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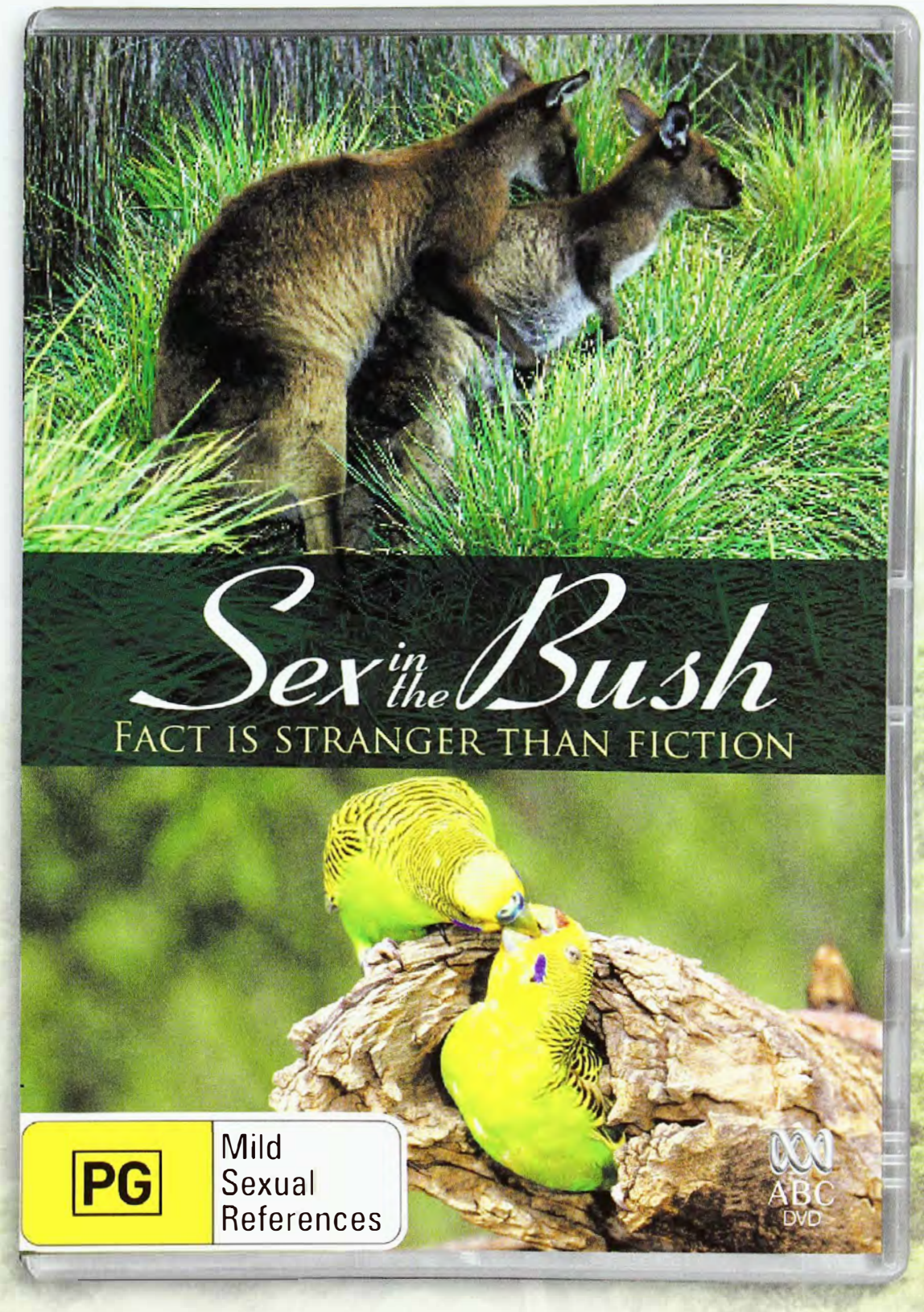

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FRONT COVER
The Antilopine Wallaroo (*Macropus antilopinus*) appears to be holding its own in Queensland's tropical savanna woodlands.
PHOTO BY DAVID WEBB.

up front

I have a thing for sea urchin skeletons—their delicate patterns, muted colours and extraordinary symmetry. I always look out for them along beaches, often washed up amongst the kelp. However, I'm ashamed to admit that, beyond what I learnt in First Year Biology, I knew very little about the live animals. But thanks to Jane Williamson, from Macquarie University, I now know a lot more. They play a complex and important role in the ecology of marine ecosystems but are also sought after for their roe (eggs). Jane hopes to address this imbalance with the development of echiniculture in Australia.

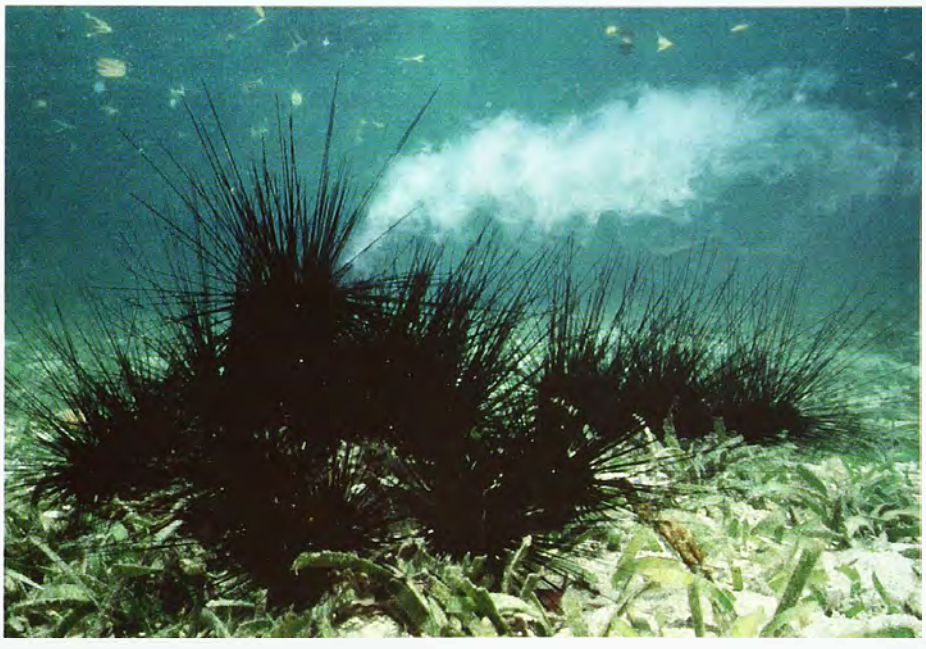
I also have a thing for sex—well, at least for the sex lives of animals—as it seems does Clive Marks (Nocturnal Wildlife Research in Victoria) who managed to videotape, for the first time, Common Wombats mating in the wild. The sometimes-shaky hand-held infrared video footage shows the comical, if not violent and repetitive, lengths wombats go to for sex. The male chases the female around, bites her on the bum, either gets a kick for his troubles or rolls her over for some sex on the side, and then they're off again for more chasing, biting, mounting, kicking and mating. Wombat sex was once thought to be confined to the burrow but this film footage confirms that what wombats really want is space. It just goes to show how little we still know even about common animals.

