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WHERE BEACHES COME FROM
DEADLY MOSQUITOES
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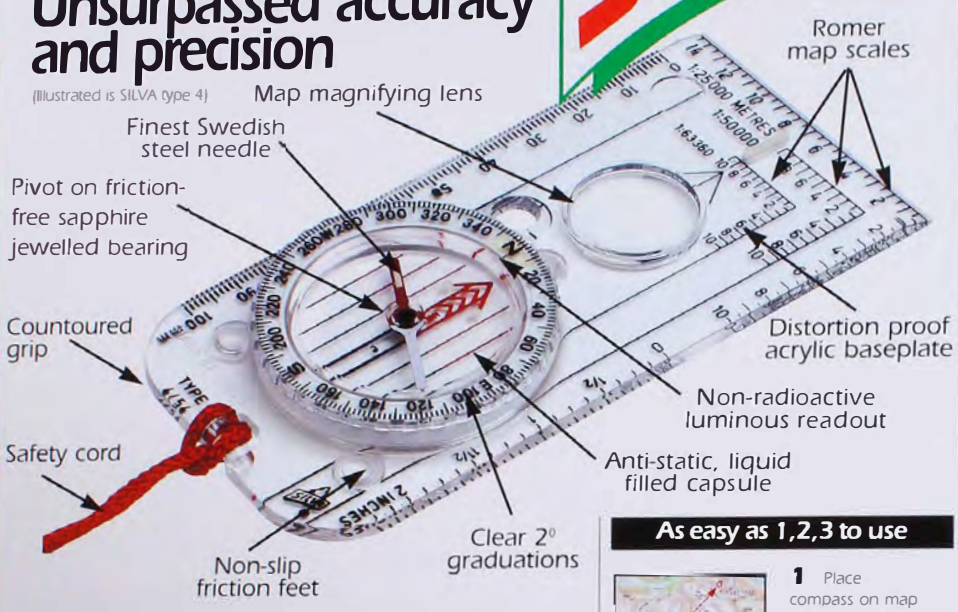

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Up Front

STEPHEN DOGGETT

It's late. You turn out the light and begin to drift into a blissful sleep . . . but you can't. Something is there, and it has found you, and now it's time for it to feed. That rotten #$%@*$# mosquito is driving you completely insane and if you could only just catch it you'd splatter its buzzing little body all over the bedroom wall. It's a scene repeated again and again across Australia as these insects hunt us down in order to extract a blood meal. And so we fight back. We spray them with chemicals, we spray ourselves with chemicals, cover our beds with nets, burn pyrethrin candles, grow plants that repel them, place screens over our windows—we've tried it all and still they bite us. Why? Why do they need our blood and why do they prefer to feed on some people rather than others? Where are they coming from and what diseases might they be infecting us with when they bite us? Turn to page 38 and find out.

Once upon a time in the mountainous areas of south-eastern Australia, Brush-tailed Rock-wallabies were everywhere. Today they are so rare and elusive they have been nicknamed 'The Shadow' and, if something is not done about it now, they will be lost forever. With this in mind, a group of scientists joined forces and began an innovative cross-fostering program that involves putting baby brush-tails into the pouches of other wallabies.

Australia is known for its sandy beaches and just about every Australian at some time in their life has experienced the problem of extracting that sand from themselves and their belongings. But why do we have such beautiful sand and where has it come from? Keith Sircombe decided to search for the origins of the sand on Australia's east-coast beaches . . . and found the answer in Antarctica.

Birds are also big in this issue. Over two metres high and 300 kilograms big! Meet the thunder birds that ruled northern Australia around 15 million years ago. Steve Wroe asks, just what did these giant flightless birds eat? In Views From the Fourth Dimension, Mike Archer ponders about the owner of the perfectly preserved petrified bird brain found at Riversleigh in Queensland. And Tamra Chapman puts the Glossy Black-Cockatoos of Kangaroo Island under the spotlight. This population is all that remains of the South Australian Glossy Black and it is now under threat.

Other stories in this issue include a warts-and-all expose of the Cane Toad, the rediscovery of Australia's only wingless dung beetle, an alternative idea for keeping our river systems healthy, and why it's often impossible to tell whether something's native or not.

Finally, we are proud to announce that *Nature Australia* has been awarded the NSW Royal Zoological Society's 1999 Whitley Award for Best Zoological Periodical. We would like to thank the Society for their recognition—we couldn't think of a better way to round off the millennium.

—Jennifer Saunders

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Front Cover
An adult male Glossy Black-Cockatoo (*Calyptorhynchus lathami*) feeds on the seeds of a sheoak cone. Photo by Tony Karacsonyi.

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RARE & ENDANGERED

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BY NATURE FOCUS

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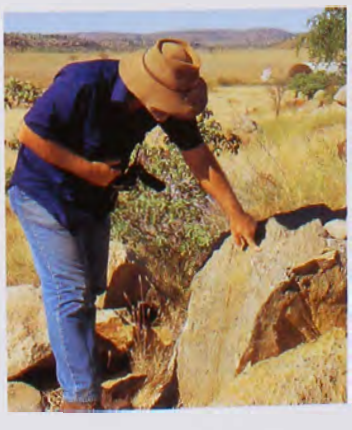
Riversleigh has yielded yet another spectacular fossil—a petrified brain so perfectly preserved that its blood vessels stand out in proud relief. But just what kind of animal did this brain service?

BY MICHAEL ARCHER



THE LAST WORD

THE RIVERKEEPERS
Australia's rivers are our most precious resource, yet the responsibility for their protection often falls through the holes of various bureaucracies. But there may be a better solution.

BY JOHN CHRISTOPHER GAZECKI

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SOCIETY PAGE
Interested in nature but not sure what to do or where to go? Nature Australia's *Society Page is a great place to start.*

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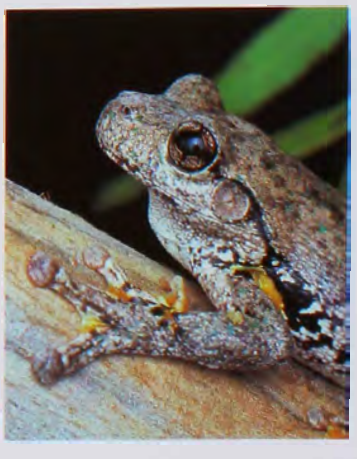
Q&A
Frog Find; Dinosaur Bones; Only Skin Deep; Long Webs; Pic Teaser.



LETTERS

The forum for readers to air their views about their concerns, past articles and interesting personal events.

Anthropomorphism

To some extent I agree with Dean Portelli's objections (Letters, *Nature Aust.* Winter 1999) to the anthropomorphic treatment of animal behaviour in my article on parenting in Peregrine Falcons. As he said, it is common practice and scientifically unsound. Nevertheless, it is done so often simply because it is the most apt and compelling way to describe behaviour, and it is done in the belief that the average reader will understand its limitations. We cannot help but view the universe from a human perspective. I believe it is human arrogance that asserts, as Portelli does, that animal behaviour is instinctive, not learned, and, by inference, that human behaviour is rational and independent of instinct. There is ample evidence that human females tend to 'choose' older, wealthy males and that human males 'prefer' young, well-proportioned females. In most cases they aren't consciously looking ahead to future generations, but their genes sure are! If words like 'decide' and 'choose' adequately describe such behaviour in humans, then they are just as applicable to animals.

—Penny Olsen
Australian National University

Guyon Guyon Paintings

I have read with great interest an article entitled "Magical Paintings of the Kimberley" by Paul Taçon (*Nature Aust.* Summer 1998–99). The article discusses the origins of a kind of rock painting until now wrongly referred to as the 'Bradshaw paintings'.

I am an Elder of the Kwini tribe. Kwini means 'the people from the East'. My people lived along the north coast of the Kimberley as well as inland as far as Wyndham in the east, and Kalumburu in the west. My country is along the King George River. My people have been living in that country for a long, long time, and the rock paintings that the white people call Bradshaws belong to the Aboriginal people, because our ancestors put them there.

Paddy Neowarra and others made a big effort to change the name by calling them Guyon Guyon paintings, meaning the old people from long ago, and the paintings should be called that from now on. We don't like to hear them called by a white man's name, who didn't even believe they are our paintings. I have been writing stories and I have written a story about the paintings. It is bad how that fella Grahame Walsh says the paintings are too beautiful to have been done by my people. I am also writing to the Bush Tucker Man to let him know.

There are still old people around today who can tell you what the things are that people see in the paintings, like what they wear and things like that. There are words for everything in the paintings in my language. I would be glad if you could pass this information on.

—Ambrose Chalarimeri
Willetton, WA

Jumping Species

Much as I was impressed by Brian Cooke's encouraging article on the spread of calicivirus and the consequent decimation of the European Rabbit population accompanied by a resurgence of our native flora and fauna (*Nature Aust.* Autumn 1999), I was rather surprised at his easy dismissal of 'species jumping' with reference to this virus. I gather that not a lot of research has been done in this area but

DAVE WATTS/NATURE FOCUS

A male Peregrine Falcon (*Falco peregrinus*) with its prey—a Green Rosella (*Platycercus caledonicus*).

there seems to be strong evidence that viral 'species jumping' can and does occur. HIV springs to mind as almost certainly having 'jumped' to humans from other primates. Nearer home, the recent 'jumping' to humans of the equine killer virus (EMV) in Queensland and its probable existence also in flying-foxes gives one pause. One recalls too the recent 'mad cow' epidemic in Britain (BSE virus) with its economic as well as pathological implications. I would venture to say then that viral 'species jumping' can have drastic consequences for humans.

—Anne Drover
Wollstonecraft, NSW

Pollen-eating Spiders

I do not know what nutritional benefit Eleanor Stodart's jumping spider might have gained from eating cake (*Nature Aust.* Autumn 1999), but I do know of one example of orb-weaving spiders benefiting by becoming partial herbivores.

Orb-weaving spiderlings survive the first instar on their reserve of egg yolk. Only after they have moulted to the second instar do they spin a web. Then, however, they face a relative shortage of food (few of the many small insects in their environment actually come in contact with their webs, and even fewer are small enough to be captured), which soon proves fatal for most of them.

In 1984, Risa Smith and Thomas Mommsen conducted experiments to see how spiderlings fared on a diet of pollen (*Science* 226: 1330–1332). Second-instar spiderlings were allowed to spin their first webs in individual closed cages. Some of them were starved, the webs of others were dusted with birch pollen. Those with pollen to eat had double the life expectancy of the starved ones. Third-instar spiderlings, raised on a diet of aphids, were also given the same treatment (pollen or nothing) and again, those on the diet of pollen lived twice as long.

These young carnivores are doing the reverse of what so many young herbivores do—supplementing scarce animal protein with plant protein. But it is still only a supplement. Birch pollen is deficient in the essential amino acid tyrosine. Without this spiderlings cannot form a new cuticle and therefore cannot moult. Like all young animals, they must eat animal protein.

—Tom White
University of Adelaide

Tsunami Backfire?

I was recently reading a back issue of *Nature Australia* (Summer 1998–99) and came across a Letter titled "Tsunami Hype" by Eric Vanderduys. Vanderduys starts out by saying that he "loved the picture of Michael Archer's 'one-in-600-year wave' about to dump a million tonnes of water onto what appears to be a prize home in the Gold Coast hinterland" and cannot "suppress the harmless pedant that lives within", and then goes on to explain the inaccuracies with the idea that tsunamis can "tower above the surface of the ocean". My complaint is that the picture does not depict a tsunami towering above the middle of the ocean (as he goes into great detail to discredit) but towers over a house on the coast (the exact situation he claims occurs as the wave hits the shore). If the picture was of a towering tsunami about to hit an ocean liner in the middle of the ocean, then I could see his argument—but it's not. Eric thus totally contradicts himself.

—Tom Richards
Brisbane, Qld

In Vanderduy's original Letter he writes "My criticism is not with the picture but with the idea that tsunamis can 'tower above the surface of the ocean'." Here he is quoting Archer's text, and so he is quite right in pointing out the error.

—G.H.

UV Eyes?

"A Sight for UV Eyes" (Nature Strips, Autumn 1999) revisits an old misinterpretation. The item reports that male and female Blue Tits show colour differences when examined under UV light, and concludes that they see UV light.

A similar story appeared on Eastern Rosellas in your Spring 1991 issue. As I pointed out (Winter 1992), birds may or may not be able to see in the UV, but the colours we see with human eyes when we shine UV light on a bird cannot possibly tell us anything about what a bird sees.

Certain substances fluoresce—they absorb light at one wavelength and re-emit it at a higher wavelength. Thus UV light can be emitted as visible (to us) light. As the authors of the article point out, human eyes do not 'see' UV, so what the observers are seeing is fluorescence. That tells them that there are fluorescent pigments on the bird; it tells them nothing about what the bird sees.

Certain red seaweeds contain substances, phycobiliproteins, that emit bright red light when irradiated with a blue laser. What does that tell us about the role of lasers in seaweed society? Absolutely nothing, although I could make up a good fantasy.

Birds may well have UV-sensitive photoreceptors. I would imagine it would be very easy to design an experiment to find out, if it has not already been done. But shining UV light on them and looking at them with (UV-blind) human eyes is certainly not the way to find out.

Can *Nature Australia* get someone who knows about avian vision and understands the experimental method to comment on whether birds can see UV light, and summarise the evidence critically?

—Heddy Zola
Seacliff, SA

A peril in summarising scientific papers for the Nature Strips section is that some details must inevitably be left out. Zola has pointed out that, in concentrating (perhaps unduly) on the ecology and natural history of the subject, we omitted references to the papers that give the basis for why UV can be supposed to have a role in avian ecology. Those papers illustrate not only that birds can indeed detect UV wavelengths, but they also discuss the anatomical basis for arguing that the visual world of birds is more extensive than that of humans. These papers, and there are many, are cited in the two key papers we were summarising (for which full reference details are provided).

I agree with Zola's suggestion of a full article exploring birds 'seeing in the UV', but in the meantime I suggest Zola and other interested readers consult the references quoted in the key papers. After all, that is why references are included in the Nature Strips section—so that people can follow up their own research if they wish to.

—Leo Joseph
Academy of Natural Sciences, Philadelphia

Conservation Myths

Mark Elgar's "Conservation Myths" (*Nature Aust.* Spring 1998) contains myths other than the ones intended.

Myth no. 1: genetics cannot have immediate effects on demography. Inbreeding depression (loss of individual survivorship and fertility through inbreeding) is well researched and has rapid consequences for populations.

Myth no. 2: mortality such as predation on Cheetah cubs. cannot be influenced by genetics. To evolve, predator susceptibility must have a genetic component. There are good examples in the literature of genetic predisposition to predation pressure. More generally, few would doubt that many diseases and weaknesses have genetic origins, and that predators often target the weak. Eldridge's work (cited by Elgar) provides a simple example: inbred Euros on Barrow Island are anaemic and collapse on being chased.

Myth no. 3: survival of some inbred populations means that inbreeding does not cause extinction. "Grandad smoked 30 a day and lived to 80, so smoking doesn't contribute to cancer." Analysis of all the available evidence shows that genetic factors cannot be discounted.

Myth no. 4: there is little evidence that genetic factors affect extinction. There is a wealth of relevant experimental data in major scientific journals. Saccheri and col-

leagues (in *Nature*, 1998) showed, in the sort of experiment demanded by Elgar, that genetic factors contribute to extinctions in wild-living butterflies. Does the point have to be proven over and over, until there is nothing left to conserve?

Myth no. 5: genetic data cannot contribute to conservation. There is a range of important information in conservation planning that can be contributed solely by genetic analysis. Perhaps most importantly, modern biodiversity assessment is dependent on genetics. An easily understood example is the uncovering of large numbers of 'cryptic species', which are very different although they look similar: if we do not know what is there, we certainly cannot protect it.

There is not room here to do justice to the case that genetic factors are important in endangerment, and that molecular genetics has a lot to offer conservation biology. I hope I have cast doubt on the bleak view presented by Elgar. Most population geneticists are well-motivated conservationists and intelligent scientists who recognise that an interdisciplinary approach to conservation is most likely to be successful. We should support and encourage this view.

—Paul Sunnucks
Monash University

Human Nature

I was perplexed by the views displayed by Allen E. Greer that "the less human influence there is, the more natural the outcome" (Last Word, *Nature Aust.* Autumn 1999). I prefer to believe that humans, for better or for worse, are an intrinsic part of the natural environment and unavoidably play their part—some might argue too great a part—in natural selection and evolution.

—Neil Willetts
Lindfield, NSW

Congratulations

As a relatively new subscriber to *Nature Australia* I write to express my admiration for the quality of your magazine. The photographs and articles are superb, and you are to be congratulated on the excellent presentation of a diverse range of topics. I particularly enjoy Steve Van Dyck's regular "The Backyard Naturalist" column. Apart from being informative, his witty writing style is just delightful, and I always get a chuckle out of the visions his creative turn of phrase conjures up!

—Vicki Bressan
Southport, Qld

Ambergris

On a recent late-night radio quiz show, the question "What is ambergris?" was asked. It was passed by at least eight contestants before someone stumbled on the answer. It prompted me to pen the following ditty. I plead poetic licence for using "prawn" when I know Sperm Whales eat squid.

Ambergris! Ambergris!
What in the world is that?
Is it a rejection from a
cachalot slightly over fat?
Its gastric system shaken by
excessive meals of prawn,
Resulting in a tummy ache
and a technicolour yawn.
A floating mass of rubbish
polluting the salty air,
To be rendered into perfume to
grace my lady fair.

—Bill Yates
Kandos, NSW

Easter Bilby Origins

The Anti-Rabbit Research Foundation of Australia (ARRFA) may control the trademark 'Easter Bilby' (*Nature Aust.* Spring 1998), but as John Hunwick pointed out (*Nature Aust.* Winter 1999), the ARRFA did not originate the concept, which was developed and popularised some years earlier.

Hunwick mentions Rose-Marie Dusting's 1979 book *Billy the Aussie Easter Bilby*, possibly the first published reference. The Easter Bilby is referred to on several occasions from 1984 onwards in *The Junior Naturalist*, published by the Hawthorn Junior Field Naturalists Club (HJFNC) in Melbourne. This documentation, along with other material and the memories of former members of the Club, suggest that the idea had currency even earlier. My research (to be published elsewhere) indicates that Malcolm Turner, a former President of the HJFNC, may have invented the Easter Bilby idea and first put it into practice at an annual Easter camp of the junior nats in the Little Desert in 1976. Instead of the kids (and their parents) getting the 'good rabbit' chocolate message on Easter morning, they were privileged to take part in the early development of this new cultural icon, one that fitted much better to the aims and sympathies of young naturalists. Malcolm, it should be noted, is quite prepared to countenance competing claims.

The issues of priority are important when one group with particular interests and objectives claims ownership and legal control of a concept in order to obtain benefits from its commercial use. However it is important that we attempt to gain a better understanding of the origin, development and popularisation of this idea and a keener appreciation of its utility while the idea and its manifestations are still young. The gradual winning of symbolic and iconic significance and influence by the Easter Bilby provides a beautiful object lesson on the types of actions and changes that are necessary to enculturate our natural environment and so protect it. However, the hard-won gains of such exercises have not been enough to stem the tide of destruction. Can strategies, practices and methods be adopted that will motivate the origination and propagation of a large swarm of such concepts to counter the Mickey Mouses and Bugs Bunnies of the world and help us to live better with nature?

—Ian Faithful
Carrum Downs, Vic.

In *Nature Australia* (Winter 1999), John Hunwick disputes that the Easter Bilby was the 1991 creation of the Anti-Rabbit Research Foundation of Australia, now the Foundation for Rabbit-Free Australia (RFA), stating that he possesses a book *Billy the Aussie Easter Bilby*, first published in 1979.

I have the same book. It was actually first published in 1997, a fact easily verified through the records of the National Library of Australia. No edition prior to that of 1997 is recorded.

His further claim that Melbas made and sold chocolate Easter Bilbies before Haighs is a curious attack, since that information is drawn from RFA's own publicity. More curiously, he ignores those produced even earlier, commissioned by RFA from an independent manufacturer, and widely recognised in media reports of the time as the "first chocolate Easter Bilbies".

Hunwick states that, ever since, Melbas, from the sales of its products, "have contributed proceeds to the saving of Bilbies . . . without reference to ARRFA", a damaging and untrue claim, since RFA supplies our trademark stickers to Melbas for these products, Melbas returns royalties to RFA from their sales and was last year awarded RFA's rarely bestowed Certificate of Appreciation for doing so.

Such attacks on a national conservation body may mystify your readers. In short, following RFA's successful creation of the Easter Bilby as a fund-raising trademark, others tried to divert royalties arising from it for their own ends. RFA's legal procedures stopped this, but some on the receiving end of them still try to muddy the historical waters.

Fortunately the waters remain clear, and the author of *Billy the Aussie Easter Bilby* is not among the culprits. We promote Dusting's book, which includes lavish praise of RFA's research and conservation work and a promise to forward royalties from the book's sales to RFA. These have been delivered, as promised, since its first publication in 1997.

—Robert G.B. Morrison
Foundation for Rabbit-Free Australia

Gecko Guff

By now you have probably been told that the "Wood Gecko" on page 50 of the Winter 1999 issue is in fact a velvet gecko, almost certainly a Robust Velvet Gecko (*Oedura robusta*). That article is also a bit misleading in saying that Lesueur's Velvet Gecko

is probably the most common gecko on the coast of New South Wales when in fact its coastal distribution only goes from about Wollongong to Newcastle (it extends inland to southern Queensland). The Broad-headed Snake is confined to this small coastal region and farther north the gecko has entirely different predatory snakes to contend with.

P.S. I thought Steve Van Dyck's article on earthworms was very funny.

—Tim Low
Chapel Hill, Qld

Conservation through Knowledge, or Not?

Wade Sherbrooke's article on Tree Lizards and the temperature needed for the change of belly colour (*Nature Aust.* Spring 1998) was a horrible example of 'stupid experiments'. Placing lizards into a glass case with little room to move and watching their bellies turn blue—how will this protect the species? Isn't there more crucial research needed when so many species are lost every day?

As a naturalist, it is a worry to see 'fluffy' articles with pretty pictures (great photography) and little substance, while environmental scientists sit and watch threatened species' remaining habitat get destroyed. There isn't that much left after 200 years and there is going to be a lot less tomorrow. It is a shame scientists don't seem to come out of the closet about the serious environmental crisis our country is facing at the moment.

I do wish to thank Mark Elgar on his article "Conservation Myths", for some informative journalism. The articles by Paul Jepson ("Yellow-crested Cockatoo") and Tom Heinsohn ("Captive Ecology") were also excellent.

'Conservation through knowledge' is an expression adopted by Birds Australia, but is this really the case? And if not, what is? I wish to know.

—Bruce Taylor
Armidale, NSW

Taylor's comments on my "stupid experiment" on lizard colours suggest a lack of understanding of the relationship between 'pure' and 'applied (in this case conservation) science' in our society.

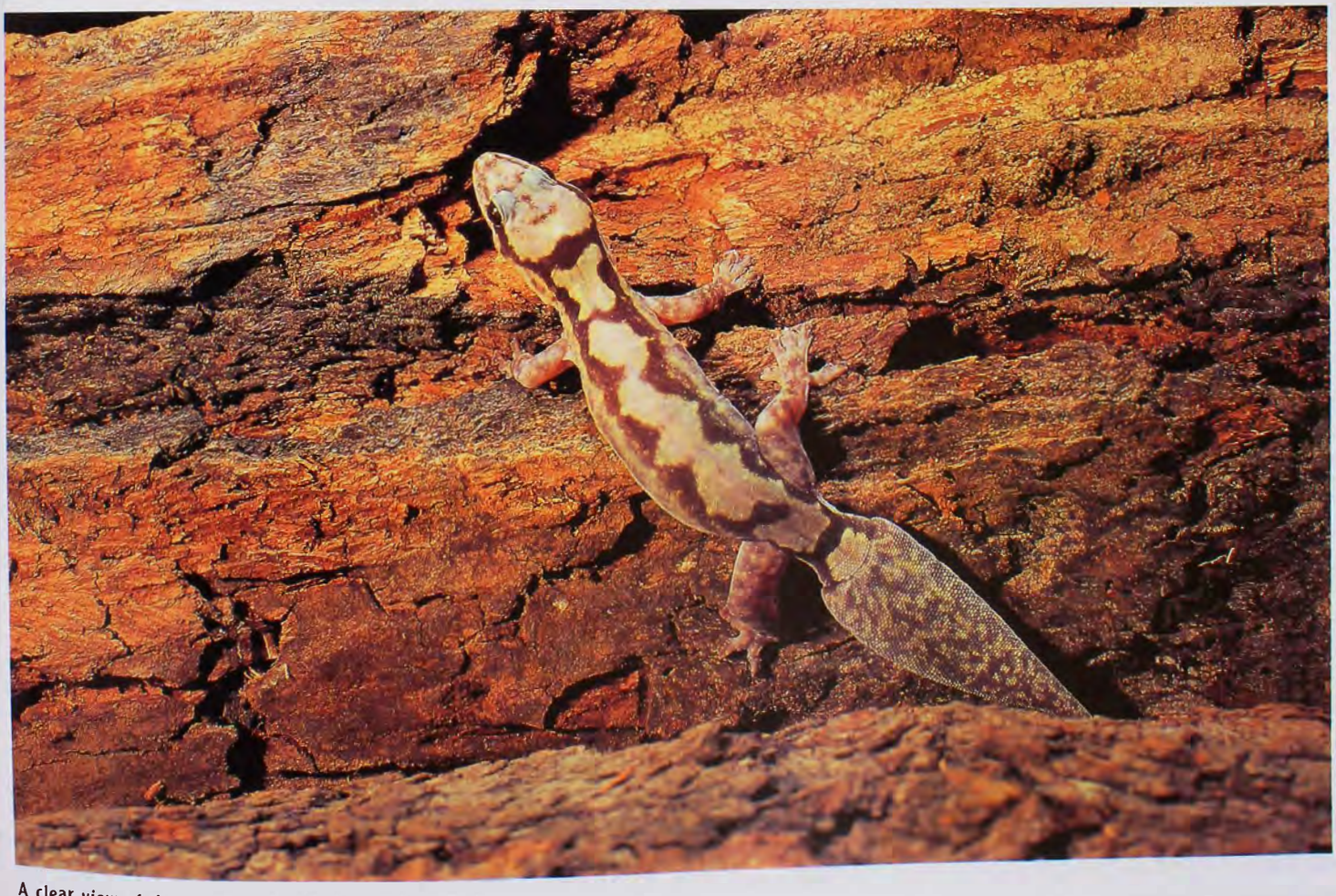
Decisions about how modern societies choose, legally and economically, to interact with the natural world, depend on human values. Concerning nature, we tend to value highly what we know, what we understand, and what we find to be intrinsically beautiful. We only fight and sacrifice for things and ideas we deeply understand and truly care about.

If I had an evening around a campfire with Mr Taylor, I am sure I could convince him that I have long been "out of the closet" on environmental concerns, as almost all biologists are. Hopefully he would see that bringing people's perspectives around to appreciating the finesse of a lizard's belly-colour changes can contribute to their understanding and appreciation of nature, and thus to the development of positive values toward the conservation of nature. The crisis he is concerned about is very real. The planet is experiencing human-generated collapse of the world's biodiversity.

The important battles in conservation today are not on the endangered species lists, but are in the hearts and minds of people whose actions will chart the course for what kinds of conservation values we will practise in the future. Every piece of our planet that we currently use for crops, buildings and car parks was previously the home of an evolved community of natural organisms. You and I have choices to make as the future engulfs us. Choices are based on values. I value lizards with blue bellies, and I sense that Mr Taylor and others could too. So, I research and write.

—Wade Sherbrooke
American Museum of Natural History

NATURE AUSTRALIA **welcomes letters for publication and requests that they be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in this issue will receive a copy of *Taming the great south land* from the Museum Shop. The winner this issue is Ambrose Chalarimeri.**



KATHIE ATKINSON

A clear view of the misidentified Robust Velvet Gecko.

Nature Strips

COMPILED BY
GEORGINA HICKEY

'Fairy' Penguins?

During a routine visit to Antarctic Ross Island, to study courtship behaviour in Adelie Penguins (*Pygoscelis adeliae*), researchers came across an extraordinary sight: two male Adelies mating. Not only is this the first time that homosexual mating has been observed in penguins, but the first time for any bird species that a homosexual pair was seen swapping positions.

As Lloyd Davis (University of Otago in New Zealand) and colleagues describe, the two penguins bowed deeply to each other—a precursor to copulation. One male lay down on a nest, and the other mounted him. The first male arched his head and bill upwards and raised his tail, while the other walked up and down his back, vibrating his bill against the other's bill—all standard courtship procedure.

The two then swapped positions, and went through the same mating behaviour again. The birds brought their cloacas into contact and the top penguin was seen to ejaculate. In response, the other contracted his cloaca in the same manner females do to help draw up semen into the reproductive tract.

Obviously there can be no adaptive value associated with same-sex mountings, so why did these Adelies do it? Davis and colleagues note that, during the relatively short (four-week) breeding season, a male penguin's testosterone levels can shoot up to 40 times that of normal levels. It may be that surging hormones create an overwhelming urge to mate, whether or not there are females present. Alternatively, for birds that don't have a great track record when it comes to mating (two-thirds of all couplings fail to deposit sperm in the female's reproductive tract), the authors suggest, tongue in cheek, that male penguins are simply following the principle that practice makes perfect.

—A.T.

