). Much of the Australian outback is too hot for such plants. Succulents are also deterred by fires, an important consideration in Australia where highly flammable spinifex (*Triodia*) clothes stony slopes that might otherwise suit them.

But when succulents get the chance they sometimes prosper here. Caustic Bush (*Sarcostemma viminale*), a shrub or creeper with long succulent stems, does well on rocky slopes and plains, although only on fire-protected sites. Native to Africa and Asia as well as Australia, it evolved overseas before somehow reaching Australia in the distant past. It is the only robustly succulent perennial found across most of central Australia.

Foreign cacti also thrive. More than a dozen prickly pear species (*Opuntia*) have established as weeds of semi-arid woodlands and pastures, although they shun our deserts. Other invading succulents include Harrisia Cactus (*Harrisia martinii*) and members of the stonecrop family (Crassulaceae), including *Bryophyllum* and *Crassula* species. These plants have succeeded partly by escaping from the insects and diseases that control them back home, but also by finding new environments that meet their needs. Semi-arid Australia is not so much a place where succulents cannot grow, as a place where they cannot evolve. □

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THE GREENGROCER PRODUCES A FORMIDABLE NOISE, MAKING IT AN IDEAL CHOICE FOR LEARNING ABOUT SOUND PRODUCTION IN CICADAS.

TUNING *in to* CICADAS

BY DAVID YOUNG

"HOW *DO* THEY MAKE ALL THAT noise?" This question often comes to mind in the summer when we hear a piercing chorus of cicadas. It's a good question and, with the help of several collaborators, I've devoted some 25 years to answering it.

A Greengrocer makes an impressive sight in this close encounter. Typical cicada features are the broad head with compound eyes on either side, together with three simple eyes near the midline.

DENLEY CLYNE

An adult Greengrocer in the process of emerging from the cuticle of the last larval stage. The two large flaps (opercula) next to the back legs show that this is a male.

Of the cicadas in Australia's south-east, none does more to make its presence felt than the Greengrocer (*Cyclochila australasiae*). A well-known resident in the leafy suburbs of Sydney and Melbourne, this species gets its common name because it is normally bright green in colour. It is a large insect, with a body length of about 4.5 centimetres, and it produces a formidable noise. These features make the Greengrocer an ideal study choice for learning about sound production in cicadas.

In all cicadas, only the males produce sound. The characteristic sound that emerges from a group of males is known as the calling song because it attracts female cicadas of the same species. The females, which cannot sing, respond by flying in from nearby trees and alighting among the group of calling males. Once a female has alighted, she is courted by nearby males and mating follows.

Each species of cicada has its own distinctive song. The Greengrocer has a harsh, continuous call without any significant fluctuations in frequency or volume. An individual male usually begins his song rather hesitantly, with short bursts of sound, each lasting only a second or two. As other males join in, the individual's song shifts to a continuous call of increased volume, which can go on for many minutes without interruption. The resulting chorus of Green-

grocer song may be heard at intervals during a hot day and occurs again at dusk if the evening stays warm enough.

TO STUDY CICADA SONG, I FIRST have to find a male that is singing in a relatively isolated and accessible position. I then record his song separately from the songs of other males, using a portable tape recorder and directional microphone. This sometimes elicits a curious response from passers-by because I look for all the world like a reporter interviewing the trees.

Once back in the laboratory, I display the recording on an oscilloscope or computer as a trace showing loudness over time. This shows that the Greengrocer's song, which we perceive as a continuous noise, actually consists of a succession of brief sound pulses repeated about 2,300times per second. Each pulse rises rapidly to a maximum volume and then fades away to almost nothing before the next pulse begins. On an expanded time axis, each pulse is seen to consist of smooth oscillations that occur at a constant rate of just over 4,000 per second (that is, with a frequency of 4,000 hertz, or four kilohertz).

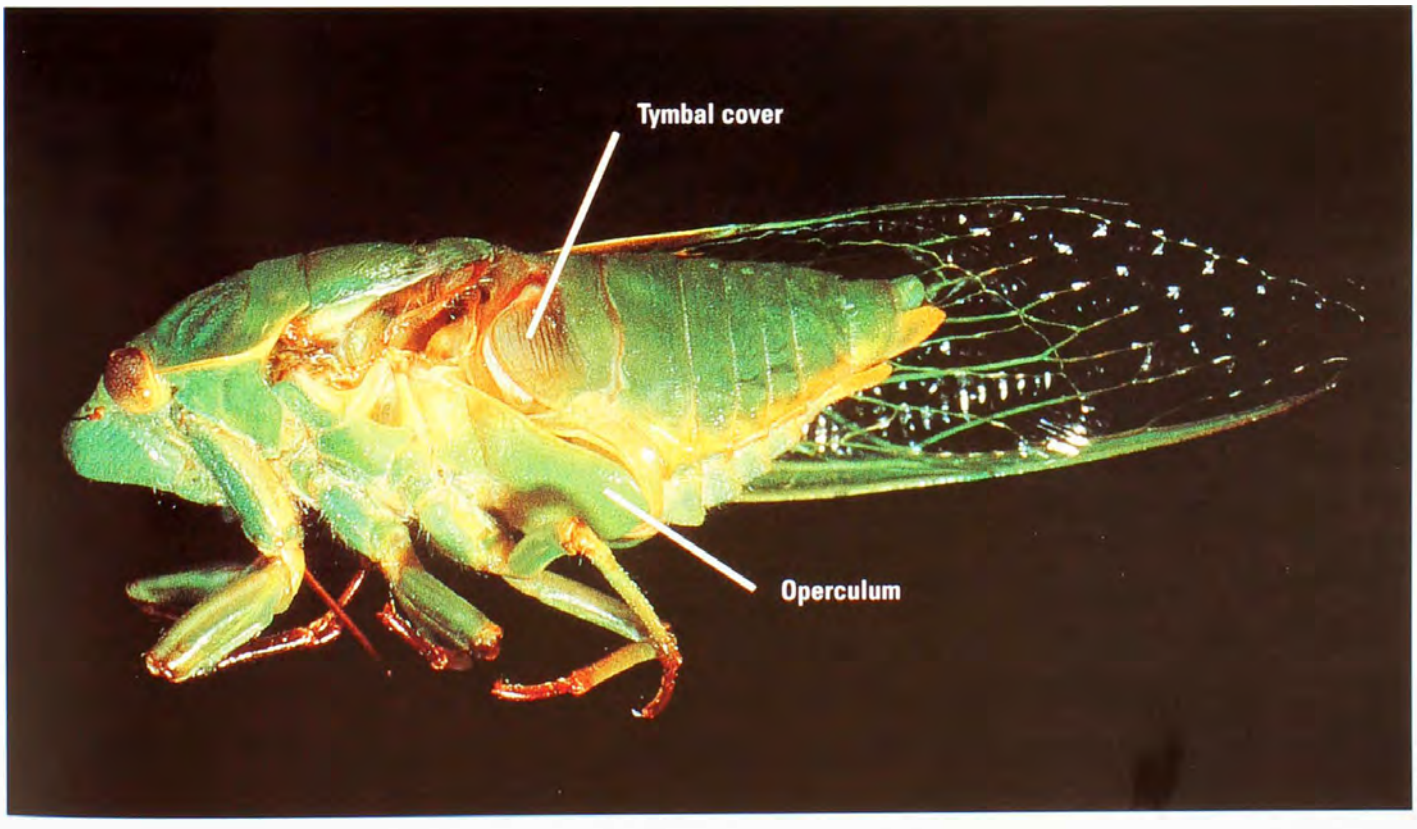
USING A PORTABLE *tape recorder and microphone, I look for all the world like a reporter interviewing the trees.*

The way in which these sound pulses are generated depends on the fact that all insects have an external skeleton or cuticle, which surrounds the internal organs. Cicadas illustrate this charmingly with the empty shells they leave behind on tree trunks in early summer. Each of these shells represents the old cuticle of the last larval stage, from which the adult cicada emerged. The newly emerged adult has a soft cuticle that takes a day or two to harden. Once the cuticle is hard, the male cicada is ready to sing.

The parts that actually generate the sound are modified parts of the cuticle called tymbals. There is one on each side, located behind the wings and just above the midline. In the Greengrocer, each tymbal is protected by an outer flap of hard cuticle, called the tymbal cover. Beneath this cover, the tymbal consists of a soft membrane, with an irregularly shaped plate of cuticle (the tymbal plate) towards the back and four long ribs towards the front.

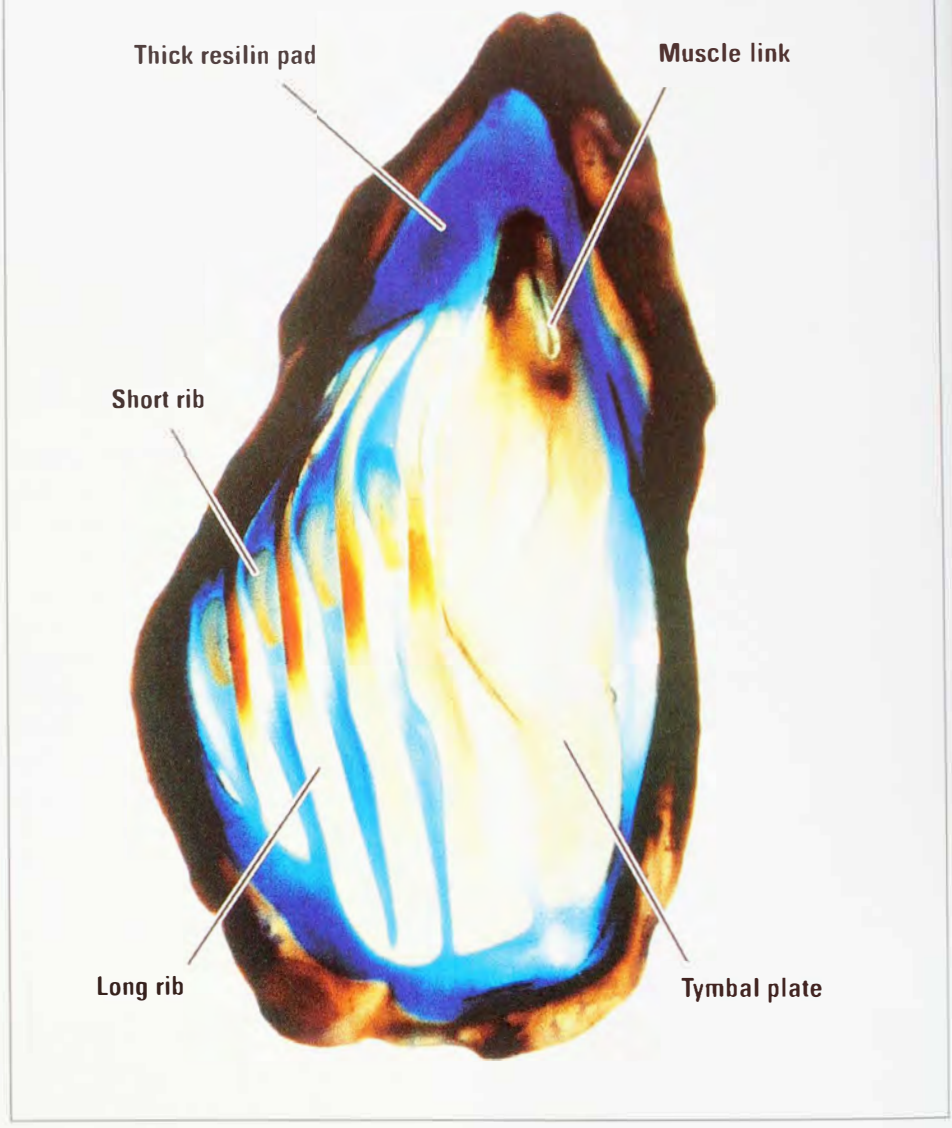
A muscle attaches to the upper part of the tymbal plate and is anchored to the lower side of the cicada's body. Contraction of this tymbal muscle causes the tymbal plate to swing inwards, which in turn causes the ribs to buckle at their narrow mid-regions, in sequence. This inward buckling of the tymbal produces a pulse of sound in much the same way that pushing in the tin lid of a jam jar generates an audible pop. The properties of the tymbal membrane and ribs determine the precise frequency of the sound.

When the tymbal muscle relaxes, the tymbal pops back out to its original position due to the elasticity of the softer parts of the membrane. The membrane is elastic because it contains a



Location of the sound-producing structures on the left side of a male Greengrocer. The tymbal lies behind its protective tymbal cover and the eardrum lies behind an even larger protective flap, the operculum.

(Above) The tymbal of a male Greengrocer, made visible by cutting away the tymbal cover on the insect's left side. The pale membrane of the tymbal is highly flexible, while the darker ribs and tymbal plate are hardened and are relatively stiff.



(Right) A tymbal stained with blue dye to reveal the presence of resilin, an elastic protein. A thick pad of resilin lies alongside the point where the tymbal muscle is linked to the upper part of the tymbal plate.

rubber-like protein called resilin and there is a thick pad of resilin just above the ends of the ribs. This acts as a spring, which returns the tymbal to its outward position. In some cicada species, the outward movement of the tymbal also produces a loud sound, but in the Greengrocer this noise is insignificant.

By inserting a tiny silver wire into the Greengrocer's tymbal muscles, Robert Josephson (University of California at Irvine) and I were able to monitor their activity during sound production. We found that the left and right muscles contract alternately, and that each muscle contraction is followed by a single pulse of sound. To produce the high pulse rate of the calling song, each tymbal muscle contracts more than 100 times per second. Such a high rate of contraction can only be sustained when the tymbal muscle is warm enough. At cooler temperatures, the muscle contractions slow down and then fail altogether. This is why male Greengrocers can only produce their calling songs on hot days.

On its own, the tymbal does not produce a particularly loud sound even in a large cicada like the Greengrocer. What happens is that sound generated by the tymbal is amplified by an air chamber present in the body of the male cicada. The region of the body behind the legs and wings, the abdomen, is largely filled with intestines and reproductive organs in the female. But in the male, these organs are pushed aside by a large air sac, which envelops the tymbal muscle and presses up against the internal surface of the tymbal.

An air chamber of a given size will enhance sound vibrations of a particular frequency, as in the case of a wine glass 'ringing' when we blow across the top of it. An echo chamber like this is said to be a resonator. Henry Bennet-Clark (Oxford University) and I tested the air sac of the male Greengrocer and found that it acts as a resonator tuned to a frequency of just over four kilohertz. This is also the frequency generated by the tymbals, and so the sound they produce is selectively amplified by the air sac.

BUT THE STORY OF SOUND production in cicadas doesn't end there. The large air sac also makes contact with the cicada's two eardrums, which are located underneath and towards the front of the abdomen. Each

A mating pair of Greengrocers. The male, facing downward, is the typical green colour while the female is of the less usual yellow variety.

eardrum or tympanum consists of a thin membrane protected externally by a flap of hard cuticle (the operculum). A small ridge of cuticle links each membrane to the cicada's inner ears. Interestingly, the male Greengrocer's eardrums are about five times larger than the female's. In fact, this difference is the easiest way to tell sexes apart: turn the insect on its back and move the back legs aside to view the undersurface of the abdomen. The two large opercula of the male are then obvious, whereas they are hard to make out in the female, even though they are there. This difference led me to suspect that the eardrums might play some role in cicada sound production.

To test this idea, I measured sound output over the male's body using a small probe microphone, and found that the loudest sound emanates from the space between each eardrum and its protective operculum. The reason for this is that the two tympanic membranes are so thin that they are effectively transparent to sound. They therefore function as the openings through which sound vibrations within the air sac are broadcast into the environment.

Anyone with the patience to creep up on a male Greengrocer when it is singing, without disturbing it, will see that the male adopts a special posture. As it begins to sing, the male stands up on tip-toes so that its body is well clear of the tree trunk or branch. It also spreads its wings so that they no longer touch the body, and raises the abdomen.

By raising the abdomen like this, the cicada creates a wide gap between the eardrums and their covering opercula, enabling the sound to leave the body by these routes. Raising and extending the abdomen by just the right amount also allows the singing male to fine-tune the air sac to the precise frequency being generated by the tymbals. Finally, standing erect and spreading the wings prevent the sound being dampened by contact with nearby objects.

This is a highly efficient system and,

A group of black cicadas (*Psaltoda* sp.) on the trunk of a eucalypt. Sometimes such groupings may run into hundreds of individuals with calling, courtship and mating all taking place.

A male Greengrocer in full song. A calling male always adopts the characteristic posture seen here. The legs are extended and the wings are held apart. The hind part of the body (abdomen) is raised and extended into the gap between the wings.

In the Greengrocer, the sound-pressure level just outside an ear-drum is almost 150 decibels—a painfully loud sound! To prevent deafening itself by its own song, the male cicada is able to uncouple the inner ear from the eardrum during sound production.