Jo Isaac, from James Cook University, looks at another common animal, the Common Brushtail Possum, but ones with a penchant for the beach. These adaptable possums have taken to life on Queensland's Magnetic Island amongst the granite boulders, which make a fine substitute for tree hollows. And with little competition on the island, they are thriving. Jo is studying these beach brushtails with an eye to extending her knowledge to management of pest possums in New Zealand.

Bats are in the spotlight again, but this time we look at how they respond to forestry practices. We also learn about life in the tropics for the Antilopine Wallaroo, the aggressive antics of the Noisy Miner, plants that stretch the limits of life, and the long and the short of human hair. Plus lots more.

Georgina

— **GEORGINA HICKEY**
Editor



Sea urchin spawning.

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Predicted effects of increased greenhouse gases range from the benign to the cataclysmic, and such uncertainty is delaying adaptive responses to global environmental change.

BY DAVID BOWMAN

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COLUMNS

letters

Lady's Man?

I enjoyed Richard Fullagar's article on the "Little Lady of Flores" (*Nature Aust.* Spring 2005). However, I'm curious as to why Peter Schouten's illustration of Hobbit (*Homo floresiensis*) was of a male when the partial skeleton on which it was based was female.

—Gina Bailey
Queanbeyan, NSW

Woman the Hunter

I must correct the commonly held assumption iterated by John Davidson in his speculative Letter "Menopause and Mothers-in-law" (*Nature Aust.* Winter 2005) that "humans are unusual in that only men are able to hunt". Davidson need look no further than Australia to see that Aboriginal women were, and in many areas still are, keen hunters, regularly providing their families with meat as well as vegetable food. Desert women hunted reptiles, marsupials of all kinds, Dingoes, certain birds and, since their introduction, Cats. They used hunting and digging sticks and, often, spears (but not woomeras). Their husbands hunted similar animals and, rarely, Emus. Coastal women hunted land animals and went fishing, as they still do. Their menfolk also hunted turtles and Dugongs.

Aboriginal literature includes many accounts of women hunting. The role of the grandmother had less to do with protecting the virtue of her peripatetic daughters-in-law than with looking after children while the younger women went food-gathering. She also contributed to the family economy: women in their fifties and sixties may no longer spear Dingoes or kangaroos, but they still track and kill reptiles and, on the coast, catch fish.

—Pat Lowe
Broome, WA

Upside-down Shower

Reading a Letter in a back issue of your magazine (Summer 1995–96)—about Black-faced Cuckoo-Shrikes having a 'bath' in a fig tree—reminded me of an 'incident' my husband and I witnessed in the summer of 2002. It had been very hot and dry for a long time, Geelong being a dry area generally. Then, one day, we were treated to a magnificent thunderstorm, which we watched from the safety of our outside living room. From where we stood we could see the electrical wires in the street of our backyard neighbours. And there we saw seven Galahs hanging upside down with all their feathers fluffed out, bottoms up, wings spread out and inverted, just like our grandchildren on the trapeze of their swing set.

The birds were obviously allowing the torrential rain to wash away the dust, parasites etc. accumulated over all those dry weeks. They did it all in unison, and for the same length of time. How I wish I had had a camera on hand to record this extraordinary event. It just goes to show that retirement has its rewards. Previously we never had the time to just watch the birds!

—Francina P. Postuma
Corio, Vic.

Mona Chuguna hunting goanna in the Kimberley.

Nature Australia requests letters be limited to 200 words and reserves the right to edit them for sense. Please supply a daytime phone number and type or print your name and address clearly. The best letter in this issue will receive a copy of *Tasmanian Devil: a unique and threatened animal*. The winner this issue is Pat Lowe.

WILDLIFE PHOTOGRAPHER OF THE YEAR 2005

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Summer

Compiled by Geordie Torr and Martyn Robinson

P. KIRK

Saltwater Crocodile.

HOT TO CROC

The nesting season of the Saltwater Crocodile (*Crocodylus porosus*) extends from October to May, spanning the wet season of northern Australia. As a result, summer is peak breeding time, so you should be even more careful if you're planning to visit any tropical swamps around this time.

Nesting occurs in a variety of habitats, from riverbanks to swamps. Female 'Salties' build a mound nest using vegetation and mud, into which they lay 40–60 eggs. The raised nest helps reduce the likelihood of eggs being drowned by rising floodwaters. Females stay with their eggs, protecting them from predators. Still, despite all this care and attention, on average at least 80 per cent of eggs die during incubation.

After about 90 days, depending on nest temperature, the baby crocs start to emerge from the eggs. In response to their cries, the female digs open the nest and gently caries them in her mouth to safety. The nest temperature will also have determined the sex of the babies—the closer the temperature is to 32° C, the higher the proportion of males; the further away, whether hotter or cooler, the higher proportion of females.

For more about these awesome predators, check out *Australian crocodiles: a natural history* (2002) by Grahame Webb and Charlie Manolis.

YOU NOT-SO-DIRTY RAT

"Look at the size of that Sewer Rat!" As mistaken-identity cases go, it's fairly understandable, but still unfair. Yes, the Water-rat (*Hydromys chrysogaster*) really is a large rodent, but it's considerably more appealing than your average introduced Sewer or Brown Rat (*Rattus norvegicus*).

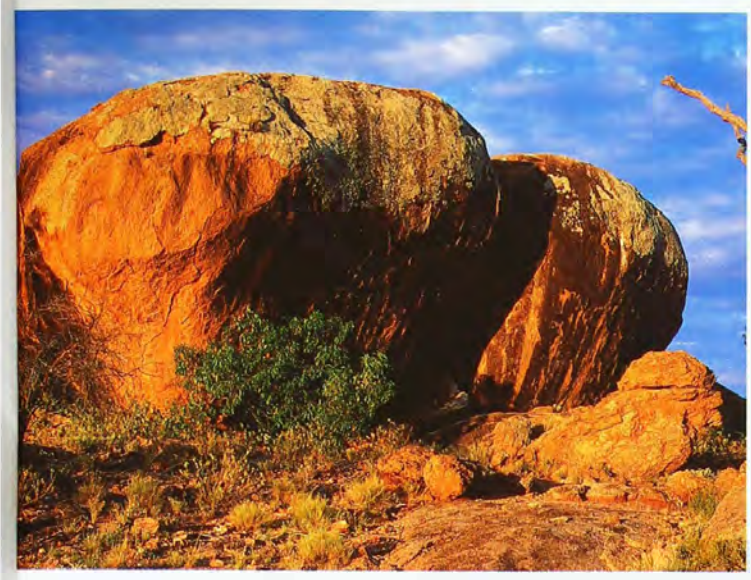
Up to nearly 40 centimetres in body length and boasting a distinctive, thick, white-tipped tail that adds about another 30 centimetres, the Water-rat looks more like a small otter. Indeed, it was once known as an Otter Rat and, sadly, like the true otters, it was enthusiastically hunted for its thick, waterproof pelt. Such was the level of hunting that it eventually became Australia's first protected rodent species.