Penguin Prostitutes

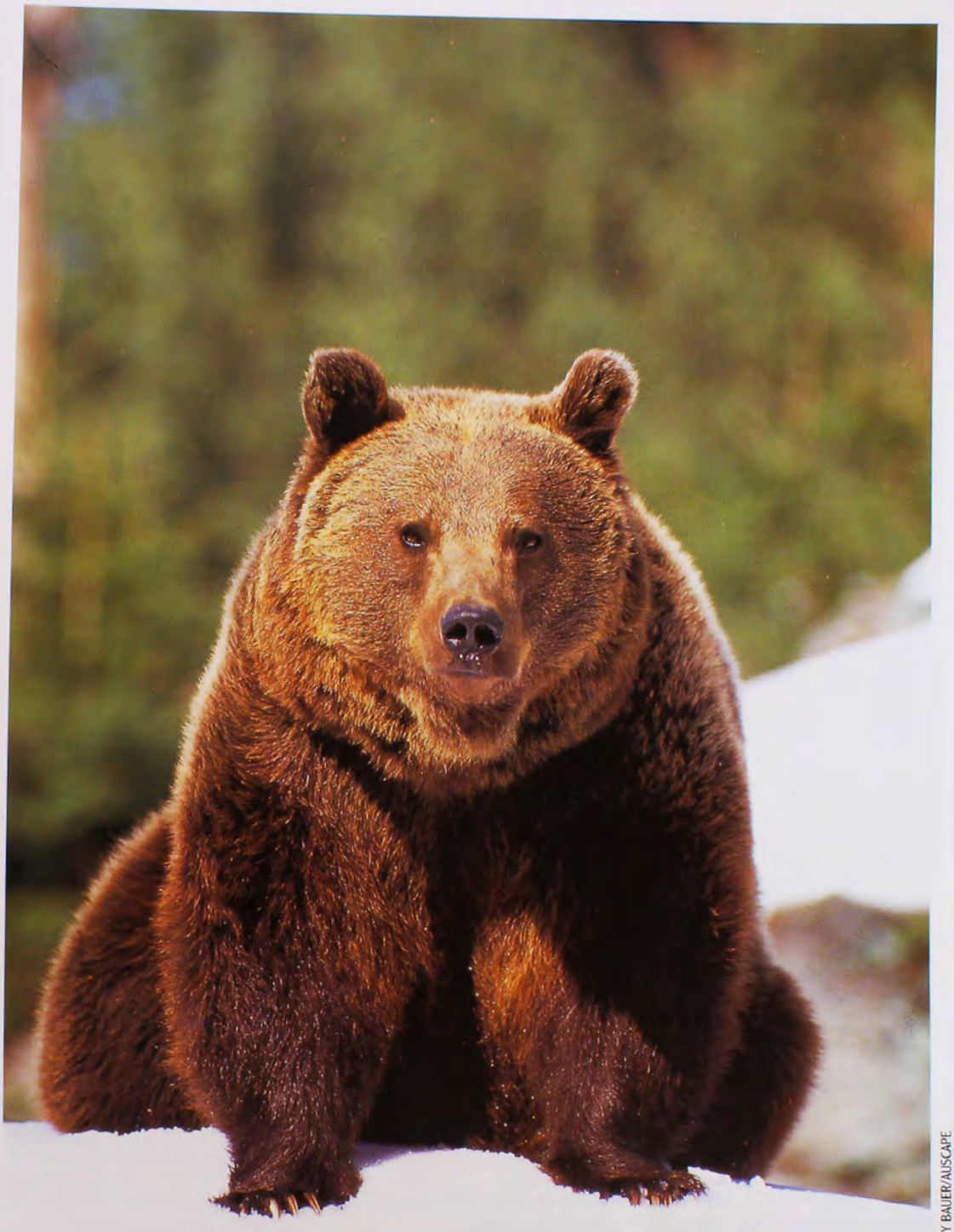
And if homosexual penguins weren't enough, how about penguins that prostitute themselves? Adelie Penguins on Ross Island have provided us with another first—the first time that a monogamous bird species has been caught having extramarital sex in return for material items. The currency, in this case, is stones.

Fiona Hunter from the University of Cambridge (UK) and Lloyd Davis (as in 'fairy'-penguin fame; see above) witnessed paired females soliciting sex with unpaired males. Immediately after copulation, the female picked up one of his nest stones and carried it back to her own nest. Some females went through the courtship ritual, then up and left, with stone in beak, before the male had a chance to mount her. Some returned

COLIN MONTEATH/AUSCAPE

Homosexuals, prostitutes . . . Adelie Penguins have it all.

Red pepper spray used as a Brown Bear repellent may actually have the opposite effect.



ERWIN & PEGGY BAUER/AUSCAPE

again and again, with one bird procuring a total of 62 stones within an hour.

But what's so special about stones? Adelie Penguins use them to form a raised platform on which they lay their two eggs. This way, when the ice melts in spring, the nest is not inundated.

And why are unpaired males so tolerant of these females' pebble-pinching ways, especially when they don't always get what they paid for? Hunter and Davis believe the males live in hope that they may eventually get to father an offspring, or, perhaps, that the female will return to settle down.

—G.H.

Mitey Dinosaurs?

Parasites have always been a large and important, if slightly unsavoury, component of biodiversity. Signs of parasitic infection appear over 550 million years ago as lesions on trilobites. It seems that almost as soon as animals became large enough to become infected, parasites evolved to hitch a free ride.

Birds can be attacked by a wide range of specialised parasites, including feather mites, which feed, mate and lay their eggs in the plumage. However, the fossil record of feather mites, as of most parasites, is very poor, and it was uncertain whether they evolved soon after feathers appeared over 140 million years ago. Thus, when British palaeontologists Dave Martill and Paul Davis from the University of Portsmouth noticed small spherical structures on a 120-million-year-old feather they were studying, they quickly realised the implications. The tiny structures were the eggs of feather mites, implying that feather-borne parasites are almost as old as feathers themselves.

Spectacular fossil discoveries in China have recently demonstrated that feathers were present on the small meat-eating theropod dinosaurs ancestral to birds. Feathers therefore first evolved in dinosaurs such as the appropriately named *Protarchaeopteryx*, and were passed on to their avian descendants. The ancient age of feather-borne parasites means that they probably evolved early enough to infect dinosaur plumage as well. Thus, it is likely that birds inherited from their dinosaurian ancestors not only feathers, but also a host (pun intended) of associated parasites.

—Michael Lee
University of Queensland

Bear Spray

Red pepper or capsicum spray is sold commercially in the United States as a defence against aggressive bears. Sprayed directly into a bear's face, it produces a painful burning sensation, temporarily disabling the animal. Campers have also been using the irritant spray as if it were a repellent, spraying objects and camp sites to ward off bears. However, a recent study has shown that using the spray in this way actually has the opposite effect.

Tom Smith of the US Geological Survey watched the response of Brown Bears (*Ursus arctos*) to red pepper spray residues, at test sites in Alaska's Katmai National Park. He found that most of the bears were interested in the smell—sniffing, pawing, rubbing or rolling in it—and in no case were bears repelled from a treatment site. This indicates that the use of red pepper spray around camp sites may be dangerous

D. HARING/DUPC/OSF/AUSCAPE

Wood-tapping Aye-ayes home in on the sound of a subsurface crack.

as it would make the area more inviting to curious bears.

Since Brown Bears rely most heavily on smell to locate food in their environment, it is not surprising that pungent and novel scents are attractive. Indeed, as a general safety precaution, visitors to bear country are encouraged to rid camp sites of all strongly scented articles, including toothpaste, soap and aromatic food items. The misuse of red pepper spray as a repellent is presently omitted from the product's warning labels. To further compound the problem, the manufacturers recommend that newly purchased red pepper spray canisters be test-fired, which campers frequently do near camp sites.

—P.R.

Aye-ayes Look for a Break

Wood-boring larvae of moths and beetles are among the favourite foods of the Aye-aye (*Daubentonia madagascariensis*), an endangered primate found only on the Indian Ocean island of Madagascar.

The Aye-aye locates these soft, plump morsels by tapping the wood of trees with its long fingers—in particular, the skinny middle finger on each of its hands. It then gnaws down through the wood and prises the grubs out with its long digits.

Research has confirmed that the Aye-aye tracks down its larval prey by following acoustic signals that bounce back not so much from the insects themselves but from the wood cavities in which they dwell (see *Nature Aust.* Spring 1992). A recent study led by Carl Erickson, of North Carolina's Duke University, attempted to clarify exactly what sound cues the Aye-aye follows when it is foraging.

The researchers filled cavities in spruce wood blocks with a range of materials of different densities and monitored the responses of captive Aye-ayes. They found that, even when the cavities were filled, the Aye-ayes still scratched away at them, suggesting that it isn't echoes from empty spaces to which they respond. And nor do they seem to recognise changes in density within the wood because it didn't matter what the cavities were filled with (metal, wood or foam), the Aye-ayes still scratched away regardless. Only when wooden plugs were actually glued into place, thus eliminating any vibration at the cavity boundary, did Aye-ayes lose interest in the block.

It seems that these primates respond to the change in sound that occurs at the interface between the wood and any subsurface break or crack. And it is these breaks in the wood that also happen to house wood-boring grubs. Erickson speculates that it is probably lucky for Aye-ayes that the high humidity in their rainforest homes limits the cracking of wood so common in drier environments. Otherwise much of their efforts spent 'scratching at the surface' would be just that.

—K.McG.

Crabs with Balls

Male fiddler crabs (*Uca* spp.) are famous for having one huge claw (sometimes bigger than their body), which they wave to attract females and deter would-be rivals. But claw-waving is only part of the picture of sexual rivalry in the intertidal world of fiddler crabs, as Rui Oliveira (Instituto Superior de Psicologia Aplicada, Portugal) and colleagues discovered when they looked at mud-balling in European Fiddler Crabs (*Uca tangeri*).

Many fiddler crabs build mud or sand structures around the entrance to their burrows. Both male and female European Fiddler Crabs adorn the openings of their burrows with balls of mud. Could these mud balls be just a side-effect of excavation? Maybe so. But why do males construct 20 per cent

more mud balls than females, despite being only 12 per cent larger in body size?

When Oliveira *et al.* removed the mud balls from around a male's burrow, the male became involved in many more fights and threats with his neighbours. And this was not just because males were more visible without their mud balls (their outsized claws extend well above this barrier). Perhaps the line of mud balls acts like a territory-defining fence, deterring unnecessary incursions.

The researchers also discovered that female European Fiddler Crabs like mud balls. When offered a choice of dummy males surrounded by varying numbers of mud balls, females tended to choose the males with the most mud balls. Perhaps they use the number and/or volume of mud balls to assess the quality of the male or even the size of his brood chamber. And, if so, the combination of claws and balls makes male European Fiddler Crabs well equipped for the double role of fending off males and attracting females.

—D.C.

Debunking the Barbie Myth

In some cultures, men prefer plump women. In others, they like them slim. But whatever their weight preferences, men have a widespread predilection for females with low waist-to-hip ratios (WHRs).

This has been revealed repeatedly by anthropological surveys—across time, cultural, geographic and economic boundaries. In fact, it's been widely accepted, as one of the few constants of human attraction, that males prefer wasp-waisted or 'gynoid' women (think Barbie) over their thick-waisted sisters.

But there's a problem with this generalisation, according to Douglas Yu (Imperial College at Silwood Park, UK) and Glenn Shepard (University of California at Berkeley). Even the most remote settlements on Earth are exposed to images from the developed world in which the curves of

Are all men innately attracted to the image of a wasp-waisted woman, or is this simply an artefact of Western conditioning?

C. ANDREW HENLEY/LARUS

FERRERO-LABAT/AUSCAPE

Could the Hippopotamus (*Hippopotamus amphibius*) be a proto-whale? Recent studies demonstrate extensive genetic similarities between hippopotamuses and whales.

particularly gynoid women are used as marketing tools. Perhaps Western preferences are simply rubbing off on them?

To test this idea, Yu and Shepard sought the WHR preferences of some of the most culturally isolated humans on Earth today—a group of Matsigenka people in Yomybato village in south-east Peru. They found that Yomybato men prefer women who by Western standards would be considered overweight and, regardless of weight, they like their women to have high WHRs. Slim gynoid women, so popular in the West, are considered unhealthy.

The researchers also studied Matsigenka people from the village of Shipetiari, which has had more exposure to Western media. Shipetiari men also find overweight women attractive and regard a high WHR as a sign of good health, but they rate women with low WHRs even more attractive and preferable as spouses, which suggests their preferences are shifting.

The men of even more Westernised indigenous people that live a little farther away have similar WHR preferences to men in the United States.

It seems, therefore, that the human male's preference for wasp-waisted females is not so much an innate part of the human condition but an artefact created by the influences of Western media.

—K.McG.

The Way to a Whale

The origin of whales from typical land mammals has posed a long-standing challenge for evolutionary biologists. Discoveries of primitive fossil whales with well-developed legs appeared to resolve the issue by linking cetaceans with extinct hoofed carnivores called mesonychids, which are only distantly related to modern hoofed mammals. If so, whales are descended from these ancient terrestrial predators, and they too must have no close modern relatives.

However, an intriguing alternative scenario has recently emerged. In two separate studies, John Gatesy from the University of Arizona (USA), and Bjorn Ursing and Ulfur Arnason from Lund University (Sweden), examined extensive DNA sequences from whales and a range of other mammals. The molecular evidence demonstrated that hippopotamuses are very closely related to whales (an idea first proposed in 1994), and further reflection revealed that hippos are actually very whale-like in both anatomy and behaviour. Both hippos and whales possess bloated, elongated bodies and ridiculously little limbs, both lack hair and sebaceous (oil) glands over much of the skin, and both have their testicles positioned within the body rather than dangling free. Also, unlike most mammals but like whales, hippos mate, suckle their young and communicate extensively while under water. Could the surprisingly whale-like squeals and clicks emitted by hippos represent a primordial stage in the evolution of whale song?

Until now these similarities were dismissed as convergent adaptations to life in water, but the molecular studies suggest whales directly inherited them from an aquatic, hippo-like ancestor (rather than a cursorial carnivore). If living hippos indeed represent 'proto-whales', the missing link between whales and land mammals was never missing after all.

—Michael Le
University of Queensland

Burnt Offerings for Big Bird?

Fossil eggshells of the large flightless 'thunder bird' *Genyornis newtoni* offe a crucial insight into the Pleistocene extinction of Aus tralia's megafauna. The extinctions are a mystery t

many scientists who cannot agree on a single main cause or an explanation as to why some large species disappeared while others like the Red Kangaroo and Emu survived. Did increasingly arid climates give Emus and other surviving species a competitive edge? Did the early Aborigines hunt the giant animals and *Genyornis* to extinction? Or was their last meal so badly burnt by the first Australians that the Big Birds (and other megafauna) starved to death?

Gifford Miller (University of Colorado) and colleagues have found exciting evidence that fire may be the main cause. Their argument is based on the resistant chemical properties of eggshell, which allow precise estimates to be made of the age, associated climate and feeding habits of the birds, even from the tiniest fragments. For the first time, attempts to directly date an actual element of the megafauna (eggshell) have produced reliable and consistent results. By sampling eggshell from three different regions of arid and semi-arid Australia, the researchers demonstrated that Emus and *Genyornis* were companions for hundreds of thousands of years until, in one fell swoop about 50,000 years ago, *Genyornis* died out from each of the areas (and presumably the rest of the continent). They found no evidence that climatic change triggered the extinctions but do point out that 50,000 years ago was around the time that humans may first have arrived in Australia. Isotopic analysis of the eggshells indicates that *Genyornis* relied on a specialised diet of leaves, while Emus ate both leaves and grasses. The researchers suggest that the change in landscape-burning regimes caused by the earliest Australians led to the loss of leafy habitat, which in turn led to the extinction of *Genyornis* and other large browsers (indeed, most of the megafauna were probably browsers). The less fussy Emus (with their broader-based diet) were able to survive the change to a more grassy vegetation.

Was their last meal so badly burnt by the first Australians that the Big Birds starved to death?

While certainly plausible, the 'burnt offerings' explanation for megafaunal extinctions invites the testing of several implications and assumptions. For example, is there secure evidence of humans in the landscape 50,000 years ago, or even that this was the time of their first arrival? Do ecological data support an increase or change in burning at this time? Could younger 30,000-year-old age estimates for *Genyornis* (found at Cuddie Springs, New South Wales) suggest a more gradual demise? Although each of these issues is hotly debated, the tiny eggshell fragments of this Big Bird may yet solve the greatest mystery of Australian prehistory.

—Richard Fullagar
Australian Museum

The King's Poo

Recently, palaeontologists struck paydirt when they discovered an enormous piece of fossilised dung protruding from a Canadian rock formation. Not only did it

K. SCHAFER-PETER ARNOLD/AUSCAPE

COURTESY DAVID LUBMAN

Design or accident? Echoes produced from the steep staircases of the Mayan Temple of Kukulkan sound like the chirping of the sacred Resplendent Quetzal (top).

reveal what its owner ate, but how it processed its food as well.

Karen Chin (United States Geological Survey) and colleagues found a high proportion of small bone fragments in the 7.1-kilogram coprolite, indicating it came from a large carnivorous dinosaur. Of the theropods known from the sediments in the area, only *Tyrannosaurus rex* was capable of producing such a deposit. This is very exciting because coprolites are usually taxonomically indistinct.

The sharp edges of the bone fragments (probably a juvenile hadrosaur or ceratopsian dinosaur) indicate the bones were fractured before eating, and were incompletely digested. This is contrary to some suggestions that, like living reptiles with poor dental occlusion, the extinct theropods did little in the way of reducing prey items to a manageable size before eating them.

Also recently emerged from the 'bowels' of the Earth, this time from a cave in Nevada, is a 20,000-year-old lump of sloth poo. Believed to be from the extinct ground sloth *Nothrotheriops shastensis* whose skeleton was found nearby, Hendrik Poinar (University of Munich) and colleagues were able to identify DNA from the plants consumed by the doomed animal.

While DNA from fresh excrement is easily extracted, this is the first time it has worked on ancient faeces. They found DNA from seven groups of plants, which presently exist only at elevations about 800 metres above the cave, suggesting the climate was colder and wetter than today. One of the plants was a type of grape that today only grows around springs and streams. The closest known water sources or palaeosprings of relevant age are between 10 and 20 kilometres away, suggesting the sloth had a long hike to quench his thirst.

—R.S.

Pyramids Mimic Bird Calls

When tourists clap their hands at the base of the steep limestone staircases that climb the outside walls of the Mayan pyramid known as the Temple of Kukulkan (at Chichén Itza, Mexico), a curious bird-like echo is produced.

Intrigued by such reports, David Lubman, an acoustical consultant from California, decided to visit the 1,300-year-old site for himself. One look at the structure of the staircases (completed about 900 years ago) made it clear to him how such a distinctive echo could be produced. The hundred or so evenly spaced steps give rise to periodically spaced echoes, and these produce the tonal sounds heard by visitors. The steps have relatively high risers and short treads (the part where you put your foot). Although sound is echoed from each of

JEAN-PAUL FERRERO/AUSCAPE

Monkey business: rank differences in Japanese Macaques may determine whether the female reaches orgasm.

these step-faces, acoustical engineering predicts that the individual echoes produced first from the lower, closer steps will be higher in pitch compared to those from the progressively higher and more distant steps. The result is a rapid succession of echoes descending in pitch that sounds remarkably like the chirping of a bird.

Is the bird-like echo an accidental by-product of pyramid design? After all, buskers in today's cities often choose to perform near bridges or steps to enhance acoustics, even though the original architects did not anticipate these uses. However, Lubman thinks otherwise. He believes the pyramid stairs were intentionally built for their peculiar sonic properties.

The echo is reminiscent of the cry of the Resplendent Quetzal (*Pharomachrus mocinno*)—the national bird of Guatamala. This magnificent bird, now critically endangered, was considered sacred by the Mayan people. Indeed, it is often depicted with the mythical human-like figure of Kukulkan. When Lubman compared sonagraphs of the echo with that of the bird, he found a remarkable match. (If you want to listen to it for yourself, click on "Quetzal bird chirps" at *http://www.ocasa.org/MayanPyramid.htm*.) Lubman believes that the Mayan people incorporated the quetzal-like cries into the sacred ceremonies conducted at the pyramid. Although there is no other evidence that the Mayans used quetzal cries in their ceremonies, the idea certainly sounds good and archaeologists applaud the research.

—Richard Fullagar
Australian Museum

Alpha Males Make the Earth Move

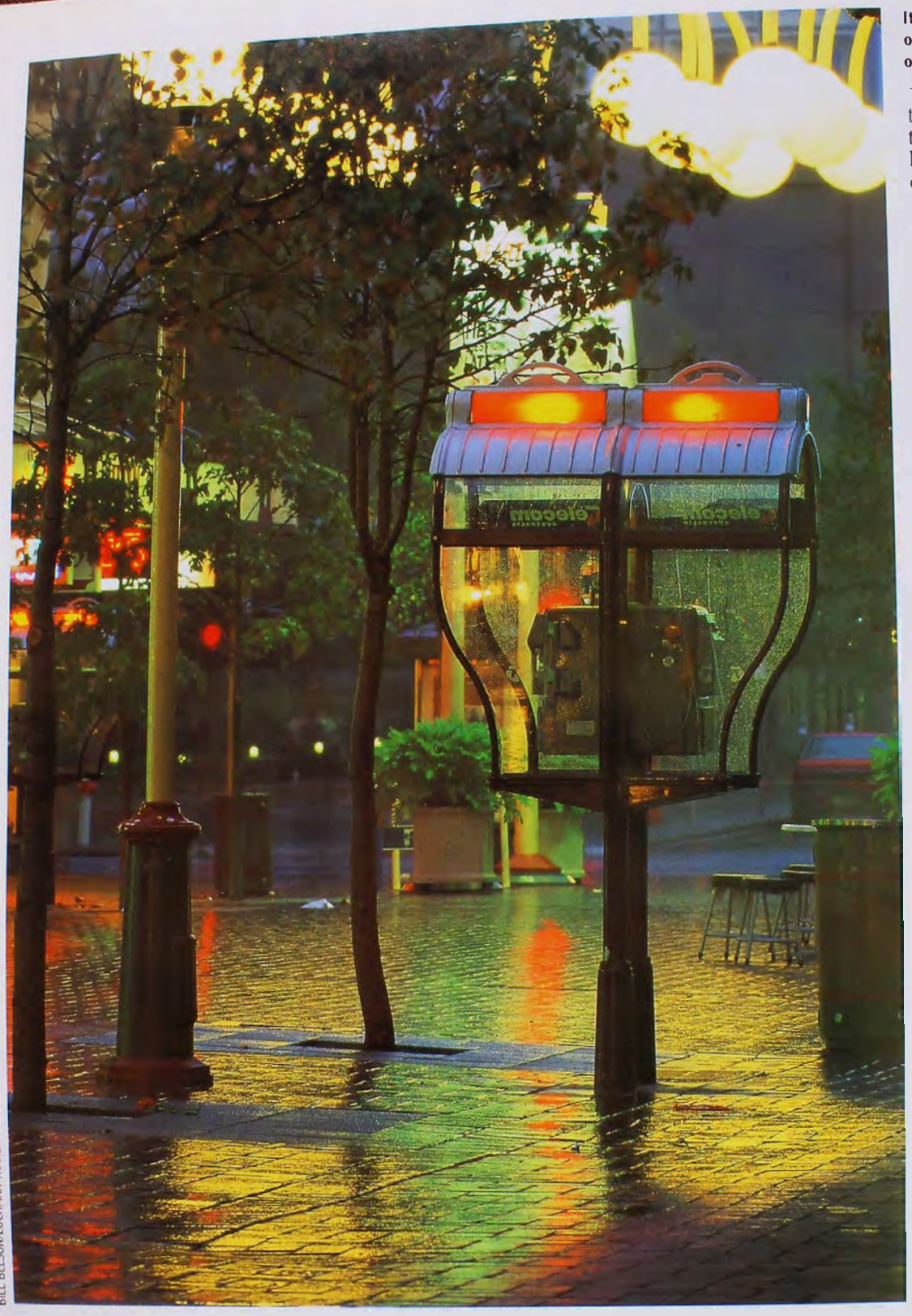
Female orgasms are a sensitive issue in more ways than one, with their very existence being called into question by past scientists. While few scientists today debate the existence of female orgasms in humans, the evolutionary significance and existence of the female orgasm in other primates is still hotly debated.

Recent work by Alfonso Troisi (Università di Roma Tor Vergata) and Monica Carosi (Università di Roma La Sapienza) casts light upon the role of female orgasms in captive Japanese Macaques (*Macaca fuscata*). While observing the natural behaviours of a large colony of macaques over eight months, Troisi and Carosi counted 240 heterosexual copulations between 68 different pairs of macaques. Of these copulations, a third of the females showed behaviours indicative of orgasms (clutching, body spasms and characteristic vocalisations).

There was no overall difference in the age or dominance of females that experienced orgasms, but longer copulations, with a greater number of mounts and pelvic thrusts, were more likely to result in female orgasm. However, an even more significant factor leading to female orgasm involved the social relationships between the mating partners. More orgasms occurred in copulations between low-ranking females and high-ranking males, than between males and females of equivalent rank or between high-ranking females and low-ranking males.

Some scientists think that female orgasm at the time of ejaculation increases the chances of fertilisation, or that the clutching reaction helps trigger ejaculation. Orgasms might increase a low-ranking female's chance of having offspring with a high-ranking male, and being mother to the boss's kids has other benefits like protection and access to resources. High-ranking females, in comparison, mate with high-ranking males more often anyway and may not need to rely on orgasms to ensure paternity by the dominant male. For female macaques at least, there may be some rewards for being at the bottom of the pecking order!

—D.C.



BILL BELSON/LOCHMAN TRANSPARENCIES

It seems it really does rain more on weekends, and we only have ourselves to blame.

Rainy Weekends

Isn't it typical? You work for five days in glorious weather, then the weekend comes and it rains. Well, it's not just a coincidence, according to new research. Randall Cerveny and Robert Balling, climatologists from Arizona State University, have linked the build-up of pollution from traffic and industry during the week with an increase in rainfall on weekends.

Cerveny and Balling analysed three-and-a-half years of air-quality data for the north-east coast of North America and discovered a weekly cycle in the concentrations of carbon monoxide and ozone. Highest levels were recorded late in the week (Thursday and Friday) and lowest levels early in the week (Sunday to Tuesday). Since weekly cycles are a strictly human phenomenon, the researchers believe that, as pollution increases during the week, it absorbs heat, causing the air to rise, leading to more clouds and rain. Between 1979 and 1985, the north-west Atlantic coast received 22 per cent more rain on Saturdays than on Mondays. Interestingly, a weekly but delayed cycle of precipitation occurred in the mid-Atlantic, with rain peaking on Tuesdays. Since the prevailing wind direction is to the east, this is just the pattern one would expect if pollution was indeed helping to create rain clouds.

It seems we can no longer curse higher powers for ruining our weekend barbeques. We now have only ourselves to blame.

—J.M.

Opposites Attract

What makes two people fall in love? New research has lent credence to the old wives' tale that opposites attract—on a genetic level anyway.

Carole Ober (University of Chicago) has found that we avoid prospective mates whose genes that control the immune system are too similar to our own, particularly those known as the major histocompatability complex (MHC) or, in humans, the human leukocyte antigen (HLA) system. These groups of genes guide the production of antibodies and rejection of foreign tissue.

Work with inbred mice in the late 1970s demonstrated that individuals were more likely to mate with those with different MHC genes; subsequent research revealed that when newborn male mice were placed with foster mothers of a different MHC strain, they subsequently avoided females whose MHCs were similar to their foster mother's. It seems that the mice somehow imprint on their mother's (or foster mother's) MHC at an early age.

Ober investigated this theory in relation to the genetics of fertility in the Hutterites, a special group of inbred people from the USA. As expected, she found that the number of miscarriages increased significantly when parents shared the same HLA genes. Since the best immune systems are those with a wide array of antibodies, it is not surprising that natural selection would tend to favour fetuses with HLA systems different from their mothers'. When Ober traced HLA inheritance, she found that, if

a couple had a matching set of HLA genes, it usually came from the paternal side. Like the mice, it seems, both partners avoided choosing a mate with genes resembling their mothers'.

But how? Smell could play a key role—not only are people able to smell the difference between mice of different MHC types, a recent study found that, when T-shirts were imbued with the scent of men with different HLA systems, women preferred those with systems different to their own. I guess we've known all along that the scent of a man is all-important when a woman chooses a lover. But now, perhaps, we know why.

—R.S.

Bee's Swan Sting

If we know we are going to die soon, how valuable is the life we have left? In the world of the Honey Bee (*Apis mellifera*), it seems that the bees that are closest to death could be the ones that make the greatest contribution.

PASCAL GOETGHELUCK/AUSCAPE

With part of its guts attached to the sting, this Honey Bee has nothing much left to lose.

While a bee sting means pain for the stung, it means certain death for the insect. Not only is the entire stinging apparatus left behind in its victim, but the end of the digestive tract is as well. Bees usually die within 18 to 114 hours.

Sarah Cunard and Michael Breed from the University of Colorado wondered if these colonial insects, with nothing much left to lose, might take greater risks in defending the hive. Worker bees were made to sting a piece of leather by treating it with an alarm pheromone, normally released during ejection or removal of a sting, which induces other bees to attack. Next, someone stood in front of the hive to alert the bees, then walked away. The researchers found that over a quarter of the bees that chased and harassed the intruder had stung the leather. In a separate experiment, in which the bees were confronted with a bee from another colony, bees that had stung were again found to be more aggressive than those that had not stung.

Interestingly it seems that it takes more than just the physical stimulus of losing a

MARIE LOCHMAN/LOCHMAN TRANSPARENCIES

The golden orb-weaver *Nephila edulis*. Scientists are one step closer to manufacturing artificial spider silk.

sting to arouse the bees into pursuit behaviour. Bees that had had their sting removed while anaesthetised did not engage in defensive behaviour, only those that had lost their sting in full swing.

—A.T.

Spider Silk Production Line?

A spider's silk is stronger than steel and more elastic than the fibres used in bulletproof vests. A recent study on how the Garden Cross Spider (*Araneus diadematus*) makes its dragline silk is providing clues as to how we can artificially manufacture such silk on an industrial scale.

Silk production in spiders begins as a liquid protein secreted in special glands. In dragline silk, the liquid then travels down a progressively narrowing spinning tubule and eventually emerges as a solid through a spigot to the outside. But what is it that turns the liquid silk into the solid, elastic state? Fritz Vollrath (University of Aarhus in Denmark) and colleagues believe it is the acid bath that the spider creates for itself.

Examination of the inner walls of the spinning tubule showed fine corrugations, which are thought to be involved in ion transport. Water is removed from the top end of the spinning tubule and then hydrogen ions (H^+) from the water are pumped back into the tubule farther down, increasing the pH level (making it acidic). This results in strong hydrogen bonds forming between the thickening 'paste' of silk molecules, which interlink firmly to harden into the insoluble fibre that emerges from the spigot.

Acid baths are also used in the manufacture of today's industrial polymers (such as rayon) but Nature's method, through millions of years of evolution, has shown itself to be much more sophisticated and economical. If we could only simulate natural spider silk production, we would also have a recyclable product. We could dispose of it without guilt, or we could eat it—it works for the spiders anyway.