This way of producing sound is unique to cicadas, although not all species share every detail of the Greengrocer's mechanism. There are many variations on the basic theme. But the functional elements of the mechanism are common to all cicadas and are also found in other systems, such as musical instruments. Consider a didgeridoo or a guitar. These too have a vibrating element to generate the sound, an air chamber to amplify it, and an opening through which the sound is broadcast into the surrounding air.

So next time you are deafened by a cicada chorus, spare a thought for the exquisite mechanisms that underlie the male's love song. □

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Greengrocer

Cyclochila australasiae

Classification
Order Hemiptera, family Cicadidae.

Identification
Large (4.5 cm long), broad body with clear wings extending well beyond body. Three simple, golden-yellow eyes set in a black background in centre of head (main eyes at side of head). Usually green, but may be blue or yellow.

Distribution and Habitat
Southern Qld to eastern SA in coastal districts. Native to tall eucalypt forests but has taken to many introduced tree species found in residential areas.

Life History
As a plant-sucking bug, spends whole life (about 6 or 7 years) closely associated with host trees. Most of life cycle spent underground as larval stages feeding on tree roots. Adults emerge from last larval stage and live above ground for about a month. After mating, females lay eggs in twigs; newly hatched larvae drop to ground.

WHILE PEOPLE MAY OCCASIONALLY REPORT SEEING PINK ELEPHANTS, PURPLE MAMMALS OF ANY SORT REMAIN RARE.

A PURPLE PUZZLE

BY MARK ELDRIDGE

On 2 June 1924, W.B. Sinclair collected two peculiar rock-wallabies near Dajarra in far north-western Queensland. Their face, head and neck were bright purple—a highly unusual colour for a wallaby or indeed any mammal. Having regularly seen these wallabies bounding among the rocky outcrops on his remote property, Sinclair was curious about their identification and so he sent them to Sydney's Taronga Zoological Park where the Director at the time, Albert S. Le Souef, swiftly concluded they represented a species previously unknown to science. Later that same year Le Souef formally described them as a new species—the Purple-necked Rock-wallaby (*Petrogale purpureicollis*)—distinguished from other rock-wallabies by the pinkish purple colouration on the face, head and neck. However, the pigmentation was not permanent, fading rapidly (sometimes within hours) upon an animal's death. On one specimen Sinclair noted that "the pink around the neck was very marked" but when Le Souef was formally describing the skin some weeks later he commented that the fur was only "washed with vinaceous [red-purple] brown".

Although some pigmentation is nearly always present on the Purple-necked Rock-wallaby's head, face and neck, its intensity varies both between individuals and during the year.

JEAN-PAUL FERRERO/AUSCAPE

In far north-western Queensland, a Purple-necked Rock-wallaby surveys its boulder-strewn ridge-top habitat in the Selwyn Range, near Mt Isa.

The transient nature of the colouration led people to doubt that the purple pigment was actually produced by the animal itself. The eminent Australian mammalogist Ellis Troughton, whose classic book *Furred animals of Australia* (1941) was the definitive text on Australian mammals for almost 30 years, concluded that the purple colouration was "due, apparently, to some kind of stain from the local foliage or rocks". As a result, Troughton did not consider the Purple-neck to be a separate species but a western population of the rather plain Unadorned Rock-wallaby (*Petrogale inornata*). Over the next 60 years scientific opinions waxed and waned, with the Purple-neck sometimes considered a separate species, but mostly placed within other rock-wallaby species, including at various times the Unadorned, Brush-tailed (*P. penicillata*) and Black-footed (*P. lateralis*) Rock-wallabies.

By the 1970s a small number of Purple-necked Rock-wallabies were held in captivity at research institutions, and it rapidly became clear that the purple pigment is produced by the animals themselves, although the intensity of the colouration varies markedly both between individuals and during the year. Sometimes only a faint pink wash is discernible on an animal's face, while at other times the whole head, neck and shoulders can be a bright red-purple. However, there appears to be no obvious seasonal pattern to the changes in colouration or intensity, although males are often more strongly pigmented than females. Closer examination has revealed that the purple pigment is not part of the wallaby's fur, but is secreted through the skin on the upper part of the body and simply sticks to the surface of the hairs, giving them their distinct purple appearance. As a consequence, the pigment is readily removed by brushing the wallaby's fur, and it stains the hands and clothes of those who handle them. The pigment is also water-soluble and animals lose their colouration after periods of heavy rain. However, the loss of pigmentation is only temporary, with the wallabies usually regaining their colouration with a few days.

Although the question of the purple pigment's origin had been solved, it was still unclear whether Le Souef had been correct in recognising Purple-necks as a

new species. Since the early 1980s, they were classified as a subspecies of the Black-footed Rock-wallaby, due to the similarity of their chromosomes. However, there were major differences between Black-foots and Purple-necks, particularly in their coat markings and colouration, as well as the size and shape of their skulls. The advent of modern DNA technology offered, for the first time, a means of independently assessing the degree of difference between Purple-necks and other rock-wallaby species. In 1992 I began a multifaceted

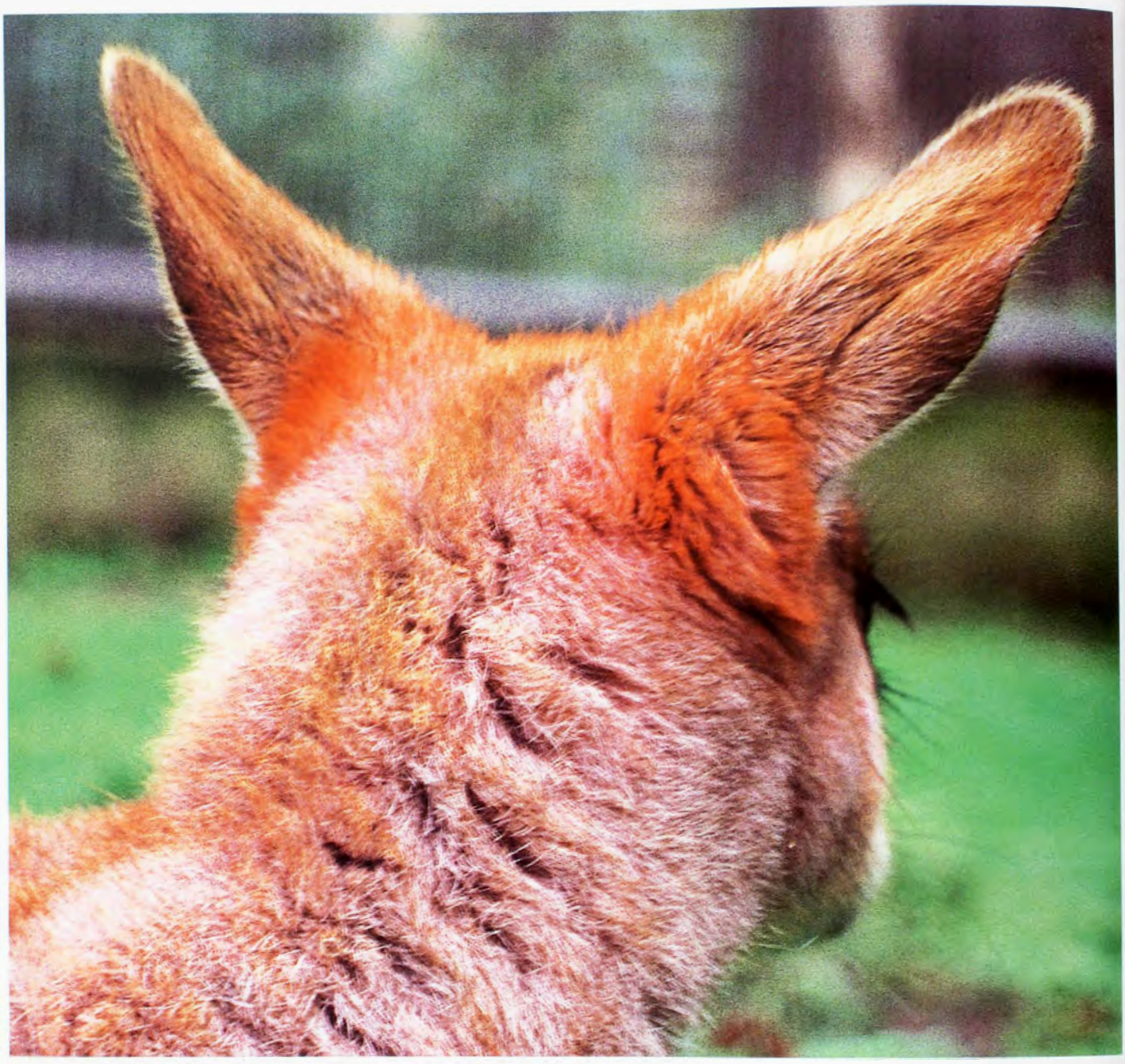
IT RAPIDLY BECAME CLEAR

that the purple pigment is produced by the animals themselves, although the intensity of the colouration varies markedly both between individuals and during the year.

genetic study, in collaboration with colleagues from Queensland Parks and Wildlife Service, the University of Western Sydney and CSIRO, to determine once and for all just how different Purple-necks were from Black-foots and other rock-wallaby species.

We used a range of different molecular genetic techniques, including the comparison of several nuclear genes, mitochondrial DNA sequences, and chromosomes. The results all said the same thing—Purple-necks are very different from Black-foots and other rock-

The Purple-necked Rock-wallaby was previously classified as a subspecies of the widespread Black-footed Rock-wallaby (pictured), despite obvious differences in their coat markings and colouration. However, recent research has shown that Purple-necks and Black-foots are sufficiently different to be classified as separate species.



GREG ELDRIDGE

In this young male Purple-neck, an accumulation of pigment at the base of the ears illustrates the intense colouration that is sometimes present over the rock-wallaby's entire face, head and neck.

wallabies. For example, on the basis of mitochondrial DNA sequences, Purple-necks are as different from Black-footed, Unadorned and Brush-tailed Rock-wallabies as all these species are from each other. The sequences differ by between 10 and 12 per cent, so clearly each one is a separate species.

We also made some hybrids in captivity, by crossing Purple-necks with Black-foots. Since separate animal species usually don't produce fertile offspring, looking at hybrids is another useful way to determine if animals really are different species. For example, when you cross a Donkey with a Horse you get a Mule, which is almost invariably sterile. We found that male Purple-neck/Black-foot hybrids were sterile, producing no sperm, while female hybrids had some major problems with their ovaries. The differences between Purple-necks and Black-foots thus seem sufficient to prevent them from freely interbreeding. Again the evidence was clear: Purple-necks and Black-foots are different rock-wallaby species. So after almost 80 years of uncertainty and debate we were able to finally reinstate the Purple-necked Rock-wallaby (*Petrogale purpureicollis*) to its original separate-species status.

WHILE OUR KNOWLEDGE OF PURPLE-necks has increased greatly over the last 20 years, many questions remain unanswered. Most obviously: how and why are these wallabies purple? While people (usually not sober) may occasionally report seeing pink elephants, purple mammals of any sort remain rare and examples are few and far between. The African Okapi (*Okapia johnstoni*), a magnificent but bizarre cousin of the Giraffe that lives deep in the tropical rainforests of the Congo, is predominately a dark purplish-black; while the Mandrill (*Mandrillus sphinx*) has purple amongst the rainbow of colours that

The purple pigment is not part of the rock-wallaby's fur, but is secreted through the skin. Small particles of pigment then adhere to the surface of the hairs resulting in the animal's distinct purple appearance. The colouration runs in the rain, and stains the hands and clothes of anyone who touches them.

adorns its spectacular face, buttocks and genitals. Closer to home, Rothschild's Rock-wallaby (*Petrogale rothschildi*) from the Pilbara region of Western Australia sometimes has a purple sheen to the fur on the back of its neck and shoulders. But no other mammal species has quite the bright purple face, head and neck of a Purple-necked Rock-wallaby in full bloom.

Although the identity of the pigment that gives Purple-necks their colouration is currently unknown, cinnabarinic acid or a related compound would seem a likely candidate. Cinnabarinic acid is a bright red, water-soluble pigment found on the outside surface of hairs in the Red Kangaroo (*Macropus rufus*) and also,

intriguingly, in red mushrooms. In the Red Kangaroo, this pigment is rapidly lost from preserved skins, which appear to fade, and the colouration of living animals is often more subdued after rain. Although the bright red pigment coating the hairs is readily lost, the pigment within each hair remains, so loss of colour is not total. Cinnabarinic acid is present in both male and female Red Kangaroos, although it is more abundant in males. It is also found in the pouch of females. In male Red Kangaroos, cinnabarinic acid is predominately secreted through the skin on the chest, and adult males often have a bright crimson-pink patch on their lower neck and upper chest. The colour of this highly pigmented area is somewhat similar to the pigmentation found over the face, head and neck of the Purple-necked Rock-wallaby, and the purple pigment certainly shares other similarities with cinnabarinic acid. However, until the purple pigment is actually tested in a laboratory, we can only guess about its chemical makeup.

But what could be the function of the Purple-necked Rock-wallaby's purple pigment? Camouflage would seem unlikely, as the rocks on which the animals live are not especially purple, and instead vary from pale yellow sandstone to dark grey limestone. In addition the pigment's usefulness in enhancing concealment would vary considerably during the course of the year as the distribution and intensity of colouration varied. However, when present, the pigment may serve to break up the animals' outlines, making it harder for predators to spot them sitting on the rocks.

In the Red Kangaroo, the secreted red pigment appears to be associated with behaviour and reproduction. The same is true in another marsupial, the Common Brush-tailed Possum (*Trichosurus vulpecula*), where tryptopham, a related brown pigment, is also secreted from chest glands, particularly in males. It is tempting to speculate on a similar role of the pigment for the Purple-necked Rock-wallaby. That the purple colouration of Purple-necks is more prominent in males than in females, and in both sexes is largely confined to the upper parts of the body, suggests a role in mediating social activity and/or reproduction via visual or olfactory cues (for example attracting potential mates, advertising reproductive status, displaying dominance or territoriality). In addition, the use of a water-soluble pigment for any important biological function would seem most suited to animals living in arid or semi-arid environments—as do both the Red Kangaroo and the Purple-necked Rock-wallaby. Another possibility is that the secretion is rubbed onto rocks or vegetation as a form of colour- or scent-marking. However this sort of behaviour has not yet been observed in Purple-necks or in other rock-wallabies. Alternatively, the secreted pigment may act to deter skin parasites and diseases.

We still have much to learn about the natural history, behaviour and ecology of Purple-necks, and the role that their extraordinary purple colouration plays in their lives. This will require many more years of detailed research, both in the field and the laboratory. Meanwhile the Purple-necked Rock-wallaby can hold its purple head up high in the full knowledge that it is indeed a distinct species.

An adult female Purple-necked Rock-wallaby, with well-developed colouration on her face and head. Males are often more richly pigmented.

Purple-necked Rock-wallaby

Petrogale purpureicollis

Classification
Family Macropodidae. One of 16 rock-wallaby (*Petrogale*) species.

Identification
Weight 4.7–6.5 kg, head–body length 49–61 cm, tail 45–61 cm, males larger than females. Winter coat light grey-brown; summer coat light sandy-orange. Distinct pink/purple colouration over face, head and neck.

Habitat and Distribution
Rock outcrops, boulder piles, gorges, rocky ridges and slopes. North-western Qld, around Mt Isa, Dajarra, Lawn Hill, Winton and Cloncurry. Limits uncertain; may extend into NT.

Biology
Breeds continuously and throughout year, 1 young born after about 30 days gestation, pouch life about 6 months.