What's more, it behaves like an otter, too. It's a superb swimmer, diving to catch its food—mostly fish, crustaceans, large aquatic insects and other arthropods, and molluscs. Shelled food is typically taken to an exposed site such as a log or sand bar and there dismembered and eaten—the discarded hard parts are a telltale indicator of its presence.

Water-rats can breed at any time of year, but typically young are born in late spring and summer. Females construct their nests in burrows in the banks of lakes, rivers, creeks and other bodies of water. An average litter consists of three or four young, but can be as high as seven. The young are

HANS & JUDY BESTE/AUSCAPE INTERNATIONAL

Water-rat.



WAYNE LAWLER/AUSCAPE

Rounded granite boulders created by exfoliation.

suckled for about four weeks and remain with their mother for up to four more weeks. And by the age of four months, some females will be ready to start breeding themselves.

To learn more about these appealing rodents, visit **www1.healthycountry.com/CCScience/TB/Hydromys-chrysogaster**

NATURE'S SEASONAL BOMBS

Have you ever been around an area of granite on a very hot or cold day and heard a resounding 'crack' like a rifle shot? Don't worry, you're not being used for target practice—it's the rocks themselves that are exploding.

Granite, like other igneous rocks that have formed deep inside the Earth under high temperatures and pressures, is prone to a weathering process known as exfoliation. As the rocks are exposed by weathering and erosion of the overlying material, their internal pressure is reduced, which causes fine expansion cracks to form. These enable water to get into the rock, where it reacts chemically with the minerals, leading to further propagation of the cracks. If it gets cold enough, the water can freeze, causing the cracks to expand, sometimes violently.

The interior of the rock is fairly well insulated from the sun's heat by the layer above and doesn't expand or contract at the same rate as the outer surface. So on hot days too, the weakened outside layer can suddenly (and loudly) separate from the underlying cooler layers. In rounded granite boulders, the layers often flake off in concentric layers, just like onion skins, so this process is called onion-skin weathering.

All this explosive exfoliation is good news for the local fauna and flora. The exfoliated layers, whether still attached or laying on the ground below, make great shelters for insects, spiders and reptiles. In addition, the process hastens erosion of the rock and frees up minerals and trace elements essential for plant growth.

For more, see **www.gpc.edu/~pgore/geology/history_lab/weathering.php**

CARL BENTO/AUSTRALIAN MUSEUM

Preserved holotype of the Stout Infantfish.

FROM THE COLLECTION

*This is the current holder of the title of world's smallest vertebrate. At just 8.4 millimetres in length, the largest known specimen of the Stout Infantfish (*Schindleria brevipinguis*) is smaller than many insects. Males mature at just 6.5–7.0 millimetres.*

This is one of only six specimens, all collected by Jeff Leis (Australian Museum) in water ranging from 15 to 30 metres deep in coral lagoons near Lizard Island. All but one were collected in summer, but this probably has more to do with when ichthyologists do their fieldwork than the species' biology.

Infantfishes retain many characteristics of larval fish, such as a lack of pigmentation, relatively large eyes and a reduced number and size of fins and teeth—hence the name. The 'Stout' part refers to the deep body compared with the other two described species of the genus. Even so, it's the lightest known vertebrate, with a weight of just one milligram.

For more about this miniature marvel, check out **www.amonline.net.au/fishes/fishfacts/fish/sbrevip.htm**

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

nature strips

COMPILED BY GEORGINA HICKEY

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

To Bee or Not to Bee

There's something very endearing about European Bumblebees (*Bombus terrestris*). With their big, fuzzy bodies, they're about as close as insects get to being cute and cuddly.

And they're particularly appealing to some horticulturists, who would love to see them allowed into Australia to help pollinate their crops. But their requests have been rejected due to fears that they may harm Australian ecosystems, primarily through competition for nectar and pollen with native insects and birds, and reduced seed production in native plants. The horticulturists counter that the bees would do little damage as they prefer introduced to native plant species.

But do they? The evidence for this supposed preference is pretty sketchy, so Andrew Hingston (University of Tasmania) set out to see if it was real or not. Working in a garden in the suburbs of Hobart, where a feral Bumblebee population has been established for over a decade, Hingston monitored the bees' foraging preferences approximately every 10 days between November and March when they are most common. He simply walked through the garden at 30-minute intervals between dawn and dusk for two days, noting the flowers on which he first saw each Bumblebee (*Aust. J. Zool.* 53: 29).

After determining the abundance of each of the different types of flowers, he calculated the number of Bumblebees observed foraging during each study period per 1,000 flowers for both native and introduced species. When he compared these data he found that the bees showed no real preference at all. Indeed their preferred plants included both native and introduced species. So, endearing as they are, Bumblebees look set to remain undesirable aliens for the foreseeable future.

—G.T.

ATHOLL FOLLICHEST

Are European Bumblebees a threat to Australian wildlife?

Marsupials See Red

Australia's marsupials have long had a reputation for being the primitive cousins of placental mammals. In recent years, however, scientists have been building a different evolutionary picture of our marsupials, with increasing evidence revealing several unique specialisations.

The latest breakthroughs involve the way they see the world. Research headed by Catherine Arrese (University of Western Australia) has demonstrated a colour-vision system in marsupials that is as well, if not more, developed than our own.

Arrese and her team have recently shown the presence of three different types of cones (colour photoreceptor cells) in the retina of the Quokka (*Setonix brachyurus*) and Southern Brown Bandicoot (*Isoodon obesulus*) (*Proc. R. Soc. B* 272: 791). Most mammals possess only two cone types (that is, are dichromatic). Previously, only primates were known to have the three-cone condition (trichromacy) now being reported for marsupials.

Having three cones allows the perception of a wider range of colours than the two-cone system. One cone type detects shorter wavelengths, from ultraviolet to violet; another detects long wavelengths, in the red region of the spectrum; while the third cone type, which detects middle wavelengths, is most sensitive to green light.

This study builds on previous discoveries of trichromacy in the Fat-tailed Dunnart (*Sminthopsis crassicaudata*) and Honey Possum (*Tarsipes rostratus*) (*Curr. Biol.* 12: 657). The presence of three cone types in four phylogenetically distant species indicates that trichromacy is a common feature among the Australian marsupials.

—K.McG.