—J.M.

Indonesian Coelacanth

The discovery of the first live Coelacanth in 1938 caused great excitement because it was the sole surviving member of a lineage of fishes thought to have become extinct about 80 million years ago. Living Coelacanths are rarely collected, and when they are it is from their presumed home in the Comoro archipelago near Madagascar. Three specimens were found to the south of the Comoros, but genetic analysis has shown that these were strays from the same population. It was with great surprise, therefore, that in July 1998 a Coelacanth was collected by fishermen off northern Sulawesi, 10,000 kilometres from the Comoros. The new Indonesian specimen is not actually the first to be reported from northern Sulawesi. In 1997 Mark Erdmann (University of California at Berkeley) photographed a Coelacanth that his wife noticed being wheeled across a fish market in Manado and, during subsequent interviews, several fishermen claimed to have captured Coelacanths, which they call *raja laut*, or 'king of the sea'. These extraordinary new discoveries provide strong evidence that there is a permanent Indonesian population of Coelacanths.

Mark Erdmann and Roy Caldwell (also from the University of California at Berkeley), and Kasim Moosa from the Indonesian Institute of Sciences, suspect that the Indonesian Coelacanth may be the same species (*Latimeria chalumnae*) as the population known from the Comoro Islands, although only a complete genetic and morphological analysis will tell for sure. Certainly they appear very similar from the outside, except that, rather than being a mottled steel blue colour, the Indonesian Coelacanth is mottled brown. It is unlikely that Coelacanths exist in two small, highly disjunct populations, and Erdmann and colleagues argue that additional populations may be discovered between the Comoros and Indonesia. Arnold Gordon of Lamont-Doherty Earth Observatory in New York agrees. He suggests that Coelacanth populations may exist along the route of an oceanographic current linking the Indonesian Islands with the Comoros. If this is true, the discovery of additional populations will enhance the prospects of survival for this fascinating and critically endangered fish.

—S.R.

Further Reading

Cerveny, R.S. & Balling, R.C. Jr, 1998. Weekly cycles of air pollutants, precipitation and tropical cyclones in the coastal NW Atlantic region. *Nature* 394: 561–563.

Chin, K., Tokaryk, T.T., Erickson, G.M. & Calk, L.C., 1998. A king-sized theropod coprolite. *Nature* 393: 680–682.

Cunard, S.J. & Breed, M.D., 1998. Post-stinging behavior of worker honey bees (Hymenoptera: Apidae). *Ann. Entomol. Soc. Am.* 91(5): 754–757.

Davis, L.S., Hunter, F.M., Harcourt, R.G.

& Heath, S.M., 1998. Reciprocal homosexual mounting in Adélie Penguins Pygoscelis adeliae. *Emu* 98: 136–137.

Erdmann, M.V., Caldwell, R.L. & Moosa, M.K., 1998. Indonesian 'king of the sea' discovered. *Nature* 395: 335.

Erickson, C.J., Nowicki, S., Dollar, L. & Goehring, N., 1998. Percussive foraging: stimuli for prey location by aye-ayes (*Daubentonia madagascariensis*). *Internatl J. Primatol.* 19(1): 111–122.

Gatesy, J., 1997. More DNA support for a Cetacea-Hippopotamidae clade: the blood-clotting protein gene gamma-fibrinogen. *Molec. Biol. Evol.* 14: 537–543.

Gordon, A.L., 1998. Coelacanth populations may go with the flow. *Nature* 395: 634.

Hunter, F.M. & Davis, L.S., 1998. Female Adélie Penguins acquire nest material from extrapair males after engaging in extrapair copulations. *The Auk* 115(2): 526–528.

Lubman, D., 1988. *Archaeological acoustic study of chirped echo from the Mayan pyramid of Chichén Itzá*. Meeting of the Acoustical Society of America. 12–16 October 1998. Norfolk, Vancouver.

Martill, D.M. & Davis, P.G., 1998. Did dinosaurs come up to scratch? *Nature* 396: 528–529.

Miller, G.H., Magee, J.W., Johnson, B.J., Fogel, M.L., Spooner, N.A., McCulloch, M.T. & Ayliffe, L.K., 1999. Pleistocene extinction of *Genyornis newtoni*: human impact on Australian megafauna. *Science* 283: 205–208.

Ober, C., Hyslop, T., Elias, S., Weitkamp, L.R. & Hauck, W.W., 1998. HLA matching and fetal loss: results of a 10-year prospective study. *Human Reproduction* 13: 33–38.

Ober, C., Weitkamp, L.R., Dytch, H., Kostyu, D.D., Elias, S. & Cox, N., 1997. HLA and mate choice in humans. *Am. J. Hum. Genet.* 61: 497–504.

Oliveira, R.F., McGregor, P.K., Burford, F.R.L., Custódio & Latruffe, C., 1998. Functions of mudballing behaviour in the European fiddler crab *Uca tangeri*. *Anim. Behav.* 55: 1299–1309.

Poinar, H.N., Hofreiter, M., Spaulding, W.G., Martin, P.S., Stankiewicz, B.A., Bland, H., Evershed, R.P., Possnert, G., Pääbo, S., 1998. Molecular coproscopy: dung and diet of the extinct ground sloth *Nothrotheriops shastensis*. *Science* 281: 402–406.

Qiang, J., Currie, P.J., Norell, M.A. & Shu-An, J., 1998. Two feathered dinosaurs from northeastern China. *Nature* 393: 753–761.

Small, M.F., 1998. Love with the proper stranger. *Nat. Hist.* 9/98: 14–19.

Smith, T.S., 1998. Attraction of brown bears to red pepper spray deterrent: caveats for use. *Wildl. Soc. Bull.* 26(1): 92–94.

Troisi, A. & Carosi, M., 1998. Female orgasm rate increases with male dominance in Japanese macaques. *Anim. Behav.* 56: 1261–1266.

Ursing, B.M. & Arnason, U., 1998. Analyses of mitochondrial genomes strongly support a hippopotamus–whale clade. *Proc. R. Soc. Lond. Ser. B* 265: 2251–2255.

Vollrath, F., Knight, D.P. & Hu, X.W., 1998. Silk production in a spider involves acid bath treatment. *Proc. R. Soc. Lond. B* 265: 817–820.

Yu, D.W. & Shepard, G.H., 1998. Is beauty in the eye of the beholder? *Nature* 396: 321–322.

Danielle Clode, Jason Major, Karen McGhee, Stephen Richards, Philippa Rowlands, Rachel Sullivan and Abbie Thomas are regular contributors to Nature Strips.

QUICK QUIZ

1. What was the name of the devastating cyclone that hit the town of Exmouth (WA) in March 1999?
2. Where is the Ross Sea?
3. What colour are bandy-bandy snakes?
4. Which two main scientists discovered the double-helix structure of DNA?
5. What is autotomy?
6. Give the common name for *Architeuthis* species?
7. What is 3.14159 better known as?
8. Which cicada sex makes all the noise?
9. What is the name of the virus, discovered last March in Malaysia, that kills pigs and also humans (and other animals)?
10. Who is the President of the Australian Conservation Foundation?

(Answers in Q&A)

Cane Toads are no fools. They are quick-learning, opportunistic, tough and toxic.

HAVE WARTS... WILL TRAVEL

BY STEVE VAN DYCK

ONE WORD BEST DESCRIBES how tropical north Queensland must have looked through the eyes of the first Cane Toad turned loose on 22 June 1935 . . . goluptious.

"It was, indeed, the most beautiful stew in the world, being made of partridges, and pheasants, and chickens, and hares, and rabbits, and peahens, and guinea fowls, and one or two other things. Toad took the plate on his lap, almost crying, and stuffed, and stuffed, and kept asking for more . . . (*The Wind in the Willows*, Kenneth Grahame, 1908).

And so, guided by an undiscriminating palate and an appetite like the Moura Coal Drag Line, that first toad, one of the original 120-strong army of unsavoury importees, set off to give cane beetles a lashing. The whole charade was an ill-fated gamble whose backfire is celebrated among the most notable of Australian ecological cock-ups.

The South American Marine or Cane Toads (*Bufo marinus*), which had actually been imported from Hawaii, couldn't tell scarabs from skinks, and for most of the time their target diet of cane beetles was either up out of sight in the cane stalks, or out of mind pupating underground. So the toads ate everything their clever flying tongues could make a grab for . . . lizards, spiders, small snakes, mouse-sized marsupials and rodents, but mostly all kinds of insects, 'beneficial' or otherwise.

Like the Indian or Common Mynas (*Acridotheres tristis*) taken to Townsville in 1876, toads failed to make an impression on cane beetles. But unlike those cocky birds that stuck mostly to the towns of the north, the toads gobbled their way up and down the Queensland coast until today they are found in suburbs and bushland well into both New South Wales and the Northern Territory.

I saw my first Cane Toads in Sydney about 40 years ago when Toy Fisheries, an enormous, avant-garde tropical fish emporium, was plunging into untested waters selling designer pets like newly hatched Estuarine or Saltwater Crocodiles for around ten pounds each, and Cane Toads for the discerning buyer. There in a dry plastic-lined above-ground pool were about a zillion Sunshine State toads in a grizzly continuum of life and death, clambering over one another, puddling and amplexing in their own filth. I think the going price was around five shillings each, which by the look and smell of the groping mass was a gross presumption on southern cosmopolitanism.

I do remember being genuinely tempted to buy one of these northern curiosities, but it was their contagious-looking skin condition that clinched the no-deal clause for me. The uneven, pitted, warty-looking texture, scorched and dry, gave them the appearance of confused survivors of an unpublished government experiment into pond life

JEAN-PAUL FERRERO/AUSCAPE

Thick, creamy venom exudes from the parotoid gland of a Cane Toad.

around abandoned nuclear reactors.

Few people then had any idea that toad skin was loaded with glands capable of secreting toxic venom, in particular from the two fleshy, strawberry-shaped earmuffs just above the shoulders. These glands called parotoids react much the same under pressure as peeled orange skin . . . a good squeeze and fluid is ejected from the ducts. In the Cane Toad's case the thick fluid is a creamy venom that resembles oleander or fig-tree sap. Most toad literature reports that pressure might build up inside the venom reservoirs of the parotoid gland so that a milky jet squirts a metre or so from the toad. This creates an unsettling impression that Queensland after dark must resemble Rotorua as millions of turgid parotoids spurt gland-glug into the evening air. The truth, known to most toad busters, is that squirts are nearly always mechanically induced, like from the whack of a baseball bat, or a Doc Martin squashing the parotoids so flat the venom is sent flying.

But the toxic nature of Cane Toads should not be taken for granted, the venom being a mix of steroid derivatives that may act promptly and savagely on heart muscle. Its passage into the human blood system can be effected not only through cuts or abrasions but even by penetration through intact skin, and for that reason people with known heart conditions are warned off handling toads. As for those that smoke a dry-shredded, road-kill panatella as a recreational adjuvant, their hearts are on the line. Humans have died after eating soup made from boiled-up toad eggs, and it is not uncommon for Dogs to die within 15 minutes of biting or mouthing a toad. One Dog I recently heard about lived long enough to develop something of a toad habit. Of an evening the Dog used to find a toad, lick or mouth its back, then career mindlessly around the yard in a coil of circles until it collapsed in a frothy heap, later to recover its wits and set out for its next lick.

One of the more serious concerns associated with Cane Toads lies in their potential effects on native birds, reptiles, amphibians, fish and mammals that mistake toads' thighs for frogs' legs and swallow them. Such gourmands might not get to face a second serve of the same dish, and reports of declines in Lace Monitors, Red-bellied Black Snakes and Spotted-tailed Quolls add to this concern. On the other hand some animals like Torresian Crows, Water-rats and Freshwater Snakes are dealing with them and profiting from their full stomachs. The dilemma with hitting the Cane Toad panic button is that research is still relatively young and scientists don't yet know if native predators are on the rebound after the initial toxic knock-down. No wonder tempers flared a few years ago when toad research funds were split between studies assessing the reality of 'the threat' and investigations into the search for the ultimate toad terminator.

When female toads can churn out 35,000 eggs at a sitting, it is not surprising that the competitive effect of Cane Toads is a great concern. Sometimes after heavy rains, certain creeks almost clog with the schooling black tadpoles, and in backyards and bushland the ground is literally alive and hopping with tiny, newly metamorphosed toadlets. The tragedy of the Cane Toad debacle lies in their being the most unfortunate choice as importees. Cane Toads are no fools. They are quick-learning, opportunistic, tough and toxic . . . attributes of success that have not escaped emulation in the higher orders of politics and real estate.

About the only positive contribution Cane Toads have made to the Australian way of life is their use, during the early 1950s and early '60s, in human pregnancy tests. In a procedure more befitting an Edgar Allan Poe thriller, a male toad was injected with could-be-mother's urine in the lymphatic tissue below the toad's neck. Within a few hours the toad's cloaca was flushed and its urine microscopically examined for sperm cells, which develop in response to human pregnancy hormones (if present). Prior to the test women were asked if they had recently taken aspirin. If they had, the test was abandoned for a few days because the aspirin lacing their urine killed the toad.

I've often wondered what became of all those toads in the Driclad pool at the Toy Fisheries shop. It was clear then that just about nobody in Sydney wanted to buy them. However, not long ago Arthur White, Secretary of the New South Wales Frog and Tadpole Study Group, announced with concern that a number of toads had been heard trilling in a swamp at the Olympic City site, Homebush. Homebush is half-a-parotoid squirt from Strathfield where Toy Fisheries used to be. If I were a visitor to the Games I'd be a little more apprehensive about how crocodile sales had gone 40 years back! ■

Further Reading

Cogger, H., 1994. *Reptiles and amphibians of Australia.* Reed Books: Chatswood.

Ingram, G., 1988. The "Australian" Cane Toad. Pp. 59–66 in *Venoms and victims*, ed. by J. Pearn and J. Covacevich. Queensland Museum and Amphion Press: Brisbane.

Sutherland, S., 1983. *Australian animal toxins.* Oxford University Press: Melbourne

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He warmly acknowledges the help of Dr Theo Baer (Brisbane) who generously provided first-hand information on the Cane Toad's contribution to Queensland pregnancies.

CANE TOAD
Bufo marinus

Classification
Family Bufonidae ('true toads')

Identification
Adults usually to 15 cm long, olive-brown, greyish or yellow-tan, warty dry skin, beetle brows forming a 'V' ridge to nose, strawberry-shaped venom glands on shoulders, fingers unwebbed, toes webbed. Juveniles confusingly different to adults with dark lines, splashes and bands on limbs, head and back. Tadpoles black with pointed nose. Toxic in all life forms.

Distribution and Habitat
Occurs naturally in South and Central America. In Australia tropical northern and eastern Qld, the Gulf in NT and breeding as far south as Port Macquarie in NSW. Broad range of habitat tolerances from mangroves, sand dunes, grasslands, forests, freshwater swamps and semi-arid woodlands. Also at ease in suburban backyards, under street lights, in parks and around swimming pools. Endangered around schoolyards and in beer gardens.

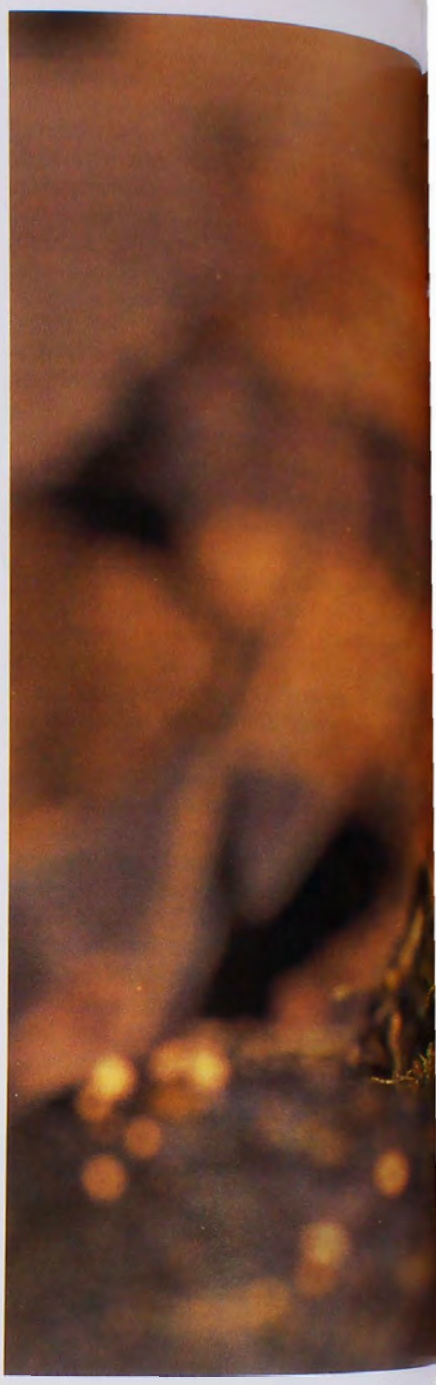
Behaviour
Although officially a 'non-climber', capable of the most extraordinary feats associated with getting to water or food or escaping incarceration. Eats practically anything, even dry Dog or Cat biscuits, shellfish and crabs, but undoubtedly insects form the bulk of its diet. Lives under daytime cover of rubbish, rocks, fallen timber and iron sheets, dark drains, holes.

Breeding
Male's call is a pleasant continuous warbling trill. Females lay eggs in any permanent, ephemeral, or slow-moving body of water. Thousands of eggs laid in long sticky rosary bead strands.

It has stumbled on an easy lifestyle where the dung comes to it, instead of vice versa.

WINGLESS DUNG BEETLE

BY GEOFF MONTEITH



I GREW UP ON A QUEENSLAND DAIRY farm in the 1950s and was intimately acquainted with a foreign material that had insidiously become a landscape icon in Australia—cow dung. No rural scene was complete without it, as either warm, semi-liquid paste that squeezed up between bare toes, or as dried clods that persisted as toe-stubbing obstacles months after deposition.

Scientists at the CSIRO realised in the 1960s that these long-lasting cow pats were environmentally deleterious because they bred flies, harboured parasites and locked up potential soil nutrients. They began to test African dung beetles for import into Australia to disperse this dungfest. African beetles had evolved to cope with the squishy dung of the many cattle-like herbivores on the African plains, so they were well equipped for the task. But the CSIRO importation campaign was carried out with such vigour and publicity that it became a popular fallacy that Australia had no native dung beetles. Nothing could be further from the truth. We have a rich and diverse fauna of around 400 native species. However, one only has to mentally compare the economical, dry, hard dung pellets that Australia's marsupials produce, with the steaming, wet pile that a cow generates ten times a day, to realise that very different beetle strategies are required to cope with these contrasting foodstuffs.

What do dung beetles do with dung? They suck some juices out as their own food, but mostly they carve it up into chunks, which they bury in the ground as food for their larvae. To do this the dung must still be soft and moist. But kangaroos are wide-ranging creatures that drop their meagre pellets far and wide across the landscape. To track these pellets down before they dry rock-hard, dung beetles need to be strong fliers and have a keen sense of smell. Inland Australia is dominated by the strong-flying dung beetles of the cosmopolitan genus *Onthophagus*. Some even pursue the kangaroos themselves, then, using enlarged, hairpin-like claws on the ends of their legs, cling to the cloacal fur so they can jump aboard at the 'factory door' as a pellet emerges.

PHOTOS: GARY CRANITCH/QUEENSLAND MUSEUM

When Eric Matthews (South Australian Museum) revised the taxonomy of the Australian *Onthophagus* in 1972, he found a curious, large specimen in the Paris Museum. It was labelled simply "Queensland" and marked "ex musao H.W. Bates 1892". Its short body and convex wing covers made him suspicious. When its wing covers were lifted it proved to be completely wingless, counter to every assumption about the genus *Onthophagus*. He named it *Onthophagus apterus*, meaning 'wingless', and thrust the unique specimen, from 80 years obscurity in the Paris Museum, to the status of a modern enigma. Where did it really come from and what evolutionary process had caused it to lose its power of flight?

Twenty-four years later, in 1996, several chunky dung beetles turned up in a

pitfall trap, set by the Queensland Museum just north of Taroom, in central western Queensland. To everyone's astonishment, they were the long-lost Wingless Dung Beetle. They came from a small hill, cleared of most vegetation except for narrow thickets of vine scrub between rocky outcrops, which had obviously prevented the vegetation from being completely cleared. Resident on the hill, and a closely kept secret of the landowner, was a semi-tame colony of Herbert's Rock-wallabies (*Petrogale herberti*) that returned to the thickets each day to rest, where they deposited little food parcels for the dung beetles.

The discovery allows us to speculate a little on the provenance of that original specimen in the Paris Museum. Henry Walter Bates was one of the great explorer-naturalists of the 19th century, and beetles were his game. His collection was passed to the Paris Museum on his death in 1892. The Amazon was Bates' bailiwick and he never set foot in Australia. But he purchased beetles from a Western Australian collector named Francis du Boulay who spent three months in Queensland in 1870. Part of that time was spent at "Coomooboolaroo" station, west of Rockhampton and only 150 kilometres north of where our modern *Onthophagus apterus* came from. Du Boulay almost certainly collected that original specimen and sold it to Bates.

Our searches have so far located the beetle at only one other site, in a larger fragment of vine scrub preserved in Isla Gorge National Park. Here it lives on the droppings of a dense colony of Black-striped Wallabies (*Macropus dorsalis*), which use the vine scrub as a daytime refuge.

Why has *Onthophagus apterus* lost its wings? It seems that it has stumbled on an easy lifestyle where the dung comes to it, instead of *vice versa*. By utilising the dung of mammals that return in reasonable aggregations to regular daytime retreats, populations of the beetle can prosper without the need for flight. But with a life of ease comes vulnerability. Those vine scrubs, which once occurred extensively throughout the subcoastal Brigalow Belt, have been decimated by pastoral clearing and are now among the most threatened plant communities in Australia. With them have declined a wealth of animal species about which we are just starting to learn. ■

Further Reading

Matthews, E.G., 1972. A revision of the scarabaeine beetles of Australia. 1. Tribe Onthophagini. *Aust. J. Zool. Suppl. Ser.* 9: 1–329.

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In Australia today, plenty of exotic pests are masquerading as wildlife.

NATIVE OR NOT?

BY TIM LOW

AUSTRALIANS CHERISH their native animals and plants and detest exotic invaders. But seldom do they realise that this love-or-hate relationship rests on shaky ground; that biologists often don't know what is native and what is not. Many of Australia's 'native' plants and animals are also found naturally on other continents, especially Asia, and although we assume that most of them reached Australia by natural means thousands or millions of years ago, the possibility is there that some of them are exotic species brought here by people, either by ancient mariners from Asia, or by European explorers and early settlers, operating in the years before the first nature surveys were undertaken.

Botanists in the 19th century were often confused by weeds that had spread afield so fast they seemed to be native plants. Most of this uncertainty has been resolved today but there are still disagreements about such plants as Native Thornapple (*Datura leichhardtii*), Native Gooseberry (*Physalis minima*) and Native Poppy (*Papaver aculeatum*; probably a weed from South Africa). There are also disagreements between the States. Water Primrose (*Ludwigia peploides*), White Eclipta (*Eclipta prostrata*) and Prickly Moses (*Acacia farnesiana*), among others, are native plants according to botanists in New South Wales, but north of the border they turn into foreign weeds. Other plants under a cloud include Urena Burr (*Urena lobata*), Vernonia (*Vernonia cinerea*) and Crab's-eye (*Abrus precatorius*). The problem is compounded by plants with both native and exotic populations, such as Caltrop (*Tribulus terrestris*) and (probably) Couch (*Cynodon dactylon*).

This problem of origin is particularly acute for marine life. Ships have been plying the seas for thousands of years and many barnacles, worms, shellfish and seaweeds have no doubt been hitching rides on hulls for just as long. Many of the sea creatures we see in our waters today, which we assume to be native but which occur in seas elsewhere, may well be foreign invaders, brought here by Macassans, Lapitan sailors, explorers, or by other forgotten visitors. The

PHOTOS: TIM LOW

Papuans and Aborigines glued the colourful seeds of Crab's-eye to their tools, and this plant may well have entered Australia as an adornment on such implements. In 1898, on Murray Island (Mer), the anthropologist William Haddon obtained a bone dagger traded down from New Guinea that carried these seeds.

Native Gooseberry is classified as a native plant in Australila, yet some Aboriginal groups who harvest the fruits have no traditional name for the plant, implying recent arrival.

American biologist James Carlton (Williams College) coined the label 'cryptogenic' for species whose origin remains doubtful. "In the absence of a fossil record", he wrote, "for thousands of species of shelf-dwelling (neritic, inshore) marine organisms that now occur transoceanically or interoceanically, and in habitats wherever ships have gone or oysters have been moved, their categorization as 'cryptogenic' seems inevitable." If these species are common, we may be profoundly underestimating the scale of exotic invasions.

Chad Hewitt of CSIRO in Hobart has drawn up a list of over 100 cryptogenic species from Australian seas, including crustaceans, jellyfish, shellfish, even a fish. Among the brown algae, he classifies seven species as exotic and 36 as cryptogenic. In other words, Australia has somewhere between seven and 43 exotic brown algae. Hewitt suggests that some of Australia's best-known marine dwellers could be exotic, including the abundant Giant Kelp (*Macrocystis pyrifera*) and the Edible Mussel (*Mytilus edulis planulatus*).

There are hundreds of plants, invertebrates and fungi that belong in the cryptogenic basket. Among the more primitive organisms, those neglected by taxonomists, the uncertainty is tremendous. With regard to the freshwater algae, for example, Tim Entwisle (National Herbarium of New South Wales) told me he couldn't even take a stab at what percentage he thought were native versus introduced by human activity. Most of the mushrooms that sprout on our lawns should also be considered cryptogenic: they are found overseas, grow mainly in man-made environments (lawns and paddocks), and their spores either came here in potting soil or blew in on air currents. The Mourning Gecko (*Lepidodactylus lugubris*) is another candidate. It is well known overseas as a traveller, and its distribution in northern Queensland is so patchy, and so dependent upon houses, that I believe it to be an exotic invader, even though reptile books list it as native.

Does it matter how we classify such species? Yes it does. Water Primrose and Swamp Foxtail (*Pennisetum alopecuroides*) are sold by native nurseries as indigenous plants, and landscape rehabilitators would like to use salt-tolerant Waterbuttons (*Cotula coronopifolia*) to reclaim degraded mudflats, but each of these plants may well be a weed. Water Lettuce (*Pistia stratiotes*) has been targeted for biocontrol on the assumption that it's exotic, yet it may be a native, at least in the Top End. Five-leaf Yam (*Dioscorea pentaphylla*) has been listed as an endangered species in Queensland, although it's probably just an old islander crop gone wild. There's an important aesthetic issue at stake as well. When I visit Fraser Island and see Emilia (*Emilia sonchifolia*) sprouting on the dunes, I want to know if I am looking at a wild flower or a weed.

Fortunately, the status of many cryptogenic species could be resolved by more scholarship. Surveys of marine life could show whether cryptogenic species are widespread, or confined to harbours (implying exotic origins). The journals of early botanists and explorers sometimes help by mentioning cryptogenic plants such as Common Sowthistle (*Sonchus oleraceus*) in remote, uncharted places. The lack of specialised insects feeding on herbs such as Purple Loosestrife (*Lythrum salicaria*) suggests recent arrival in Australia, although it does not prove exotic status. DNA fingerprinting could also help. In the meantime, biologists and naturalists ought to practise more care in the assumptions they make. In Australia today, plenty of exotic pests are masquerading as wildlife—and *vice versa*. ■

Further Reading

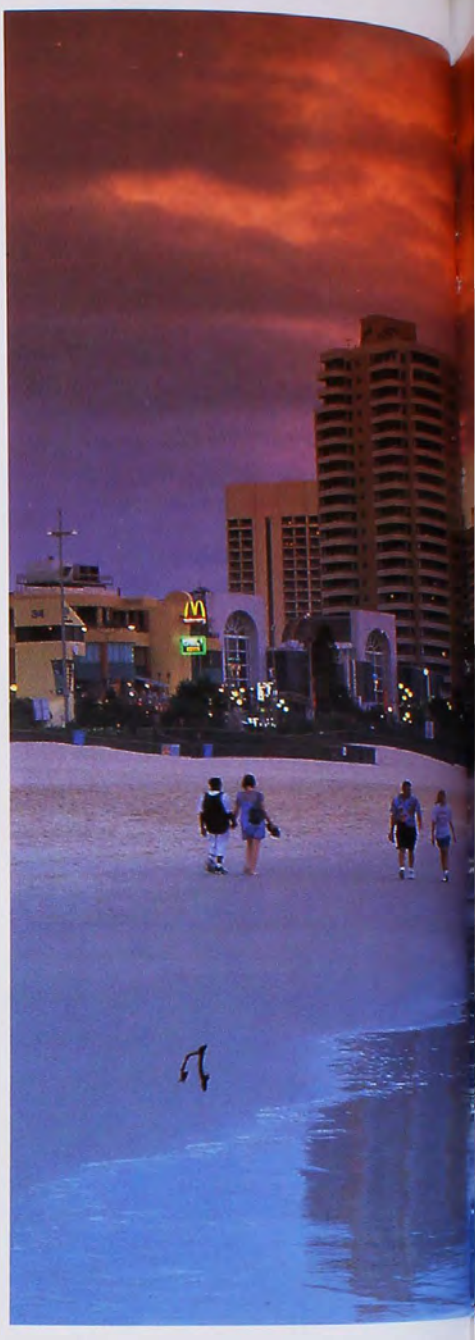
Carlton, J.T., 1996. Biological invasions and cryptogenic species. *Ecology* 77(6): 1653–1655.

Tim Low is an environmental consultant and nature writer. His latest book, Feral future *(Penguin, 1999), looks at cryptogenic species.*

GOLD COAST CHILLS?

BY KEITH SIRCOMBE

Between your toes and in your hair and bathers could be the remains of Himalayan-sized mountains that once towered over ancient Antarctica.



WHILE ENJOYING THE WARM water and sparkling sands of the Gold Coast, and numerous other beaches along Australia's east coast, you probably won't spare much thought for the harsh chill and icy expanse of distant Antarctica. Yet, between your toes and in your hair and bathers could be the remains of Himalayan-sized mountains that once towered over ancient Antarctica.