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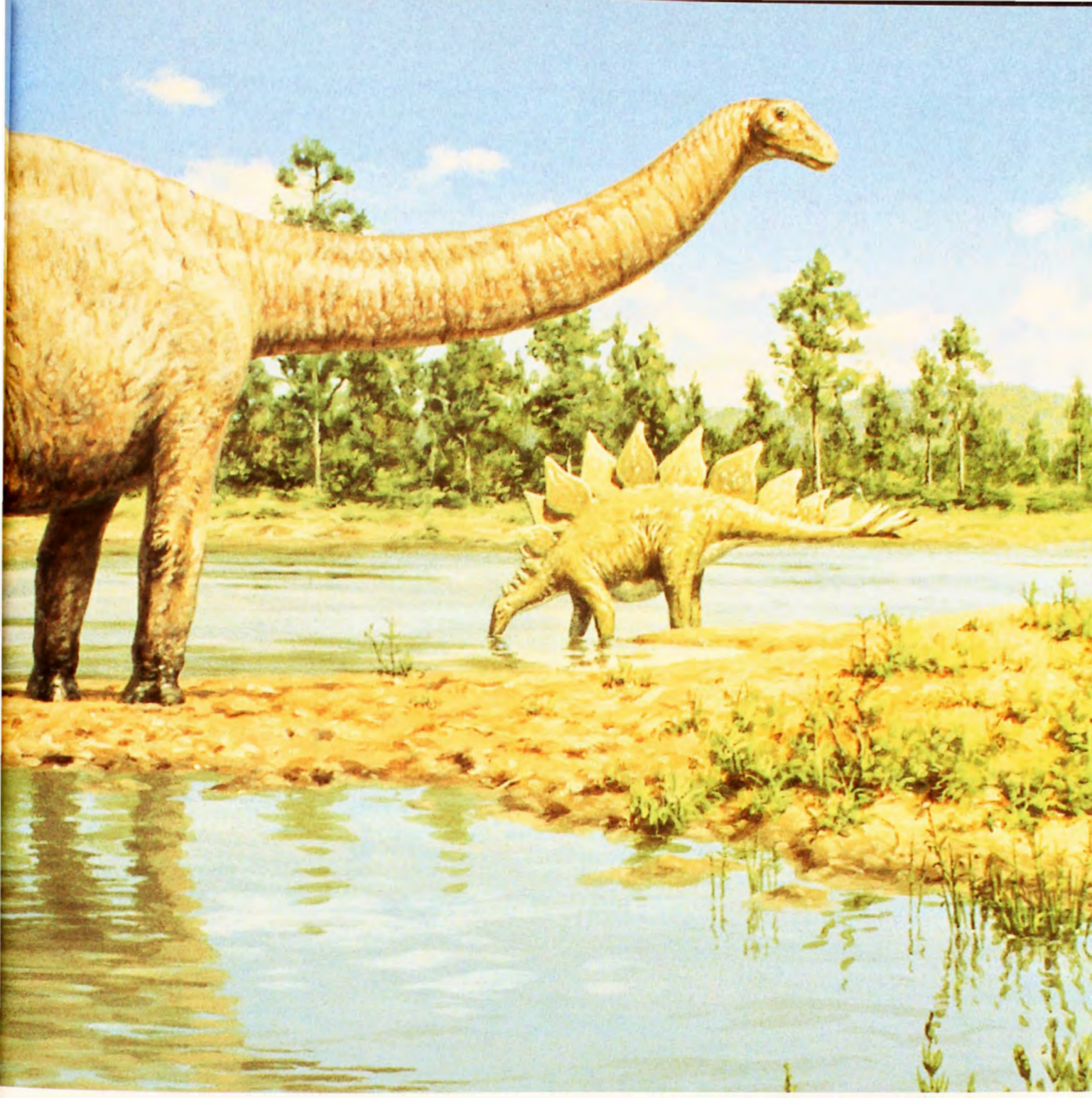
A diverse array of dinosaurs roamed the forested plains of central North America 160 million years ago. Among them were massive sauropods such as the 23-metre-long *Apatosaurus* (*Brontosaurus*) *excelsus*. Other dinosaurs attracted to the seasonally flooding streams included the plant-eating *Stegosaurus stenops* and the small carnivorous theropod *Ornitholestes hermanni*.

LAURIE BERKNE

SAUROPODS REPRESENT THE LARGE

CLASH of



ANIMALS TO HAVE EVER WALKED THE EARTH.

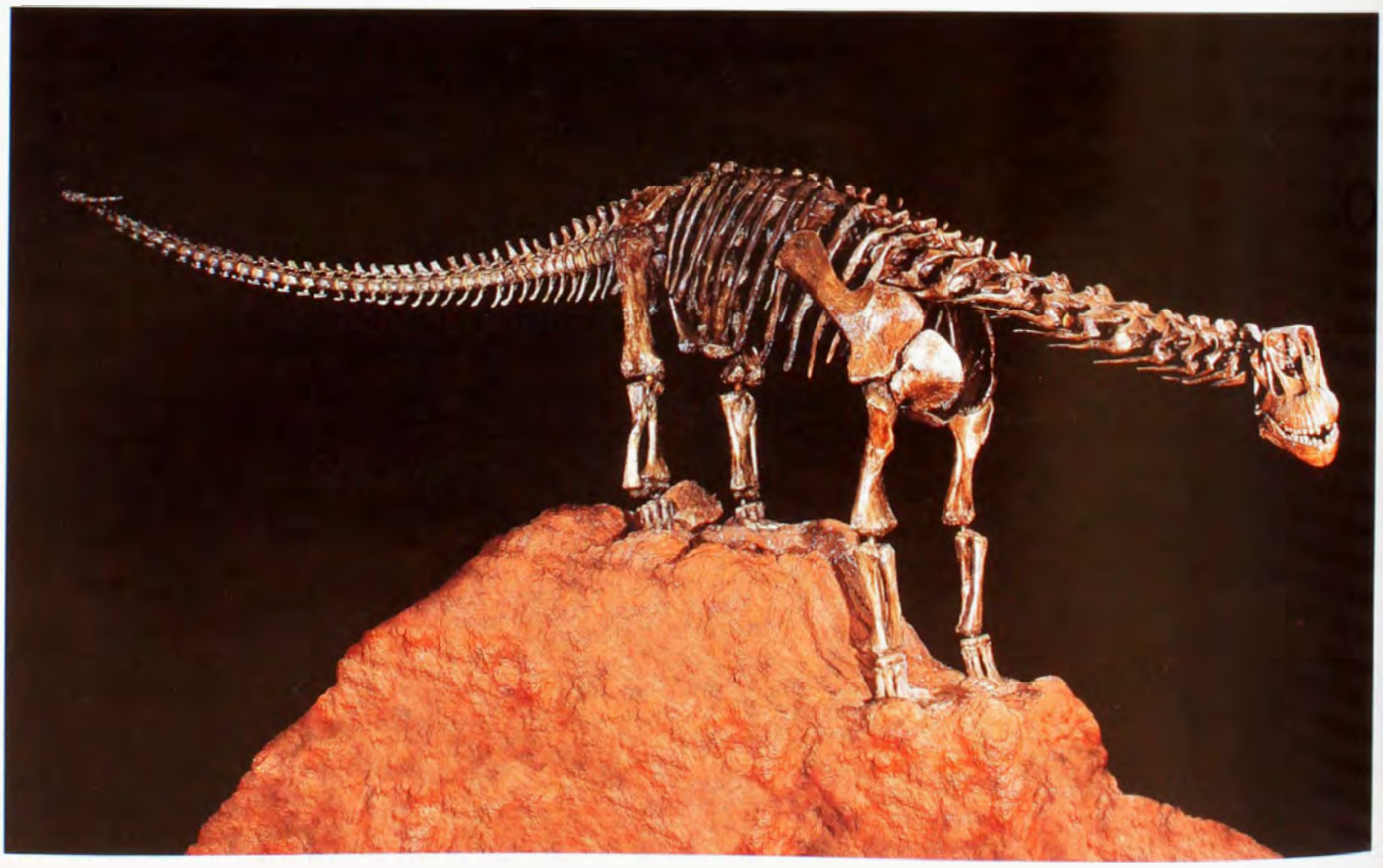
the TITANS

BY STEVE SALISBURY

AUSTRALIA'S BIGGEST-EVER dinosaur was recently discovered by a farmer near the outback Queensland town of Winton. Nicknamed 'Elliot', the new dinosaur is a type of sauropod. With four elephantine legs and a long neck and tail, the plant-eating sauropods were the giants of the dinosaurian world. Based on the size of his thighbone, Elliot is estimated to have been 16–21 metres long, 3.5–4 metres high at the rump, and weighed 22–28 tonnes. But how does Elliot shape up against the rest of the world's sauropods, and what are our chances of finding an even bigger one on Australian soil?

SAUROPODS RANGED IN LENGTH from about eight metres up to about 40 metres, although most were between 12 and 18 metres long. These 'moderate-sized' giants include the first sauropod ever discovered, *Cetiosaurus medius* (14–16 metres) from the Middle Jurassic of England, and *Camarasaurus lentus* (15–16 metres) and the lesser-known *Haplocanthosaurus priscus* (14–15 metres), both from North America. Australia's own *Rhoetosaurus brownei* from Roma, south-eastern Queensland, is estimated to have been 14–16 metres long, and *Austrosaurus mckillopi*, another Queensland sauropod, about 12–16 metres. Small to moderate-sized sauropods have also been found in South America and Asia. At least three species of *Saltosaurus* (10–12 metres) are known from the Upper Cretaceous of Argentina and *Shunosaurus lii* from Sichuan in the Peoples' Republic of China, at just eight metres from head to tail, was probably the world's smallest sauropod.

Not surprisingly, the best-known sauropods are those that exceeded 20 metres in length. Well-established North American species such as *Apatosaurus* (= *Brontosaurus*) *excelsus* (23 metres), *Diplodocus carnegii* (23–27 metres) and *Barosaurus lentus* (27 metres) all stretched beyond the magic 20-metre line. These sauropods are known from nearly complete skeletons discovered at Dinosaur National Monument, Utah. While not as long as either *Diplodocus* or *Barosaurus*, a childhood favourite of mine, *Brachiosaurus altithorax*, was still an imposing 22–23 metres from head to tail. Most of these cel-



FRANÇOIS GOHIER, AUSCAPE

A mounted skeleton of *Camarasaurus lentus*, one of the best-known North American sauropods. At 15–16 metres in length, *Camarasaurus lentus* was about the same size as Australia's own *Rhoetosaurus brownei* from Roma, south-eastern Queensland

Queensland Museum palaeontologists Alex Cook (left) and Scott Hocknull (right), along with the farmer (centre) who discovered Elliot in 1999, scour the soil around the site for fragments of bone. Concentrations of bone fragments on the surface can be used to pinpoint the location of more complete elements below ground.

ebrity sauropods would have weighed 15–30 tonnes, roughly the same as Elliot, but *Brachiosaurus* was heavier, coming in at around 30–50 tonnes.

ONLY A HANDFUL OF SAUROPODS are known to have exceeded 30 metres. These are the so-called 'super giants' and they represent the largest animals to have ever walked the Earth. One of the first sauropods to break the 30-metre barrier and stamp its mark on the heavyweight scene was *Seismosaurus* ('Earth shaker') *hallorum*. Estimated to have been 28–34 metres long, *Seismosaurus* was discovered in 1985 in the badlands of New Mexico. Its skeleton is about 30 per cent complete, comprising the hip bones and a large part of the backbone.

In the same year that *Seismosaurus* was unleashed on the world, an announcement was made that three "even bigger" sauropods had been discovered in western Colorado. *Supersaurus vivianae*, *Ultrasauros macintoshi* and *Dystylosaurus edwini* were based on three separate bones found at a locality known as Dry Mesa Quarry, not far from where the first *Brachiosaurus* bones were collected. *Supersaurus* and *Ultrasauros* gained notoriety overnight, but *Dystylosaurus* languished in the public eye, burdened perhaps by its cumbersome name.

Assuming that each of the three bones found at Dry Mesa Quarry belonged to different individuals, let alone three new taxa, was a bold move. A number of palaeontologists have since suggested that at least two of the bones (the shoulder bones referred to *Supersaurus* and *Ultrasauros*) were almost certainly from large individuals of *Brachiosaurus*. While other palaeontologists agree that *Ultrasauros* is synonymous with *Brachiosaurus*, they consider *Supersaurus* to be a type of diplodocid—the family that includes *Apatosaurus* and *Diplodocus*. Represented by a single sacral (hip) vertebra, *Dystylosaurus* is now considered to belong to Brachiosauridae—the family that includes *Brachiosaurus*.

Calculating reliable sizes for *Ultrasauros*, *Supersaurus* and *Dystylosaurus* is

STEVE SALISBURY

Participants on the 2002 Elliot Dig help put plaster jackets on newly discovered bones. Between 15 and 20 new bones, all from Elliot's tail and hindquarters, were recovered over a three-week period by a team of more than 40 people.

reported 1.5-metre-tall partial trunk vertebra of this towering behemoth, found in 1878 in Upper Jurassic rocks at Garden Park, Colorado, was 'lost' during shipment to the American Museum of Natural History, and has never been seen since. The complete vertebra is estimated to have been 2.4–2.6 metres high. Based on comparisons with the smaller, but more complete, *Amphicoelias atlus*, *A. fragillimus* is estimated to have had a thighbone 3.8 metres long, and rump height of about nine metres. At this size its total length may have been 40–45 metres, and its mass over 100 tonnes—a true giant even among the super giants.

BUT JUST HOW CONFIDENT ARE palaeontologists of these size estimates? With a near complete skeleton, as is the case with sauropods like *Diplodocus carnegii* and *Barosaurus lentus*, there can be little doubt over the overall length. Estimating the mass is then a matter of calculating the volume of a fleshed-out scale model. With incomplete specimens, however, size estimates are much trickier. Sauropods show great variation in the length of their neck and tail, with some of the longest getting most of their length from either an enormous tail or an elongate neck. For instance, the graceful tail of *Barosaurus lentus*, a diplodocid, accounts for almost

47 per cent of its total length of 27 metres. On the other hand, *Brachiosaurus altithorax*, a brachiosaurid, had a relatively short tail (30 per cent of its total length), but its Giraffe-like neck was almost ten metres long, accounting for 43 per cent of its overall length (22–23 metres). But even *Brachiosaurus* was out-necked by the recently discovered *Sauroposeidon proteles* from the Lower Cretaceous of Oklahoma, which is estimated to have had a neck that was a phenomenal 12 metres long.

All the 30+-metre sauropods are known from incomplete skeletons. In the case of *Argentinosaurus*, only nine bones are known. Estimating its overall length and weight thus depends on scaling up smaller, more complete, but proportionately similar animals of the same taxonomic affinity. This process can result in some major discrepancies. As mentioned previously, *Supersaurus*, which is known chiefly from a single shoulder bone, is sometimes thought to be a brachiosaurid. This gives it a total length of 25–30 metres. While this is still pretty impressive, it's nothing compared with the 35+-metre length it gets as a diplodocid. It's for these very reasons that the lengths (and hence weights) of the super giants fluctuate so much, varying from author to author by as much as ten metres. Indeed, some palaeontologists are convinced that *Supersaurus* was at least 40 metres long, and weighed as much as 100 tonnes!

With Elliot we are faced with exactly the same problem. Like the majority of Australian sauropod finds, there simply isn't enough of his skeleton to accurately determine his overall length. The lack of material also means that we can't be entirely certain exactly what kind of sauropod he is. (Hopefully this will change as we unearth more of his skeleton.) The same holds true for the seven other sauropods that have been found in the Winton area. Although they're all thought to be *Austrosaurus*, none of the skeletons is complete enough to tell us what kind of sauropod *Austrosaurus* is. Some palaeontologists consider *Austrosaurus* to belong to the same family as *Argentinosaurus* and *Paralititan*—Titanosauridae. Found on every continent except Australia and Antarctica during the Cretaceous, it would come as no surprise to find titanosaurids 'Down Under'. But from what I've seen, none of the *Austrosaurus* specimens displays any of the key characteristics normally associated with this group, particularly strongly procoelous (concave at the front and convex at the back) vertebrae at the base of the tail.

I can't help but think we're pigeonholing our sauropods into a group to which they don't really belong. I've already noticed a few differences between the Winton sauropods (including Elliot) and titanosaurids, such as the proportions of the thigh bone. In this light, the possibility that we might be

ROBERT JONES/AUSTRALIAN MUSEUM

Part of one of Elliot's tail vertebrae reveals itself for the first time in over 95 million years during the 2002 excavation.

Elliot: Australia's biggest dinosaur

Classification

Order Saurischia, suborder Sauropoda. At present it is unclear exactly what type of sauropod Elliot is. Most likely he belongs to *Austrosaurus*, but he may represent a new genus. In the past it's been suggested that *Austrosaurus* belongs to either Cetiosauridae, Brachiosauridae or Titanosauridae, although none of these assignments seems satisfactory. Both Elliot and *Austrosaurus* probably belong to a uniquely Australian group of Cretaceous sauropods.

Locality and Age

Found in 1999 by a farmer near Winton, central-western Qld, in 98–95-million-year-old rocks from the Lower Cretaceous Winton Formation.