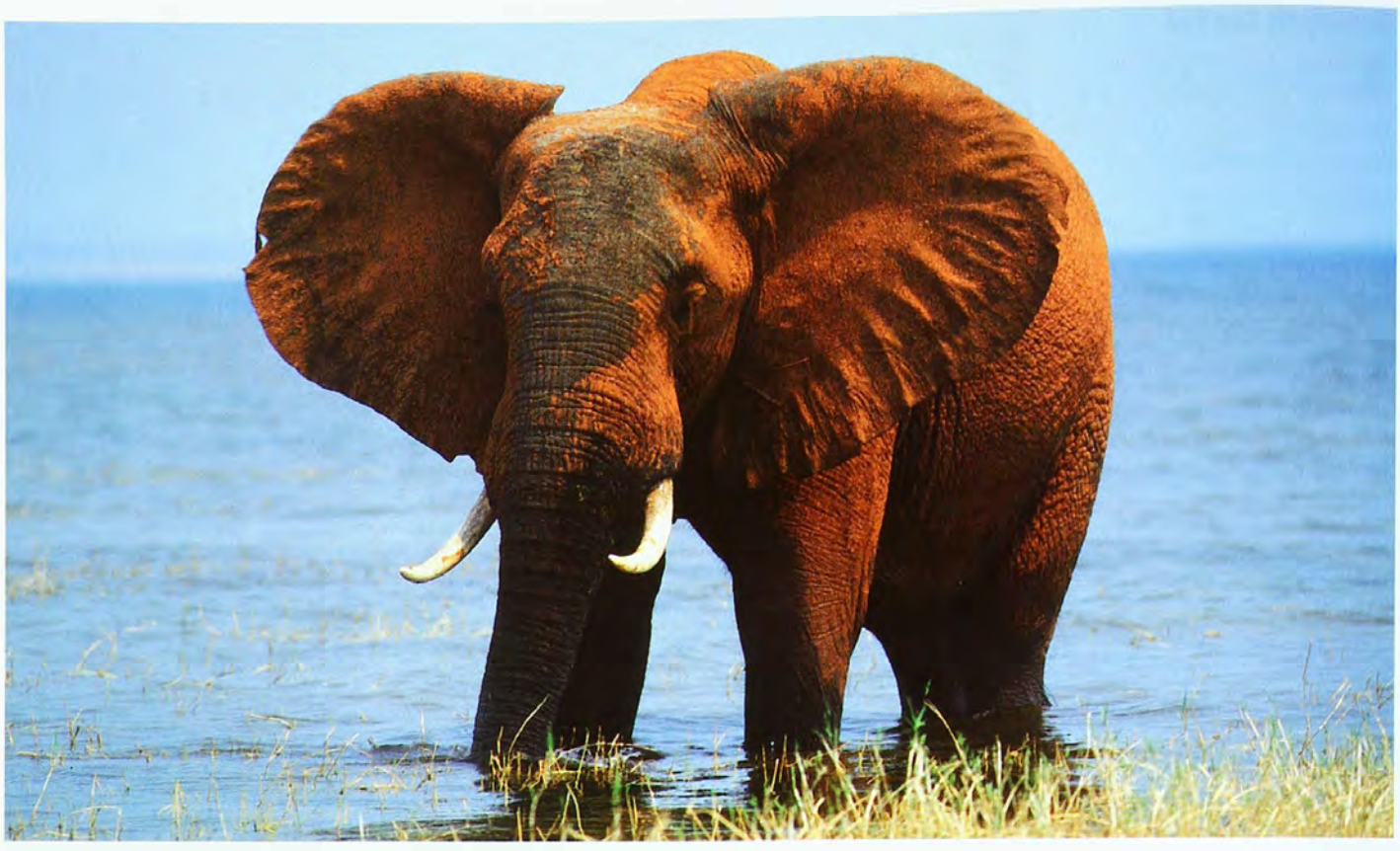
Marsupials, like the Quokka, join primates in full-colour vision.

Copy-catting Elephants

There's a saying that if you live with a cripple long enough, you limp. This 'rubbing off' of habits (whether good, bad or indifferent) certainly applies to overseas travellers who adopt the accent of their host country. And it now also applies to elephants, two of which have been found to copy the sounds of their neighbours.

The first case involved a ten-year-old female African Savanna Elephant (*Loxodonta africana*) called Mlaika, who was heard making strange sounds while living in semi-captivity in Kenya, about three kilometres from the busy Nairobi–Mombassa highway. When Peter Tyack (Woods Hole Oceanographic Institution) and colleagues analysed recordings of her calls, they found them to be nothing like the grunts and rumbles of other African Savanna Elephants, but a near-perfect match to the roar of a distance truck (*Nature* 434: 455).

The other case involved Calimero, a 23-year-old male African Savanna Elephant that had lived for



African Savanna Elephants copy the sounds of their neighbours.

18 years alongside two female Asian Elephants (*Elephas maximus*) in Switzerland's Basel Zoo. Rather than emitting the normal grunts of his own language, Calimero was only ever heard to make the chirp-like vocalisations typical of Asian Elephants. Comparison of the spectrograms of Calimero's chirps and that of his Asian room mates showed the match to be remarkable.

These are the first known examples of vocal learning and mimicry in a terrestrial mammal other than primates. Vocal mimicry also occurs in birds, bats and dolphins, and studies have suggested it helps strengthen individual bonds within the social group. Even though Mlaika may have got it wrong by mimicking an inanimate noise, sounding like your neighbours appears to have its advantages.

—G.H.

Chewsy Termites

Termites are quite choosey about the wood they munch on, both in terms of its size and type. Presumably this allows for different species to live in the same area without competition. But what has always puzzled researchers is how termites can quickly tell so much about a certain piece of wood, given that they are blind.

Theodore Evans (CSIRO), Joseph Lai (ADFA/UNSW) and colleagues offered termite workers (*Cryptotermes domesticus*) pieces of pine that were either 20 or 160 millimetres in length. This particular species of termite showed a greater preference for the shorter pieces, chewing significantly more and deeper tunnels into the wood (*PNAS* 102: 3732). The researchers suspected termites used vibrations to choose between the sizes, so they recorded the sound of termites chewing into both small and large pieces of wood, and then played these recordings back to the termites. When the signals from chewing a large piece of wood were played into a small piece of wood, the termites would stop their tunnelling; and when vibrations from eating small pieces of wood were played, the termites sprang into action, regardless of the size of the wood they were in at the time.

Termites generate vibroacoustic signals that bounce off the interior of the wood and back through the body of the insect, bringing information about the size of the wood. The lower the frequency, the larger the piece of wood and therefore the less desirable. Evans *et al.* suspect that the termites have 'ears' (vibration-detecting organs) on their feet. This research is not only of interest to die-hard termite fans but could also be used by pest controllers. All they would have to do is to play recordings of termites chewing big bits of wood (which they don't like) into infested parts of a house and the termites in theory should pack up and leave.

—A.T.

White-Arse Pigeons

There aren't too many places to hide in the sky, so it's a good idea to have at least one trick up your sleeve to throw predators off the trail.

Feral pigeons (Rock Doves, *Columba livia*) exhibit a range of plumage colourations including the 'wild' variant, which is blue-grey with a white rump patch between the base of the tail and lower back. Interested in how the various plumage

Peregrine Falcon chases a white-rumped pigeon.

combinations affect predation in a population, and in what advantage wild colouration might convey to its owners, Albert Palleroni (Harvard University) and colleagues studied the frequency of each of six pigeon phenotypes among the fatal victims of Peregrine Falcons (*Falco peregrinus*).