Although most of the sand on our beaches is quartz, there are also darker minerals that may be concentrated by wave action into noticeable patches. Some of these minerals, such as rutile, zircon and monazite, are economically valuable and are mined to provide the raw materials for paint, furnace linings, mantles for gas lamps etc. These same minerals also provide clues that help geologists trace the origins of the sand.

Rutile, zircon and monazite often contain small amounts of uranium—not enough to warrant any health concerns from a day at the beach, but enough to be measured on sensitive instruments. Being large, heavy and unstable, uranium atoms are naturally radioactive and decay over time at a slow and steady rate to form smaller, stable lead atoms. Thus, if we measure the amount of uranium and lead in a mineral grain, we can calculate the age of that mineral. Basically the more lead, the older the mineral. And because sand comes from the weathering and erosion of solid rocks, the age of an individual grain of sand gives the age of the igneous or metamorphic rock in which it originally formed.

When samples of rutile, zircon and monazite from along the east coast were analysed for their uranium–lead ages, three main groups were found. The first group ranges from 100 to 375 million years old, which is the same age as igneous and metamorphic rocks in and around the New England region north of Newcastle through to Townsville. The second group ranges from 375 to 550 million years old, which matches the age of igneous and metamorphic rocks seen through the south-eastern highlands from south of Sydney, across to the Snowy Mountains and into central and western Victoria. While these sources for the sand are fairly obvious, sand from an even older age group, 550 to 750 million years old, also occurs. Unlike the other two groups, however, there are no suitable rocks that match this age in south-eastern Australia. (The nearest possibility are rocks around Broken Hill and west of Adelaide, but these are actually much older again.) The 550-to-750-million-year-old grains of sand must have come from somewhere else and are hence labelled 'exotic'.

Looking in more detail, the exotic sand grains occur in varying proportions along the entire east coastline but are most common on the central coast beaches, in particular just north of Newcastle on Stockton Beach. Farther north more sand grains match the ages of rocks from the New England area and farther south they are more like the

ROBERT WALLACE

W. WATT

Above: Although perhaps thousands of miles from their wintry homes, visitors to the Gold Coast may actually be walking on bits of Antarctica. Right: A typical coastal cliff of Hawkesbury Sandstone. The wavy patterns indicate the size and flow direction of the river that deposited the sand around 240 million years ago.

rocks from the south-eastern highlands. Generally beach sand moves slowly northward along the coast, pushed along by waves from the south and south-east. Therefore, whatever is contributing to the central coast sand has to be nearby.

For any Sydney-sider, or even a knowledgeable tourist, the answer would seem obvious. Sydney is built on a beautiful white sandstone known as the Hawkesbury Sandstone. The sand in this sandstone was left by a large river that used to flow across the Sydney area around 240 million years ago. The dark, uranium-bearing minerals are also found

REG MORRISON/AUSCAPE

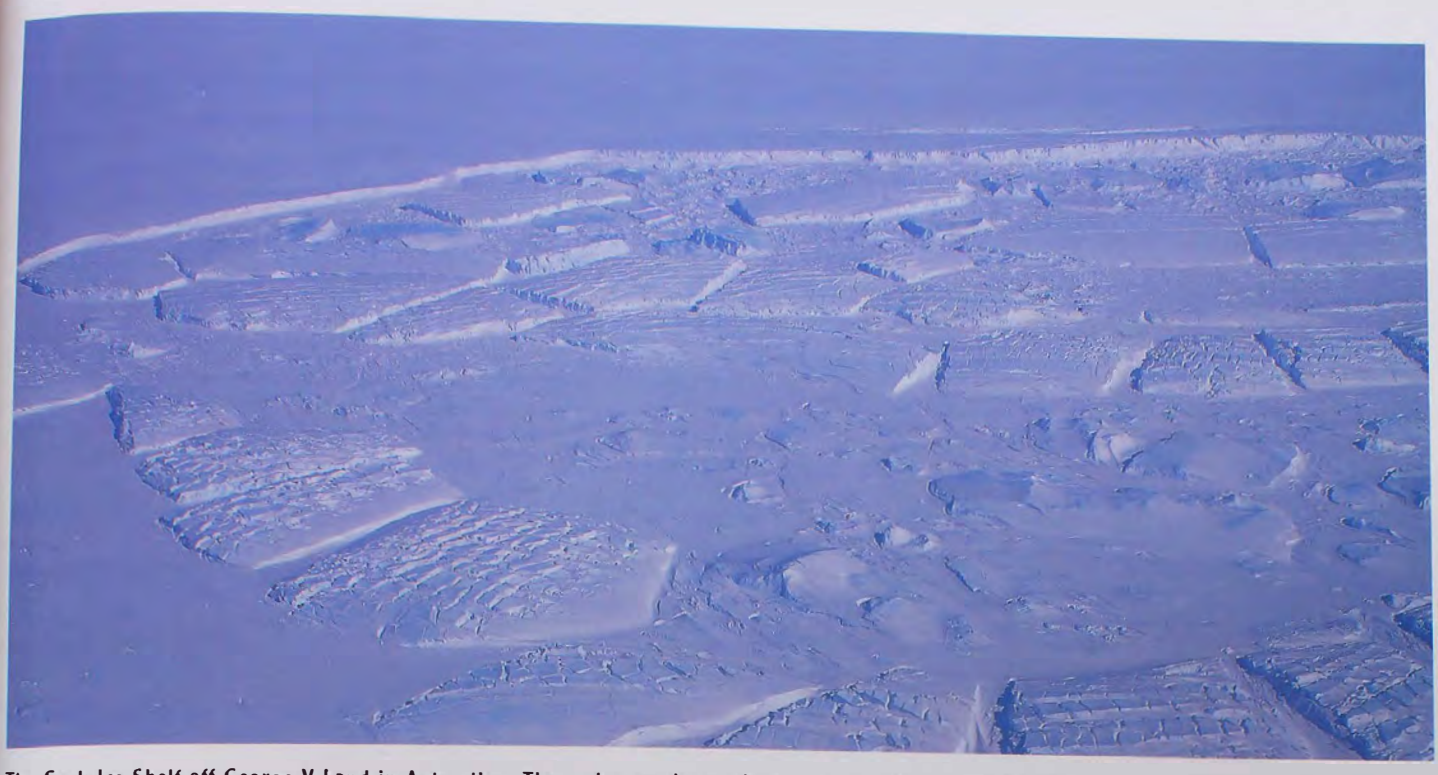
Minerals such as zircon, rutile and monazite are typically found concentrated in darker bands of beach sand as revealed here in a section of a sand-dune on Fraser Island. These minerals also lend clues as to the origin of the sand.

in this rock and have revealed the same dominance of 550-to-750-million-year-old ages seen in the nearby beaches—evidence that the erosion of the Hawkesbury Sandstone is providing some of the sand of the central coast. Thus we are one step closer to the ultimate source of the exotic sand grains, but the next question is: where did the sand in the Hawkesbury Sandstone come from?

THE PATTERNS OF RIPPLES AND WAVES IN the Hawkesbury Sandstone, which can often be seen in coastal cliffs and road cuts in and around Sydney, indicate the river that created them flowed from the south-west and was unlike anything in Australia today. Indeed, similar sand patterns are found in modern-day rivers like the Brahmaputra River in eastern India and Bangladesh. This is a large river, over 2,000 kilometres long, draining the lofty Himalayan Mountains and with a discharge volume that rates it among the top ten rivers in the world today. Assuming a similar continent-spanning scale for the 240-million-year-old river that formed the Hawkesbury Sandstone, it would have had a vast

HAMILTON LUND

As well as providing material for beautiful scenery, the beach sands of eastern Australia also tell an intriguing story about their origin.



JEAN-PAUL FERRERO/AUSCAPE

The Cook Ice Shelf off George V Land in Antarctica. The rocks now buried by this ice may have been the ultimate source of some of the sand on the beaches of eastern Australia.

catchment area that covered south-eastern Australia with possible headwaters well into the present Southern Ocean. However, 240 million years ago the Southern Ocean didn't exist and Australia was joined to Antarctica as part of the supercontinent Gondwana. Somewhere along the course of this river was the original source of the exotic sand grains.

It is possible that the grains may have come from an earlier round of 'recycling' in south-eastern Australia. Some older sediments among the south-eastern highlands also contain the exotic grains, and these could have contributed to the Hawkesbury Sandstone just as the Hawkesbury Sandstone contributes to the modern beach. However, two problems count against this. First, these older sediments are so intermingled with younger-aged (375-to-550-million-year-old) rocks that sand derived from the region contains both groups of grains and the younger grains are dominant. This arrangement of ages is seen in samples from the southern end of the coastline and in sediments below the Hawkesbury Sandstone, but the Hawkesbury Sandstone itself and the central beaches are clearly dominated by the exotic grains. The south-eastern sediments may have been a contributor, but it seems they weren't the biggest. Second, the exotic grains in the south-eastern sediments had to have originally come from somewhere else too. The patterns in these sedimentary rocks also point to a source lying to the south-west—towards Antarctica.

The eastern margins of Australia and Antarctica share a lot of geology that indicates their common history prior to the break-up of Gondwana. However there are some features unique to Antarctica that point to it as being the ultimate source of some of the sand in the Hawkesbury Sandstone and thus, in turn, much of Australia's east coast. In isolated mountains among Antarctica's glaciers there is evidence for rocks aged between 550 to 750 million years old. Unfortunately the icesheet that covers most of the continent obscures any large extent of these rocks, and the possible location of the headwaters of the river that formed the Hawkesbury Sandstone now sits beneath a kilometre of ice. Although the ice may, for the moment at least, prevent a conclusive test for the origin of the sand, it doesn't block the whole picture. Just beneath the vast expanse of the East Antarctic icesheet, and detectable by sonar from the surface, are the remnants of a large range of mountains known as the Gamburtsev Subglacial Mountains. Around 280 million years ago these mountains may have been as large as the present Himalayas and at the heart of Gondwana. Over time erosion created sand that was carried by numerous rivers that drained away from the mountains and into the other Gondwanan regions such as Africa and India.

Although the final piece of the puzzle awaits discovery beneath the ice, it seems the river that formed the Hawkesbury Sandstone was also one of the great Gondwanan rivers. The sand it carried came from eroded mountains in the heart of Antarctica and included some rutile, zircon and monazite that had formed 550 to 750 million years ago. These were deposited in the Hawkesbury Sandstone in and around present-day Sydney. When Gondwana broke up, Australia slowly drifted north, taking the Hawkesbury Sandstone with it. The beaches along the east coast eventually accumulated as sand was eroded from nearby rocks, including the Hawkesbury Sandstone, and the waves on the beaches mixed the sand and slowly carried it north.

So, for those people who like to think they are escaping their cold wintry homes for the tropical pleasures of the more northerly beaches, think again. Antarctica may be under your feet. ■

Further Reading

Rust, B.R. & Jones, B.G., 1987. The Hawkesbury Sandstone south of Sydney, Australia: Triassic analogue for the deposit of a large, braided river. *J. Sedimentary Petrology* 57(2): 222–233.

Siever, R., 1988. *Sand.* Scientific American Library, W.H. Freeman & Co.: New York.

Sircombe, K.N., 1999. Tracing provenance through the isotope ages of littoral and sedimentary detrital zircon, eastern Australia. *Sedimentary Geology* 124: 47–67.

Veevers, J.J., 1994. Case for the Gamburtsev Subglacial Mountains of East Antarctica originating by mid-Carboniferous shortening of an intracratonic basin. *Geology* 22: 593–596.

Dr Keith Sircombe studied the origin of eastern Australian sediments, including beach sands, as part of his PhD thesis at the Research School of Earth Sciences, Australian National University. He is currently continuing research at the Geological Survey of Canada, this time looking at the origin of sand in ancient sedimentary rocks amidst the tundra of the Canadian Arctic.

PHOTOS: KATHIE ATKINSON

The Brush-tailed Rock-wallaby is now so rare and elusive in south-eastern Australia that it has been nicknamed 'The Shadow'.

CHASING SHADOWS

BY DAVID TAGGART, JAMES RESIDE & RAZ MARTIN

BANJO PATTERSON WOULD SURELY CRINGE WERE HE TO REVISIT the setting of his famous poem "The Man from Snowy River". Today, the water flowing down the Snowy is a mere trickle compared to former times; much of the land has been logged; and many of the resident animals have dramatically declined. The Brush-tailed Rock-wallaby (*Petrogale penicillata*) is one such animal that used to frequent "the cliffs and crags that beetled overhead". In fact, this rock-

Left: Brush-tailed Rock-wallabies are incredibly agile, favouring habitat that provides access to steep cliffs and complex rock escarpments within which they den. In the past animals were often observed on rocky ledges and overhangs, similar to that pictured here, where they spent considerable amounts of time basking, particularly in the early morning and late afternoon. Above: Netting Tammar Wallabies at Tidbinbilla Nature Reserve in order to locate a suitable female to act as a foster mother for the endangered Brush-tailed Rock-wallaby pouch young.

BRUSH-TAILED ROCK-WALLABY

Petrogale penicillata

Classification
Family Macropodidae, genus *Petrogale* (15 spp. within Aust.).

Identification
Medium-sized wallaby, about 1.2 m total length. Brown above, tending to rufous on rump and grey on shoulders. Chest and belly fur paler, sometimes white. White cheek stripe and black dorsal head stripe. Feet and paws dark brown to black. Distinctive tail (greater than half its total length) that darkens toward tip with a prominent brush.

Habitat and Distribution
Suitable rocky areas within rainforest gullies, wet and dry sclerophyll forest, open woodland and semi-arid country. Rocky outcrops with multiple escape routes and numerous ledges, caves and crevices preferred. Found on both sides of Great Dividing Range from southern Qld to Grampians in western Vic. In the past 150 years, undergone an extensive range reduction, with only 2 populations now located west of Great Divide.

Behaviour
Reputedly inquisitive, they emerge soon after dusk to forage. Diet predominantly grasses and forbs, but also leafy material. Seeds, fruit and flowers eaten when available. Prefer sites with a northerly aspect, as they enjoy sunning themselves in morning and evening.

Reproduction
Very little published information. Mating and births can occur all year round (gestation about 30–35 days). Pouch life about 200 days with young weaned at about 290 days. Mothers typically produce 1 offspring annually. Females sexually mature at about 18 months.

Status
Vulnerable nationally, but critically endangered in Vic., southern NSW and ACT.

wallaby was once so common throughout the mountainous areas of south-eastern Australia that in 1908 more than 92,500 skins were sold by one Sydney fur trader alone. Unfortunately those days have long gone and the cliffs and crags are all but empty of rock-wallabies; a direct result of the demand for pelts and, later, the arrival of the European Fox and other introduced predators and competitors.

The Brush-tailed Rock-wallaby is now so rare and elusive in south-eastern Australia that it has been nicknamed 'The Shadow' after the main character in a 1960s children's book (*The story of Shadow the rock wallaby*, by Leslie Rees). This species is one of about 15 rock-wallaby species in Australia but the only one to occur in the south-east. It is currently listed as vulnerable nationally, but within Victoria, southern New South Wales and the ACT, where there are less than 40–50 individuals spread across four sites, the species is considered critically endangered. The south-eastern populations of the Brush-tailed Rock-wallaby are likely to become extinct within the next few years unless the decline can be reversed rapidly.

Currently in the wild three populations of fewer than about 8–12 individuals are located along the steep rocky gorges of the upper reaches of the Snowy River; and in the Victoria Range, within the Grampians National Park, a population of less than six literally hangs on by the skin of its teeth . . . or, rather, feet. Fortunately for these animals, they are superbly adapted for 'life on the edge', with extensive granulations on the soles of their rubber-like feet, providing them with tremendous grip and amazing agility in the rugged terrain in which they persist. In addition, their bushy black tail allows them to balance as they move quickly and surely over their precipitous habitat.

With widespread decline and habitat fragmentation across its range, the main threat to the continued survival of the Brush-tail now appears to be the successive extinction of the remaining small

Female Brush-tailed Rock-wallaby with young at foot. Young are weaned at approximately 40 weeks of age and don't reach sexual maturity until an age of 18–20 months.

KATHIE ATKINSON

JEAN-PAUL FERRERO/AUSCAPE

NICHOLAS BIRKS/AUSCAPE

Top left: Tammar Wallabies were selected as a surrogate species for rearing Brush-tailed Rock-wallabies because of similarities in size and length of lactation. Bottom left: The Yellow-footed Rock-wallaby; the second of the surrogate species being used to rear the endangered Brush-tailed Rock-wallaby pouch young.

isolated colonies following natural disasters such as fire, disease and drought. In addition, the abundance of predators, particularly Foxes and feral Cats, results in unnaturally high levels of mortality in the young. This in turn reduces migration between isolated colonies and the likelihood of the Brush-tail successfully recolonising areas where populations have recently become extinct.

IN AN ATTEMPT TO RESCUE THIS SPECIES from the edge of extinction, we and other scientists from a diverse range of disciplines formed the Brush-tailed Rock-wallaby Recovery Team. Our aim is to ensure the survival of the species in the wild, using predator control and a radical breeding technique that rapidly builds up numbers in captivity for reintroduction back into suitably protected habitat.

Extensive predator-control measures have already been implemented in the Grampians National Park, where 43 kilometres of tracks surrounding the Brush-tailed Rock-wallaby colony are being baited fortnightly. At the Snowy River sites, "where the hills are twice as steep and twice as rough", the baiting effort is even more intensive, with 79 kilometres of tracks and trails baited monthly.

Now to catch your animal. In an extensive trapping program during 1996 and 1997, we caught nine animals (two males and seven females) to establish captive-breeding colonies. One male and two females were sent to Adelaide Zoo, which has over 100 years experience breeding and maintaining rock-wallabies. The others were sent to Healesville Sanctuary in Victoria.

We then designed an innovative captive-breeding strategy, called cross-fostering, to accelerate breeding in female Brush-tailed Rock-wallabies. Cross-fostering uses foster females from another species to rear Brush-tailed Rock-wallaby pouch young. It involves transferring the tiny Brush-tails (often as small as a jelly bean and less than seven days old) from the pouch of their natural mother into the pouch and onto a teat of the foster mother. For foster species we chose the Tammar Wallaby (*Macropus eugenii*) and Yellow-footed Rock-wallaby (*Petrogale xanthopus*), both of which are easily accessible and breed well in captivity, and for which much of the basic information on reproduction is known.

The transfer of pouch young frees the Brush-tail mothers from having to nurse their young for eight to ten months and enables them to cycle again and produce

DAVID HUMFREY

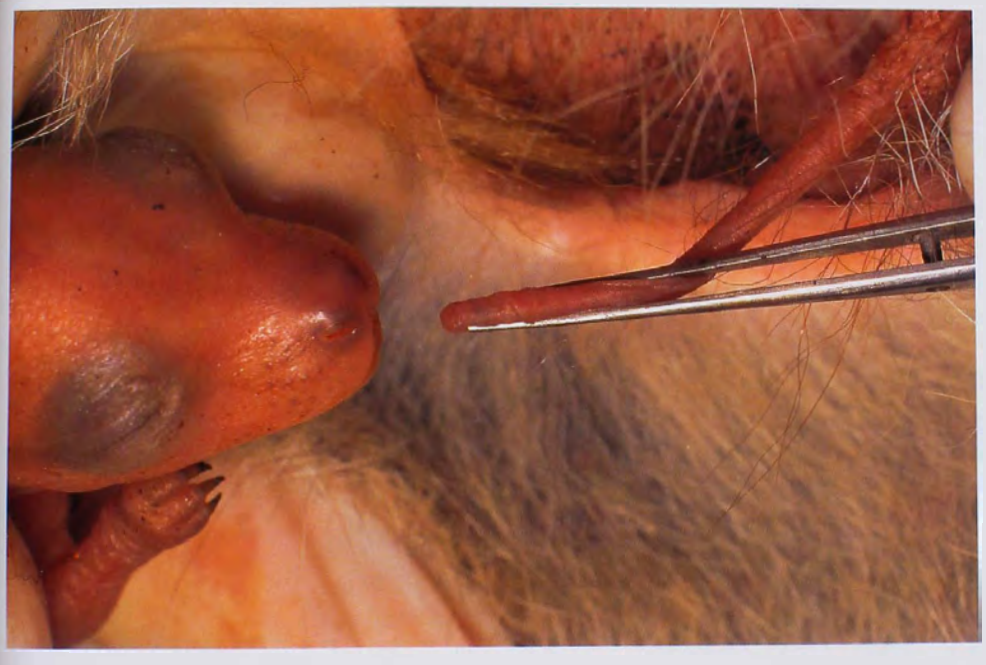
Immediately prior to cross-fostering, the female Brush-tailed Rock-wallaby and soon-to-be surrogate mother (in this case a Tammar Wallaby) are anaesthetised. The whole procedure takes less than one to two minutes. Note the difference in coat colour between the Brush-tail on the right and the Tammar on the left.

further young, which in turn can be fostered off to another Tammar or Yellow-foot foster mum. Brush-tails normally only produce one offspring annually, however by using cross-fostering techniques we can increase the rate to six to eight young per year.

Does cross-fostering leave the young Brush-tails confused as to what species they actually are? Not according to caretakers at the Tidbinbilla Nature Reserve (ACT), where the program is being trialed. Upon leaving the pouch, the young spend their days bounding around the rocks and tree branches just like any other young Brush-tail, which, if anything, must confuse their more sedentary foster mothers! And will foster-bred Brush-tails recognise their own kind, when it comes to breeding in the wild? As soon as the fostered young are weaned, their surrogate mothers are removed from the enclosure and they grow to maturity in the presence of other Brush-tails only. All the signs to date suggest that social interaction and breeding behaviour are normal.

This is the first time that cross-fostering has been applied to the conservation of an endangered marsupial species. The ability to breed so many Brush-tailed Rock-wallaby young in such a short space of time is a real victory for this species and bodes well for its future recovery. The Recovery Team is currently preparing a reintroduction plan for the species, and examining areas for suitable release sites. We hope to start reintroducing Brush-tails into the East Gippsland area within the next two to

PHOTOS: DAVID HUMFREY



LEFT: RAZ MARTIN

Top: The author preparing to transfer a young Brush-tailed Rock-wallaby into the pouch of an anaesthetised Tammar Wallaby—soon to be a foster mother. Middle: Preparing to insert the teat of the foster mother into the mouth of the Brush-tailed Rock-wallaby pouch young during the cross-fostering process. This can be done on pouch young as small as a kidney bean, when less than one gram in weight. Bottom: A Brush-tailed Rock-wallaby pouch young (approximately 25 grams) moments after its attachment to a teat in the pouch of a Tammar Wallaby foster mother. Note that the eyes of the pouch young are closed at this stage.

Far left: An adult female Brush-tailed Rock-wallaby. Note the rufous coat, and long brushy tail after which the species was named. The tail helps provide balance as the animal moves across its precipitous habitat.

three years. Although we still have a long way to go before it can be removed from the endangered list, for the first time since European settlement of Australia, we can say that the future of The Shadow is looking bright! ■

Corporate sponsorship is now urgently required to continue and expand the breeding program, maintain existing baiting programs, and to prepare sites for reintroduction of captive-bred stock. Interested parties can contact either David Taggart (03 9344 4346) or Jim Reside (03 5152 6367).

Further Reading

Lunney, D., Law, B. & Rummery, C., 1997. An ecological interpretation of the historical decline of the brush-tailed rock-wallaby, *P. penicillata*, in New South Wales. *Aust. Mamm.* 19(2): 281–296.

Short, J., 1982. Habitat requirements of the Brush-tailed Rock-wallaby, *Petrogale penicillata* in New South Wales. *Aust. Wildl. Res.* 9: 239–246.

Short, J. & Milkovits, G., 1990. Distribution and status of the Brush-tailed Rock-wallaby in south-eastern Australia. *Aust. Wildl. Res.* 17: 169–179.

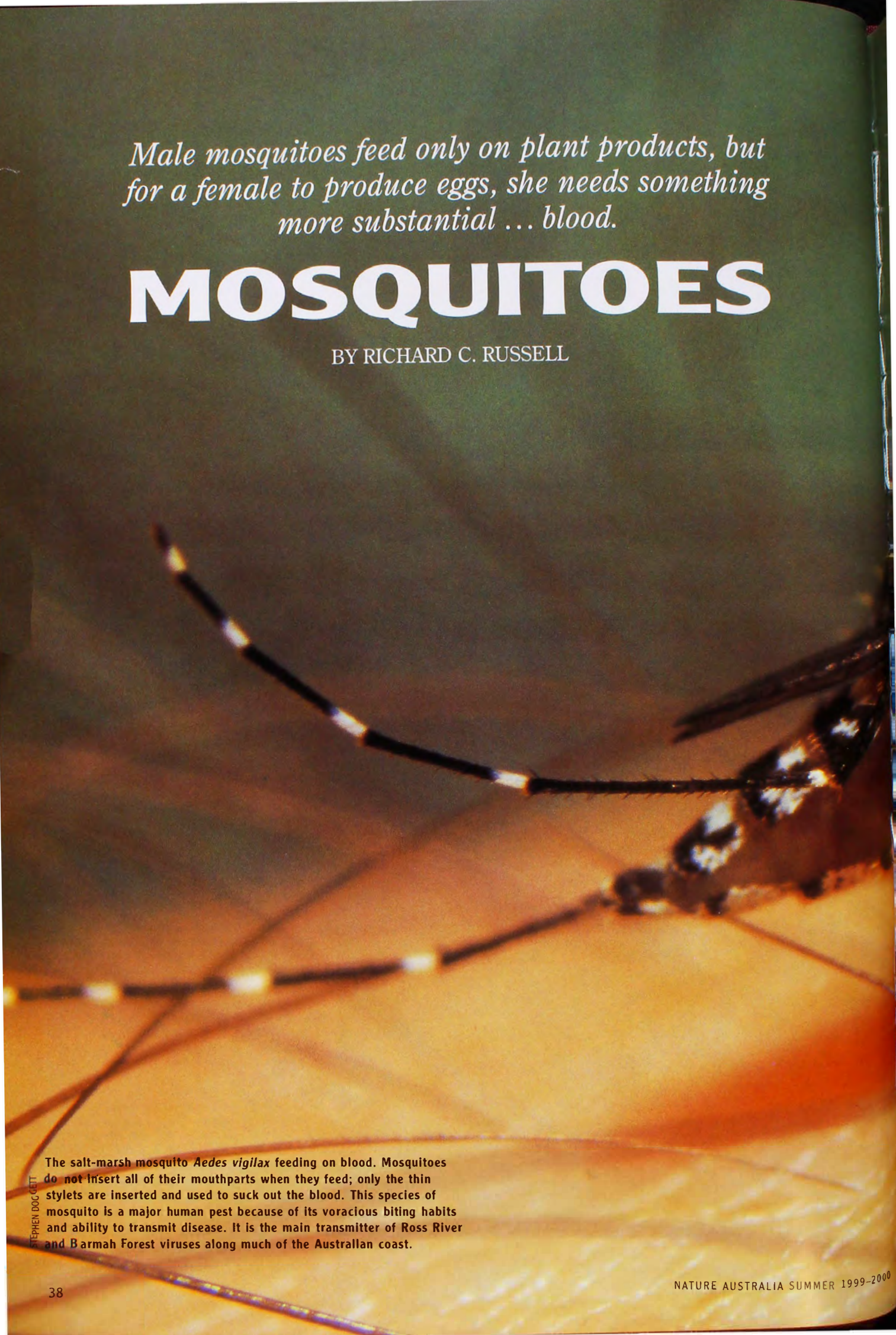
Taggart, D.A., Schultz, D. & Temple-Smith, P.D., 1997. Development and application of assisted reproductive technologies in marsupials: their value for conservation of rock-wallabies. *Aust. Mamm.* 19(2): 183–190.

Dr David Taggart is a research fellow with the Zoology Department at the University of Melbourne and with the Conservation and Research Unit at the Zoological Parks and Gardens Board of Victoria, Jim Reside runs an environmental consulting business called Wildlife Unlimited, and Raz Martin is a wildlife officer with the Department of Natural Resources and Environment in Bairnsdale, Victoria. All are members of the Brush-tailed Rock-wallaby Recovery Team. Jim is Chairman of the team, David is responsible for the development and application of cross-fostering techniques for the species, and Raz maintains the baiting program and monitors the remaining wild colonies in the East Gippsland area.

Male mosquitoes feed only on plant products, but for a female to produce eggs, she needs something more substantial ... blood.

MOSQUITOES

BY RICHARD C. RUSSELL



STEPHEN DOGGETT

The salt-marsh mosquito *Aedes vigilax* feeding on blood. Mosquitoes do not insert all of their mouthparts when they feed; only the thin stylets are inserted and used to suck out the blood. This species of mosquito is a major human pest because of its voracious biting habits and ability to transmit disease. It is the main transmitter of Ross River and Barmah Forest viruses along much of the Australian coast.

MOST OF US KNOW THAT THE itchiness following an almost imperceptible pin-prick of pain on our ankle, as we sit in the backyard at an evening barbecue, is caused by a mosquito. Likewise we know the annoying buzzing around our pillow in the middle of the night is also made by a mosquito. However, fewer people would be aware that the bites are almost certainly from different species of mosquito!

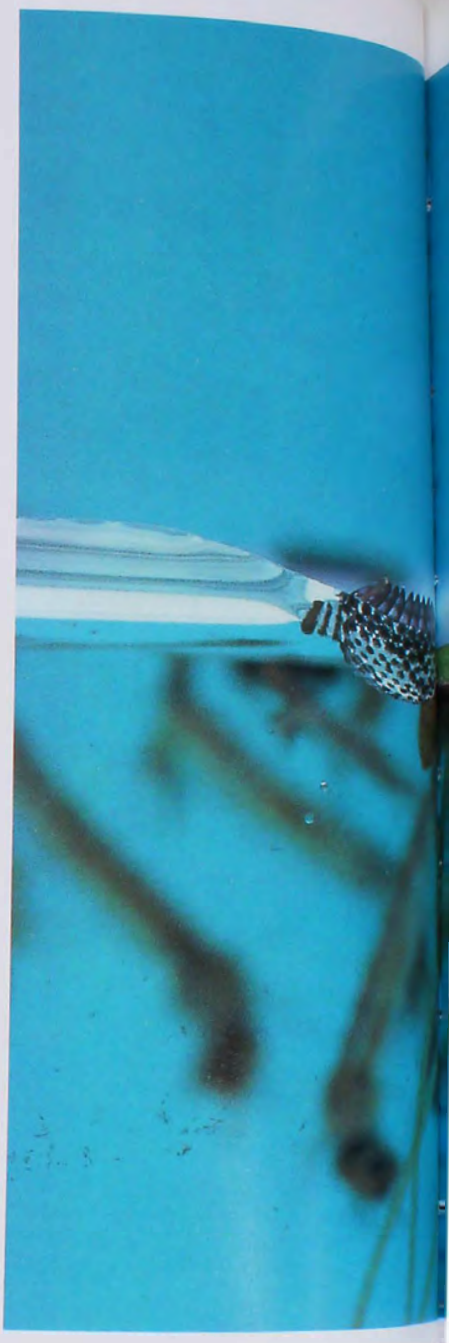
So, different mosquitoes are responsible; does that really matter? It does if I wish to prevent it from happening again, or am worried about being infected with a disease-causing organism (like Ross River virus, dengue, or even malaria). The first thing I need to know is which species of mosquito bit me.