Known Bones

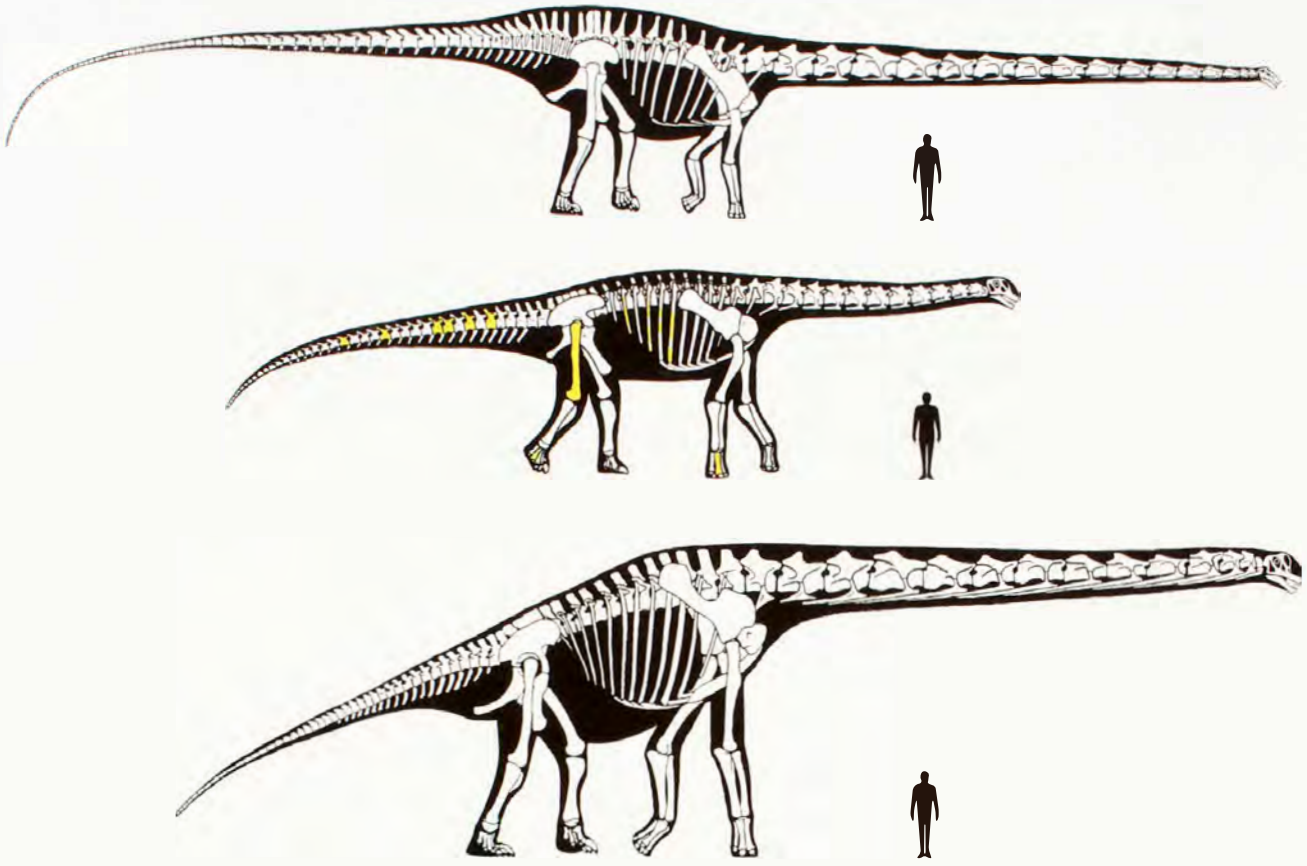
A nearly complete right thighbone, several tail vertebrae, rib fragments, and incomplete hand and foot bones.

Size

Estimated 16–21 m long, 3.5–4 m high at the rump, and 22–28 t in weight, assuming generalised titanosaurid proportions.

Diet

Like all sauropods, probably a plant-eater.



Elliot (centre) sizes up against some North American heavyweights: the diplodocid *Barosaurus lentus* (top) and the brachiosaurid *Brachiosaurus altithorax* (bottom). Differences in the proportions of the tail and neck can greatly influence the overall length of these gigantic animals.

dealing with an endemic radiation of Australian sauropods—albeit one that may be closely allied to Titanosauridae—is starting to look promising. Our two most complete dinosaurs, the seven-metre-long ornithopod *Muttaburrasaurus langdoni* and the 'armoured' ankylosaur *Minmi paravertebra*, are both uniquely Australian, lacking any clear taxonomic counterparts overseas, so why should it be any different with our sauropods?

Returning to the issue of size, not knowing what kind of sauropod Elliot is makes estimating his size a speculative operation. If he had the proportions of a generalised titanosaurid (that is, somewhere between those of a diplodocid and brachiosaurid), his overall length could have been anywhere from 16–21 metres. But if he had the proportions of a diplodocid, Elliot's overall length would have been far greater. A 27-metre *Diplodocus carnegii* has a thighbone that is 1.5 metres long; Elliot's thighbone could be as long as 1.7 metres. With *Diplodocus*-like proportions Elliot would probably have exceeded 30 metres in length, entering the exclusive class of 'super giant'.

Even if Elliot wasn't a super giant, imagining herds of 30+-metre sauropods crashing their way through the ancient river plains of Cretaceous Australia might not be so far-fetched. Fossilised sauropod footprints discovered near Broome, Western Australia, are an incredible 1.5 metres long. Tony Thulborn (University of Queensland) believes these footprints belonged to animals that may have been as much as 40–45 metres long—almost as long as an Olympic swimming pool, and perhaps even bigger than the legendary *Amphicoelias fragillimus*.

Surely one of these gigantic sauropods died under conditions conducive to fossilisation. If so, then future exploration in Australia might yield not only the remains of a sauropod that was bigger than Elliot, but one that was bigger than any previously found. That's enough to keep me searching. Whoever said size doesn't matter? □

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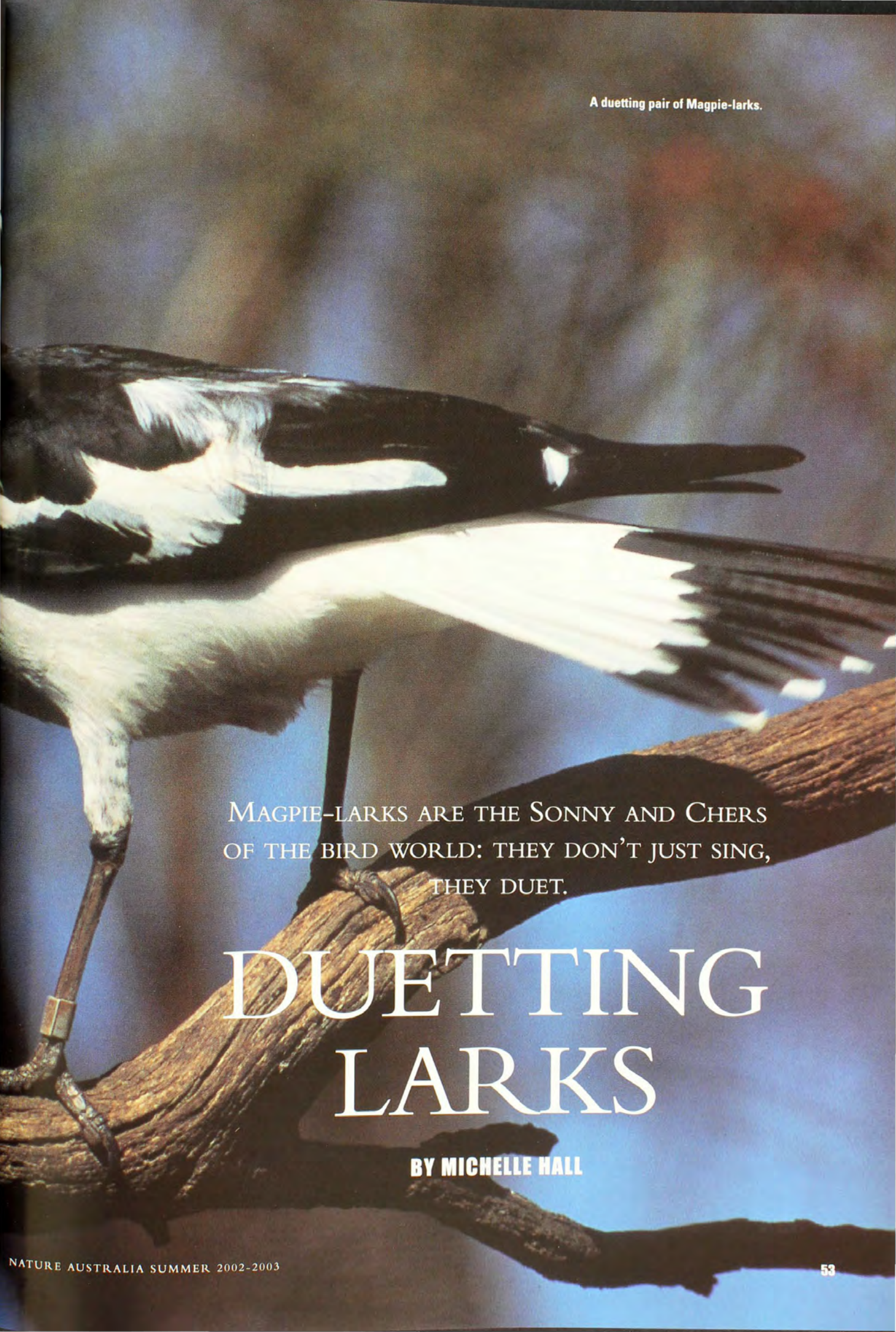
LYNN PEDLER



A duetting pair of Magpie-larks.

MAGPIE-LARKS ARE THE SONNY AND CHERS OF THE BIRD WORLD: THEY DON'T JUST SING, THEY DUET.

DUETTING LARKS

BY MICHELLE HALL

HAVE YOU EVER BEEN woken by Peewees singing right outside your bedroom window? Perhaps you even cursed them as you struggled in vain to go back to sleep. I'm afraid my friends get little sympathy from me when they complain of such avian-induced sleep deprivation, and that's because I've got a soft spot for Peewees, or Magpie-larks, and their songs. You see, Magpie-larks (*Grallina cyanoleuca*) are the Sonny and Chers of the bird world: they don't just sing, they duet.

The function of duetting, where partners sing in synchrony or alternation, is not well understood. Much of the research on birdsong has been on northern hemisphere species where it is often only male birds that sing. In many Australian species, females sing too, and in some, like Magpie-larks, males and females coordinate their songs, sometimes so precisely that it can sound like a solo performance. The main reasons that male birds sing are to keep other males off their territories, and to attract females and stimulate them to begin nest-building. At least some of the functions of female song are similar. For example, female Superb Fairy-wrens (*Malurus cyaneus*) sing to defend their territory against other females. But why do birds duet?

THE FUNCTION

of duetting, where partners sing in synchrony or alternation, is not well understood.

OF THE WORLD'S 9,000 OR SO bird species, over 200 are known to duet. Australian examples include Eastern Whipbirds (*Psophodes olivaceus*), Chirruping Wedgebills (*P. cristatus*) and Western Bristlebirds (*Dasyornis longirostris*). Other animals duet too, and some gibbons, frogs and insects are thought to use duetting to attract or guard mates. Traditionally duetting in birds was thought to be a cooperative display to maintain the territory and the pair-bond, although no-one had actually shown that partners achieved something by coordinating songs that they couldn't achieve by singing independently of one another. More recently this 'happy families' theory has been challenged by the idea that duetting might be a result of conflict between partners. According to the 'mate-guarding' theory, a bird sings to attract members of the opposite sex, and its partner joins in quickly to let rivals know that the bird is taken. I decided to test these ideas for my doctoral research using the Australian Magpie-lark.

Although Magpie-larks are common,

The author used a long pole with a mirror on its end to see inside nests and find out when and how many eggs were laid. Only one egg so far in this nest. Females usually keep laying until they have four eggs.

PHOTOS: MICHELLE HALL

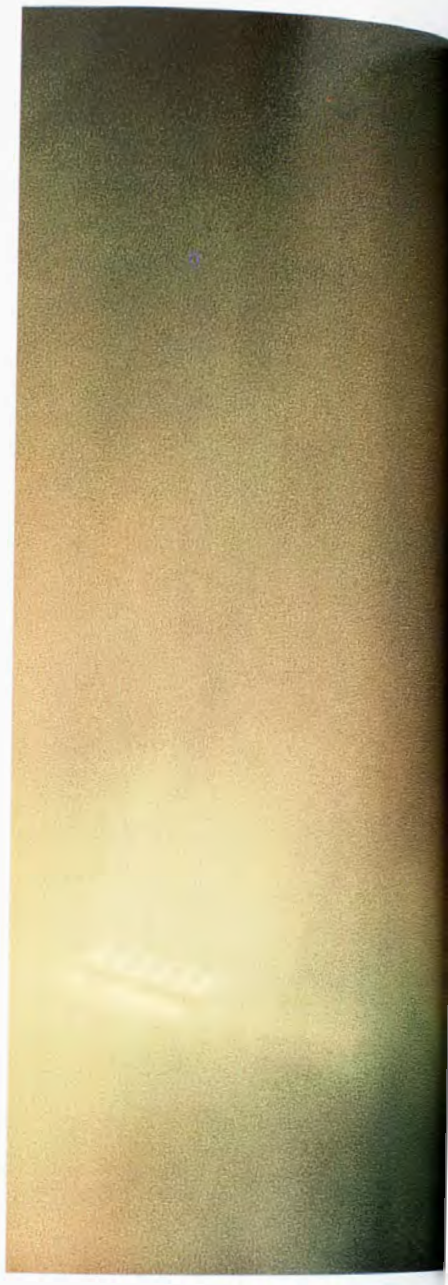
A female Magpie-lark feeds two chicks in their mud nest. Chicks remain in the nest for 18–20 days after they hatch, and are fed by both parents.

many people overlook their fascinating duetting behaviour, perhaps because they mistake the calls for just one bird singing. However duets are easy to pick once you know what to listen for. When males or females sing alone, they repeat notes at intervals of about one second. When they duet, the tempo is faster because the answering bird times its notes to fall in the gaps between its partner's notes, producing what is called an 'antiphonal' duet. The tempo of alarm calls is faster still, but alarm calls are given by a single bird using a stereotyped note rather than a repertoire of more complex notes used in solos or duets. I used sonagrams, which show changes in frequency (pitch) over time, to analyse Magpie-lark vocalisations recorded on the campus of the Australian National University.

An essential part of any behavioural study is being able to recognise individuals with certainty, so my first step was to catch the birds and give them each a unique combination of coloured leg bands. Just catching them gave me some interesting insights into individual differences. Some birds were extremely cautious, walking round and round the trap, eyeing the grated cheese and trying to reach through the mesh, but not walking in. Others were far more bold (or liked cheese more). One young male watched his father get caught, yet raced into the trap as soon as I had removed his father! The stress of being handled seemed to be forgotten quickly, as he walked into the trap for more cheese soon after I'd banded him.

PARTNERS USUALLY *stayed together until one of them died, although there were cases of 'divorce'.*

Once I'd colour-banded over 20 pairs, I started some general observations because I wanted to understand duetting in the context of the social system. I watched partners building their distinctive mud nests, incubating eggs and feeding chicks, and found that males and females shared parental duties equally. These breeding partnerships were long-term and monogamous; colour-banded partners usually stayed together until one of them died, although there were a few cases of 'divorce'. However, not all socially monogamous bird species are faithful, so I used DNA fingerprinting to analyse parentage. To get the DNA, I needed small blood samples from parents and chicks. Since Magpie-lark nests can be 4–20 metres high and are often on outer branches, reaching the chicks required a few new skills. In addition to climbing a ladder supported solely by guy ropes, I also learned how to operate an elevated work platform, or 'cherry picker', owned by the university. The DNA analysis showed that



Magpie-lark

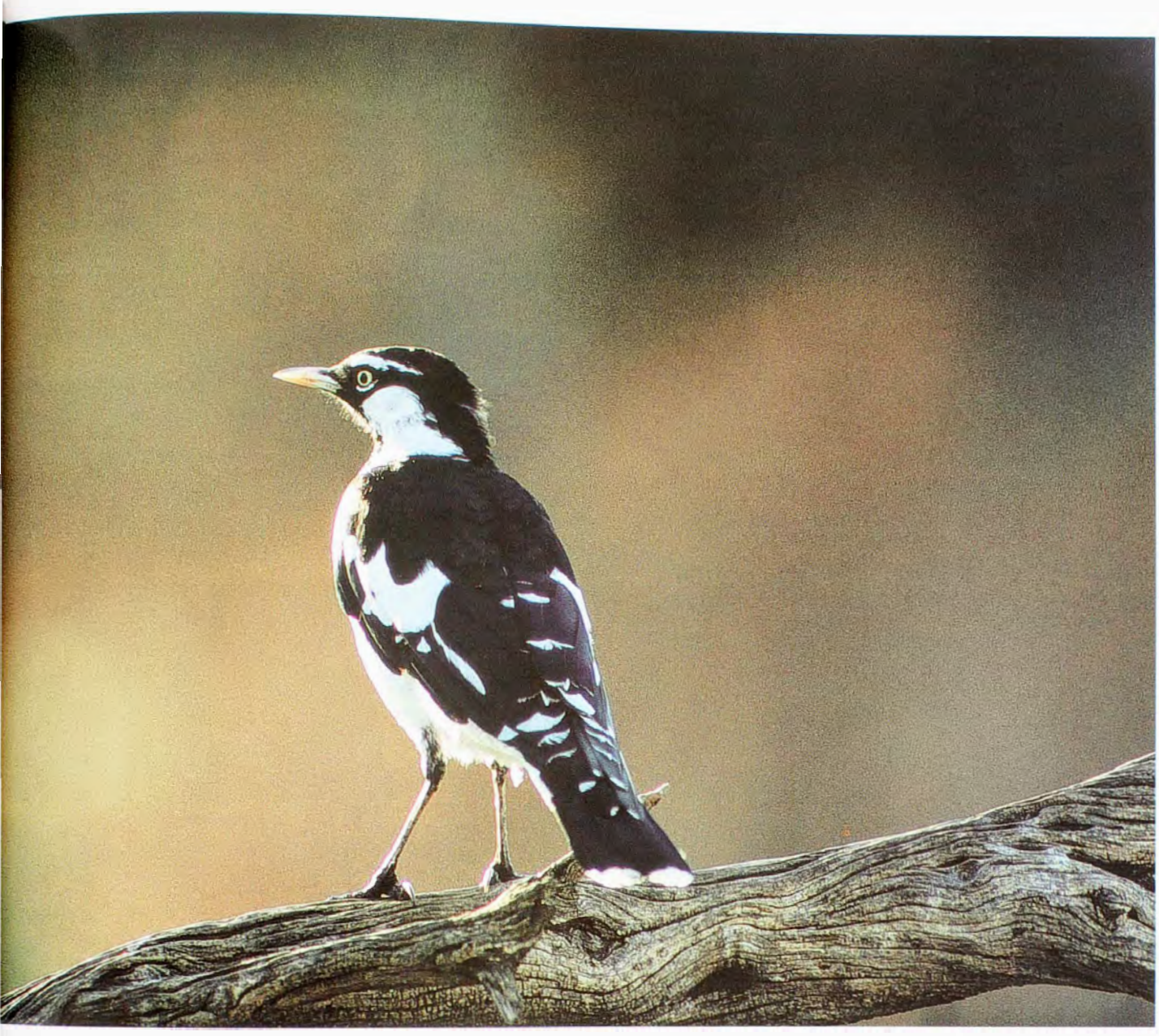
Grallina cyanoleuca

Classification
Family Dicruridae. Also called Peewee or Mudlark.