They found that, although most plumage types were captured in the same relative proportions as they occurred in the population, only one dead pigeon in 50 had a white rump, despite comprising over 20 per cent of the population (*Nature* 434: 973). To confirm their observations, the researchers swapped the rump plumage of 756 pigeons. They found that previously white-rumped pigeons were killed in the same proportions as the other colours, while newly whites had greatly improved survival statistics.

Because no pigeon can out-fly an attacking Peregrine Falcon (which can get up to 157 metres per second), and because all pigeons perform the same evasive rolling manoeuvre to avoid attack, Palleroni suggests that the flash of white must somehow distract the predator, giving the pigeon an added second or so to make its escape.

—R.S.

Living with Giants

Scientists agree that the first Australians must have lived alongside many large (now extinct) birds, reptiles and marsupials, collectively called megafauna. But how long did the relationship last? How did they cope?

Some have argued that the relationship went sour quite quickly, but not all can agree exactly when humans first arrived in Australia (certainly by 45,000 years ago), or when each megafaunal species became extinct (few if any survived the glacial extremes 30,000–20,000 years ago). While there is no direct evidence that Aborigines even hunted megafauna, Gifford Miller (University of Colorado) and colleagues support the theory that Aboriginal ancestors who first colonised Australia inadvertently modified the vegetation by burning the bush. They argue that Aboriginal fires devastated

COURTESY ROB PALMER

pickings of specialised browsers like *Genyornis newtoni*—a giant bird almost twice the size of today's Emu—whereas the Emu survived on a less fussy diet (*Science* 309: 287). The scientists studied thousands of eggshell fragments, determining their ages and also extinct diets (by analysing isotopes), and concluded that *Genyornis* apparently ceased laying in several parts of Australia about 45,000 years ago. After then, only Emu eggshells are found.

Others argue that increasing aridity played a critical role in the vegetation changes, and that *Genyornis* actually survived until about 30,000 years ago, co-existing with humans in Australia for at least 15,000 years. New evidence comes from Cuddie Springs (south-eastern Australia)—an ancient lakebed where thousands of stone artefacts and megafaunal bones have been found in discrete layers, dated to between 28,000 and 36,000 years ago.

Some scientists have doubted the integrity of the site, suggesting that older bones have worked their way up to younger sediment levels. However Clive Trueman (University of Portsmouth) together with Judith Field and colleagues (University of Sydney) recently studied the geochemistry of the bones, which acquire trace amounts of rare earth elements that indicate whether fossil bones have remained in their original position after burial (*PNAS* 102: 8381). They found that some bones had moved around in lower (older) units, but argue against mixing of bones in the successive archaeological layers with stone artefacts and extinct megafauna (*Genyornis*, *Diprotodon*, *Sthenurus* and *Protemnodon*).

The archaeologists argue that the fate of the megafauna was driven by continental and global climate change, and was out of the hands of humans. They support the theory that humans may have had the giants for dinner but Aboriginal ancestors cannot be guilty of either megafaunal or environmental genocide. Instead, they tend to blame it on the weather.

—R.F.

COURTESY NSW MUSEUM AUSTRALIAN MUSEUM

***Genyornis newtoni* was a giant bird, nearly twice the size of an Emu.**

Seahorse Balls

In the strange life of fishes, one of the strategies used by those species that fertilise externally is to produce huge amounts of sperm from large testes. This helps reduce the chance of a female's eggs being fertilised with sperm from another male (sperm competition), and reduces the impact of dilution of sperm by seawater. But in seahorses and pipefishes (family Syngnathidae), some species fertilise externally while others fertilise internally.

The males of all syngnathids have the responsibility of carrying the eggs somewhere on their bodies. But whereas those thought to fertilise eggs externally carry them attached to the skin (in *Entelurus* and *Nerophis* pipefishes) or in shallow skin depressions (the seadragons), the internal fertilisers brood and nurture their eggs in a substantial brood pouch (seahorses and *Syngnathus* pipefishes). In the pouch brooders, the female lays her eggs directly into the male's brood pouch, which he fertilises internally. This makes it virtually impossible for another male to fertilise that particular female.

Charlotta Kvarnemo (Stockholm University) and Leigh Simmons (University of Western Australia) predicted that the externally fertilising syngnathids would have proportionally larger testes than those that fertilise internally. To their surprise, however, they found no difference (*Biol. J. Linn. Soc.* 83: 369). The researchers boldly question a long-held assumption of external fertilisation in syngnathids, which holds that males 'decorated' with unfertilised eggs must swim through a cloud of their own sperm to fertilise them. They instead suggest some radical new ways of fertilisation. Perhaps the female brushes up against the male just long enough to fertilise each egg before she attaches it to the male's body. In other words, it's not what he's got that's important, but how he uses it.

—A.T.

Noisy Reefs

To fish and invertebrates, reefs can be like noisy underwater cities: hubs of intense activity from which the 'chattering' of busy marine life-forms can be detected in the surrounding water for many kilometres.

Now University of Edinburgh biologist Stephen

KEVIN DEACON/ AUSCAPE

The sounds of the reef lure young fish.

Simpson and colleagues believe this clamour might be important in luring fish and invertebrate larvae out from the persuasive pull of ocean currents to the reef homes where they settle ready for adult life.

They tested the theory in a recent series of experiments on patch reefs constructed from coral rubble in waters off Lizard Island, at the northern end of the Great Barrier Reef (*Science* 308: 221). Nightly for almost a week, the researchers played snapping shrimp sounds and fish calls on half the reefs while leaving the others silent.

They then measured the level of new recruits to each site from two key reef-fish families, the cardinalfishes and damselfishes. They found considerably more larvae from both families had settled out of the water column to take up residence on the noisy reefs compared with the silent ones.

Next the researchers investigated whether high-frequency and low-frequency reef chatter resulted in different recruitment levels. Damselfish species showed a preference for reefs with high-frequency (predominantly shrimp) sounds, while cardinalfish larvae settled on reefs with high- and low-frequency (fish) sounds in equal numbers.

The research raises questions about the potential impacts of noise pollution from marine-based human activities such as shipping and drilling for minerals. And it could also lead to the development of new ways to restock depleted marine reserves.

—K.McG.

Giant Eagles of Middle Earth

In Tolkien's *Lord of the Rings*, Middle Earth is inhabited by giant eagles that swoop in to rescue Frodo from the dangers of Mordor. The idea of monster-sized eagles flying around New Zealand on *The Lord of the Rings* film set might seem like a fanciful idea. Yet, according to recent DNA research, it is not that far from the truth.

Only 500 years ago, New Zealand was home to one of the largest birds of prey ever to have graced our skies. Now extinct, Haast's Eagle (*Harpagornis moorei*) had a wingspan up to three metres and weighed as much as 15 kilograms. This fierce predator launched brutal attacks on moas, flightless birds that weighed up to 200 kilograms yet were defenceless against aerial assault.