All adult mosquitoes derive from larvae (wrigglers) that live in aquatic habitats, but the nature of those habitats varies dramatically and can be characteristic for many species. For example, the wrigglers in the pot-plant saucer or the discarded paint tin behind the garage produce adults that will be responsible for outdoor evening bites, while the midnight bedroom biters come from adults emerging from wrigglers in the drum behind the chicken shed full of composting liquid manure. Once we know what species is biting us and where its 'breeding site' is, we can then devise appropriate strategies to reduce or eliminate that particular habitat and thus the nuisance biters themselves. Additionally, since not all mosquito species bite humans, and relatively few are major pests or carriers of disease-causing organisms (pathogens), an accurate identification of the mosquito in question is important.

Australia has more than 350 species of mosquito in 15 genera. Of most concern to humans are some of the *Aedes*, *Anopheles* and *Culex* species. These include the pest species *Aedes notoscriptus* (from backyard containers), *Anopheles annulipes* (from rural irrigation) and *Culex quinquefasciatus* (from domestic sewage), and the disease carriers *Aedes aegypti* (dengue fever) and *Aedes vigilax* (Ross River virus), *Anopheles farauti* (malaria) and *Culex annulirostris* (Ross River and Murray Valley encephalitis viruses).

DENSEY CLYNE

Most mosquitoes obtain their blood meals from warm-blooded animals, however some, like these *Uranotaenia* mosquitoes, feed on amphibians such as this Wood Frog (*Rana daemeli*).



The number and diversity of species reflect the diverse nature of the Australian environment and the many different aquatic niches mosquitoes exploit. These range from extensive mangrove and salt-marsh habitats, through inland billabongs, temporary snow-melt pools in the highland ranges and rain-filled depressions on arid outback flood plains, to streamside rock pools in temperate forests, tree holes and pandanus axils in tropical forests.

When mosquitoes emerge from the aquatic pupal case as terrestrial flying adults, they require sustenance. Some energy and protein reserves are carried over from the aquatic larval stage but these are generally quite limited. Energy to fly is derived from sugars, and male

KATHIE ATKINSON

The life cycle of a *Culex annulirostris* mosquito, including eggs, larvae (wrigglers), pupae and adult. A bite from one of these mosquitoes could leave you infected with Ross River or Murray Valley encephalitis.

and female mosquitoes obtain these from plants (nectars, fruits, saps, plant tissues and honeydew), often on a daily basis. Male mosquitoes feed only on plant products, but for a female to produce eggs, she needs something more substantial . . . blood.

Mating usually occurs shortly after adult emergence from the pupa, and the female mates only once in her life (the male implants a 'plug' of sperm that will fertilise all eggs to be laid thereafter). Without blood, most female mosquitoes cannot lay eggs, and those that can may lay only one batch. The nectar meals that sustain the mosquito in her search for the essential blood meal do not pass into the gut but are stored in the crop and are passed through to the gut as required. This leaves the gut empty and able to receive the vital blood meal when it is found. If the mosquito lives long enough, she may go through several blood-feeding and egg-laying cycles.

Blood comes from all manner of animal 'containers', and the many types of mosquito cover the range of animals available. Warm-blooded animals are the normal source of blood for most mosquitoes, with some mosquitoes being particularly attracted to certain vertebrate hosts. There are bird feeders (many *Culex* spp.) and mammal feeders (many *Aedes* spp.), but only a few that have a preferential attraction to humans. There are even a few species that prefer a cold drink on a hot night, feeding on reptiles, amphibians and fish (such as mudskippers that have emerged from their burrows).

Just as mosquitoes can have characteristic hosts for feeding, they can also have characteristic times for feeding. Some (mostly *Aedes* spp.) can be described as diurnal, some as nocturnal, and others as crepuscular (dawn and dusk), although the latter may also tend to bite well into the night hours. Some daytime feeders will bite in the open in full sun, but most prefer to congregate in

shady humid areas and bite if we venture near. Some night-time biters will bite primarily in the early hours of darkness, while others will build up their activity as the night progresses.

Those mosquitoes that have most contact with humans are also those most likely to pick up or pass on pathogens—providing they are competent carriers. Diseases such as malaria and dengue do not involve other animals and are passed from human to human via particular mosquitoes, but the mosquitoes that attack both birds and mammals (the 'opportunist' species) are those of greatest concern for the potential infection of humans with animal pathogens. There are many of these so-called zoonotic infections, particularly the arboviruses (*ar*thropod-*bo*rne *viruses*), with yellow fever in Africa and South America being the classic example where mosquitoes that feed on monkeys pick up the virus and later pass it on when they bite humans.

Not all mosquitoes that feed on infected animals are able to pass on the pathogens. There are a number of biological and environmental factors that determine whether a species of mosquito or an individual of that species can be involved in transmission of pathogens. These include susceptibility to infection and multiplication of the pathogen in the mosquito (genetically and physiologically controlled), longevity of the mosquito (surviving the incubation period of the pathogen in the mosquito) and abundance (and thus likelihood of biting).

When a mosquito takes in a blood meal, it may ingest a number of blood-borne micro-organisms. If an arbovirus or malaria parasite is in the blood, and the mosquito is susceptible, the pathogen will infect the gut, various internal organs, and eventually the salivary glands. Once the salivary glands are infected, the pathogen can be injected into a new vertebrate host during feeding. The mosquito can be infectious for the rest of its life (perhaps another week or two), during which time it may pass on pathogens at three or four more feeds. But the critical issue is whether a particular mosquito species and its host are susceptible to the pathogen. Thus, HIV, influenza, measles and hepatitis viruses, and myriad other micro-organisms that may be ingested but cannot infect the mosquito, cannot go on to be transmitted and are simply digested or excreted with the remnants of the blood meal.

Likewise some pathogens are transmitted by certain mosquitoes, but not others. For example, human malaria organisms can be carried by a number of species of *Anopheles* mosquitoes, but not by any *Culex* or *Aedes* species because they are not susceptible; dengue virus is transmitted by one species of *Aedes* (*Aedes aegypti*) but not other species of mosquito; and Murray Valley encephalitis is transmitted to humans primarily by *Culex annulirostris*. One unusual case however, is Ross River virus, which is found in many different mosquitoes in various genera, including *Aedes, Anopheles, Culex* and others, although the isolation of a virus from a mosquito does not necessarily indicate that species is capable of infecting a human.

SO, IT IS THE FEMALE REQUIREMENT for blood that causes the problems. But just how do mosquitoes find a blood meal? How do they find the general or more specific type of host they prefer?

PHOTOS : PAUL ZBOROWSKI

Left: Australia has over 350 species of mosquitoes but not all of them are pests, in fact some like this *Toxorhynchitis* mosquito are actually helpful. The larvae of this giant mozzie (its body can reach over 12 millimetres long) eat the larvae of other mosquitoes. Right: An *Anopheles farauti* mosquito has concentrated the blood cells from its meal and is passing an unwanted droplet of fluid. By getting rid of the unwanted fluid, the mosquito is able to continue feeding, ingesting up to twice its own weight.

MOSQUITOES

Classification
Class Insecta, order Diptera, family Culicidae. More than 3,000 spp. worldwide and over 350 spp. in Australia.

Distribution and Habitat
Found in all regions of the world except the Antarctic. In Australia they occur in all regions of all States, with regional, climatic and habitat characteristics for most species and a restricted distribution for many, although some are found throughout Australia.

Biology
Eggs laid as single units or clutches of 100 or more (depending on species) on or near a water surface (depending on species) and hatch within 2–3 days, or after flooding. Immatures (larvae and pupae) are aquatic but air-breathing, and habitats vary from vast swamps to temporary roadside pools to small leaf axils, from hypersaline littoral rock pools to rainwater storage tanks to sewerage treatment ponds. Larvae feed on live and decaying organic matter on the water surface, in the water column and on the bottom of the various habitats (depending on species and situation), and duration of larval stage is approx. 1–2 weeks but again varies with species and conditions. Pupae are non-feeding but motile, and duration of pupal stage is 2–3 days.

Adults feed on plant juices (for energy), and blood (females only for egg development) from a variety of vertebrate hosts, depending on mosquito species and host availability. Adults may live for 1–3 weeks on average, depending on species and environmental conditions, and take blood meals and lay eggs every 2–5 days, depending on species. Adults disperse from less than 100 m to over 50 km depending on species.

PAUL ZBOROWSKI

Above: A male (right) and female *Culex quinquefasciatus* mosquito. Both male and female mosquitoes feed on plant products, but it is only the females that need a blood meal in order to produce their eggs.

JAMES INDSTO

The mosquito larvae of *Aedes notoscriptus* breed in a wide variety of artificial containers common in backyards, including pot plant bases, blocked gutters, disused pools and vehicle tyres. They also breed in natural containers such as tree hollows.

Typically, mosquitoes are attracted to their preferred host by chemical cues detected downwind of the host. Respiratory products (carbon dioxide) and skin emanations (such as lactic acid) are known to be relatively important. Carbon dioxide is common to all potential hosts so it may be the alerting cue for mosquitoes; other chemicals (like body odours) may be required for discrimination between hosts. Octenol, for example, has been identified from cattle breath as an attractant for tsetse flies, and also some mosquitoes. However, *Culex* species (typically bird feeders) are relatively non-responsive to this mammalian odour compared with *Aedes* species (mammal feeders).

Some mosquitoes appear to release an 'invitation' pheromone when feeding and this attracts others to the host. Additionally, physical cues of temperature, humidity and colour at a host may help the mosquito more accurately tar-

get the prospective blood meal. There is much that is unknown about mosquito attraction to particular hosts. For instance some individual humans are more attractive to mosquitoes than others (presumably because of differences in individual skin 'chemistry', probably produced by both internal processes and external microbial activity), and some people seem not to be bitten at all. Also, different mosquitoes like to bite different areas of the body. Some *Anopheles* species have been shown to be more attracted to the feet, apparently preferring foot odour to respiratory gas. ('Stinky' Limburger cheese has also been shown to attract one *Anopheles* species and, perhaps not by coincidence, the bacteria that produce the smell in feet and cheese are from the same genus!) At least one *Aedes* species prefers hands to feet or Limburger, while some *Tripteroides* species go for the head and circle the nose—an obvious (at least for the mosquito) source of attractive cues and hopefully blood. Incidentally, the commercial products sold as insect repellents do not so much repel mosquitoes as cover up our attractiveness as a potential blood host. The principal active ingredient in most of these products is diethyl toluamide (deet), now with the official name of N,N-diethyl-3-methylbenzamide. It is the most effective 'repellent' chemical available, much more so than citronella and other 'natural' products. Reports that ingestion of vitamin B, garlic and other 'herbal' products will protect against bites have no scientific basis.

Mosquito mouthparts comprise a number of cutting stylets that can penetrate the skin and probe for capillaries. These blood vessels may be pierced and entered for direct feeding, or lacerated so they leak blood into the tissues and the mosquito can feed from the pool (haematoma) that is formed. The saliva that is discharged during probing and feeding dilates the vessels to increase blood flow and inhibits 'clotting' of the blood, thus aiding rapid ingestion. The itch we (and other animals) get from a mosquito bite is an allergic reaction to the saliva.

The amount of blood imbibed determines the number of eggs that can be laid. Most mosquitoes are able to greatly distend their gut when feeding, and their elastic-sided body expands and stretches so that we can see the red colour of their meal. They commonly ingest more than their own weight, up to four times in some species. Those that cannot produce such distensions concentrate the blood cells and pass a clear or coloured fluid while feeding so they can still ingest more than twice their own weight. The distension of the gut (and thus the amount of blood ingested) is under nervous control and the mosquito knows when it has had enough, but if these nerves are cut (as has been done in the laboratory) then the mosquito will continue to suck blood until it (literally) bursts. Reports that holding your breath or stretching your skin taut while a mosquito is feeding will trap the mosquito in the skin and force it to feed until bursting, should be treated as urban myths.

Most mosquitoes take between two and five milligrams (0.002–0.005 millilitres) of blood, but they are usually disturbed before they become fully engorged. The disturbed female may then move to another host (same or different species) to continue feeding, providing an opportunity for multiple infections during a 'single' feeding session. Although the amount of blood ingested by a mosquito may seem small, the multiplier effect can make this quite significant. During the peak (summer) mosquito season in Queensland, cattle may lose over 150 millilitres per cow per night over a few months, leading to severe hypersensitivity (allergic reactions), and possibly death from exsanguination and shock.

To find blood hosts, mosquitoes have to travel greater or lesser distances

STEPHEN DOGGETT

A fully blood-fed adult *Aedes notoscriptus*. These mosquitoes are a major pest in urban areas, and in the laboratory have been shown to be good vectors for Ross River and Barmah Forest viruses. These mosquitoes are also the major vector for the transmission of the nematode that causes heartworm in Dogs.

depending on their environment. *Culex, Coquillettidia* and *Mansonia* mosquitoes associated with the more permanent natural wetlands usually have close contact with water birds that inhabit the site or the mammals that visit, and do not have to travel far. However, *Aedes* mosquitoes associated with temporary bushland or flood-plain pools may have to travel many kilometres to find mammalian hosts, and some salt-marsh *Aedes* will travel 10–50 kilometres downwind (although such movement is more a dispersal activity).

Overall, however, most mosquitoes that affect us in urban areas come from relatively nearby, and are species that have become adapted to living within the human environment. The two best examples are *Aedes notoscriptus* and *Culex quinquefasciatus*. *Aedes notoscriptus* is a native mosquito that has adapted from tree-hole and rock-pool habitats to artificial containers. It breeds in clean water in drums, barrels, cans, tyres, roof guttering etc., in close association with houses, and bites humans around the home during the late afternoon and early evening—at the barbecue. *Culex quinquefasciatus* has been associated with human settlement probably since 'time immemorial' and colonises waste and other polluted waters not generally tolerated by other mosquitoes. It breeds in drains and septic tanks, sewage treatment works, and also some clean water in ground or container situations, and generally bites inside houses and other shelters during the night—in the bedroom.

Notwithstanding the above, many people in urban areas will be 'hit' by non-domestic mosquitoes. This is particularly the case in small rural towns, or suburban areas on the outskirts of cities. In coastal regions, where there are estuarine saline wetlands, the mosquitoes *Aedes vigilax* and *Aedes camptorhynchus* can be a severe nuisance to people living up to ten kilometres from the larval habitats. These species lay their eggs beneath salt-marsh plants at the edge of a depression that is filled monthly by the spring high tides. In inland areas near billabongs, other freshwater wetlands and irrigated agriculture, *Culex annulirostris* and *Coquillettidia linealis* (in southern Australia) or *Coquillettidia xanthogaster* (in northern Australia) can be a pest to residents within at least five kilometres from the aquatic habitats. These species lay batches of eggs in floating rafts on the surface of water bodies that are typically vegetated. *Culex annulirostris* can utilise many variations on this general theme, but the *Coquillettidia* species have a specific biological association with emergent reeds from which the larvae obtain their oxygen (unlike other mosquito larvae that breathe air from the water surface via a siphon at the end of their abdomen).

MOSQUITO-BORNE DISEASES IN AUSTRALIA

Malaria
Malaria in humans is caused by parasitic protozoans (*Plasmodium* spp.). The disease is no longer endemic in Australia but occasional cases occur when a local *Anopheles* mosquito bites a traveller infected outside the country and passes the infection on to a local resident. Malaria usually causes severe fevers, but there can be complications that can be fatal. Most of the (few) cases occur in northern Australia, where there is a greater risk because of the presence of particular mosquito species, especially *Anopheles farauti*, and favourable environmental conditions, but there are *Anopheles* species in all States and malaria has been transmitted in southern areas (like Melbourne and Perth).

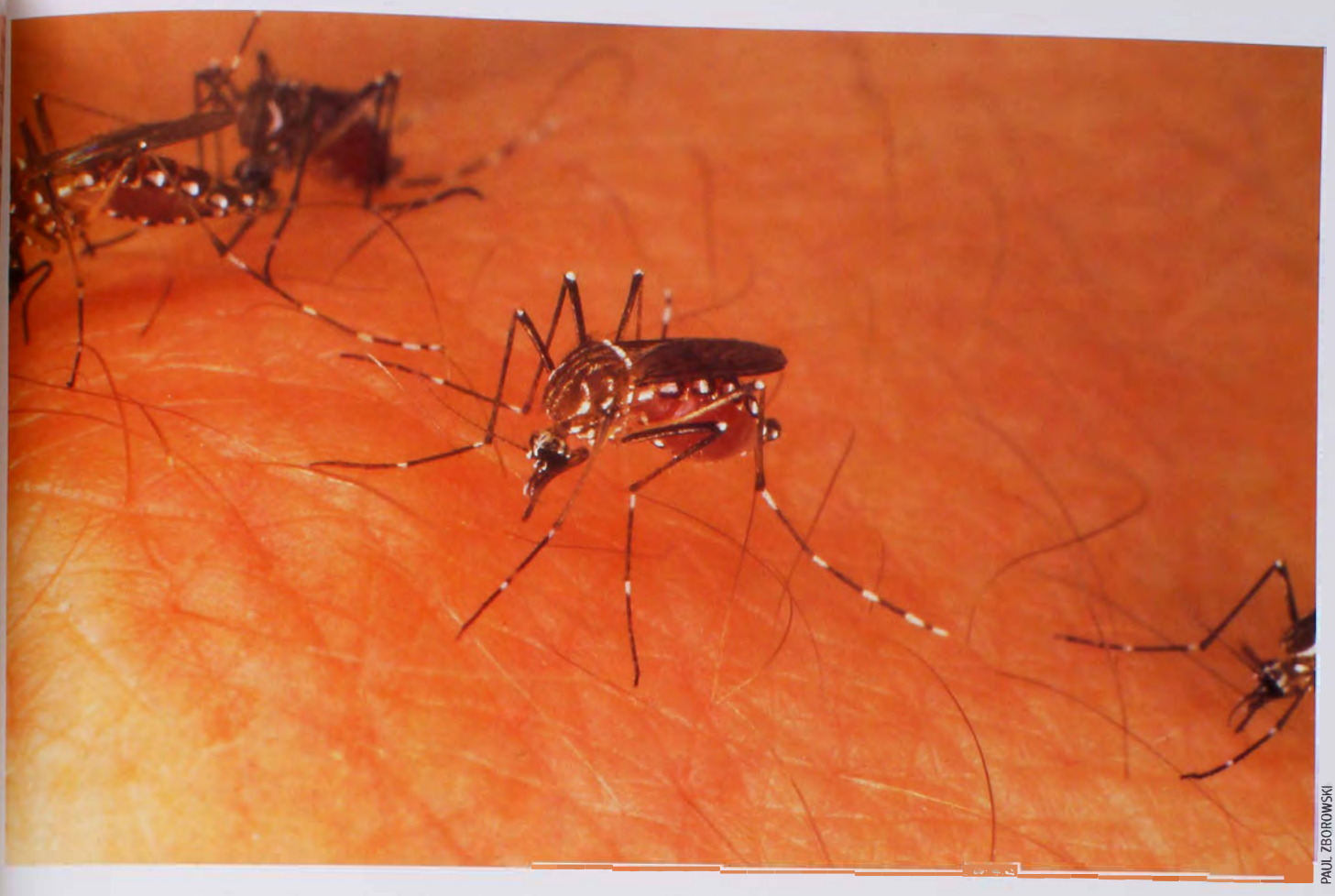
Dengue
Dengue (DEN) viruses cause fever, and muscle and joint pains (and potentially haemorrhage and death). DEN is associated with humans and not other vertebrates. It is imported with travellers infected elsewhere, and is transmitted in Australia by a single mosquito, *Aedes aegypti*. This mosquito breeds exclusively in containers in domestic situations and is not found outside Queensland, although it was well known from NSW, NT and WA prior to the 1950s.

Ross River and Barmah Forest
Ross River (RR) and Barmah Forest (BF) viruses have been active in all mainland States, and RR is also known from Tasmania. The viruses are grouped together here because they cause a similar syndrome, polyarthritis, which can be debilitating to the point of precluding normal occupational activities for months to years. RR is considered to be naturally associated with native macropods (kangaroos and wallabies), although it appears that horses and humans may be involved in disseminating the virus; birds do not appear to be important in natural cycles. There is little knowledge of the natural hosts for BF virus; there are some indications that native mammals are involved but birds have not been excluded. The vectors of RR and BF are similar and, as mentioned above, comprise a range of species; the most important are the salt-marsh *Aedes camptorhynchus* in southern Australia and *Aedes vigilax* in southern and northern Australia, and *Culex annulirostris*, *Coquillettidia linealis* and *Aedes normanensis* in various inland regions.

Murray Valley Encephalitis, Kunjin and Japanese Encephalitis
Murray Valley encephalitis (MVE) and Kunjin (KUN) are endemic and annually active with occasional deaths from MVE in the north-west of Australia, and sporadically active in the south-east. Japanese encephalitis (JE) causes many thousands of deaths annually in Asia, has recently been introduced into the Torres Strait Islands and Cape York (although possibly only for short durations), and has the potential to spread widely through the continent. The viruses are grouped together here as they cause a common syndrome of encephalitis (inflammation of the brain), which for MVE and JE can be fatal and, if not, result in brain damage. MVE and KUN are associated principally with inland wetland wading birds (e.g. herons) and mosquitoes that proliferate in those habitats. One mosquito in particular, *Culex annulirostris*, which is distributed throughout mainland Australia, appears to be the major vector for epidemic activity in times of heavy rain and flooding when the bird/virus/mosquito cycles proliferate. JE is associated with wetland birds and pigs, and the local *Culex annulirostris* is a competent vector for this exotic virus.

AUSTRALIA CERTAINLY HAS A RANGE OF interesting mosquitoes, and it has an interesting history of mosquito-borne disease. Malaria has been eradicated but transmission is still possible in northern regions, and with the many hundreds of cases imported to the country annually it is not surprising there are occasional local infections. Human filariasis (elephantiasis) is no longer a concern in Australia, although mosquitoes are responsible for a dog filariasis (heartworm) which is an important veterinary concern. Arboviruses are the most common and widespread mosquito-borne infections of humans in Australia, and these are a serious public health concern in many regions. The most important medically are Murray Valley encephalitis and Kunjin viruses, which can cause severe and, in the case of Murray Valley encephalitis, fatal inflammation of the brain. However, Ross River and Barmah Forest viruses cause severe and debilitating polyarthritis (arthritis in a number of joints) and probably have a greater economic impact on the community (see box on mosquito-borne diseases).

The activity of arboviruses in Australia has become quite disconcerting. There



PAUL ZBOROWSKI

***Aedes aegypti* mosquitoes are disease carriers and the only ones responsible for the transmission of dengue fever.**

have been large numbers of cases of Ross River virus infection in many regions in the past two decades, and extraordinary outbreaks of Barmah Forest virus between 1991 and 1998, for example, almost 40,000 confirmed cases of Ross River were reported. Although people have been more aware of arboviral infections since the 1980s, and detection and reporting systems have certainly improved, the increase in arbovirus activity during the last 15 years appears to be genuine. Much of this activity has been in rural areas, where mosquito habitat has been created with the increased use of irrigation, and in coastal centres, where humans have built ever closer to the mosquito's estuarine habitat.

For our Australian arboviruses, there is no specific treatment for infection and there are no antiviral drugs to cure the infections. There are no vaccines, although there has been some research towards developing one for Ross River virus. Current management hinges on preventing infection by reducing human-mosquito contact through the control of mosquito populations and the use of personal protection measures such as insect repellents, protective clothing, and simply staying indoors during periods of peak activity.

And what can we expect with mosquito-borne disease within a future scenario of global warming? Models of climate change predict increases in rainfall, tides and temperature for parts of Australia, and such changes have the potential to increase the risk of arbovirus transmission by increasing the distribution and abundance of mosquitoes, and duration of mosquito and arbovirus seasons. However, the degree of climate change is uncertain and the ecology of arbovirus transmission complex. Overall, it is likely that some areas will have increases in arbovirus activity and human infection with predicted climate change, but risk of increased transmission will vary with locality, vector, host and human factors.

So, back at the barbie or in bed, where do we stand (or lie) with mosquitoes? Notwithstanding their natural habitats (such as the wetlands we are trying to preserve, enhance and even construct), for as long as we provide breeding sites for mosquitoes with our residential, industrial and agricultural development, mosquitoes will be with us to torment us. Hopefully, however, we can learn more about them, their place in the environment, and the natural history of the pathogens they carry. In this way we should be able to better 'manage' the mosquito populations around us, without damaging the environment and its other inhabitants, and reduce the risk of pest nuisance and disease infection. Only then will we relax more at the barbie and rest easy in bed. ■

Further Reading

Clements, A.N., 1992. *The biology of mosquitoes. Vol. 1. Development, nutrition and reproduction.* Chapman and Hall: London. [*Vol. 2. Sensory reception and behaviour* is in press.]

Kettle, D.S., 1995. *Medical and veterinary entomology. 2nd ed.* Centre for Agriculture and Biotechnology (CAB) International: Wallingford, UK.

Laird, M., 1988. *The natural history of larval mosquito habitats.* Academic Press: London.

Russell, R.C., 1993. *Mosquito and mosquito-borne disease in southeastern Australia.* Department of Medical Entomology, University of Sydney at Westmead Hospital: Sydney.

Service, M.W., 1993. *Mosquito ecology.* 2nd ed. Elsevier: London.

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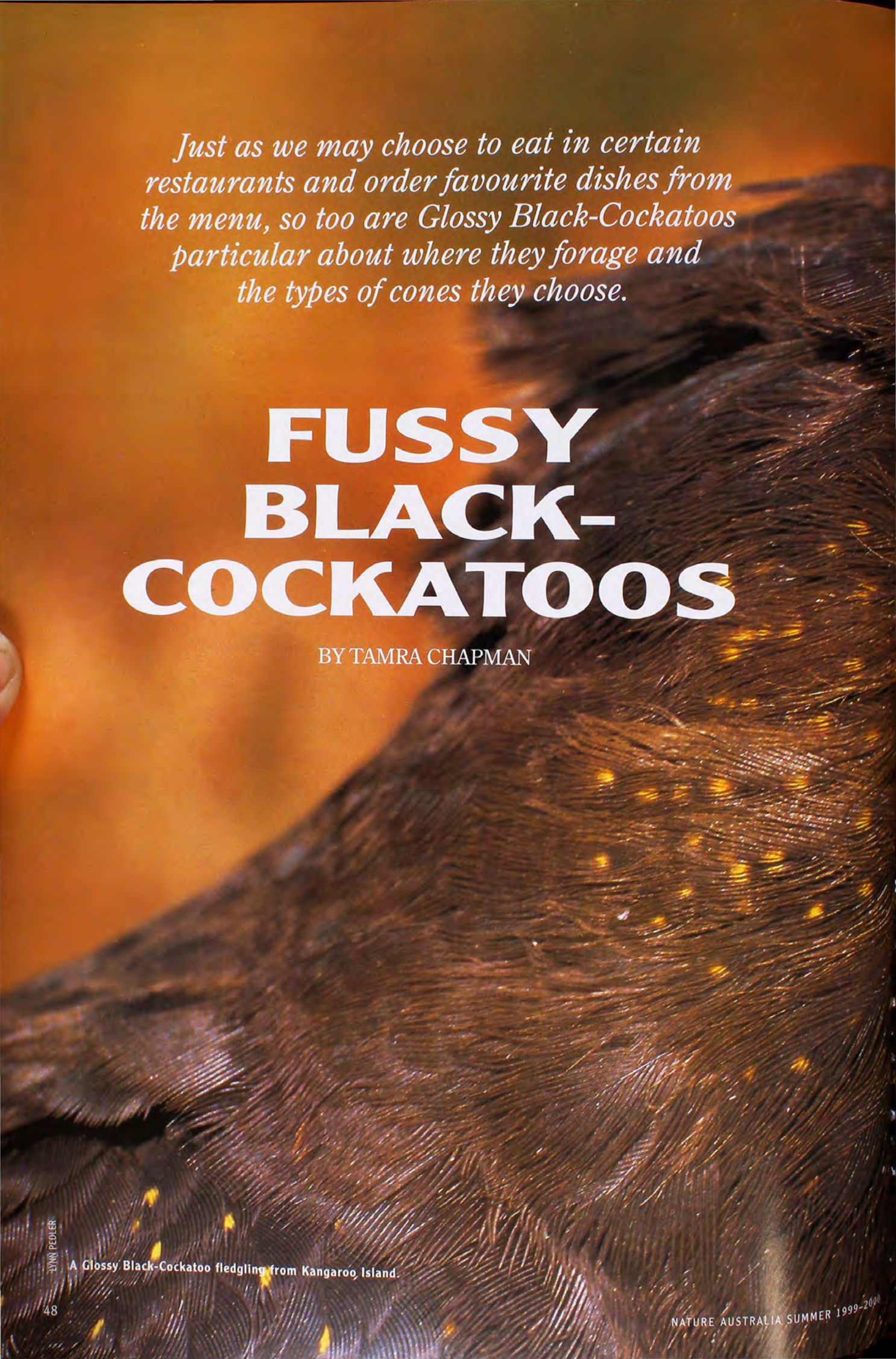
Just as we may choose to eat in certain restaurants and order favourite dishes from the menu, so too are Glossy Black-Cockatoos particular about where they forage and the types of cones they choose.

FUSSY BLACK-COCKATOOS

BY TAMRA CHAPMAN



LYNN PEDLER

A Glossy Black-Cockatoo fledgling from Kangaroo Island.