Identification
Black and white, underside white with a black bib. Male has black throat and white eyebrow; female has white throat and forehead and no white eyebrow; juvenile has white throat and white eyebrow. Bill and iris white in adults, dark in juveniles.

Distribution and Habitat
Common throughout Aust. and surrounding islands, also in southern New Guinea and Timor. Occupies diverse habitats; requires open ground for foraging, and trees and water (or rain) for nesting.

Biology
Breeds Aug.–Feb. Bowl-shaped nest made of mud with grass and fibres. Females lay 3–5 eggs, nestlings fledge after about 18–20 days but remain dependent on parents for another month. Males and females share nest-building, incubation and feeding of chicks. Pairs defend territories of 2–10 ha. Food includes various invertebrates.



Young Magpie-larks have distinctive plumage that distinguishes juveniles from adult males and females for the first few months of life.

Magpie-larks were generally faithful to their partners, with only three per cent of nestlings not fathered by the male that cared for them. Since males invest so much in parental care, it is in their interests to make sure the chicks they care for are their own. One way they could do that would be to guard their partners from the attentions of rivals.

Males are most likely to guard their partners when females are fertile in the few days before they lay their first egg. So I started to watch them early in the breeding season in the lead-up to egg-laying. I recorded the proportion of the time that partners were within five metres of one another, whether they moved towards or away from one another, and whether movements away were followed. I also noted when each bird sang, and whether or not their partner joined in to form a duet. To work out when the female was fertile, I had to backdate from the day she laid her first egg. To avoid the climb up to the nest for this, I manoeuvred a long pole with a mirror on the end into the tree and positioned it so that I could see the nest contents reflected in the mirror. Having established what day the female started laying, I could then compare observations from the fertile period with those before the female was fertile.

What I found was that males did indeed guard females. Partners spent far more time close together when the female was fertile than at other times, and this was because the male followed the female when she moved away from him. However, males were not more

likely to duet with their partners during the fertile period. Males actually responded to a smaller proportion of female songs during this time than before, and females also initiated fewer songs. Clearly, fertile females don't sing to attract other males, and males don't use duetting to warn rivals off.

ONCE I KNEW THAT DUETTING wasn't used for guarding paternity, I returned to one of the traditional theories—that birds duet for cooperative territorial defence. Magpie-larks are territorial throughout the year, and pairs don't tolerate other Magpie-larks on their patch. They start the day early, singing from their roost trees before the sun rises and then doing a few circuits of the territory, duetting from the tree tops. Since most birds sing in defence of their territories, I wanted to find out if coordinating their songs to form duets was somehow more effective than singing solo.

One way of working out the function of a song is to see how birds respond to it. I used an experimental technique called playback, where recordings of different songs are played through loudspeakers positioned on territories and the reactions of the territory-owners monitored. Magpie-larks responded vigorously to playback, flying towards the speaker and singing, just as they would if there was an intruder. I tried a classic playback experiment on Magpie-larks, comparing their responses to the songs of their neighbours and of strangers. They responded like many bird species do to this experiment: the more threatening the playback, the more they flew towards the speaker and sang. So an unfamiliar song got a far more vigorous response than a neighbour's song, unless the neighbour's song was played from the wrong territory boundary, in which case the response was just as vigorous as the response to the unfamiliar song. Magpie-larks obviously recognise their neighbours by their songs, and don't get too upset by them as long as they stay where they are supposed to be!

I then compared the responses of territory holders to playbacks of duets versus solos. I found that males sang more

in response to playbacks of a duet than playbacks of a solo, suggesting that duets are more threatening territorial signals than solos. Another way of comparing the role of duets and solos in territorial defence is to see how they are used in response to playback. Partners were more likely to call together in duets rather than alone during playback sessions, again suggesting that duets are more effective for territorial defence than solos.

So for Magpie-larks, at least, we now know that the function of male–female duetting is to defend the pair's territory. Duetting in other bird species may or may not have a similar function, and the only way to find out is to conduct the same sorts of playback experiments used in this study. In the meantime, the next time you hear a pair of Magpie-larks duetting furiously at dawn outside your bedroom window, you'll know what they are up to and perhaps be more forgiving. Working as a team pays when it comes to defending a territory. □

Male and female Magpie-larks are easily distinguished by differences in their facial plumage patterns. In this photograph it is the male that is singing, accompanying his song with synchronised wing movements, and fanning and flicking his tail.

Bird Sound

What is Sound?

Sound consists of waves of alternating high and low pressure generated by a vibrating object. The length of one complete cycle of high and low pressure, the wavelength, determines the frequency of the sound (number of wavelengths reaching a point per second, measured in Hertz). The higher the frequency, the higher the pitch. The amplitude, or intensity, of the pressure in the sound waves determines how loud the sound is.

Song Production

Birds sing using the syrinx, an organ that functions similarly to the mammalian larynx. Whereas the larynx is located towards the top of the windpipe, or trachea, the syrinx is at the bottom of the trachea where it splits into two bronchi. As a consequence, birds have 'two voices' and can produce two harmonically unrelated sounds at the same time. Air flowing through the bronchi passes across the tympaniform membranes of the syrinx, causing them to vibrate and create sound waves. Syringeal muscles vary the tension on the tympaniform membranes to modify the characteristics of the sounds produced.

Song Perception

Unlike humans, birds do not have an outer ear, although some birds have special feather structures, such as the dish-shaped faces of owls, that direct sound waves to the ear openings. Internally, bird ears are similar to those of other vertebrates, with a thin membrane, the tympanum, that detects sound waves. Movements of the tympanum are transferred to the fluid-filled cochlea of the inner ear, which stimulates underlying hair cells that are sensitive to different frequencies. These activate nerve cells connected to specialised areas of the brain that integrate signals from both ears to identify songs and locate the direction and distance of the singer.

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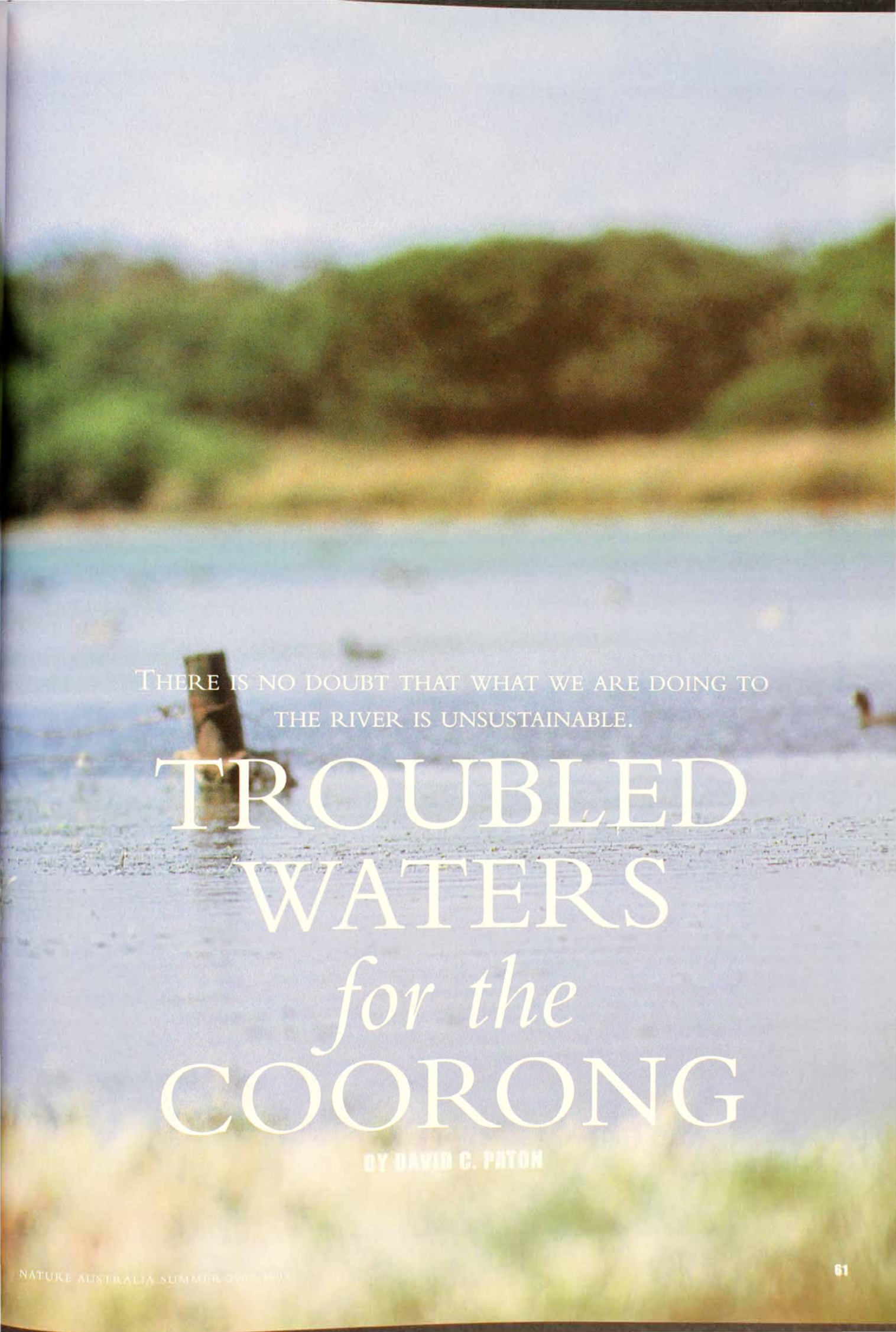
DAVO BLAIR, WILDERNESS ARCHIVES

Great Egret (*Ardea alba*) on Salt Creek.



There is no doubt that what we are doing to the river is unsustainable.

TROUBLED WATERS *for the* COORONG

BY DAVID C. PATON

(Left) Crested Terns (*Sterna bergii*) nesting on one of the islands in the southern Coorong with Caspian Terns (*S. caspia*) in the foreground. (Right) The mouth of the Murray River looking south-east along the Coorong.

STRETCHING 100 KILOMETRES south-east from the mouth of the Murray River in South Australia is the Coorong, a wetland of international significance. The word Coorong comes from the Ngarrindjeri name 'Karangh' meaning long neck of water. The Ngarrindjeri lived sustainably in the region for centuries. Prior to European occupation fish were bountiful, and hundreds of thousands of waterfowl and waders congregated on its waters, particularly during the summer.

The Coorong system has changed dramatically in the last 50–80 years. Weirs have been constructed upstream across the Murray, and barrages built across the southern edges of Lake Alexandrina just upstream of the Murray's mouth. Much of the water that once flowed down the Murray is now extracted for agricultural and domestic purposes. Currently only 20 per cent of the Murray's water flows out to sea. This reduction in flow has caused immense environmental changes, and the mouth of Australia's largest river regularly threatens to close due to insufficient flows. Commercial fish stocks in the Coorong region are also at their lowest levels and migratory waders have declined at least ten-fold in the last 30 years.

THE REDUCTION IN COMMERCIAL fish species was predictable. When the barrages were built in the 1930s, vast areas of the estuarine waters of Lakes Alexandrina and Albert became inaccessible to fishes. Sadly no fish gates were put in at the time because they added a million pounds to the estimated costs. (Who said economic rationalism was a modern disease?) Consequently the nursery grounds for the fishes became the much smaller estuarine regions between the barrages and the mouth of the river. The lakes also changed from being estuarine to constantly fresh, and their water levels, rather than being variable, became relatively constant.

The decline in bird numbers is less

easily explained. In the 1960s there were reports of as many as 250,000 small migratory sandpipers using the northern reaches of the Coorong between the barrages and mouth during summer. By the 1980s there were around 30,000 to 40,000 sandpipers in this region, declining further by the end of the century to only 5,000 to 15,000.

Twice each year these sparrow-sized migratory waders make an epic trans-equatorial journey. From late February the birds leave Australian shores and fly north, stopping en route several times to refuel before reaching their breeding grounds in the palaearctic regions of Mongolia, Russia and northern China. After breeding, the birds return south to Australia, typically arriving during September, October and November. All of these migrants are listed on international agreements between Australia and Japan and Australia and China, the signatories agreeing to protect and enhance the habitats needed by these birds. Upholding the principles of these agreements is also firmly entrenched within Australia's new *Environment Protection and Biodiversity Conservation Act* 1999.

Once in Australia, the sandpipers recover from the exertions of migration, then moult—a process by which the birds replace their feathers, particularly the important flight feathers. Towards the end of summer after moulting is complete, the birds increase their foraging activity, consume more food and gain fat to fuel their return journey. At these times many of the birds become restless, and in late February and March large, tight flocks can be seen wheeling in the Coorong sky, possibly training for their long-distance flights.

Most of these migratory waders eat small aquatic invertebrates that they pick off the surface of the mudflats. Red-necked Stints (*Calidris ruficollis*), Sharp-tailed Sandpipers (*C. acuminata*) and Curlew Sandpipers (*C. ferruginea*), the prominent small waders in the Coorong, forage mainly on mudflats covered with a thin film of water up to a few centimetres deep. Broad coastal mudflats that are gradually exposed as tides rise and fall are ideal feeding places for these birds. The birds simply shift their foraging to new sections of the mudflat as the water's edge moves up and down with the tides. Tidally influenced areas near estuaries are particularly productive, in part because during flows the river adds nutrients and fine particulate matter to the mudflats and this stimulates productivity.

If the frequency and volumes of these flows are reduced, the productivity of these systems will also be reduced, but

JULIA ROQUE AUSCAPE

Section of Tauwitchere Barrage that now separates the Coorong from the Murray River.

IN THE 1960s

there were as many as 250,000 sandpipers using the Coorong. By the end of the century this had declined to only 15,000.

Aerial view of the southern end of the Coorong during late summer.

for the estuarine regions of the Coorong the relationship is more complex. Reductions in flow have led to incursions of coarse marine sands into the estuary. These coarse sands not only detract from the productivity of the mudflats, but can also impinge on the foraging efficiency of waders. Furthermore, the sand clogs up the channels and greatly reduces the volume of water entering and exiting the Coorong on the tides. As a result, less of the Coorong is now tidally influenced, the magnitude of the tidal changes in water levels is reduced, and a smaller portion

Hoary-headed Grebes are one of the most abundant birds in the southern Coorong where they feed on hardyhead fish.

DAVID BEARD WILDERNESS ARCHIVES

of the mudflats is exposed for the waders. Each of these factors has the ability to erode the quantity and quality of the habitat needed by the migratory waders, and potentially tips the balance against them.

If our activities along the Murray were truly sustainable, the mouth of the Murray would not be regularly threatened with closure and the fishing stocks would have been sustained. Similarly, the areas of suitable habitats for the migratory waders, the composition and productivity of those mudflats, and the numbers of waders, would be unchanged. That these have changed is a clear indictment that Australia has not met the environmental obligations to sustain wetland habitats under the various international agreements that have been put in place. Some might argue that the reduction in waders is due to factors acting outside Australia along other parts of the birds' flyway. However, there is no doubt that what we are doing to the river is unsustainable and has a detrimental effect on the Coorong environment.