To learn more about the eagle's evolutionary history, Michael Bunce (Oxford University) and colleagues extracted DNA from 2,000-year-old fossil bones and compared it with DNA from 16 extant species (*PLoS Biology* 3: 1). They expected to find the extinct bird closely related to the large Australian Wedge-tailed Eagle (*Aquila audax*). The results showed that, while it did have an Australian ancestor, its closest relative was the Little Eagle (*Hieraaetus morphnoides*), which at less than one kilogram is one of the world's smallest eagles. Stranger still, their common ancestor lived only about a million years ago, which means that Haast's Eagle increased in weight by 10 to 15 times in this relatively short period of time. Such a rapid change in size is

ARTWORK COURTESY JOHN MEGAHAN

Haast's Eagle, with its wingspan of three metres, attacks a pair of moas.

unprecedented in evolutionary records. And the fact that it occurred in a species still capable of flight makes it even more remarkable.

So why did Haast's Eagle grow so big, so quickly? The researchers say it's likely to be due to the size of their prey and the absence of mammalian predators. Ruling the roost, with no competition from mammals, Haast's Eagle would have fed unhindered on its island paradise. That is, until humans came along. Archaeological evidence shows the eagle died out within two centuries of human settlement, so any giant eagles seen flying over Middle Earth today belong in the realms of fantasy.

—K.H.

Friendly Foxes

LOOKING FOR A NEW PET? How about a Fox?

Brian Hare, from the Max Planck Institute in Leipzig, Germany, studied Foxes (*Vulpes vulpes*) in Siberia where they were bred to be friendly towards humans. Over 45 years, the Foxes have come to resemble Dogs, with floppy ears, multi-coloured coats and curly tails. And they can even read human body language.

Hare hid food under containers, and when he pointed towards the food, the Siberian Foxes found it easily. It sounds simple, but

COURTESY BRIAN HARE

Pet Foxes: a friendly Fox is a smart Fox.

the ability to guess what a human is thinking (that food is under the container) is no small accomplishment, and normal Foxes, Chimpanzees and Grey Wolves failed the test (*Curr. Biol.* 15: 1).

It seems that by breeding the Foxes to be friendlier, they accidentally became smarter. Hare believes the same thing happened with Dogs and Grey Wolves. Dogs are better at reading our body language than wolves, but perhaps it wasn't because we bred them to be intelligent, but because we bred them to be friendly.

In terms of pet potential, Hare says the Foxes are not quite perfect. They hide food under the sofa and leave it there to rot. Foxes in a pet store near you? Not yet.

—V.W.

Falling *Cephalotes atratus* ants can steer themselves back to the safety of the tree trunk.

COURTESY STEPHEN P. YANOVIAK

Ants' Aerial Acrobats

When it comes to navigating the jungle canopy, many animals find it easier to glide through the open spaces and make a quick free-fall descent. Squirrels do it, frogs do it, snakes do it and, it now seems, even ants do it.

Ecologist Stephen Yanoviak (University of Texas Medical Branch) and colleagues made this unusual discovery while working in the Peruvian rainforest.

Perched 30 metres up in the canopy, Yanoviak noticed when he brushed off biting ants that they'd fall then land on the tree trunk and climb back up. These arboreal ants, *Cephalotes atratus*, appeared to be actively steering their free fall. As no other wingless insects are known to do this, Yanoviak decided to investigate further.

By painting the ants' rear legs with white nail polish, dropping them, then videotaping their fall, the researchers were able to track their dive through the air. They found that about 85 per cent of ants landed on the tree, compared with an expected five per cent if they were falling randomly

QUICK QUIZ

1. *What are casuarinas also commonly known as?*
2. Gwion Gwion, Mimi and Wandjina *are examples of what?*
3. *How many planets are there in the solar system?*
4. *What do silviculturists cultivate?*
5. *What is the nickname of the new* Homo *species found on the Indonesian island of Flores?*
6. *In which year did the Chernobyl nuclear reactor explode?*
7. *What objects do some female dolphins in Shark Bay carry on their noses while foraging?*
8. *What percentage of the Earth's atmosphere is oxygen?*
9. *Name the protein found in feathers, hair and hoofs.*
10. *What type of tree is the 'Prison Tree' in Derby, WA?*

(Answers on page 79)

(*Nature* 433: 624). On takeoff, the plummeting ants splayed their legs to slow their fall, increasing drag like a parachutist. Then, to gain control of their trajectory, the ants orientated their bodies so their hind legs pointed towards the tree. Incredibly, the ants were also seen to make 180° turns in midair, so if they missed the landing, they'd make a hair-pin turn and glide in for a second attempt.

Gliding is obviously an advantage for high-canopy dwellers like *Cephalotes*. If approached by a predator, the tiny daredevils can BASE-jump to safety at four metres per second without falling all the way to the forest floor.

—K.H.

Sexy Platypus

Not only is the Platypus weird on the outside, its genes and chromosomes are weird too. Frank Grützner (Australian National University) and colleagues have discovered that, rather than a single pair of sex chromosomes, the Platypus (*Ornithorhynchus anatinus*) has five.

Using fluorescent 'chromosome paints' to identify and track chromosomes under the microscope during cell division, the researchers were able to identify which of the Platypus's 52 chromosomes were autosomal (inherited equally by both sexes), and which determine sex (*Nature* 432: 913; *PNAS* 101: 16257).

Most mammals and birds have one pair of sex chromosomes. In humans, females have two X chromosomes and males an X and a Y, while in birds it is the opposite, with males having a pair of Z chromosomes and females a Z and a W. In Platypuses, however, females have two copies each of five X chromosomes, while males have one copy of the five X_s and one copy of five Ys. Grützner and colleagues were able to watch how, during the process of sperm formation (meiosis), the ten marked sex chromosomes formed a long chain, all lining up in perfect alternating fashion (X1Y1 X2Y2 X3Y3 X4Y4 X5Y5). This is the only way to manage such an unwieldy system, allowing all five Ys to end up in one sperm (to produce male offspring), and all the Xs in another (to produce females). Any mixing of X and Y chromosomes in the same sperm would lead to unviable offspring. Amazingly, no mistakes were witnessed in the hundreds of sperm examined.

Significantly, the researchers found the X5 chromosome to resemble the bird Z chromosome, while the X1 chromosome

DAVE WATTS/LOCHMAN TRANSPARENCIES

The Platypus is a continual source of wonder—both inside and out.

COURTESY STEVEN ELLIS

A service counter used to sell food and drink to the ancient citizens of Pompeii.

at the other end of the chain resembles the human X. This suggests a completely unexpected evolutionary linkage between the sex-chromosome systems of mammals and birds, challenging the long-held view that the two systems evolved independently.

—R.S.

Ancient Pubs

Bars in the ancient town of Pompeii were not the dens of iniquity they were thought to have been, according to archaeologist Steven Ellis (University of Sydney). Previous writers, ancient and modern, associated bars with Pompeii's low life—drunks, thieves and prostitutes (Pompeii brothels are notorious for erotic frescoes), but Ellis counters that bars provided regular services like accommodation and a place to rest, talk, buy food and drink (*Food & History* 21: 41).