IF GLOSSY BLACK-COCKATOOS WERE humans, they wouldn't eat their brussels sprouts. They are such fussy eaters that some populations feed almost exclusively on the seeds of a single species of plant. They also have a precise and repetitive feeding drill. They tear a sheoak cone from a branch with their bill, transfer it to their left foot (the odd bird is right-footed) and rotate it in an anticlockwise direction, chewing it to remove the seeds. So complex is their feeding behaviour that juvenile birds remain dependent on their parents for at least six months.

Glossy Black-Cockatoos aren't just fussy about the way they eat. Just as we may choose to eat in certain restaurants and order favourite dishes from the menu, so too are Glossy Black-Cockatoos particular about where they forage and the types of cones they choose.

Glossy Black-Cockatoos (*Calyptorhynchus lathami*) occur in eastern Australia from central Queensland to eastern Victoria, and an isolated population occurs on Kangaroo Island, about 22 kilometres off the south coast of South Australia. Throughout their range they feed on the seeds of sheoaks (*Allocasuarina* and *Casuarina* spp.) and several species are used, but usually only one is exploited in each location. They mainly eat Forest Oak (*A. torulosa*) in Queensland, Black Sheoak (*A. littoralis*) in eastern New South Wales and eastern Victoria, and Drooping Sheoak (*A. verticillata*) in inland New South Wales and South Australia.

Since the 1970s, the South Australian Glossy Black-Cockatoo (*Calyptorhynchus lathami halmaturinus*) has disappeared from the mainland and is now confined to Kangaroo Island. Large-scale clearance of its habitat from the mainland is the principle cause for its contraction, and the subspecies is now considered critically endangered. A survey in 1995 estimated there were about 188 Glossy Black-Cockatoos on Kangaroo Island, but only eight of these birds were juveniles. All prior surveys had also shown a low percentage of juveniles, suggesting that the population, while not rapidly declining, has a low breeding rate. What could be causing their breeding failure?

Together with fellow members of the recovery-plan team, commissioned by

An adult female Glossy Black-Cockatoo has found a sheoak cone to her liking and is in the process of tearing it from its branch.

LYNN PEDLER

A male and female Glossy Black-Cockatoo take time out to preen. Glossy Black-Cockatoos form strong bonds and are thought to pair for life.

Left: This Glossy Black-Cockatoo nestling from Kangaroo Island is just two to three days old. Right: A male and female Glossy Black-Cockatoo at their artificial nest box. Honey Bees, possums and other birds all compete with Glossy Black-Cockatoos for suitable nesting sites.

NICHOLAS BIRKS/WILDFLIGHT

the South Australian Department of Environment, Heritage and Aboriginal Affairs to identify the likely threats to the Kangaroo Island population and to appropriate management actions, we suspected one of the most pressing problems was a lack of suitable nesting sites. Glossy Black-Cockatoos nest in large hollows in mature eucalypts, which take over 100 years to form. About 50 per cent of natural vegetation has been cleared from Kangaroo Island for agriculture and commercial purposes, resulting in possible hollow shortage and competition with other animals that use hollows, such as Little Corellas (*Cacatua sanguinea*), Yellow-tailed Black-Cockatoos (*Calyptorhynchus funereus*), Galahs (*Cacatua roseicapilla*), Common Brushtail Possums (*Trichosurus vulpecula*) and feral Honey Bees (*Apis mellifera*). With the help of volunteers, field biologist Lynn Pedler erected over 80 artificial nest boxes, made from PVC water pipe and wood. Lynn and fellow biologist Stephen Garnett then proceeded to record the use of nest boxes and natural hollows by Glossy Black-Cockatoos. They also monitored their use by other animals to determine if they were having an adverse effect on the cockatoos.

Predation was another possible cause of breeding failure. Previously we had seen Wedge-tailed Eagles (*Aquila audax*) attack and kill fledglings and adults, and we found evidence that a Little Corella had killed a nestling. In addition, hairs found on destroyed nestlings and eggs matched those of Common Brushtail Possums.

Possums are highly abundant on Kangaroo Island and have increased in numbers since commercial trapping ceased in 1950. Being arboreal, hollow-dwelling creatures, they are most likely to pose a threat to Glossy Black-Cockatoos. To exclude possums from both artificial and natural nests, we fitted an iron collar to the base of all known nest trees and recorded subsequent rates of predation.

The other factor that may affect the ability of Glossy Black-Cockatoos to breed on Kangaroo Island is food. Work undertaken by Gabriel Crowley and Stephen Garnett (now at the Department of Environment and Heritage in Cairns, Queensland) included a study linking geology, soil, food quality and foraging patterns in Glossy Black-Cockatoos. I undertook a PhD project to study the foraging behaviour and feeding requirements of Kangaroo Island's Glossy Blacks. The aim was to determine if there was a sufficient amount

LYNN PEDLER

GLOSSY BLACK-COCKATOO

Calyptorhynchus lathami

Classification
Family Cacatuidae. Three subspp. based on bill size and geographic isolation: *C. l. lathami, C. l. erebus* and *C. l. halmaturinus.*

Identification
Smallest of the black-cockatoos (*Calyptorhynchus* spp.), at about 48 cm. Both males and females have shiny black feathers on the back and wings, and a scarlet red panel on the black tail, but females have black transverse bars across this panel and the red sometimes grades to yellow or orange. Sex of juveniles is determined visually by the presence of yellow in tail of females, and by the colour and abundance of spots (females have lots of yellow spots on belly, breast, shoulders and under wing, whereas males have red spots under wing and spots, if present on belly, are orange).

Habitat and Distribution
Open forest and semi-arid woodland, usually in sheoak (*Allocasuarina* and *Casuarina*) habitat, with large eucalypts for hollow-nesting. *Calyptorhynchus l. lathami* in south-eastern Aust. (southern Qld to NSW and eastern Vic.), *C. l. erebus* along central Qld coast, *C. l. halmaturinus* on Kangaroo Island.

Food
Primarily seeds of sheoaks: *Allocasuarina diminuta* (NSW), *A. gymnanthera* (NSW), *A. inophloia* (Qld), *A. littoralis* (NSW, Vic.), *A. torulosa* (Qld), *A. verticillata* (NSW, SA), *Casuarina cristata* (Qld), *C. equisetifolia* (Qld), *C. glauca* (NSW). Also been recorded eating seeds of *Acacia, Angophora, Callitris, Eucalyptus* and *Hakea*, and larvae of wood-boring insects.

Biology
Usually observed in pairs or small groups. Nesting occurs from Jan. to Nov. and the birds congregate into large groups after breeding. Probably long lived, in excess of 20 years. Strong pair bonds, young are dependent on adults for at least 6 months, fed first by parents, then may be cared for by single male, probably a suitor. Females lay 1 egg per clutch, incubation takes about a month, and young fledge 90 days after hatching. If egg fails or chick dies within first month, female may re-lay.

Status
Kangaroo Island population classified as critically endangered. Thought to be declining in other areas of Australia, due to loss of nesting and foraging habitat for agriculture, firewood and ornamental purposes. Kangaroo Island population preyed on by other birds such as Wedge-tailed Eagles, and Common Brushtail Possums. Competition for and use of hollows by Little Corellas, Galahs, Yellow-tailed Black-Cockatoos and feral Honey Bees in non-breeding season can deter Glossy Black-Cockatoos from using hollows or result in death of nestlings.

PHOTOS: LYNN PEDLER

A four-week-old Glossy Black-Cockatoo nestling. This young female will remain dependent on her parents for at least another five months while she learns the complex feeding drill.

and quality of Drooping Sheoak seed available to them.

SHEOAKS, WHICH BELONG TO THE FAMILY Casuarinaceae, are endemic to Australasia. The protein-rich seeds in their woody cones provide food for many species, from ants to rats and finches, but only Glossy Black-Cockatoos are known to extract the seeds from closed cones that are still on the tree. Glossy Black-Cockatoos forage on only a small proportion of the available Drooping Sheoaks on Kangaroo Island, exploiting each patch of trees for a few weeks before moving on to another.

Sheoak cones are about three centimetres long and come in a variety of colours. The newly produced ones are red–brown, then as they age they become brown and finally grey after about three years. Glossy Black-Cockatoos select only the red–brown cones which, being the youngest, may be softer and therefore easier to extract seeds from. They are also particular about which of the red–brown cones they choose. Each cone contains between 70 and 110 seeds, but not all seeds contain a kernel. Gabriel found that the cockatoos only bother to tackle cones that have over 50 per cent of their seeds containing a kernel.

Occasionally Glossy Black-Cockatoos on Kangaroo Island have been recorded feeding on another species of sheoak, the Slaty Sheoak (*Allocasuarina muelleriana*). Feeding on this species occurs for short periods of time outside the breeding season and may be a response to a temporary shortage of Drooping Sheoak seed. However, this may also be a period when the birds are under less pressure to find food and therefore are able to sample other, possibly less adequate, food sources.

Pale stripes across the tail feathers of young birds may, like our fingernails, indicate a period of poor nutrition.

Glossy Black-Cockatoos form strong pair bonds and are thought to pair for life. They lay one egg per clutch, mainly between February and April but as late as August if these early nesting attempts fail. Only the female broods the egg and young chick, during which time the male feeds the female, which in turn feeds the chick. The male must therefore collect enough food for himself, the female and their chick. The incubation period is about 30 days and the chick fledges 90 days after hatching.

By watching individual birds, Stephen and I soon learnt that breeding birds forage for about 80 per cent of the day, consuming the seeds from as many as 140 cones. Non-breeding birds, by comparison, forage for only about half the day and eat half as many cones.

Breeding over the winter months poses a number of potential problems. Inclement weather may threaten the lives of chicks, and the shorter day length means there is less time in which to gather food. We discovered some pale stripes across the tail feathers of young birds which may, like our fingernails, indicate a period of poor nutrition. This could occur if the father is unable to gather enough food for a day or so, due to bad weather or the presence of predators.

DESPITE THE FUSSY FEEDING HABITS OF Glossy Black-Cockatoos, it is clear that pairs are able to find enough good-

An adult female Glossy Black-Cockatoo at the entrance to one of the natural nesting hollows on Kangaroo Island. A shortage of nesting sites was suspected as being one of the reasons for the population's low breeding rate.

quality food to successfully fledge young, and, at least at the moment, there is enough sheoak habitat on Kangaroo Island to sustain the population. The principal cause of breeding failure is more likely to be predation of eggs and chicks by Common Brushtail Possums, which caused most of the losses from uncollared trees. If nests are protected from possums, young Glossy Blacks have a 42 per cent chance of fledging compared to only 23 per cent if not protected. We were able to increase the population from 188 in 1995 to 204 in 1997 simply by placing iron collars around nesting trees.

Although nest hollow competition and predation by other animals did occur, their effects seem to be relatively minor. During the course of our studies, Little Corellas and Honey Bees killed only small numbers of nestlings. And Yellow-tailed Black-Cockatoos, which breed earlier than Glossy Blacks, may have delayed some birds securing a hollow.

With the threat of possums eliminated, the Glossy Black-Cockatoo population on Kangaroo Island should continue to increase. But will there be enough food to sustain it in the future? Much of the present habitat is declining in quality and is likely to lose its capacity to produce new cones within the decade. This is because of the old age of existing trees and lack of recruitment of young trees due to fire and grazing by stock, wallabies, kangaroos and feral Goats. The good news is that revegetation programs are under way to support the expanding Glossy Black-Cockatoo population. Kangaroo Island residents have already begun a range of habitat fencing and revegetation projects, so there will still be food on the table for these fussy eaters in the future. ■

Further Reading

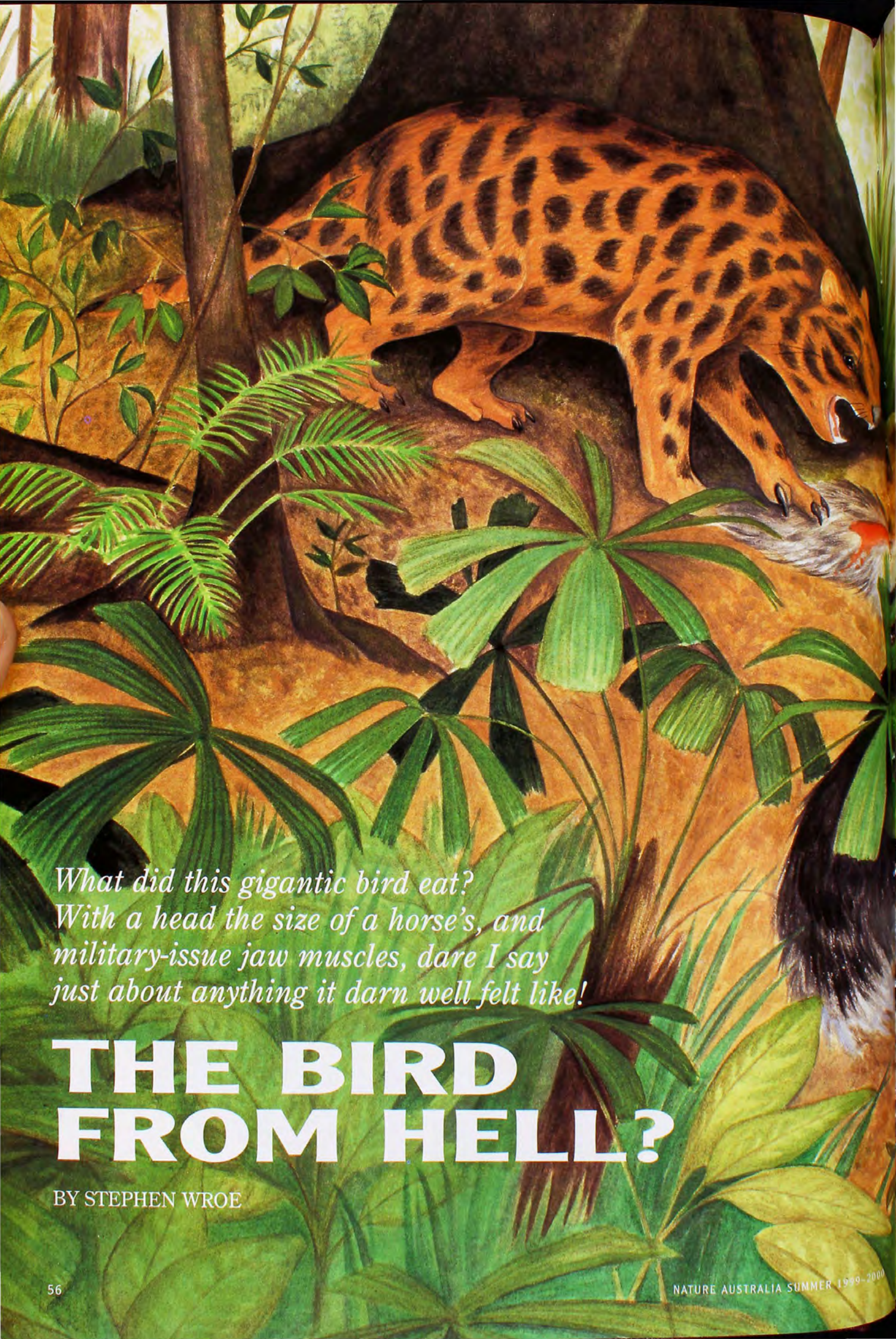
Clout, M.N., 1989. Foraging behaviour of the glossy black-cockatoo. *Aust. Wildl. Res.* 16(4): 467–473.

Garnett, S.T., Pedler, L.P. & Crowley, G.M., in press. The breeding biology of the Glossy Black-Cockatoo *Calyptorhynchus lathami* on Kangaroo Island, South Australia. *Emu.*

Pepper, J.W., 1997. A survey of the South Australian Glossy Black-Cockatoo (*Calyptorhynchus lathami halmaturinus*) and its habitat. *Wildl. Res.* 24: 209–223.

Pepper, J.W., Male, T. & Roberts, G., in press. The foraging ecology of the South Australian Glossy Black-Cockatoo *Calyptorhynchus lathami halmaturinus. Aust. J. Ecol.*

Tamra Chapman carried out her research on the feeding ecology of the Glossy Black-Cockatoos as part of a PhD project, through the Zoology Department of the University of Adelaide.



What did this gigantic bird eat? With a head the size of a horse's, and military-issue jaw muscles, dare I say just about anything it darn well felt like!

THE BIRD FROM HELL?

BY STEPHEN WROE

Confronted by a 300-kilogram *Bullockornis* with half a metre of military-grade cranial hardware, even the impressive marsupial 'lion' *Wakaleo* has no option but to back down and surrender its kill.

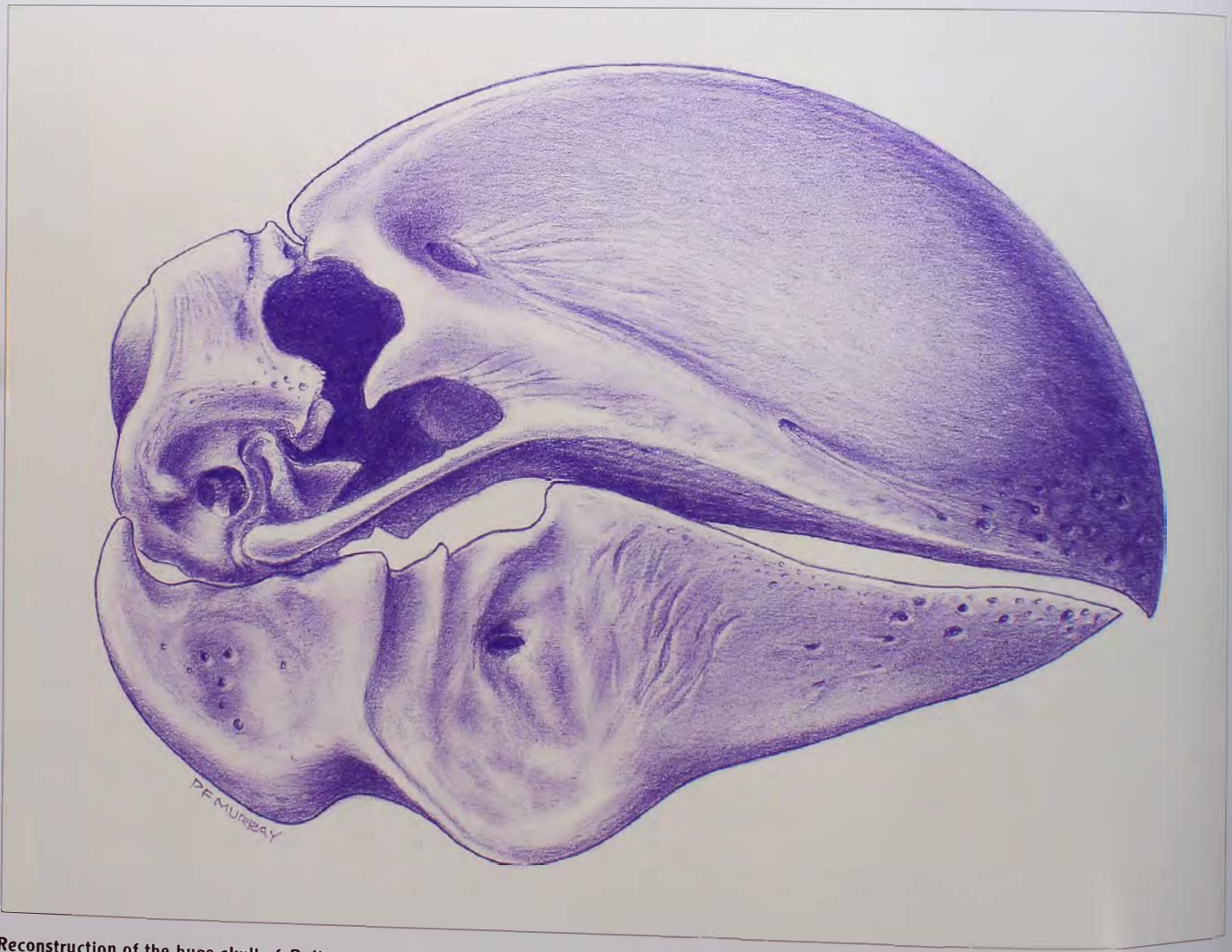
ANNE KISS

WITH HIS MASSIVE FORE-arms straddling the kangaroo carcass, the marsupial lion hurriedly scissors through his victim's tough hide with secateur-like cheek-teeth. Now with the roo's flesh exposed, he begins to bolt down steak-size slabs of meat. The size of a small Rottweiler, but far more muscular, this powerful carnivore is the top mammalian predator of his day. Even so, he can't relax. As he frantically works into the roo's hindquarters the reason for his unease becomes apparent. A distant rumble heralds the end of his meal—and he knows it. The rumble turns into a ground-shaking thunder, accompanied by the sounds of snapping undergrowth. From 2.5 metres above, three pairs of cold, almost reptilian eyes stare him down. The gig is over. With a surly but half-hearted hiss, the 'lion' backs off. But there's no shame in giving way to these adversaries. Each weighs over 300 kilograms. Our 'lion' has just been muscled off his kill by the most formidable bipedal carnivores since the extinction of the dinosaurs. Fifteen million years ago, in northern Australia, thunder birds ruled OK!

Thunder birds or mihirungs (family Dromornithidae) were gigantic, ground-dwelling birds that roamed Australia from at least 25 million to around 26,000 years ago. Among the eight species was the largest bird that ever lived, *Dromornis stirtoni*, three metres high and weighing over 500 kilograms. Fossilised remains of thunder birds were first described in 1839, but until now most material has consisted of assorted post-cranial elements. Little has been known of dromornithid skull morphology. Of course, for working out both the relationships and lifestyles of extinct animals, the skull is the business end of the animal. Consequently, dromornithids have remained conspicuous but enigmatic players in Australia's faunal history.

In the absence of conclusive evidence it has traditionally been contended that thunder birds were related to ratites (Emus, Ostriches, cassowaries etc.) and that, like ratites, they were mostly herbivorous. Spectacular new evidence in the form of the skull of a 15-million-year-old dromornithid, *Bullockornis planei*, has shed new light on the question of dromornithid origins. Peter Murray and Dirk Megirian from the Northern Territory's Central Australian Museum argue that these boofheaded dromornithids were in fact more closely related to the anseriform bird clan—geese, ducks and other water fowl. But this new material raises other questions. In particular, as suggested in my opening paragraph, did *Bullockornis planei* and perhaps other thunder birds use their powerful skulls and beaks to eat meat? Before considering this specific issue, I need to explain a little about the inference of diet in fossil animals in general, using marsupial lions and another giant terrestrial bird as examples.

RECONSTRUCTING THE LIFESTYLES OF extinct animals is fraught with difficulty. One obvious and unpleasant obstacle stands in our way—they're all dead. As a result, the task of the palaeobiologist is essentially that of the forensic scientist—to erect the best supported sce-



PETER MURRAY/RECORDS OF THE SOUTH AUSTRALIAN MUSEUM

Reconstruction of the huge skull of *Bullockornis planei*, about the length of a medium-sized Horse head. The concave muscle-insertion site in the lower jaw is massive, indisputable evidence for extraordinarily powerful jaw-closing muscles and a potentially 'back-breaking' bite. Such formidable hardware in a bird that was herbivorous probably constitutes over-design, hence the author's contention that this avian behemoth (and possibly other members of its family) were significantly carnivorous.

COURTESY Z. BURIAN/THAMES & HUDSON LTD LONDON

Reconstruction of ***Diatryma gigantea****, avian terror of early Tertiary North America and Europe.*

nario using whatever fragmentary evidence is at hand. This evidence flows from several lines of reasoning. One is phylogenetic; that is, after determining the closest extant relative of the extinct species in question, we might assume, all else being equal, that the behaviour of the deceased is reflected in that of the living. A second basic principle, that of functional analogy, operates on the assumption that, if a living animal possesses a feature present in an extinct one, then the feature was probably put to the same purpose in both. Again, by studying living forms, we gain insight into the lifestyle of the extinct. These arguments have merit, and have often been invoked by palaeobiologists. However, there are problems with both.

Thunder birds were gigantic, ground-dwelling birds that roamed Australia from at least 25 million to around 26,000 years ago.

Clearly, the more distant the relationship between an extinct species and its living relatives, the more tenuous the assumption that they shared similar lifestyles. Regarding the second principle, the possibility always remains that an extinct animal may have used a similar feature in a living species for different purposes. Moreover, in some cases, there are simply no comparable living analogues. Because of these uncertainties, it has been suggested that a third line of evidence should be considered. This method, called 'biomechanical design analysis', involves examining the feature of interest in a fossil species and then matching its form with the most likely, hypothetical function.

In 1858, the renowned palaeontologist Richard Owen described the first specimen of a curious Pleistocene-aged marsupial and named it *Thylacoleo carnifex*. Examination of its premolar teeth left Owen in no doubt that he was looking at a carnivore par excellence, based on acceptance of the theory that large, vertically slicing cheek-teeth (carnassials) are the hallmarks of a mammalian predator. Owen thus drew on inference from our second 'rule of thumb'—analogy with the closest living structural counterparts. However, it wasn't long before others questioned his reasoning and proposed alternative purposes for *Thylacoleo*'s monstrous premolars. In hindsight some were laughable, culminating in the often-ridiculed suggestion that *Thylacoleo* was a melon-muncher. But no matter how silly such explanations seem now, they were based on the generally accepted view that *Thylacoleo* was a member of Australia's great diprotodontan radiation and, because modern diprotodontans (including wombats, kangaroos, possums) are largely vegetarian, it seemed reasonable to assume *Thylacoleo* was too. In further support of this argument it was pointed out that *Thylacoleo* lacked large death-dealing canines and, instead of having large temporal muscles to control the lower jaw, like living carnivores, they had huge masseter (cheek) muscles like plant-eaters.

The debate over how *Thylacoleo* made a living has since gone full circle, thanks largely to a detailed form-function analysis by Rod Wells (Flinders University) and colleagues who convincingly argued that the carnassials were ideally suited to shearing flesh. Another important point raised by Wells and Co. was that *Thylacoleo*'s massive jaw muscles and bolt-cutting cheek-teeth were seriously 'over-designed' for any other purpose but carnivory. Using *Thylacoleo*'s cranial hardware to eat fruit, or even the hardest of nuts, would be tantamount to calling the fire brigade to put out a match. Mother Nature is a hard task mistress, and one thing she frowns on is waste. Maintaining industrial-grade hardware for a role that could be performed far more cheaply is a serious infraction. Evolutionary theory predicts that natural selection will ruthlessly weed out and exterminate features or species found

guilty of such offences.

The history of interpretation of *Diatryma gigantea*—a giant terrestrial bird excavated from 60–55-million-year-old deposits in North America and Europe, parallels that of *Thylacoleo* in some important respects, but with interesting differences. Based on the huge beak and jaw muscles, *Diatryma*'s lifestyle was likened to that of *Phorosrhacos*, another extinct giant, ground-dwelling bird. Phorusrhacoids were a diverse group, represented on every continent except Africa and Australia. Although some of the smaller species could fly, the larger, ground-dwelling varieties were either heavy, bulky scavengers or swift, active predators. The latter included the awesome *Titanis walleri* from North America, which may even have persisted as recently as 12,000 years ago, making it the closest thing to a *Velociraptor* ever

Unless *Diatryma* was regularly busting Coconuts, they argue, it couldn't have been a plant-eater—its head was too big!

seen alive by humans. Anyway, no-one ever doubted that all phorusrhacoids were carnivores. Consequently, *Diatryma* remained guilty by association until, 72 years later, an alternative theory was flagged. In 1989, Allison Andors (American Museum of Natural History) carried out a detailed biomechanical analysis and concluded that *Diatryma* was a herbivore. In addition he pointed out that *Diatryma* lacks some features common to most carnivorous birds (its beak isn't hooked and its toes are not equipped with vicious talons) and suggested that the closest comparisons among living birds are grass- and leaf-eaters. Case closed? Not quite.

Titanis walleri **was the last and most awesome of a long line of predominantly American 'terror birds'. Note the extraordinary and most 'un-bird-like' forelimbs, uncannily reminiscent of tyrannosaurid dinosaurs. Not as heavily built as *Bullockornis* or *Diatryma*, this bird was a sprinter. It may have persisted in North America until as recently as 12,000 years ago, giving early Americans a 'run' for their money!**

In 1991, following another detailed investigation, this time by Lawrence Witmer and Kenneth Rose (Ohio and John Hopkins Universities, respectively), the flesh-ripping, bone-crunching image of *Diatryma* was resurrected. They pointed out that living birds can crop grass and leaves, and crack the largest of nuts (Coconuts excepted), using heads a fraction the size of *Diatryma*'s. Unlike mammals, birds don't process food in their mouths, so for plant-eating birds, there is no advantage in increasing the absolute size of the head beyond that required to crop the grass or bust the nut of choice. Put another way, in an up-sized version of any bird the head would become smaller compared to the body, assuming that it ate the same food. For example, the Australian Palm Cockatoo (*Probosciger aterrimus*) has a fist-sized head and a very powerful beak that are relatively large compared to its body. With this equipment it can crack the largest of Aussie nuts. Of course, the Palm Cockatoo is a midget compared to *Diatryma* (or dromornithids). If we scaled the Palm Cockatoo's body up to giant-like dimensions, but kept its head fist-sized, it could still crack the largest native nuts. A bigger head and beak would provide little advantage. More to the point, this would transgress that widely accepted dictum—natural selection won't tolerate excess. Thus, as Witmer and Rose explain, the important point is not the relative size of *Diatryma*'s head compared to its body, but the absolute size of its head relative to the proposed food of choice. Unless *Diatryma* was regularly busting Coconuts, they argue, it couldn't have been a plant-eater—its head was too big! Supporting this hypothesis is the fact that, in giant birds that are known to be plant-eaters (moas, Emus etc.), the head is small compared to the body. To Witmer and Rose the only way to explain *Diatryma*'s big head was that it took larger prey.