One of the key features of the Coorong is the changing salinity-gradient down its length. Within a normal estuary, salinities decline as one moves upstream and away from the river's mouth. However in the Coorong the reverse happens. At around 100 kilometres in length, one to five kilometres wide, and one to three metres deep, the Coorong is like a blind appendix off the Murray. Salinities gradually increase with distance away from the mouth, such that the southern half of the Coorong (farthest from the mouth) is hypermarine, with the southernmost extremities typically two to three times saltier than the sea. With its changing salinity-gradient, the Coorong constitutes a marvellous field laboratory—the various estuarine organisms in the north are gradually replaced by more salt-tolerant species as one shifts down the Coorong, different species dropping out as their salinity tolerances are breached. When the barrages are open for an extended period, some of the estuarine organisms expand southwards, tracking the reduction in salinity caused by the addition of fresh water, but these are short-lived and expansion is followed by retreat when the barrages close.

Many people have blamed the reduced flows down the Murray for the high salinity in the southern Coorong, but this is not the case. When the barrages are opened, most of the Murray's water rushes out to sea. At best, fresh water only flows about half way along the Coorong, unable to travel 'uphill'. This is because water levels gradually

Drain dug through Stoneleigh Park, an area of heritage bushland, to carry ground water for discharge into the southern Coorong.

rise along the Coorong, such that the southernmost end is about a metre higher than at the mouth. This gradual rise in water level along the Coorong is linked to groundwater levels that are marginally higher at the southern end than near the mouth. This is no different from the gradual rise in water levels as one goes upstream in a river.

When the barrages are closed, Coorong water tends to flow northwards towards the mouth, but when the barrages are open, water levels rise in the southern lagoon, even though none of the Murray's fresh water reaches it. This is because the releases of fresh water at the mouth slow the gradual movement of water northwards out of the southern Coorong. These rises in water level and subsequent falls are often rapid because, instead of opening each set of barrage gates gradually, we tend to open all those that are to be opened at once and then close them at once. As a consequence we fail to mimic the natural (gradual) changes in water level that we might expect with a rising or falling river.

SHOULD WE BE CONCERNED ABOUT these rapid rises and falls in water levels in the Coorong?

In the hypermarine southern Coorong, where large numbers of waterfowl (ducks, swans, grebes) and waders (stints, sandpipers, stilts) congregate during late summer and autumn, the key foods are the perennial aquatic plant *Ruppia tuberosa*, chironomid (midge) larvae and the Small-mouthed Hardyhead (*Atherinosoma microstoma*), a small fish. Essentially *Ruppia tuberosa* provides the base to the birds' food chains. It produces starchy seeds and turions (sprouting organs), as well as decaying plant material that is eaten by aquatic invertebrates. The seeds, turions and invertebrates in turn are consumed by birds and fish.

Water levels in the southern Coorong fluctuate annually by about one metre, and *Ruppia tuberosa* 's annual cycle is tied to these fluctuations. During winter and spring when the water level is high, *Ruppia tuberosa* grows and produces seeds and turions that are left on the mudflats as the water recedes during summer. The seeds and turions survive desiccation and subsequently germinate during late autumn and winter when the water levels rise again. Successful growth and survival of *Ruppia tuberosa* are restricted to a narrow range of water depths (0.3–1.0 metre) around the ephemeral shoreline of the southern Coorong.

When the barrage gates are opened or closed suddenly, water level may rise or drop by up to half a metre in the southern Coorong. If this happens during winter and spring, growth and survival of *Ruppia tuberosa* and the production of seeds and turions may be severely impeded. This impact could easily be reduced with more gradual releases of water over the barrages. Present decisions to open and close barrage gates are based on maintaining a fairly constant water level in Lakes Alexandrina and Albert at around 0.7 metre above the level in the Coorong, which is

DAVID BLAIR, WILDERNESS ARCHIVES

Ruppia tuberosa with floating flower head—an important aquatic plant in the hypersaline southern Coorong.

unnaturally high. Allowing the water level in these lakes to fluctuate more would dampen the extent of water-level changes in the Coorong and thus reduce the impact on key resources like *Ruppia tuberosa*.

The water regime of the southern Coorong, however, is about to change far more dramatically because of the Upper South-East Dryland Salinity and Flood Management Scheme. This program involves draining surplus surface and ground water from adjacent agricultural areas into the southern Coorong at Salt Creek. This is an attempt to alleviate local flooding of low-lying areas and reduce dryland salinisation, the latter caused by rising saline ground water. The major cause of dryland salinisation, however, is excessive vegetation clearance. Drains alone will not alleviate the problems of dryland salinisation. Extensive revegetation is required. Unfortunately the areas where revegetation would have the greatest benefit in reducing the rising ground water are those that have the highest agricultural productivity. Furthermore, in an ironic twist, the final sections of the drain were dug through an extensive area of remnant native vegetation, supposedly protected by legislation under a heritage covenant. That the drain was also dug without first obtaining permission under South Australia's *Native Vegetation Act* 1991 has challenged the integrity of the Act. Politicians subsequently forced retrospective regulations through the South Australian parliament to avoid prosecution.

FINAL SECTIONS

of the drain were dug through an extensive area of remnant native vegetation, supposedly protected by legislation.

Whatever the process, the drain has been dug and the unique hypermarine waters of the southern Coorong will now receive an average of 40 gigalitres (40 billion litres) of relatively fresh water annually, with tacit approval of State and Federal politicians. Studies have shown that such volumes will decrease the salinity in the southern Coorong. Within seven to ten years the system will be estuarine, and the unique hypermarine aspects of the southern Coorong gone.

How will *Ruppia tuberosa* fare with these changes in water regime? Field experiments involving the translocation of plugs of dry sediment containing seeds and turions up and down the Coorong's salinity-gradient indicate that freshening of the southern Coorong will reduce the performance of the plant. The end result will be a reduction in the food resources that support the aquatic birds. Although other food resources may establish in the fresher water, birds like Banded Stilts (*Cladorhynchus leucocephalus*) and Hoary-headed Grebes (*Poliocephalus poliocephalus*), which largely use the hypermarine southern Coorong and not the estuarine northern Coorong, are likely to be disadvantaged.

There are other problems associated with influxes of surface and ground water from the south-east into the Coorong. The 'fresh' water that is released now is likely to carry various impurities (heavy metals such as zinc, copper, cadmium, lead) and also higher nutrient loads. This is an outcome of agricultural activities, including the application of fertilisers and trace elements to pastures. We know little about how these will influence the Coorong biota. Some people dismiss heavy metals, arguing that the high salinities and chemical composition of the Coorong water will result in those metals being precipitated out of the water column. However, the shallow nature of the Coorong system will mean that some of these heavy metals could be re-suspended regularly when wind-induced mixing of the water column takes place. Certainly one tiny crustacean that lives in the Coorong sediments, the ostracod *Diacypris compacta*, is highly sensitive to heavy metals.

Despite concerns that the Coorong environment will change, and that these changes will challenge Australia's integrity under the international Ramsar Convention, the drainage scheme has gone ahead. Even the new *Environment Protection and Biodiversity Conservation Act* 1999, with its clear statement about the need to implement the 'Precautionary Principle' when there is any risk of environmental damage, was ignored in the execution of the drainage scheme. Support for this scheme will render the Coorong to little more than a cheap agricultural drain. As signatories to various conventions, Australia is

Tranquil sunset on the southern Coorong.

DAVID BLAIR, WILDERNESS ARCHIVES

obliged to manage internationally significant wetlands wisely. This involves providing more river flow for environmental benefits, changing barrage operations aided by automation of some of the gates, blocking or diverting the drain and revegetating agricultural land. If we did this, we would fulfill our responsibilities and save what is a precious and unique ecosystem. If we do nothing, then the Coorong will change forever. □

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PHOTO BY PETER PARKS

Planktonic Slipper Lobster larva (family Palinuridae).

beyond the reef: plankton

BY IMAGE QUEST-3D

The British Council

Mixed marine plankton.

PHOTO BY PETER PARKS

Sea butterfly (shelled pteropod).

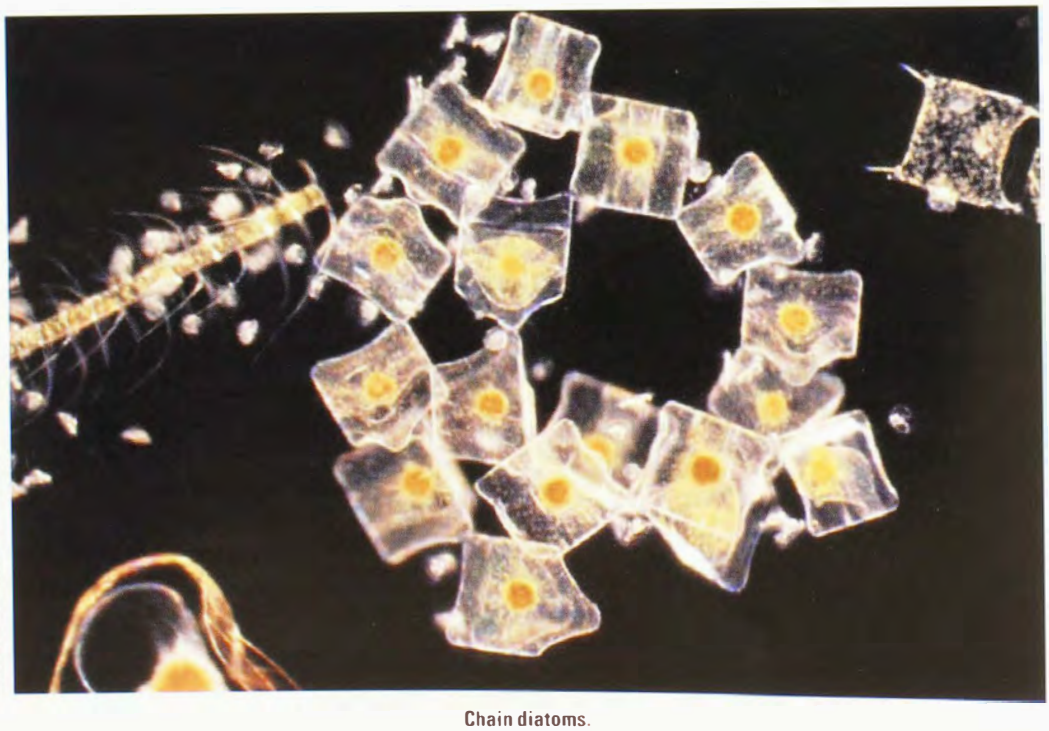

PHOTO BY PETER PARKS

Chain diatoms.

PHOTO BY PETER PARKS

Planktonic tube anemone larva (order Ceriantharia).

The start of art?

At Blombos Cave, scientists have uncovered a suite of artefacts with all the hallmarks of modern humanity.

CURRENTLY, BIG QUESTIONS IN the human-origins debate are where, when and how did modern human behaviour evolve. These questions assume an understanding of what we mean by distinctively human behaviour—a notion that underpins many current issues from animal rights and cloning, to abortion and euthanasia. As biological and genetic research decodes the human genome and prompts popular TV programs like "How to Build a Human Body", it is timely to consider what makes us human.

The major issues in human evolution over the last two centuries have concerned our ancient origins, and we know now that our human ancestors evolved in Africa between six and ten million years ago, with anatomically modern humans appearing about 100,000 years ago. Old human bones have told us a lot about disease, evolution, rituals, and even how tools were held and what people ate. But they provide few clues about the emergence of modern behaviour.

Complex social behaviour, cognitive abilities and language—all essential human qualities—remain archaeologically elusive, because we simply do not find language or behaviour in the fossil record. We have to deduce these qualities from the study of cultural remains. For example, the human ability to construct symbols (inherent in both art and language) is a prerequisite for the complex burials and spectacular rock art that first appear in Europe 30,000 to 40,000 years ago. Archaeological works of art are clear indicators of language and the ability to construct symbols. In particular, the use of red ochre to create pictures and symbolise human feelings is still common in many cultures today. Similarly, substantial sea crossings (like 60-kilometre island hops between Australia and South-East Asia) almost certainly necessitate planning and language. However, there is only one hitch with these kinds of arguments: absence of art or lack of evidence for large sea crossings does not necessarily mean the absence of language or inability to construct symbols. Negative evidence does not prove a thing.

Most archaeological indicators suggest that modern humans who migrated from Africa were responsible for the first artistic achievements in Europe—not their Neanderthal cousins or other archaic hominids who had already been living there for hundreds of thousands of years. However, latest research is now demonstrating that what appeared to many as the first modern human behavioural revolution in Europe was in fact part of a long process of gradual evolution, with its earliest roots again in Africa (see "Becoming Human", *Nature Aust.* Summer 2001–2002). The evidence is scanty—just a few archaeological sites—but the material from one site is startling. At Blombos Cave, about 300 kilometres east of Cape Town on the South African coast, Christopher Henshilwood (Iziko-South African Museum) and colleagues have uncovered a suite of artefacts with all the hallmarks of modern humanity and with an estimated age of more than 70,000 years—almost twice the age of the modern human 'revolution' in Europe.

The artefacts include bone tools and some distinctive pieces of red ochre (iron oxide). The bone tools are remarkable because they are exceedingly rare in deposits over 25,000 years old. In other words, they are a feature of modern human culture. Although simple bone points were used as early as 1.8 million years ago to dig termite mounds or process tubers (see "Termites on the Menu", *Nature Aust.* Summer 2001–2002), the Blombos points are smaller and manufactured in a sophisticated way (one that would require intellectual forethought) from larger skeletal elements. Most are likely to have been used as awls for piercing soft tissue, like animal skins, and three have the symmetry and microscopic traces of projectile tips used on hunting spears.

There are more than 8,000 pieces of red ochre, many with typical marks produced when ground into powder for paint pigment. However, two pieces, each a few centimetres long, have cross-hatched designs that scientists agree are abstract images, not mere grinding scratches. Both the use of paint pigment and the abstract engravings unequivocally imply the deliberate use of symbols—one of the major characteristics of modern human behaviour.

Whether the cross-hatches represented motifs or tallies or something else is anybody's guess. And exactly what the ground pigment was used for is also a mystery. One novel theory on the symbolic use of red ochre was proposed by Chris Knight (University of East London) and colleagues. They noted that human menstrual cycles are similar to lunar cycles (29.5 days), which may also be linked to hunting (if only to coincide with the good light under a full Moon). The researchers suggested that women synchronised menstruation to form 'menstrual coalitions' that performed rituals in which the women flaunted their fertility but withheld sex until the men left for hunting and returned home with the bacon. Breastfeeding, pregnant or other non-fertile women could also have joined in, faking menstruation, perhaps initially by 'borrowing' blood (from other women or animals) but later by painting their bodies symbolically with red-ochre.

Blombos Cave stands out among

BY RICHARD FULLAGAR

Seventy thousand years of modern art? Above: the cross-hatchings on this engraved piece of ochre from Blombos Cave are thought to be the earliest-known abstract images. Right: Trees on Hillside II painted by Fred Williams in 1964.

dozens of other Middle Stone Age sites in Africa in that its artefact assemblage seems ahead of its time. However it may fit an emerging picture of modern human behavioural evolution—one that occured in Africa and coincided with modern anatomical evolution. Rapid migrations of thoroughly modern humans out of Africa about 40,000 years ago would account for the late and sudden appearance of modern behaviour in Europe. But why does evidence for modern human behaviour appear only at Blombos and not other African sites of the same age? Perhaps the ages of these sites need to be re-assessed—they might be older than current estimates suggest. Perhaps there was something special about the coastal location. At any rate, Blombos Cave holds the best clues for understanding the evolution of modern human behaviour, and the red ochre, in particular, shows inklings of modern art. □

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First to flower

The discovery early this year reopened a conundrum—what did the first flowering plant look like?

A WEEDY AQUATIC HERB, preserved in 125-million-year-old lake deposits from north-western China, is the latest nominee for 'first flowering plant on Earth'. The discovery early this year of a complete fossil of *Archaefructus sinensis*, from root to flowers, reopened a conundrum that has troubled biologists since Charles Darwin—what did the first flowering plant look like? And is *Archaefructus* the missing link, the ape-man of the plant world?

It was only three years ago that an obscure New Caledonian shrub, *Amborella trichopoda*, made front-page news in the *New York Times* as the most primitive flowering plant alive. The word 'primitive' needs further clarification but this announcement, made during the 16th International Botanical Congress in St Louis, was the talk of the conference corridors. Discovered at last—the living ancestor to one of the most successful groups of organisms on Earth.

Scientists had just finished mapping the family tree for all flowering plants using genetic sequencing. The resulting 'Tree of Life' looked very much like a real tree, with species as the leaves, and the upper branches the most recently evolved lineages. The long lower branches included a diverse assemblage of plants with generally drab and unattractive flowers, replacing families traditionally considered as 'primitive' such as the magnolias (family Magnoliaceae) and the Mountain Pepper family (Winteraceae). The lowermost branch was *Amborella*.