The problem with studying bars in Pompeii is that few food or drink remains survived the eruptions of Mt Vesuvius that buried the city in 79 AD. However, Ellis went back to the Latin inscriptions, contemporary books and archaeological structures, and found, of an estimated 577 shops, there were 158 retail outlets with serving counters, 130 of which had cooking and storage facilities. These bars were frequently placed so that they faced bustling intersections. They were also often found near temples, for the convenient purchase of food and wine offerings for the gods. Up from the main city gates, there were 12 open shop fronts, each with a bar in full frontal view of tired travellers trudging up the hill (*J. Rom. Archaeol.* 17: 371).

Eat-in or take-away, bars were possibly more important than today, especially for poorer classes who were certainly not dining on the couches we see painted on the lavish villa walls. Life was not that good. But the bars were not that bad either.

—R.F.

FURTHER READING

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

www.natureaustralia.net

Miner misdemeanours

Not only are Noisy Miners highly aggressive, they are, in zoological circles, spectacularly (in)famous for it.

BY STEVE VAN DYCK

FOR MANY FAMILIES THE SATURDAY paper arrives in the dark to the piping 'win-win-win' calls of Noisy Miners (*Manorina melanocephala*). It's a pity that most of us snore through that ten-minute session—it is, without a doubt, the only harmonious thing miners are capable of doing all day.

But back to the newspaper. Did you know that you can assess the mental health of your family by sorting through what's left of the Saturday paper one hour after it's been disembowelled? From my teenagers I follow a trail of honey blobs sliding down images of people embellished with moustaches, blackened teeth and augmented breasts. My wife leaves Olympic chains of welting coffee-cup rings around hacked windows where interesting ideas were snipped out for her scrapbook. And me, what do I leave behind? Great tufts of ripped-out hair—enough every week to stuff a jail mattress.

The hair is torn out in desperate defeat. Not so much from my brood's crying need of professional help, but from the agony the local Noisy Miners inflict on me. Each Saturday morning I tell myself to relax, sit on the verandah, wash the Valium down with some good coffee, slump over the paper and enjoy the backyard birds. And every time the same drama unfolds. A rosella might start to nibble a lantana berry, or a Rose Robin might land above me with a moth, when down they come out of the blue, like grey sniping spitfires, snapping and squealing—warriors from the hooligan rat-pack of Noisy Miners driving out anything that hasn't got feathers as dull as their own.

I could maintain my rage with a lot more dignity if they only brutalised those birds that were either attacking and eating them, or at least stealing their insects and nectar. But when a poor old dove is nearly nutted for scoffing down a few grains of spilt chook food (the thought of which would make a miner gag) then sometimes I feel like reaching for the bazooka instead of the binoculars.

Now after observing 20 years-worth of belligerent manners from that verandah, it really is time I sat down and had a good hard think about those delinquent rubbernecks. But have you ever tried to be honestly objective when a true-blue Aussie is being called to account? We're not talking here about the introduced chocolate-brown Common (Indian) Myna (*Acridotheres tristis*) that struts around cities and is conscionably easier to knock off because it fills valuable nesting hollows with plastic bags and garbage, making them unsuitable for a lot natives, and it doesn't really belong here in the first place. We are talking about an Australian honeyeater as dinky-di as Blinky Bill. How can we appraise it honestly without letting the old school-tie strangle our objectivity?

Well, let's introduce a little science into the court room. Are Noisy Miners unduly aggressive? Volume 5 of the *Handbook* (bible) *of Australian, New Zealand and Antarctic birds* (2001) describes them as "conspicuous, noisy and aggressive, driving off all other avian species from [their] communal territory". Not a real good start. It goes on to document a study from south-eastern Queensland that actually tallied up the number of bird species attacked by Noisy Miners at the one site. Sixty-five species were hammered and molested by the miners, including not only small birds like pardalotes, finches and other honeyeaters (six species), but grebes, ducks, parrots (13 species), herons, cormorants and pigeons. Ecologist Doug Dow (University of Queensland), who did the long-term research, later described Noisy Miners as "one of the most pugnacious, aggressive species in eastern Australia" and documented several attacks where miners were seen catching and pecking the heads of other birds (House Sparrow, Black-headed Pardalote, Sacred Kingfisher) until they'd killed them. Dow concluded that the occurrence of a single species of bird successfully excluding all other species from its habitat was "unique". So the answer to the question is yes, but not only are Noisy Min-

Noisy Miner

Manorina melanocephala

Classification
Family Meliphagidae (honeyeaters and Australian chats).

Identification
Drab grey; black crown and bandit mask; bright yellow beak, legs and bare skin behind eyes. Sexes similar; length 26 cm.

Distribution
Eastern half of Qld south of Laura, throughout NSW (except extreme north-west); Vic.; south-east SA; central and eastern Tas.

Biology
Highly social, colonies comprising a few to several hundred birds. Males and females promiscuous. Only female builds cup-shaped nest and incubates 2–4 brown-blotched eggs. Nestlings fed by mother and attendant males. Staple diet invertebrates, nectar and fruit. Usually breeds winter–summer.

WAYNE LAWLER/ AUSCAPE

Noisy Miners are the bullies of the bird world.

ers highly aggressive, they are, in zoological circles, spectacularly (in)famous for it.

Following up on this, more recent studies have shown that, by removing Noisy Miners from remnant patches of degraded woodland, a major influx of honeyeaters and insectivorous birds occurs within the first three months. In fact, after their removal, species richness was up to 16 times greater than in control plots.

I can feel a shaky hand slowly reaching toward the bazooka barrel. But wait, be fair! Say something in their defence! How did it all get to this? How does one species of native bird get to follow humans around wherever they go...wherever we make backyard gardens, suburban parks, golf courses, landscaped shopping centres and schoolyards?

The simple truth is that we and the miners get off on the same things, aggression not necessarily being the least of them. But in our love of open spaces, mature trees and manicured lawns we play right into their hands. And when, in our concern to revegetate areas ravaged by new development, we plant gardens full of nectar-dripping grevilleas and bottle-brushes, we then provide fodder for more miners to defend.

The success of these prying stand-over merchants evidently stems from their well-choreographed teamwork that in turn relies on their ability to see one another quickly. Not having CB or radar, their communication network jams when trees and shrubs interfere with their lines of vision, so they usually opt for tall-treed open space and avoid densely planted areas.

Studies on what makes the miner community such a roaring success read like cult fiction. The females practically detest each other but are completely promiscuous with the males, which all pitch in to help feed and protect the chicks no matter who fathered them. Strong, aggressive, protective males are so important to the horde that males outnumber females 2.3 to 1. Male chicks nearly always hatch first in the clutch giving them that edge in the ensuing developmental struggle and the whole group is glued together by sing-songs, corroborees, mass mating orgies, gang warfare and pooled aggression.

Taking all this on board, I've decided to make a stand, deal with the problem and strike a blow for sanity. I know my course of action will shock and disappoint my family and might be distressing to others, but it's time for difficult decisions to be made. From now on...you guessed it...I stay in bed on Saturday morning and read the paper there. The business section would describe this as a 'win-win' situation for both stakeholders. □

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

Beautiful Nursery-frog

On its island in the sky the Beautiful Nursery-frog lives amongst stunted rainforest, montane heath and boulder piles.