WHAT DOES ALL THIS HAVE TO DO with the palaeobiology of thunder birds? Well, hopefully I've demonstrated the following points. First, inferring the biology of extinct animals through comparison with their closest living relatives is anything but conclusive when the two groups in question are only distantly related. Second, the fact that a fossil animal doesn't fit a given stereotype for all features common to a living guild is no reason to presume that it couldn't once have been part of such a guild, as long as some of its features do 'fit the bill'. Third, regarding the diets of extinct animals, the case should never be closed until thorough biomechanical design analyses have been conducted. The relevance of all this to dromornithid diet is clear. Their closest living relatives (whether you

STEVEN KIRK/DISCOVER MAGAZINE

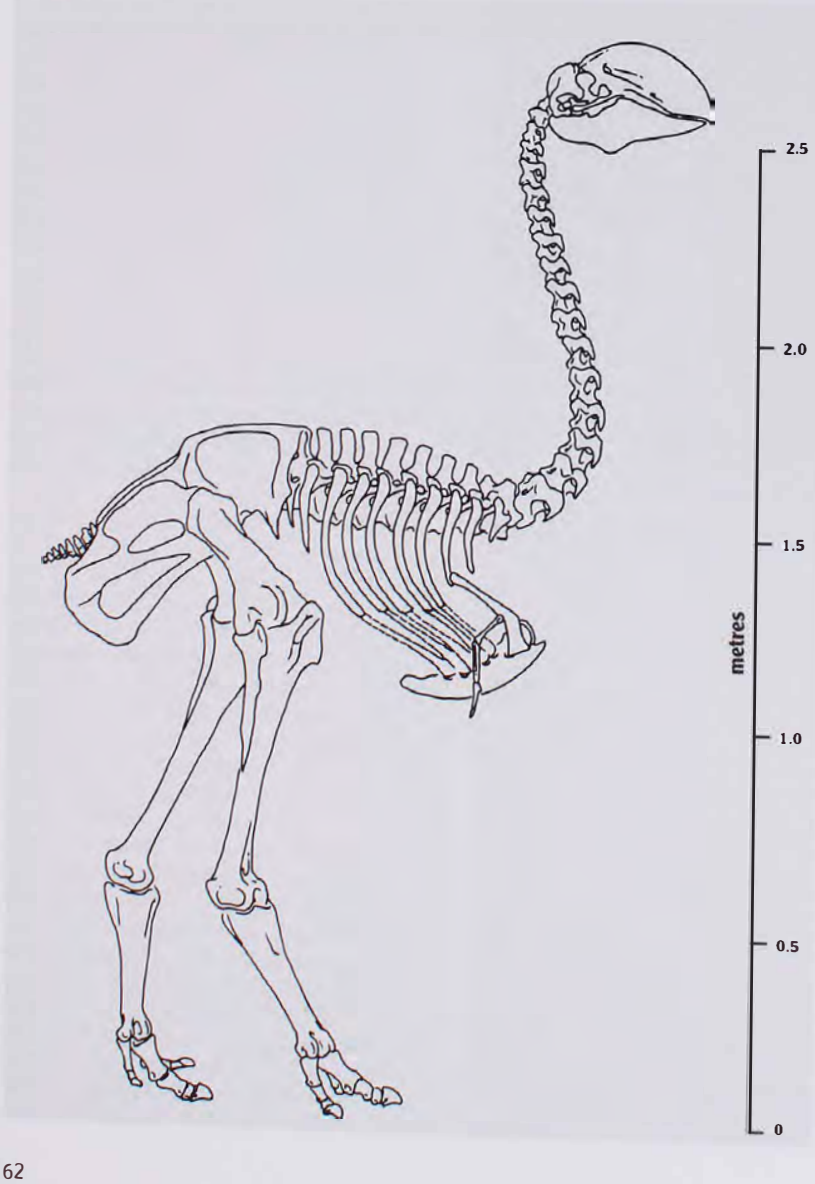
take these to be ratites or geese) are very distant, separated by tens of millions of years, and a lot can happen in this time; although they lack some features present in most living carnivorous birds, they certainly possess others; and, finally, no-one has yet indulged in a detailed biomechanical design analysis for dromornithids.

Historically, the argument against carnivory in thunder birds was never strong and the new skull material presented by Murray and Megirian strengthens my conviction, at least for *Bullockornis planei*. The bill of *Bullockornis* is convex, very deep, and driven by powerful muscles (evidenced by enormous muscle-attachment sites). These are all standard equipment in most living carnivorous birds, *Diatryma* and phorusrhacoids. It further shares with *Diatryma* and phorusrhacoids a huge head, an inability to fly and nostrils placed well back on the beak. Unlike most living raptors and most phorusrhacoids, but in common with *Diatryma*, *Bullockornis* is massively built and lacks a distinctively hooked bill and talons. But then other living carnivorous or scavenging birds, such as the African Carrion Crow (*Corvus crassirostris*), also lack these features. The bottom line is this: *Bullockornis* certainly had the features required to kill and butcher large prey. Of course, this doesn't prove that it did. Some living plant-eating birds also possess many of these features. But given that the huge head and beak of *Bullockornis* appear to have been 'over-designed' for processing available plant material, I believe there is a strong *prima facie* case for the assertion of a carnivorous lifestyle. Even if Coconut-sized nuts were present in Miocene Australia, it would have to be demonstrated that they existed in sufficient abundance to sustain 300-kilogram birds in order to explain away the 'over-design' problem.

So it's time to ask again: what did this gigantic bird eat? Built like a brick 'out house', with a head the size of a horse's, and military-issue jaw muscles, dare I say just about anything it darn well felt like!

On a less frivolous note, the *Bullockornis* skull material raises more questions than it answers. For example, do arguments for carnivory in *Bullockornis* apply to other thunder birds as well? We'll need more fossil skulls to tackle that question. Certainly, the Pleistocene dromornithid *Genyornis newtoni* had a much smaller skull than *Bullockornis*, in both absolute and relative terms. Even so, a scavenging role has been suggested for this bird. Recent evidence, based on the relative proportions of different carbon isotopes present in fossil eggshells, has been interpreted as supporting the hypothesis that *Genyornis* was primarily a browser. However, in arriving at this conclusion the authors had assumed, *a priori*, that the bird was a herbivore. If we dismiss this assumption, as we must until more conclusive evidence comes to hand, then these data could just as easily support the proposition that *Genyornis* fed largely on browsing herbivores. Consequently, I conclude that isotopic evidence lends nothing to either pro-herbivory or pro-carnivory arguments at present.

Other evidence may count against the inference of carnivory for some thunder birds. For example, unusually for big carnivores, dromornithid fossils are relatively common. Of course, fossilisation is a fickle process and many explanations could account for this excess. For *Dromornis* fossils, Peter Murray sug-



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Restorations of the skeletons of the giant North American terrestrial bird *Diatryma gigantea* (right) and the still larger Australian thunder bird *Bullockornis planei* (left). Although separated by tens of millions of years and thousands of kilometres, the similarities are striking. Most authors have interpreted *Diatryma* as a highly effective predator.

GREG CALVERT

Leopard-sized, built like a tank and formidably armed, *Wakaleo vanderleueri* was a top-ranking mammalian predator of middle Miocene northern Australia. It may well have had to compete with other predators, of the avian kind.

gests they are abundant because birds from a wide area congregated at water holes in times of drought.

Another question: how did such large birds manage to run down and secure their prey? Incidentally, this same question has been levelled at those who support a predatory habit for the ultimate bipedal monster, *Tyrannosaurus rex* (see *Nature Aust.* Summer 1996–97). A number of alternatives are available. Perhaps dromornithids weren't active predators, but scavengers, using their intimidating size to muscle other carnivores from kill sites. On the other hand, this query presupposes that the animals dromornithids hunted were themselves fast runners. This doesn't necessarily follow. Certainly not all dromornithids would have been ponderous slow movers. Maybe some scavenged and others chased? Form-function analyses for *Diatryma* and *T. rex* have indicated that they were not necessarily slow. Likewise an analysis by Peter Murray indicates that even the largest thunder bird, *Dromornis stirtoni*, may have been capable of surprising speed, up to 35 kilometres per hour.

I don't pretend to have solved the riddle of thunder bird palaeobiology. Indeed, anything but. More realistically, I hope to have raised enough doubt to stimulate further research. There are arguments for and against carnivory in *Bullockornis* and other dromornithids, but to those in the anti-camp, the function of one conspicuous complex of features demands explanation. If *Bullockornis* didn't regularly feed on vertebrate carcasses, then what was its undeniably massive and powerful skull, beak and chewing muscles used for? Invoking the principle argued above, if it was cracking nuts or cropping grass, then it suffered from a serious 'over-design' problem. Herbivory for this bird appears to defy evolutionary theory. If this is true, then evolutionary theory. If this is true, then *Bullockornis* was the bird from hell, a truly terrifying 'reincarnation' of those long-gone ancestors of all birds, the theropod dinosaurs. ■

Further Reading

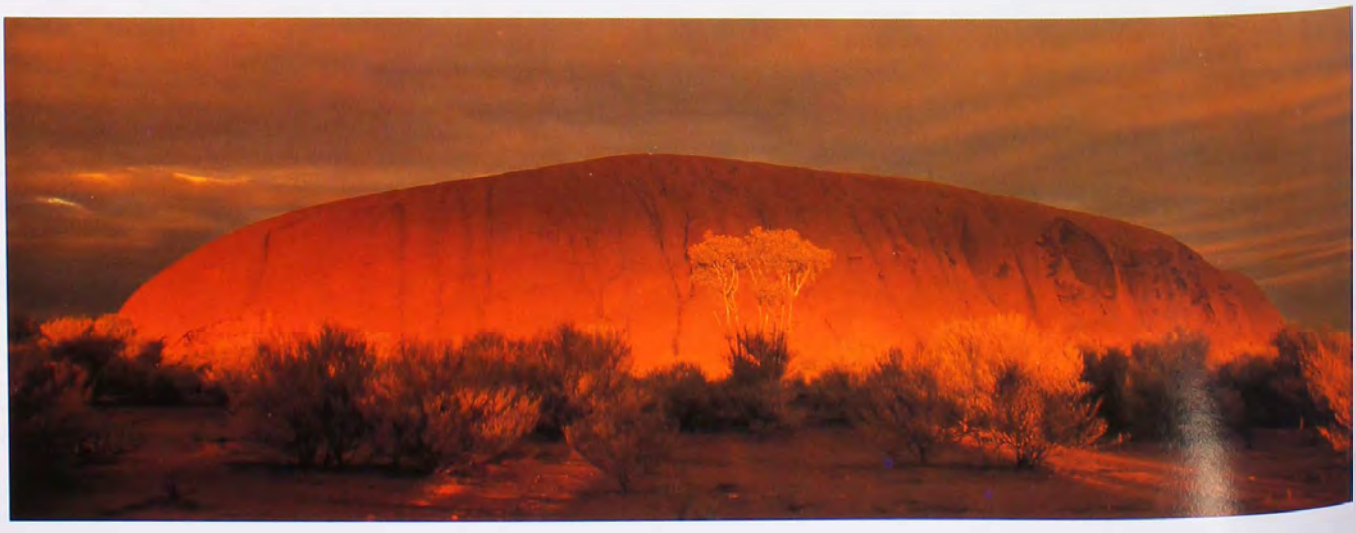
Murray, P.F. & Megirian, D., 1998. The skull of dromornithid birds: anatomical evidence for their relationship to Anseriformes. *Rec. S. Aust. Mus.* 31: 51–97.

Witmer, L.M. & Rose, K.D., 1991. Biomechanics of the jaw apparatus of the gigantic Eocene bird Diatryma: implications for diet and mode of life. *Paleobiology* 17: 95–120.

Wroe, S., 1999. Killer kangaroos and other murderous marsupials. *Sci. Amer.* May 1999: 68–74.

Wroe, S. & Myers, T., 1998. Fallacy and future-eating. *Australas. Sci.* 19(9): 27–29.

Dr Stephen Wroe is a palaeontologist at the Australian and Macleay Museums. He conducted his PhD research at the University of New South Wales. His research has centred on the evolution of Australia's marsupial carnivores, but he has a keen interest in carnivorous animals in general.



Uluru, Northern Territory, by L. & O. Schick.

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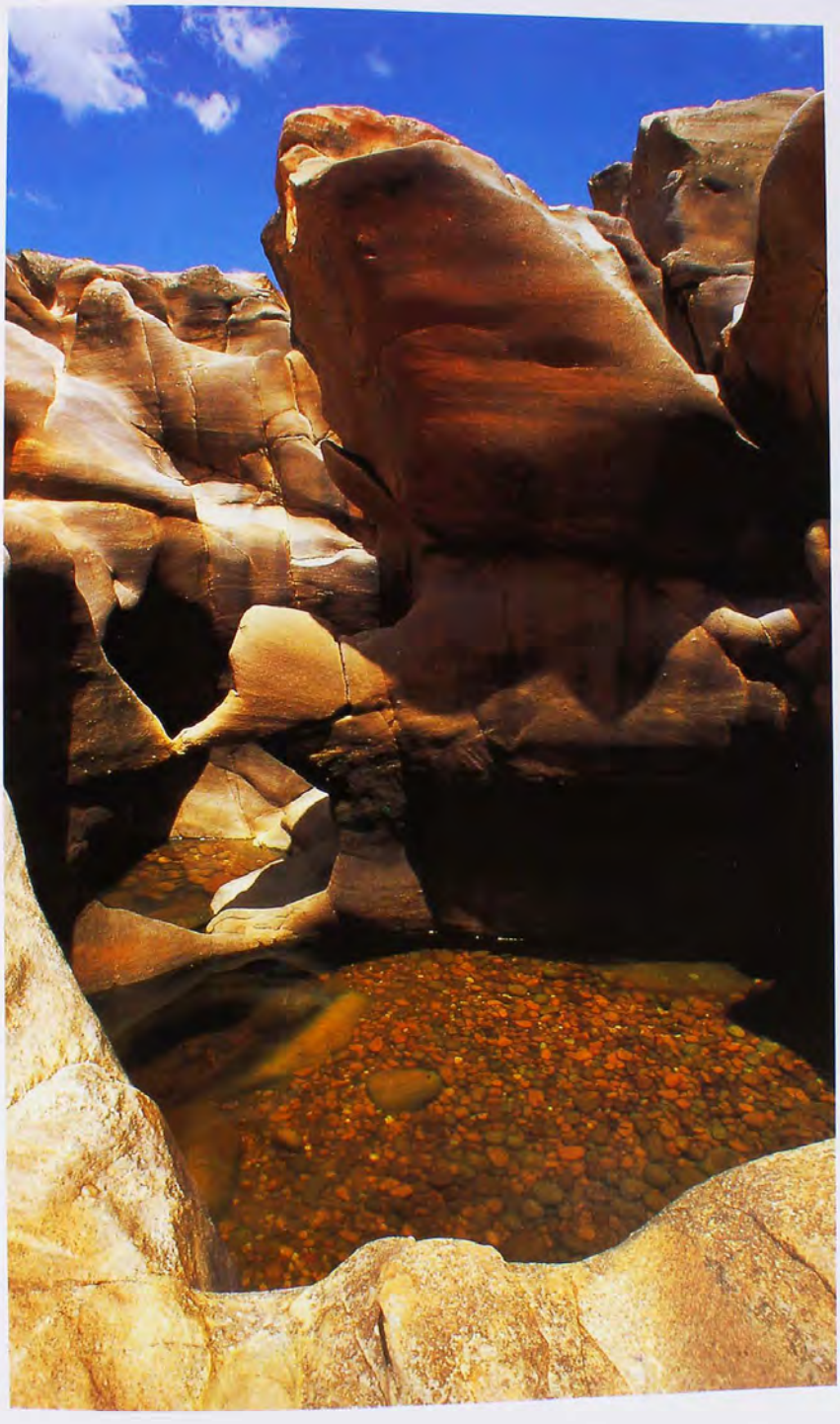
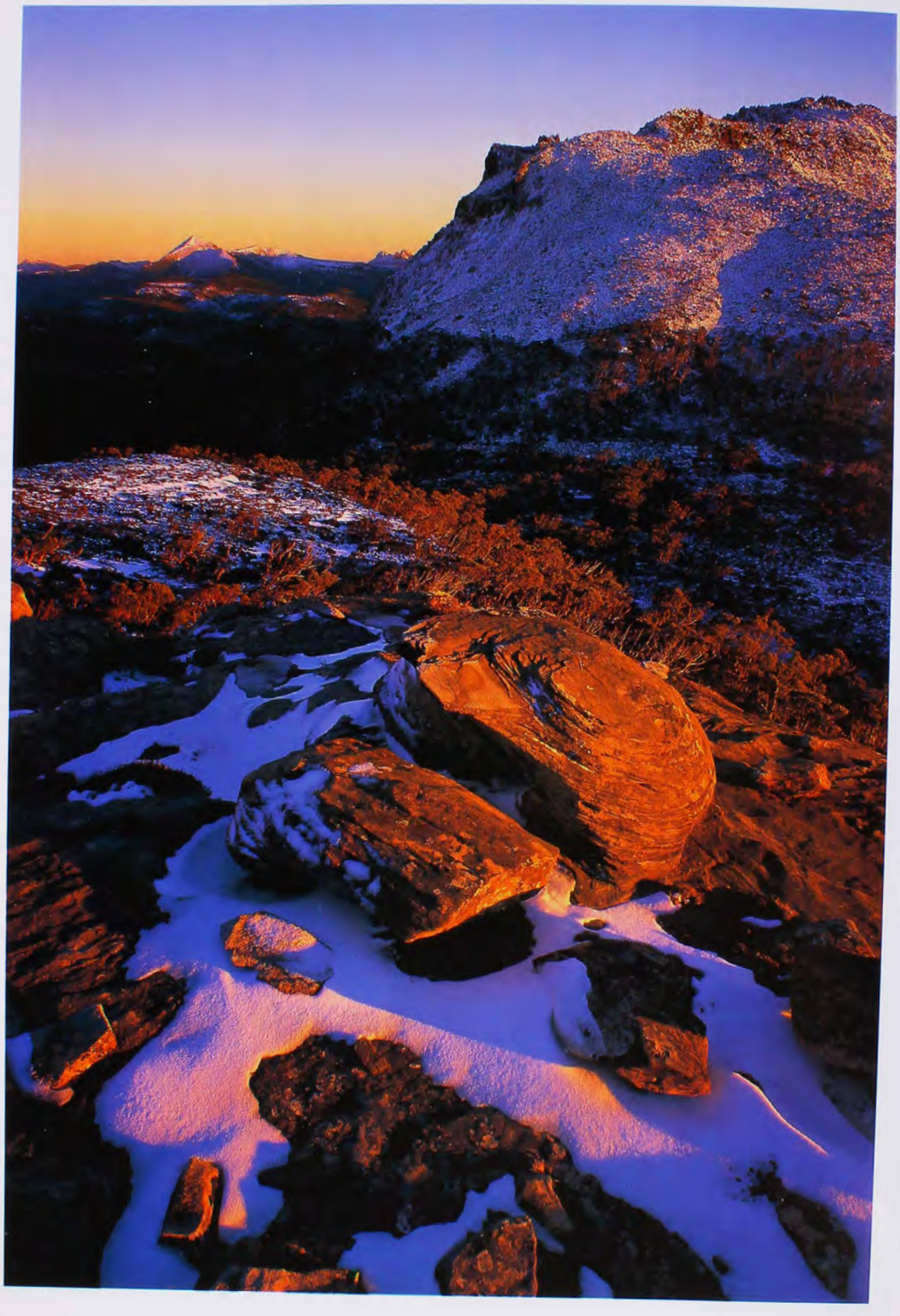
THE ART OF ROCKS



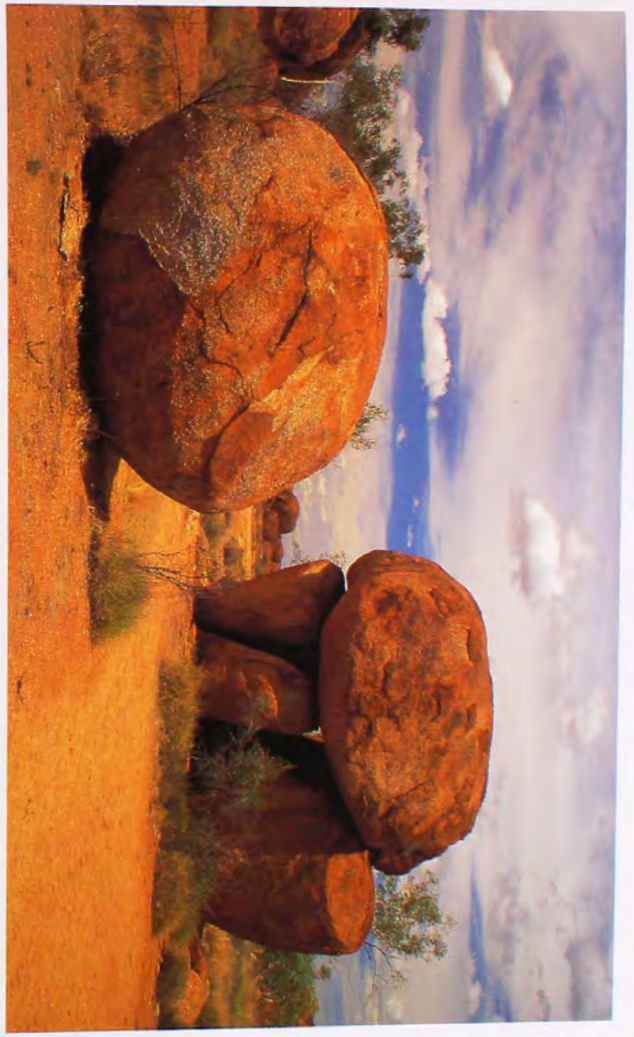
Katherine Gorge, Northern Territory, by Nigel Wesley.

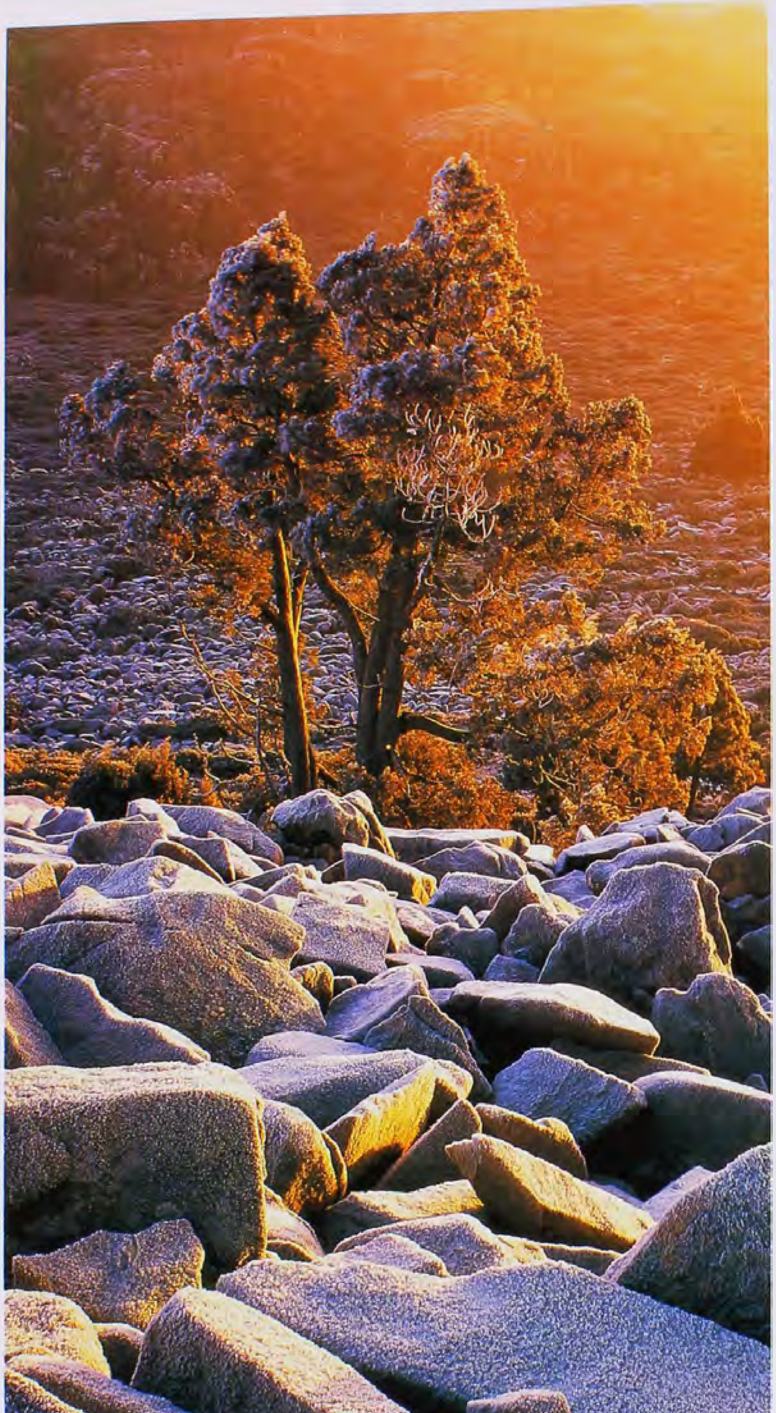


Lake St Clair, Cradle Mountain National Park, Tasmania. by Rob Blakers.

Freycinet National Park, Tasmania, by Rob Blakers.

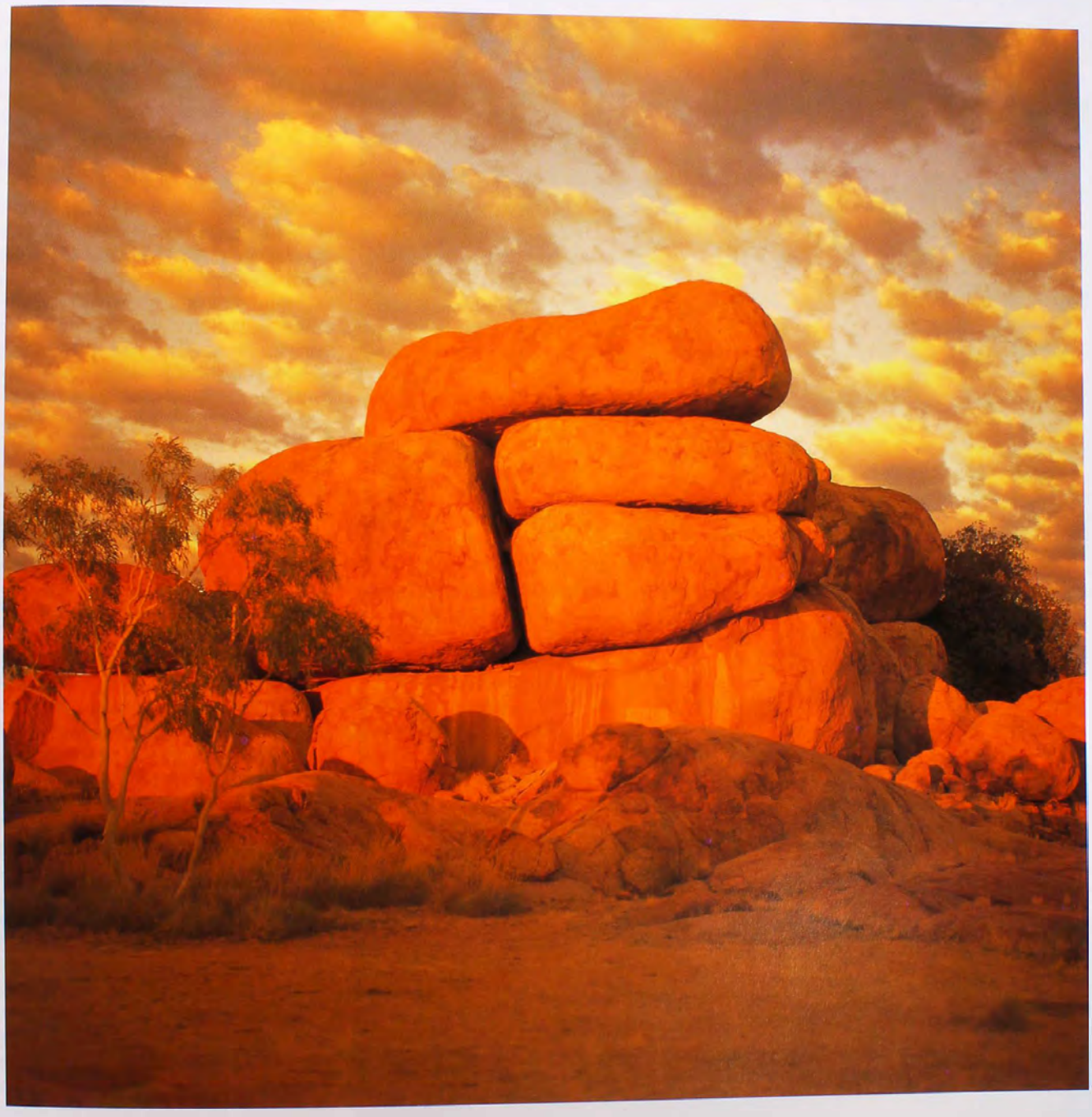
Devils Marbles, Northern Territory by Nigel Wesley.





Tasmanian forest, by Rob Blakers.

Tasmania, Rob Blakers.



Devils Marbles, Northern Territory, by Ken Stepnell.

It was a petrified brain, so perfectly preserved that the blood vessels that serviced its owner's last thoughts stood out in proud relief over its surface.

BRAIN OF THE DEMON DUCK OF DOOM

BY MICHAEL ARCHER

MYSTERIOUS ARE THE ways we first confront the unknown. In the case of New South Wales colonist George Rankin, his 1830 discovery of prehistoric bones in the Wellington Caves proved nearly fatal. Having tied a rope to what he thought was a projection of rock, he began to descend to the cave's lower depths. Moments later, the 'rock', which turned out to be the leg bone of a giant, flightless bird, snapped off to join Rankin and his rope in a heap on the cave floor. Fortunately he and the bone survived to become heralds of Wellington's rich and historically significant fossil deposits.

That untrustworthy bone, having been sent to England, was identified by Richard Owen as the leg bone of a previously unknown large bird. It was later illustrated, which was fortunate because sometime during World War 2 it disappeared. From the illustration, Patricia Vickers-Rich (Monash University) concluded it was almost certainly a femur of a dromornithid—an extinct family of large to huge flightless birds unique to Australia.

In the years that followed, many kinds of dromornithids were discovered, from the last-surviving, large-Emu-size *Genyornis newtoni* (probably the species that first let Rankin down), to the deep-beaked 12-million-year-old *Bullockornis planei* and the horrendously huge eight-million-year-old *Dromornis stirtoni*, which at three metres in height and perhaps 500 kilograms in weight may have been the largest bird in the world—ever. This feathered titan coexisted at Alcoota, in the Northern Territory, alongside two smaller and more slender species of *Ilbandornis*.