Talk of primitive species, and living ancestors, sends many botanists into apoplexy. What was really meant was that *Amborella trichopoda* represented an ancient lineage of plants with no other surviving species. *Amborella* either never diversified over time, or all its nearest relatives are now extinct. The discovery of fossil pollen similar to that of *Amborella* in England suggests the latter. In fact the 'basal' or 'primitive' position of this genus is really just an artefact of the way we draw the Tree of Life. Scientists prefer the term 'relictual', as it better reflects what is interesting about this plant—it has survived little-changed through millions of years of evolution.

Amborella also has the lead role in a recently coined acronym, ANITA, devised for a more inclusive group of relictual species in the Tree of Life. The other members of this significant but often inconspicuous assortment of plants are the Nymphaeales, Illiciales, Trimeniaceae and Austrobaileyaceae. The 90 or so species of water lilies included in the order Nymphaeales are found in freshwater habitats around the world. And the order Illiciales contains only a few species, including *Illicium* (the source of anise oil and occasional horticultural specimen), but again is fairly widespread, from India to eastern Asia and across to North America.

It's the 'T' and final 'A' of ANITA that hold greatest interest to Australians. The Trimeniaceae includes only one genus with nine species in tropical and subtropical parts of the Asia-Pacific region. One species, the Bitter Vine (*Trimenia moorei*), occurs in Australia, in the mountains of northern New South Wales. Would you notice it? It's a woody climber in rainforest and when it flowers, its three-millimetre-long white stamens are all you see. The family Austrobaileyaceae has one genus (*Austrobaileya*), with two species, restricted entirely to mountainous areas of northern Queensland. These climbing shrubs or lianas have inconspicuous, pale-green flowers that produce a rotting-fish odour to attract fly pollinators.

Although no single member of the relictual ANITA group shows us what

PETER ENDRISS

Did the first flowers look like this? The dull flowers of *Amborella trichopoda*, a species now restricted to New Caledonia and the last representative of an ancient lineage of plants.

BY TIM ENTWISLE

the first flowering plants looked like, the characters they share give us some strong hints. In other words, it is more likely that ANITA species inherited their shared characters from a common ancestor, rather than each species evolving them separately from a different-looking prototype. So, on this basis, what did the first flowering plants look like? An identikit picture can be formed of a shrub with small, spirally arranged flowers, each with about 8–10 petal-like appendages and the same number of male and female parts. It wasn't a strapping tree, and the wood didn't have vessels (the larger, water-transporting cells found in most tall flowering plants). A diverse assortment of bees, beetles, flies and other insects pollinate the ANITA group, so all we can say is that insect pollination was most likely for our ancestral flowering plant.

How does this all change with the discovery of *Archaefructus sinensis*? Based on floral traits, this Chinese aquatic slots in below *Amborella* in the Tree of Life. However scientists haven't rushed to embrace the stuttering acronym A-ANITA. The basal position of *Archaefructus* in the tree is only weakly supported, and it may end up somewhere entirely different. However, if it is correctly located, it contradicts some of the identikit picture based on living relictual species, adding evidence for petalless flowers, a non-woody habit and an aquatic origin for the first flowering plant.

Even if *Archaefructus* is correctly placed, why are there so many relictual species in the Australian region? Most likely it is because conditions have allowed them to survive since the late Cretaceous, some 70 million years ago, not because our region is some sort of cradle of evolution. As noted earlier, *Amborella*, for example, may have extended to what is now England. The environment in our neck of the woods has remained favourable for a long period due to advantageous movement of the Earth's plates, and less opportunities for aggressive invasions of plants from other regions.

The ANITA group—a curious collection of flowering plants surviving the trials of evolution—has immense scientific and conservation value. As a collection of low-lying branches on our metaphorical Tree of Flowering Plant Life, ANITA has particular importance in our appreciation of the natural world. In the same way that Orangutans, Gorillas and Chimps tell us something about ourselves, ANITA is playing a lead role in understanding one of the world's most successful groups of living organisms, the flowering plants. □

JAIME PLAZA RBG SYDNEY

The stamens are all you see in these tiny flowers of the Bitter Vine (*Trimenia moorei*) from northern New South Wales. *Trimenia* is the 'T' in the relictual group of flowering plants known by the acronym ANITA.

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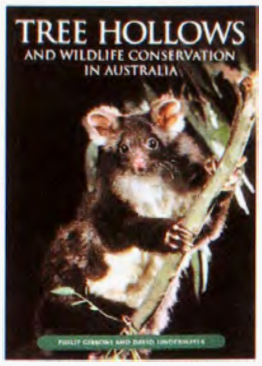
reviews



Tree Hollows and Wildlife Conservation in Australia

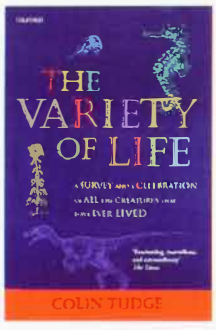
By Philip Gibbons and David Lindenmayer. CSIRO Publishing, Vic., 2002, 211pp. $59.95rrp.

Hollows in trees provide critical shelter for about 300 species of Australian vertebrates, as well as many invertebrates. Hollows take at least 220 years to become suitable homes for many species. Imagine the town-planning implications if the fastest builder took that long to construct a home!

Typical eucalypt longevity is 250 to 500 or more years, yet hollow trees are now scarce in many landscapes due to clearing, forestry, dieback and wind damage. Conservation planners face a real challenge and this book will be an essential resource as it is easily the most comprehensive and authoritative text on the subject.

There are numerous diagrams, tables and photographs, and the text is easy to read and contains much accessible information that will be useful for a wide cross-section of the community. There is an interesting chapter on nest boxes, and another on the displacement of native species from hollows by introduced pests, such as mynas and bees. The retail price is a more-than-fair exchange for access to the insights of two of the world's leading authorities on the subject.

—Harry Parnaby
Australian Museum



The Variety of Life: A Survey and a Celebration of All the Creatures That Have Ever Lived

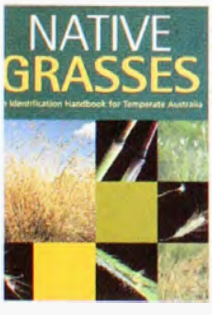
By Colin Tudge. Oxford Paperback, 2002, 684pp. $59.95rrp.

Colin Tudge's book is a bit like Robert Louis Stevenson's take on the world: so full of a number of things that we should all be as happy as kings. The "survey" part of the subtitle starts by explaining the workings of systematic biology—the scientific basis for classification. Tudge succeeds in both getting it right and making it entertaining. He then leads us on a whirlwind tour up and down the branches of the tree of life. He writes with an exuberance and a sense of joy about discovering so many curious creatures—slime moulds that crawl like little slugs, mites that live only up our noses, long-vanished amphibians with skulls shaped liked boomerangs, and the endless ways of making a living with a single cell.

The ideas are up to date and, because of consultation with many of the world's leading systematists, the error-rate is surprisingly low given the enormous scope. Each major group of organisms is illustrated with a line drawing and placed on an evolutionary branching diagram (cladogram), giving considerable weight to recent findings from molecular sequences.

This book should delight anyone who thinks it a privilege to share a planet with tens, or maybe even hundreds, of millions of species (many of them yet to be discovered).

—Greg Edgecombe
Australian Museum



Native Grasses: An Identification Handbook for Temperate Australia

By Meredith Mitchell. Landlinks Press, Vic., 2002, 3rd ed., 48pp. $24.95rrp.

The third edition of this handy guide sees it updated to include recent name changes in some of the important grass groups of temperate Australia, and expanded so that its applicability extends beyond Victoria. The utility of the booklet lies in its size and clarity of presentation. The photographs of diagnostic parts are wonderfully clear, even if the whole plant portraits (notoriously difficult subjects) are a little patchier. The text is also clear, with jargonless descriptions and information on difficult-to-source attributes such as response to fertilisers, frost tolerance and forage value. As such it is probably of most interest to graziers keen to explore the possibilities of utilising native pastures.

The guide includes information on 17 native grass species or species groups that are likely to persist in pastures and other modified environments in temperate eastern Australia (and here the title may suggest a slightly more generous coverage than provided). However, the daunting challenge of summarising the 500-odd native grasses of temperate Australia is obviously beyond the scope of a non-technical handy guide.

—Neville Walsh
Royal Botanic Gardens, Melbourne

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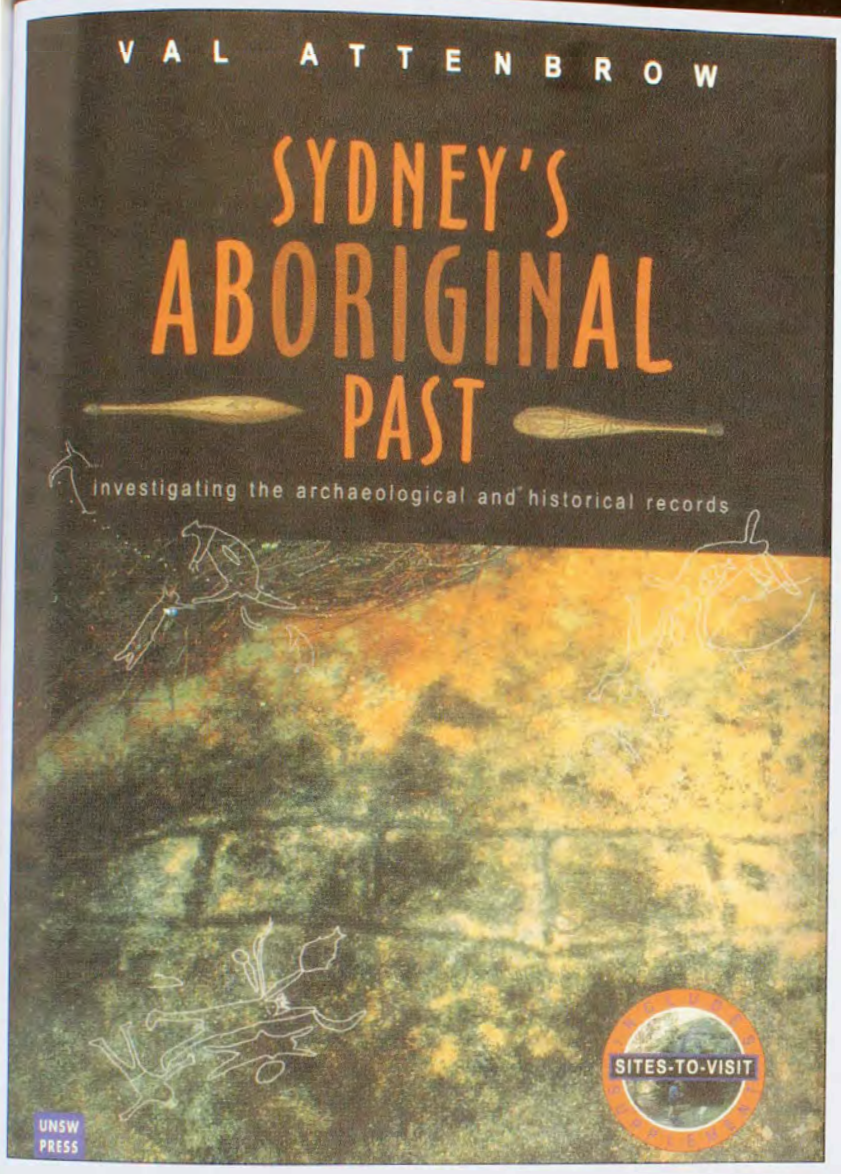

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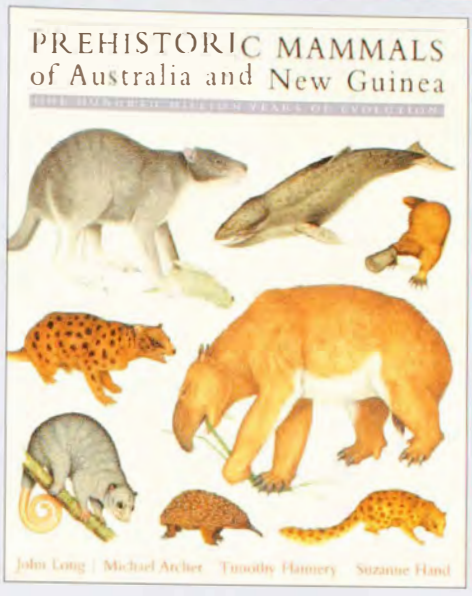

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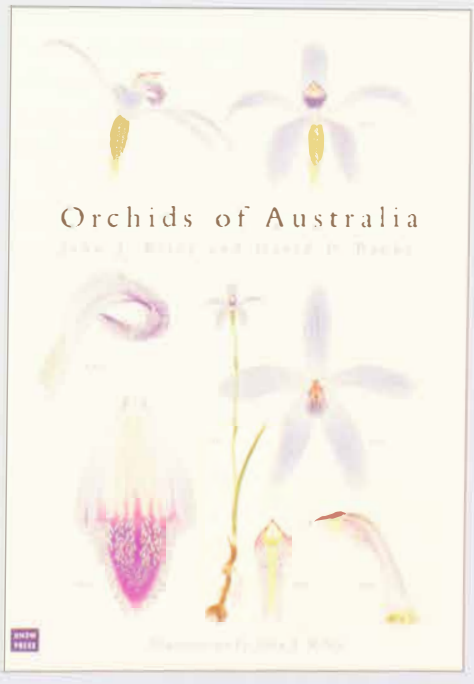

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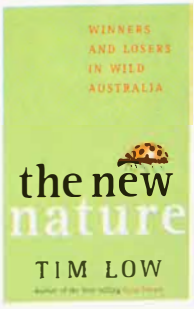


The New Nature: Winners and Losers in Wild Australia

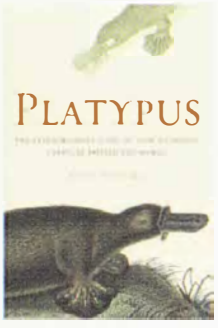
By Tim Low. Viking, Vic., 2002, 378pp. $29.95rrp.

NEW NATURE. SO WHAT IS IT? Old nature was what nature was like before the advent of humans, and new nature is what nature is increasingly becoming since the appearance of technologically sophisticated humans starting about 100,000 years ago. What we see around us is the fast-disappearing remnant of old nature and the accelerating appearance of new nature.

Tim Low's book is a compendium of examples of how species are affected by the new nature. He describes the "winners", such as Silver Gulls that grow fat and numerous on human garbage, and "losers" like Banded Stilts, the eggs and chicks of which are devoured by Silver Gulls. In the beginning of the book Low seems to marvel and almost take heart at the way so many species can fit into the increasingly humanised environment, but toward the end he seems to grow uncertain about where it will all end up and what can be done about it.

Like many conservationists, Low focuses mainly on individual species. As long as each species continues to persist on Earth, everything is, well, if not okay, then at least as much as can be expected. What he and most other conservationists don't emphasise are the interactions between species. The old nature was made up of not only individual species but also their long historical interactions with each other. These interactions can disappear long before species become extinct. For example, the interactions of Silver Gulls with other species in a prehuman world can only be guessed at. He, like others, also doesn't concern himself with the course of evolution in the new nature. To take an utterly trivial example, how will 1,000 years of eating soggy chips affect the future evolution of Silver Gulls? Does anybody, besides a few pointy-headed biologists and natural historians, really care? Of course not. And that attitude, too, is a significant aspect of the new nature.

—ALLEN E. GREER
AUSTRALIAN MUSEUM



Platypus: The Extraordinary Story of How a Curious Creature Baffled the World

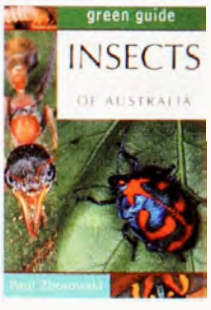
By Ann Moyal. Allen & Unwin, NSW, 2002, 226pp. $19.95rrp.

ANN MOYAL HAS PRODUCED A VERY READABLE ACCOUNT of how the Platypus has weaved its way through the thinking, debates and personalities of biologists and natural historians associated with the study of Australian fauna over the past two centuries. The text in this well-produced and compact volume is complemented with many early drawings. Most of these are fascinating but are generally ghastly representations of the "animal of all time".

Disappointingly Moyal has given little attention to the work of modern biologists who have clarified and sometimes rejected observations and conclusions made by the early biologists and naturalists, including those of "the platypus man" Harry Burrell in the 1920s. Interestingly, Moyal rightly castigates the biologist William Caldwell for killing so many Platypuses in the 1880s in his efforts to find out something that Indigenous Australians had apparently already made clear to disbelieving expatriate Europeans—that is, that the animal lays eggs. However, she gives laudatory treatment to "the platypus man" himself who also killed large numbers and carried out bizarre and awful experiments on living Platypuses.

In spite of these reservations, anyone with an interest in the history of biology in Australia will find this book a worthwhile read and I thoroughly recommend it.