Riversleigh's dromornithid discoveries have included *Barawertornis tedfordi*, the oldest (about 24 million years old) dromornithid known. Walter Boles (Australian Museum) has also been studying a beast informally dubbed 'Big Bird'. Next to its gigantic leg bone in the limestone block at Riversleigh are hundreds of polished pebbles in an otherwise pebble-free rock—evidently the gizzard stones or gastroliths that were used to grind up its food.

Working out the closest relatives of these birds has been a challenge, mainly because of the lack of adequate skull material. While first thought to be related to other large flightless birds known as ratites (Ostrich, Emu, cassowaries, kiwis, rheas, tinamous, and the extinct moas and elephant birds), later suggestions were that they were more closely related to game birds or galliforms (half-tonne 'chickens from Hell'). More recently, Peter Murray and Dirk Megirian (Central Australian Museum) have suggested, on the basis of skull material from the Northern Territory, that they are most closely related to ducks and their relatives (anseriforms).

Similarly controversial has been what dromornithids did for a living. Until recently they were presumed to be herbivores, perhaps eaters of seeds or leaves. In favour of this argument has been the abundance of some species in the deposits in which they occur, carnivores normally being rarer than herbivores. Similarly, the pile of gizzard stones suggests to some a herbivore that had to finely grind difficult-to-digest plant material, meat being much easier to digest. However, carnivores can be preserved in abundance, particularly around waterholes where other bogged creatures become someone else's dinner, and gizzard stones occur in crocodiles and even some recently discovered carnivorous dinosaurs.

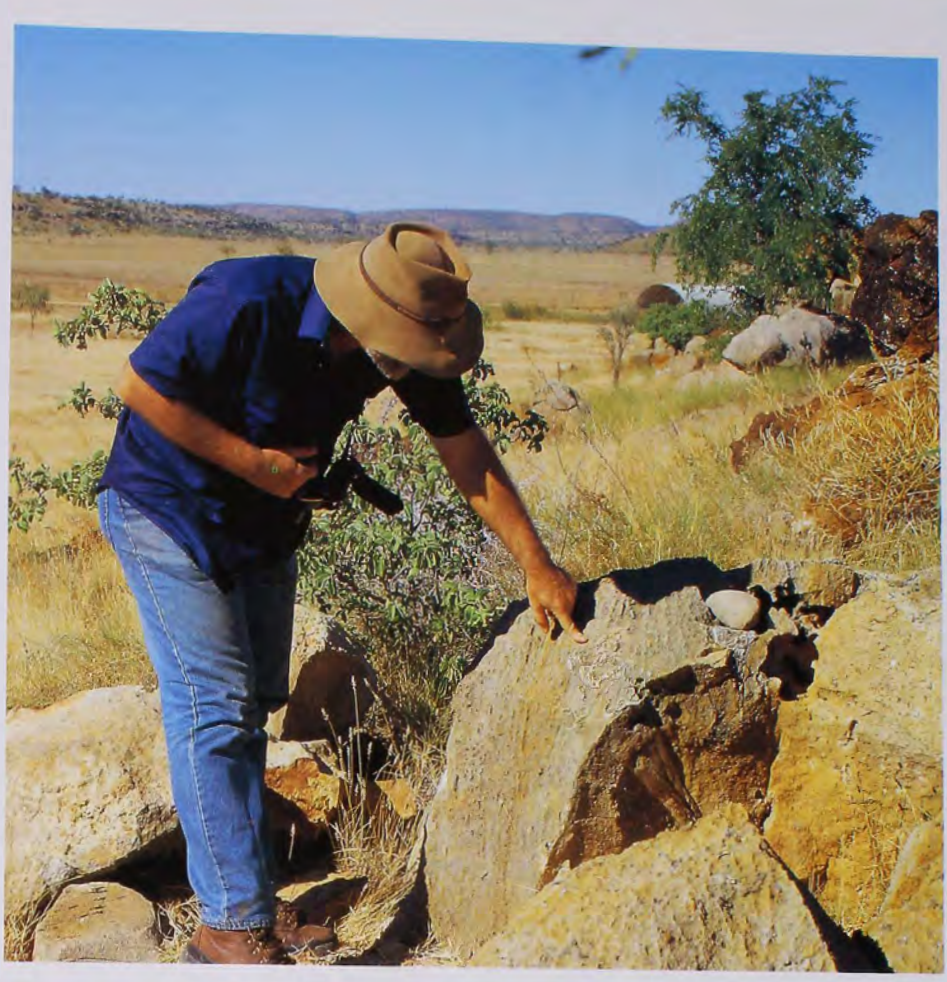
Stephen Wroe (Australian Museum and the University of New South Wales) has challenged conventional wisdom by noting that the incredibly powerful beaks and jaw musculature of at least *Bullockornis* seem 'over-designed' for an avian herbivore, but perfectly appropriate gear for a rapacious flesh-eater (see his article in this issue). If they were carnivores, these 'Demon Ducks of Doom' (as they were mischievously called by Walter Boles) would have been some of the most awesome flesh-eaters since the dinosaurs. And it wouldn't be the first time that giant flightless birds took a shine to flesh. South America once sported the gruesome phorusrhacoids ('terror cranes'), some of which had skulls half a metre in length with vicious, hooked beaks. The giant predatory diatrymids would have been similarly unpopular in North America where they probably gobbled up ancestral horses.

Enter the intrepid volunteers of the Riversleigh Expedition of 1999. When 'Lizard' (aka Chris Cannell from Pasminco) skilfully cracked open a block of chocolate-coloured limestone from a newly discovered site, Micheala Gilligan (science teacher from Seaham, New South Wales) noticed a mysterious fist-

AUSTRALIAN MUSEUM/NATURE FOCUS

Part of the ankle bone (tibiotarsus) of the as-yet-unnamed 'Big Bird' from Riversleigh compared with that of an Ostrich, the largest bird alive today.

'Big Bird' *in situ* at Riversleigh. The gigantic leg bone lies next to hundreds of gizzard stones.



sized treasure that simply popped out of the block. As she and her husband Brian (Director of New South Wales National Parks & Wildlife Service) puzzled over the object, my jaw dropped when I saw what she held. It was a petrified brain, so perfectly preserved that the blood vessels that serviced its owner's last thoughts stood out in proud relief over its surface. Even the V-shaped 'optic chiasma' that brought the nerves from the once bright eyes of this beast into the base of its brain was present.

But what sort of beast was managed by this brain? It was like no mammal brain I had ever seen, nor did it appear reptilian. The giveaway was one piece that had a bit of skull attached. This had thin layers of bone surrounding a thick spongy marrow—bird! But clearly it was far too big for an emu or cassowary, which left only one plausible candidate—the Demon Duck of Doom!

Back in Sydney, Bob Rainey (University of Texas in Austin), veteran of thousands of palaeontological jigsaw puzzles, spotted the attachment points for several isolated pieces found next to the brain. Moments later, Walter Boles folded loving fingers around the extraordinary object and reverently ferreted it away to his research lab.

What might Walter learn from studying the brain of the Demon Duck of Doom? Perhaps new understanding about how this bizarre group of gigantic birds functioned in life. After all, the endocast provides a superb view of the electrical switchboard for the whole beast. The sizes of nerve tracts and the lobes of the brain measure amounts of activity in particular parts of the body. The tiny olfactory lobes, for example, suggest on first inspection they might have had trouble smelling their own poo. Similarly, the small cerebellum probably reflects the non-functional nature of their shrivelled wings. But the enormous lobes of the central part of the brain suggest that these land-bound leviathans were no mental lightweights—perhaps something one should expect of feather-brained predators that had to outwit furry prey? ■

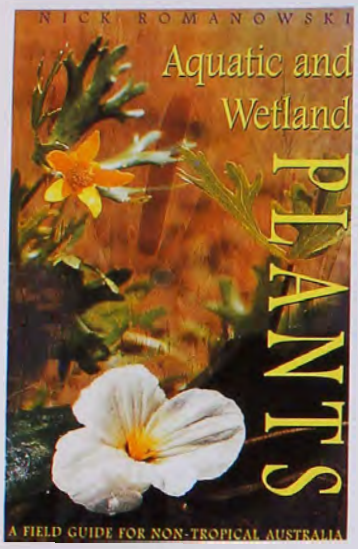
Further Reading

Murray, P.F. & Megirian, D., 1998. The skull of dromornithid birds: anatomical evidence for their relationship to Anseriformes. *Rec. S. Aust. Mus.* 31: 51–97.

Rich, P.V., 1979. The Dromornithidae, an extinct family of large ground birds endemic to Australia. *Bur. Min. Res. Geol. Geophys. Bull.* 184: 1–196.

Michael Archer is the Director of the Australian Museum and Professor of Biological Science at the University of New South Wales. His major research interests are the fossil faunas of Riversleigh, north-western Queensland.

REVIEWS



Aquatic and Wetland Plants: A Field Guide for Non-tropical Australia

By Nick Romanowski. University of New South Wales Press, NSW, 1998, 119pp. $29.95rrp.

Australian wetlands and swamps are botanically diverse and full of interesting, beautiful and bizarre-looking plants. This handy little book aims at presenting the more obvious and common plants that would be encountered in temperate Australia.

There is a brief section on the types of wetlands present in Australia, how we define native and introduced (exotic) plants, a brief but concise glossary and an excellent bibliography. The plant names are current and the author even highlights where imminent name changes are likely to occur. The botanical language has been kept to a bare minimum without sacrificing the content.

In the main body of the book plant families and genera are treated in alphabetical order. The main distinguishing features of each species are mentioned and how they differ from closely related species or species that superficially look similar.

For a book that relies heavily on photos for identification, I was dismayed to see that roughly half of the photos are taken so far away that they make accurate identification virtually impossible. Frequently the backgrounds interfere with the clarity of the individual being photographed.

It would be impractical to have a key to all the species presented in the book—it is also beyond its scope. Instead, I would like to have seen a series of tables at the back that list species and their various preferred habitats, for example, those species that are frequently fully submerged, those that flower after flooding etc. These tables would enhance the book and make identification easier and more efficient.

This book was obviously written to replace the now out-of-print *Aquatic plants of Australia* by Helen Aston. With improved photos and these tables added as an appendix, this book would definitely achieve this aim.

—Peter Jobson
National Herbarium of NSW
Royal Botanic Gardens, Sydney

Saving the Environment

By Ted Trainer. UNSW Press, NSW, 1998, 63pp. $9.95rrp.

In the 1960s, ecology was castigated as the subversive science because it challenged that holy-of-holies, economic growth. This subversion is prosecuted with a vengeance by University of New South Wales academic Ted Trainer in this slim, dense volume. His main theses are that we are headed for environmental catastrophe and that the prime causes are grossly excessive production and consumption in affluent consumer societies. To correct this, we need radical changes to our economic systems (dark green behaviour) rather than ineffective management at the margin, for example, more recycling, greater energy efficiency etc. (light green behaviour). The purpose of the book is to help people to become dark green.

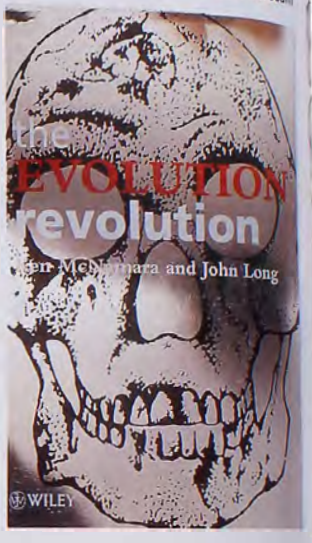
Trainer analyses the limits to material growth and discusses both the ecological problems and the counterarguments. He outlines the form a sustainable society must take and the actions needed. In doing this, he emphasises justice, peace, morality and quality-of-life as essential components of the global social fabric.

Some startling statistics provide context and urgency. If everyone alive in 2060 (possibly 11 billion people) were to have present Australian living standards, world production of resources would need to multiply by eight or ten. On top of this, three per cent annual economic growth would mean the total world economic output in 2070 would exceed that of today by more than 100 times. Yet present economic demand is ecologically unsustainable. The paradox between international commitments to ecologically sustainable development and economic growth could not be clearer.

Trainer's solution does not embrace the conventional approaches of technological fixes, a dematerialised economy and green economics. Indeed he rejects these firmly as part of the 'arrogance and thuggery' of conventional economists. Instead, a sustainable society requires drastically reduced consumption and pollution rates in the rich countries. We must develop small, self-sufficient settlements and local economies. Most goods and services would be produced from local land, resources and capital—the reverse of globalisation. Costs would fall, local recycling would increase, and there would be more communal activity and participatory democracy. Goals would include security and justice rather than conventional prosperity. Such dark green behaviour is manifest in the Global Ecovillage Movement.

Trainer is indefatigable in attempting to raise public understanding. One wishes him well in this idealistic and crucially important exercise. Given today's increasing individualism and selfishness, he has a long way to go.

—Alan Jones
Australian Museum



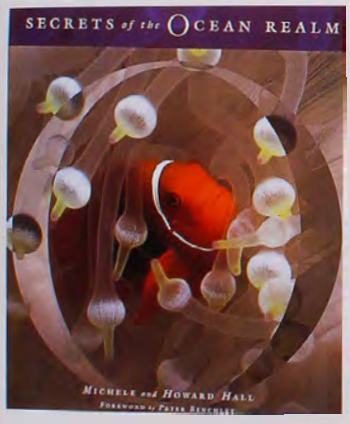
The Evolution Revolution

By Ken McNamara and John Long. Jacaranda Wiley & Sons, NSW, 1998, 298pp. $45.00rrp.

The subject matter of *The evolution revolution* is life's history as told by the fossil record. Eighteen chapters each typically treat a major evolutionary event. The science is topical, with the splashier finds of the 1990s given pre-eminence. The reader is treated to current thinking on many of palaeontology's classic questions. For example, what are the 'gutless wonders' of Ediacara? Did flight in birds arise from the ground up or the trees down? And why does *Tyrannosaurus rex* have such puny arms? While the often humorous style of the text suggests that the target audience is non-specialist, *The evolution revolution* isn't Science Lite. Indeed, in places the going gets heavy, and a glossary would have been useful (for example, a

discussion on fin development in Zebra Fish assumes that readers understand the meaning of germ layers). The balance of chapters leans towards vertebrates (three chapters on fish, two on dinosaurs, plus the latest on marine reptiles, pterosaurs, fossil birds, Gondwanan mammals, and the uptight, upright primate). Two pervasive themes that give the book a unique flavour are heterochrony (the evolutionary result of changes in life cycles) and discoveries on Australian fossils. The authors' own experiences are frequently recounted. *The evolution revolution* doesn't attempt to tackle the entirety of evolutionary biology—it isn't a gene's-eye view of the world. As a readable account of large-scale patterns in the fossil record, it offers much to a wide audience.

—Greg Edgecombe
Australian Museum



Secrets of the Ocean Realm

By Michelle and Howard Hall. New Holland Publishers, NSW, 1998, 162pp. $49.95rrp.

Sarcastic fringehead, demon stingers and irish lords are just some of the amazing creatures captured on film in Michelle and Howard Hall's book, *Secrets of the ocean realm.*

To be honest, when I was asked to review this book, I expected it to include photographs and some 'pseudo-science' facts about the relevant creatures. In reality, I was surprised to discover something quite different. *Secrets of the ocean realm* takes the reader to exotic locations, as the Halls relate their adventures in producing the television series of the same name. In their two years of work on the series, they have had many 'once-in-a-lifetime' experiences. They have surfed with whales, filmed the mass coral spawning, watched marlin slicing through schools of baitfish, and seen the sun blacked out by a huge school of rays.

Why does *Tyrannosaurus rex* have such puny arms?

The narrative is richly enhanced by the wonderful photographs from this couple who have over three decades of diving experience and seven Emmy awards to their credit. The text is easy to read, personal, and at times very humorous. Most divers and especially underwater photographers will be able to relate to many of the anecdotes. My only criticisms are that the images, while beautiful, sometimes aren't relevant to the adjacent text, and that the book has no index. The latter would have made finding a particular photograph much easier.

The book is not a scientific work. The authors state that "No one should presume this book to be a resource or reference text. Rather, it's a visual and verbal chronicle of the adventure of underwater filmmaking." This chronicle has easily earned itself a place on my coffee table.

—Mark McGrouther
Australian Museum

Burning Questions: Emerging Environmental Issues for Indigenous Peoples in Northern Australia

By Marcia Langton. Centre for Indigenous Natural and Cultural Resource Management, Northern Territory University, NT, 1998, 89pp. $17.95rrp.

As human numbers and material wellbeing increase, and more and more land is converted into humans and their material cultural objects, there is increasing debate about how to manage the remaining relatively undeveloped areas. The debate at its deepest levels is driven by concerns of power, money and personal beliefs. Almost everyone views himself as a stakeholder with a point of view.

In this book, Marcia Langton reminds us of the contemporary Aboriginal point of view of environmental management in Australia, especially as it relates to the use of fire. The importance of this point of view stems from three interrelated facts about Aboriginal relationship to the land: priority in ownership, length of management experience, and depth of attachment. Aboriginal people have not only occupied the land longer than any other group, by two orders of magnitude, but Aboriginal environmental management, both conscious and unconscious, at least until the disruptive European invasion, touched all Australian landscapes to varying degrees. And Aboriginal people continue to be among the most intimately tied to the land of any group of Australians today. Langton recognises that any decision on environmental management will be a consensus based on current needs and attitudes, but she makes a strong case that the Aboriginal view has much to contribute to this consensus. This is especially true on those lands on which Aboriginal possession, and hence management, has been virtually continuous.

Langton writes in part to correct what she sees as biases in certain mainly Western or scientific interpretations of Aboriginal environmental management. In places, this passion borders on the polemical and creates a stylistic hurdle for the reader who has not suffered the injustices of which she writes. But one can learn to read through this perhaps justified emotional undertone and to get, as a reward, a thoughtful Aboriginal point of view on matters that one has perhaps only previously considered from other perspectives.

—Allen E. Greer
Australian Museum

SOCIETY PAGE

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

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Sydney Metropolitan Wildlife Services Inc.
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Lindfield NSW 2070
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BIRDS

Bird Observers Club of Australia (Melbourne Branch)
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Website: www.birdobservers.org.au
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Contact: Heather Niggendyker

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Contact: Carol Middleton

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Contact: Jeff Banks

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Q&A

Frog Find

Q: *I found this frog on our front footpath. At first I thought it was a young Cane Toad and almost sprayed it with Dettol, then I saw in my torchlight green spots on its back and head. In ordinary daylight they were just like raised lumps but shone under torchlight. Do you know what it is?*

—Angie Heyning
Mullumbimby, NSW

A: Your frog is definitely not a Cane Toad, but rather a native Peron's Tree Frog (*Litoria peronii*). It is light to dark grey, and sometimes brown, in colour, with a scattering of small bright green flecks across the dorsal region. Its skin has raised lumps (not associated with the green spots), which give it a slightly roughened texture. Peron's Tree Frog grows to around four to six centimetres in length and occurs in eastern Australia from Victoria to Queensland. It prefers cool temperate to subtropical vegetation near static or flowing water and its call is described as a long rattle lasting approximately two seconds. Even though Peron's Tree Frog is considered common and its status is secure, it is good that you didn't douse it with Dettol.

—K.L.

Dinosaur Bones

Q: *I recently had the pleasure of viewing the assembled fossil skeleton of the dinosaur* Tyrannosaurus rex *on display at the entrance of the Australian Museum. What fascinated me were the rib-like appendages attached to the cervical (neck) vertebrae. Unlike conventional thoracic ribs, which are curved and flat, these 'neck ribs' rapidly taper into the long, thin, round and relatively straight bones almost like giant pencils. What are these bones and what was their function?*

—Mervyn D. Cobcroft
Stafford Heights, Qld

A: These curious objects are indeed ribs, in this case, cervical ribs. They occur in a variety of dinosaurs. The presence of cervical ribs is the original condition in fish and early tetrapods, but these have been gradually reduced in later vertebrates, and in some groups, lost. Because the cervical ribs in the tyrannosaur are relatively puny, it is likely they no longer served any function.

—Walter E. Boles
Australian Museum

Only Skin Deep

Q: *I photographed what looked like the nymphal skin of a Rhinoceros Beetle. It was far from its usual habitat, which I thought was much farther north than the Tahmoor-Bargo area of New South Wales. Can you identify it for me?*

—Brian Ward
Douglas Park, NSW

A: This is the pupal skin of a cossid moth. These are wood-boring larvae and often referred to as witchetty grubs (see *Nature Aust.* Autumn 1999). The creamy white grubs bore into the trunks of eucalypts and wattles where they stay until they are ready to pupate. They then crawl to the entrance of their tunnel and emerge from their pupal skin, which is then discarded.

—Martyn Robinson
Australian Museum

The beautifully patterned Peron's Tree Frog.

STEVE YOUNG/NATURE FOCUS

COURTESY BRIAN WARD

What insect left this skin lying about?

Long Webs

Q: *Recently while walking in the Royal National Park, I noticed webs that spanned great distances high up in the trees. How do spiders get the webs from one tree to the other?*

—Jenny Peters
Woolooware, NSW

A: Suspending an orb web between distant trees is the result of both luck and ingenuity. The spider walks to an extremity (the end of a branch, or top of a plant), raises its abdomen and squeezes out a thin gossamer of silk. The silk gossamer is caught by the breeze and the spider continues to release more silk, thereby extending the thread. If the spider is lucky, the thread becomes entangled in a branch some distance away, and the spider uses this thread as a bridge between the two points. The silk bridge is strengthened as the spider walks across it and lays down more silk, and it is then in a position to build the web.

—Mark A. Elgar
University of Melbourne

Answers to Quiz in Nature Strips (page 19)

1. Cyclone Vance
2. In the Antarctic
3. Black and white
4. James Watson and Francis Crick
5. Self-amputation of body parts
6. Giant squids
7. Pi
8. The male
9. Nipah
10. Peter Garrett

P I C T E A S E R

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 *Life in the treetops: adventures of a woman in field biology* from the Australian Museum Shop. Spring's Pic Teaser was a sand crab (*Ovalipes australiensis*) buried in the sand with only its eyes and antennae sticking out.

M. CERMAK/NATURE FOCUS

Each major river system in Australia could have a Riverkeeper, devoting time and effort exclusively to the river in question.

THE RIVERKEEPERS

BY JOHN CHRISTOPHER GAZECKI

FOR ITS SIZE, AUSTRALIA IS A relatively dry landmass lacking the abundance of extensive river systems existing on many other continents. For this reason alone our rivers are particularly precious. The few extensive systems that carve their way through this ancient land are of great ecological and often commercial importance.

Although our rivers are offered some protection by Fisheries and Wildlife departments, which prosecute for breaches of particular Acts and regulations, problems do exist. For instance, one State department does not generally litigate against another, so where an environmentally insensitive activity is being carried out by another State department directly, or where a department issues a licence for a private body to discharge effluent or otherwise affect a river adversely, there is usually nothing that Fisheries can do. In practice, they won't bite the hand that feeds them.

There is also a variety of independent conservation organisations, such as the Australian Conservation Foundation and Inland Rivers Network, and public-interest litigation bodies, such as the Environmental Defenders Office (EDO), which often combine to champion many worthy environmental causes in the legal arena. However, as commendable and effective as these institutions are, they do not have the resources to deal with all the problems facing our rivers. So what are the options? The answer may lie in the United States.

John Cronin was born into the first generation of children who were forbidden to swim in New York's Hudson River due to the high level of pollution. Alarmed by the poor quality of water and dropping fish numbers, Cronin embarked upon a life-long campaign to save the system. Hence was born the first US 'Riverkeeper', both as a man and as an organisation.

The idea of Riverkeepers was spawned in England where fishing clubs hired 'Keepers' to protect salmon streams from poachers and polluters. The US Riverkeeper organisations perform much the same task but on a much broader scale. Greater resources enable them to collect evidence on polluters and others who abuse the river, which is then presented to a specialised legal organisation (like the EDO in Australia) for litigation. Essentially, a Riverkeeper organisation ensures the sensible management of riverine resources in the interests of commercial and recreational fishermen, agriculturalists, public-interest groups and other parties committed to maintaining the biological integrity of a river.

The idea of Riverkeepers was spawned in England where fishing clubs hired 'Keepers' to protect salmon streams from poachers and polluters.

Each major river system in Australia could have a Riverkeeper (particularly the Murray–Darling system), devoting time and effort exclusively to the river in question. A full-time 'Keeper' would be appointed to patrol the river in a vessel (or vehicle where appropriate) carrying biological sampling and photographic equipment for gathering evidence. The organisation would thus be in a position to provide specific evidence and witnesses crucial to litigation.

A fund would have to be established to pay the wages of the full-time 'Keeper' and help cover court costs when necessary. All individuals, communities and councils sustained by the river, living in close proximity to the river, or otherwise affected by it, could be made aware of the river's ecological, aesthetic and commercial utility, thereby encouraging donations. The rest of the funds (and this is the hard part) could be contributed by State and Commonwealth governments in recognition of the vital role played by Riverkeepers for the benefit of all Australians.

Riverkeeper organisations would be integrated into the broader matrix of existing environmental protection agencies and complement their efforts. However, their main utility would lie in taking much of the strain off many of these other associations and providing a service specific to a particular river course, which is likely to be more effective in protecting that given system.

Once a Riverkeeper organisation establishes itself, the arsenal of information and resources generated may, in the long run, reduce the level of litigation and encourage out-of-court settlement as other parties recognise the Riverkeeper as a force to be reckoned with.

The Hudson River has benefited immeasurably from its US Riverkeeper organisation. Litigation, and the threat of more, has persuaded New York City Council to initiate a $US750-million watershed-protection program, entailing the hiring of over 500 environmental officers and technicians, as well as the commencement of a variety of other environmentally beneficial projects.

There are plenty of reasons to believe that a similar initiative would benefit many of Australia's riverine environments. The concept is not overly idealistic and the Hudson River example has demonstrated that it can work. Maybe it is time we seriously considered its applicability in a country where our rivers are a particularly precious resource.

Further Reading

Cronin, J. & Kennedy, R.F., 1997. *The Riverkeepers*. Scribner: New York.

John Christopher Gazecki is a Bachelor of Law and Economics from the University of Sydney. He is currently assisting the Environmental Defenders Office (Sydney Division) with public-interest litigation.

The Last Word is an opinion piece and does not necessarily reflect the views of the Australian Museum.

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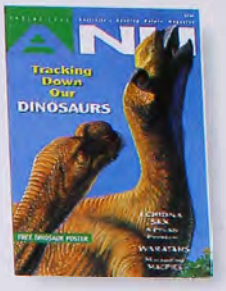

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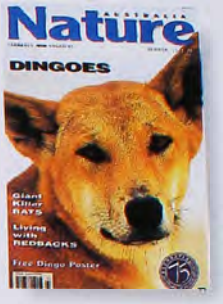

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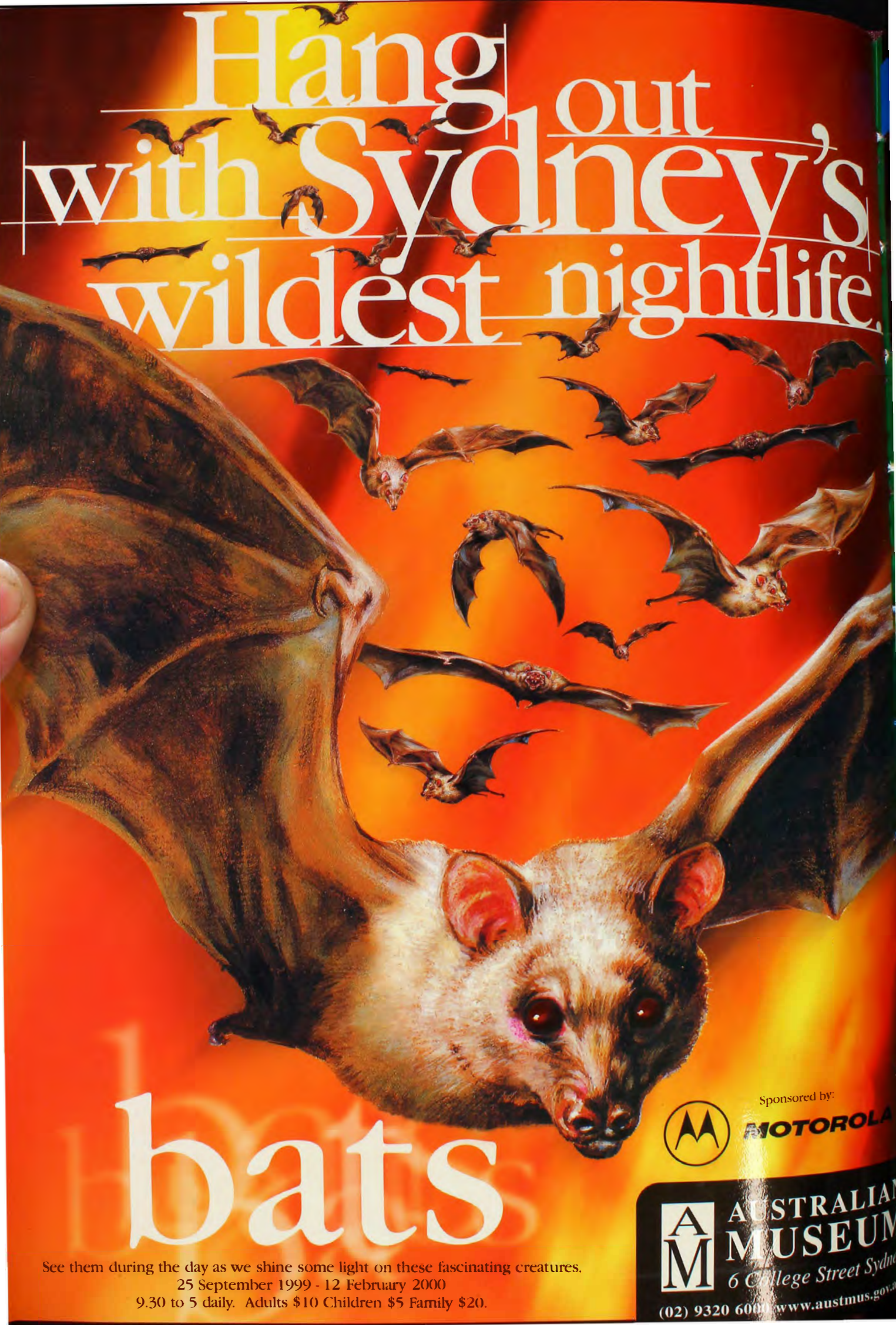
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