—TOM GRANT
UNIVERSITY OF NEW SOUTH WALES



Insects of Australia

By Paul Zborowski. Green Guide Series, New Holland, NSW, 2002, 96pp. $17.95.

THIS IS AN EXCELLENT ADDITION TO THE GREEN GUIDE SERIES. Not only is the text well written, but the author is also the photographer of the book. To those not familiar with the Series, this book is not a field guide to help identify what you find on the windowsill. It will, however, enable you to learn a great deal about Australian insects in general.

The book is arranged in sections with insect groups, or 'did-you-know?' pieces (for example "What is the difference between butterflies and moths?"). There are boxes of detailed information wherever needed, and the chapters cover a range of subjects, such as aquatic insects, social insects, and parasites and pests. Further reading lists, clubs and organisations are also provided.

The style is light and easy to read, and the numerous photos, which often depict behaviour rather than typical portrait shots, are superb. Mistakes are few and the information is relevant to anyone curious about insects.

—MARTYN ROBINSON
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SOCIETY PAGE

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q&a

Scaly Fossil

Q: *While on holiday on the New South Wales south coast we came across this fossil imprint on the rocks at low tide (see photo). The fossil appears to have a fish-scale pattern. Is it a fish? And how old is it?*

—The Brehery Family
Berowra, NSW

A: This fossil can sometimes be mistaken for that of a fish because of its scale-like pattern. However, it is actually the impression of the bark of a primitive plant *Lepidosigillaria yalwalensis*, so named because it was first described from specimens found near Yalwal on the Shoalhaven River. It comes from 370-million-year-old rocks of the Devonian Period and is known from various sites on the south coast. At one of these localities it has been found in association with one of the earliest land animals, a recently described primitive arthropod named *Maldybulakia*.

Lepidosigillaria belongs to the lycopods, a group of spore-bearing plants that in the Devonian and Carboniferous Periods grew to tree size. Today the closest relatives from Australia are species of the genus *Lycopodium*, the club mosses, which can be seen growing in the Blue Mountains west of Sydney. They grow to about 30 centimetres tall.

—Robert Jones
Australian Museum

Balled Planets

Q: *Could you please explain why planets are round?*

—Melissa Adamson
Narrabunda, ACT

A: Basically it comes down to gravity. Every bit of a planet's matter is gravitationally attracted to every other bit. Gravity therefore crushes all that dust, rock, magma and so on into the smallest possible space, and the most compact solid shape is a sphere. You can prove this to yourself by attempting to make a tall hill out of sand; the higher you go, the wider you have to make the base of the sand hill. But a base the width of the beach will still only give you a relatively low hill. Even the largest mountain in the solar system, Olympus Mons on Mars, is just 27 kilometres tall. While this may sound tall (Everest is nearly nine kilometres), its phenomenal height only represents 0.3 per cent of the diameter of the planet itself. The bottom line is planets have so much gravity that anything that tends to grow beyond a certain height collapses under its own weight. The end result is a sphere. In contrast, objects the size of minor planets (asteroids) are too small to be affected by all this. While they're held together by gravity, their mass is too low—and gravity too weak—to crush them into spheres. As a result, minor planets come in a wide range of shapes.

But even regular planets are not perfectly round; instead they are like squashed balls, flatter at the poles. Centrifugal motion brought on by the planets' rotation resists the pull of gravity and causes them to bulge in the middle. Earth, for example, is 40 kilometres wider at the equator than at the poles.

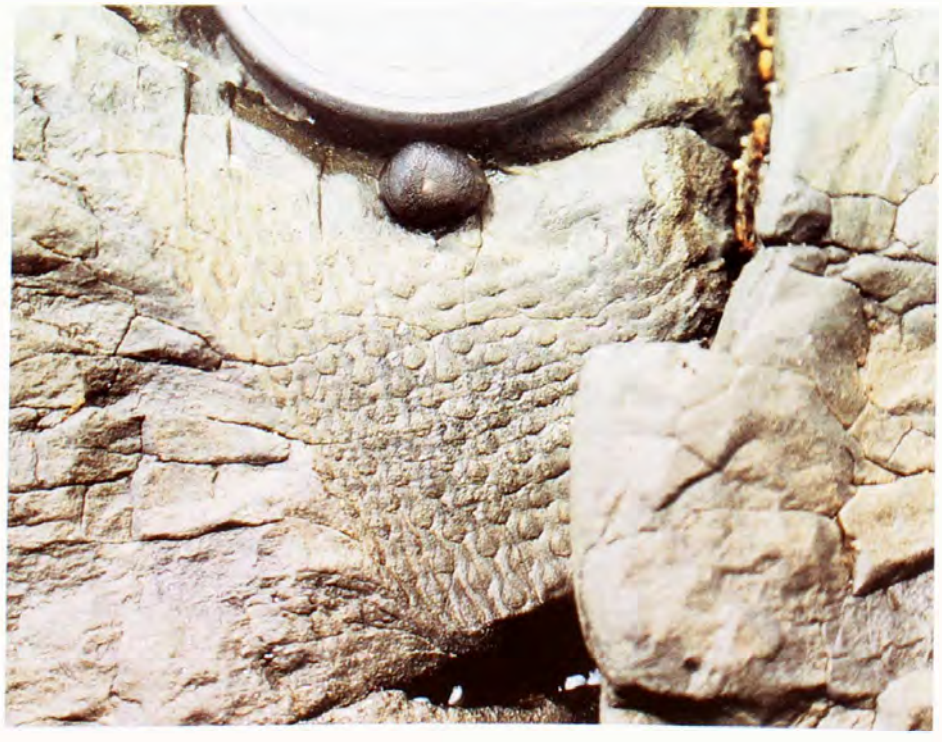
—Geoff McNamara
Evatt, ACT

Cross Lorrikeets

Q: *The two lorikeets in the accompanying photo have been regular visitors to my backyard for at least six months. The bird on the right looks like a Scaly-breasted Lorikeet, while the other looks like a cross between a Scaly-breasted and a Rainbow Lorikeet. Their two young look like normal Scaly-breasted Lorikeets. Does crossbreeding often occur between the two species, or is this rare?*

—Russell Wilson
Kotara South, NSW

A: The bird on the left does indeed appear to be a hybrid between the Rainbow Lorikeet (*Trichoglossus haematodus*) and Scaly-breasted Lorikeet (*T. chlorolepidotus*). This event is known among cage birds and, while not common, has been recorded in the wild on several occasions. The



COURTESY BREHERY FAMILY

Bark of the primitive plant *Lepidosigillaria yalwalensis* makes an impression.

COURTESY RUSSELL WILSON

Rainbow/Scaly-breasted Lorrikeet cross with its Scaly-breasted mate on the right.

resulting offspring can show a wide range of intermediate characteristics. In this instance, the hybrid has a fairly typical Rainbow head, while the breast is a mixture of patterns of both parents. The belly is more like that of the Scaly-breasted in being mottled and lacking the blue belly patch of the Rainbow.

—Walter E. Boles
Australian Museum

Answers to Quiz in Nature Strips (page 16)

1. *Two* **2.** *Lake Argyle* **3.** *In a spider's web* **4.** *No* **5.** *Three* **6.** *Lion* **7.** *Wise* **8.** *Summer* **9.** *Six* **10.** *Southern Right Whales*

AUSTRALIAN MUSEUM/NATURE PICS

Pic Teaser

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *Photographic field guide: birds of Australia*. Spring's Pic Teaser was a stalk-eyed fly (family Diopsidae).

Living with fire

The current mode of fire management is simply unsustainable.

BY DAVID BOWMAN

AN ADMIRABLE FEATURE OF THE Australian character is the capacity to see elements of triumph in what otherwise seems like defeat. The community response to bushfires fits well within this 'Anzac spirit'. Volunteer fire fighters put themselves at risk to protect other people's lives and property, and we honour them with tickertape parades and the like. However, looking at the situation from a longer-term perspective, and beyond the heroic response of fire fighters, I see only defeat, because the current mode of fire management is simply unsustainable. Regardless of land tenure, levels of biodiversity are becoming lower and lower as more and more fires get out of control.

Fire is an integral part of the Australian environment. Since flammable eucalypt forests all but replaced the rainforests that dominated Australia prior to the drying-out of the continent some 15 million years ago, Australian landscapes have been repeatedly burnt and will continue to be burnt. From this geological perspective, fire is a predictable 'tide' that washes over the landscape, driven by implacable environmental forces. True, Aboriginal people played an important part in the making of flammable Australia but, contrary to some popular ideas, they did not trigger the relentless fire cycle. Indeed, my research has led me to the conclusion that the incessant burning of landscapes throughout Australia by Aborigines arose because the hunter-gatherers themselves could not stop the wildfires. Rather, they learnt to use fire to control wildfire to their economic advantage ('fire-stick farming').

For most Australian landscapes, the changes that have occurred since 1788 mean it is impossible to 'return' to pre-settlement fire-management regimes. This can probably only be achieved on some Aboriginal lands and recent research has shown that this will require concentrated effort and resources, given the dramatic changes to Aboriginal settlement patterns.

It must be accepted that there are no simple recipes for managing a flammable continent. Land management is a tricky art, which is ultimately about balancing the conflicting values and the various risks within the strict budget constraints. Indeed, the debates as to how best to manage land are necessarily endless, because they are continuously refined by the accumulation of knowledge and experience.

However, regardless of these ecological debates, uncontrolled bushfires continue to occur. Once alight, management decisions are made, often literally in the heat of the moment. For instance, the last resort for fire fighters confronted with high-intensity wildfires in areas of heavy fuel loads is to 'back-burn', often from hastily constructed fire-breaks (wide strips of bare earth) that have their own ecological costs such as subsequent weed invasion and soil erosion. Back-burning has the unavoidable effect of sandwiching the resident wildlife between two converging walls of fire. It is far worse than a single fire front. Back-burning is particularly destructive in bushland fragments around urban areas. Once wildlife is eliminated from a bushland fragment, natural recolonisation is often impossible because of the effective isolation by busy roads.

I believe the use of numerous small, planned, low-intensity hazard-reduction fires, designed specifically to reduce fuel loads, is preferable over the current 'bushfire-disaster' mode of management in which hasty, often-drastic decisions are made. Contrary to media hysteria, not all landscape fires are environmentally negative. And the conspicuous smoke from hazard-reduction fires, often exacerbated by stable weather that provides the safest conditions for such burning, is trivial compared with the choking and injurious pollution from uncontrolled bushfires. Ecologists often argue that frequent hazard reduction may also cause considerable environmental damage, disadvantaging plants that require a substantial fire-free period to set seed, and animals that need unburnt habitat for nesting. Clearly a coordinated research program is required to critically evaluate the environmental consequences and effectiveness of the various fire-management regimes in order to develop optimal strategies.

Inevitable changes to building regulations, council by-laws, insurance premiums, property values, and perceptions of risk by landowners, mean that the days of houses built from flammable materials and completely surrounded by bushland are numbered. Eventually all Australians will adapt to this fire-prone land, for no other reason than that the system is self-correcting. Over the long term it will be impossible to sustain heroic attempts to extinguish massive bushfires like those that have swept through New South Wales in recent years. More fire fighters will lose their lives, and the financial drag associated with expensive technologies, like helicopter water bombers, will become socially unacceptable.

I am optimistic that Australians will learn to live with fire just as the Aborigines did. The question remains: how many bushfires will we have to fight before we converge on ecologically sustainable fire-management strategies?

DR DAVID BOWMAN IS A PRINCIPAL RESEARCH FELLOW WITH THE KEY CENTRE FOR TROPICAL WILDLIFE MANAGEMENT AT THE NORTHERN TERRITORY UNIVERSITY, DARWIN. HIS BOOK *AUSTRALIAN RAINFORESTS: ISLANDS OF GREEN IN THE LAND OF FIRE* (CAMBRIDGE UNIVERSITY PRESS, 2000) DISCUSSES THE ROLE OF BUSHFIRES IN THE DISTRIBUTION OF AUSTRALIAN RAINFORESTS.

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25/2	• Owls • Platypus • Dinosaur Sex • Koala Diet
25/3	• Dugongs • Killer Rats • Red Goshawk
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25/5	• St Kilda Penguins • Fire Control • Death of the Carnivore
25/8	• Ticks • Boyd's Forest Dragon • White-winged Choughs
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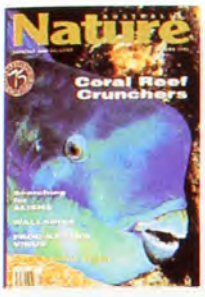

25/4

25/5

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25/9

25/11

26/1

26/2

26/3

26/4

26/5

26/7

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26/9

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26/11

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27/2

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27/5

27/6

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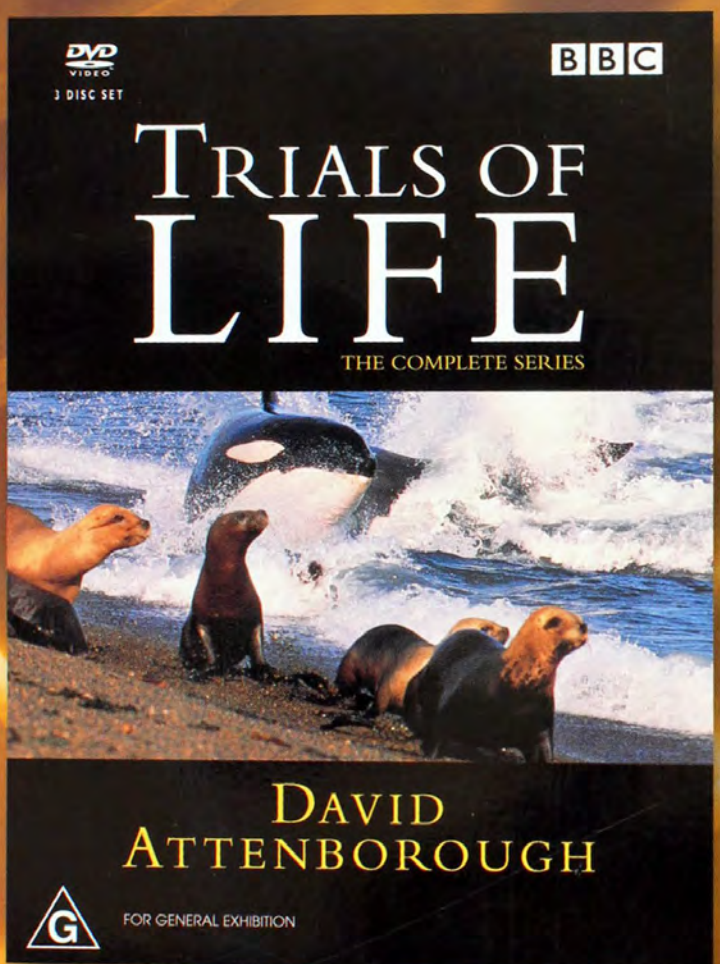

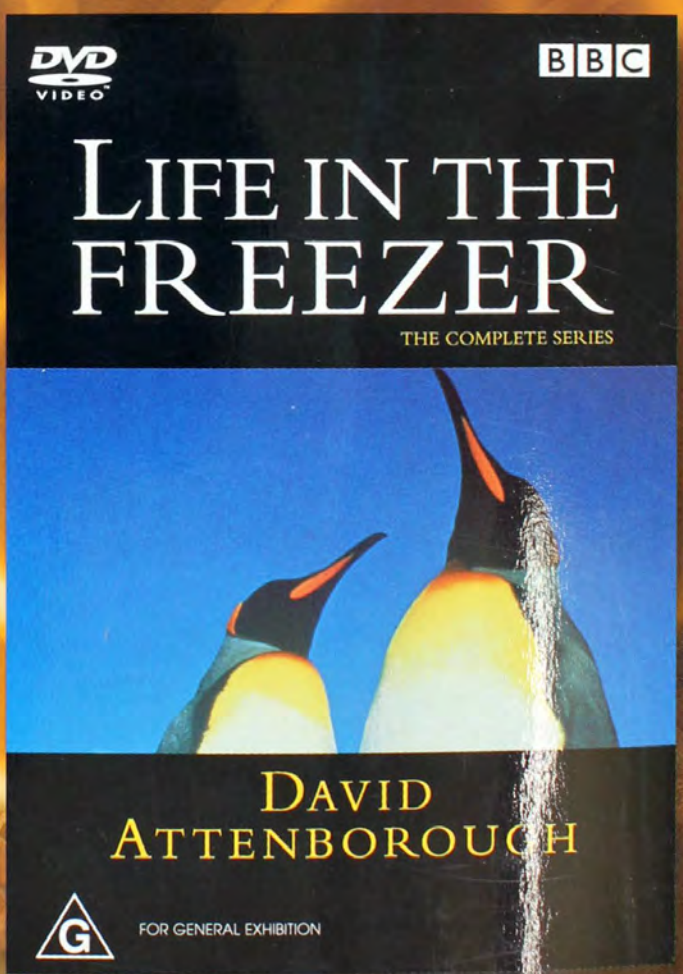

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