YOU MIGHT THINK OF NORTHERN Queensland as being hot, but standing here on Thornton Peak listening to the Beautiful Nursery-frogs calling in the pouring rain, it's far from it. It's so cold I'm shivering, and it's wet, very wet—just the way the frogs like it. In the tropical rainforests of northern Queensland, mountaintops provide cool islands in an otherwise balmy landscape. These upland refuges have retained unique flora and fauna and there is now concern regarding the impact of global climate change on these species. Thornton Peak is one such mountaintop and it is here that the Beautiful Nursery-frog (*Cophixalus concinnus*) lives.

The Beautiful Nursery-frog is a member of the microhylid frog family, which is represented in Australia by 16 species in two genera. Most species are small (approximately two centimetres) and all are terrestrial breeders, laying small clutches of about 15 eggs in moist leaf litter or amongst logs or rocks. Tadpole development is visible within the cramped confines of the eggs and fully formed froglets hatch out. Males usually tend the eggs, possibly protecting them from predation by ants and other invertebrates, but Australian species are not known to interact with the young after hatching. (The males of some New Guinean microhylids transport the froglets around the forest on their back!)

The Beautiful Nursery-frog has had a confused taxonomic history. It was formerly known as a species distributed above 700 metres elevation across several mountain ranges north-west of Cairns. However, it was recently discovered that what we were calling *Cophixalus concinnus* really included two distinct species—the relatively widespread one and a species restricted to the misty uplands surrounding Thornton Peak. Taxonomic rules dictate that the name *C. concinnus* is attached to the holotype (the specimen on which the description was based), and this was the species restricted to Thornton Peak. The common name, Beautiful Nursery-frog, was given to this species in recognition of the stunning red, black and white marbling of the throat and belly. A new name, *C. aenigma* (the Tapping Nursery-frog), was given to the more widespread species. The two species differ in appearance, calls and habits, and genetic data have revealed that they are actually only distantly related amongst the Australian *Cophixalus*.

The species only occurs above about 1,100 metres and has a total distribution of little over seven square kilometres.

Resolving the taxonomic confusion was important as it allowed the recognition of the Beautiful Nursery-frog as a species restricted to the uplands of Thornton Peak. The species only occurs above about 1,100 metres (the summit of Thornton Peak is 1,374 metres) and has a total distribution of little over seven square kilometres. On its island in the sky the Beautiful Nursery-frog lives amongst stunted rainforest, montane heath and boulder piles in an area with an annual rainfall in excess of 3,500 millimetres and an average temperature of just 17.5° C.

Although currently abundant in its restricted range, and protected in Cape Tribulation National Park within the Wet Tropics World Heritage Area, the Beautiful Nursery-frog has recently been listed as a Critically Endangered species under international criteria. This is because, in addition to being restricted to a tiny area, recent predictions of the effect of climate change on the species are dire. Stephen Williams and colleagues (James Cook University) have used bioclimatic modelling to predict the impact of climate change on vertebrate species restricted to the rainforest of the Wet Tropics. Even using the most conservative estimates of the increase in global temperature over the next century, the modelling forecasts significant range reductions in most of the species and predicts that the Beautiful Nursery-frog will be the first to go extinct—possibly within the next few decades!

The predicament of this species highlights climate change as one of the greatest current threats to the persistence of the unique upland communities on the mountaintops of the Wet Tropics. Only through intensive monitoring and research into microhabitat use, physiology and other aspects of the biology of these upland species will it be possible to make informed conservation decisions. □

BY CONRAD HOSKIN

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The Beautiful Nursery-frog, flipped onto its back (below) to reveal its colourful underside.

PHOTOS: CONRAD HOSKIN

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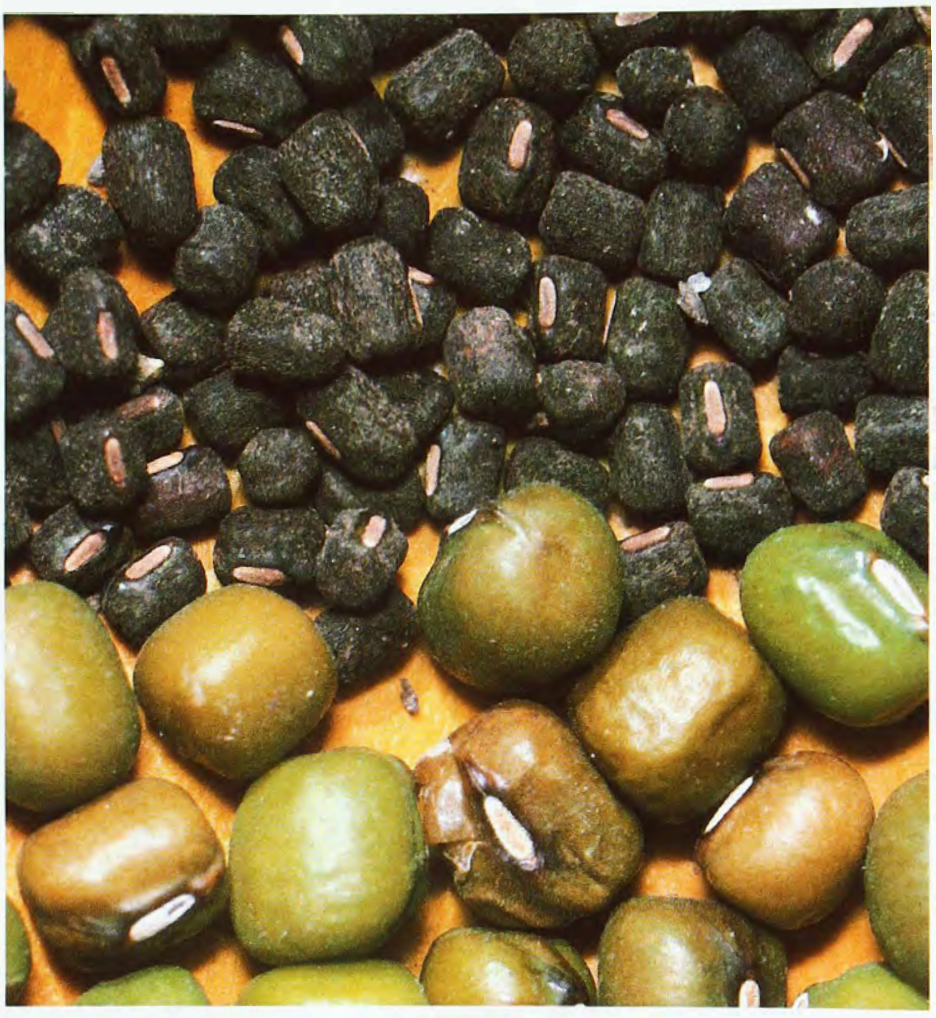
CONRAD HOSKIN IS A ZOOLOGIST IN THE SCHOOL OF INTEGRATIVE BIOLOGY AT THE UNIVERSITY OF QUEENSLAND WHERE HE IS COMPLETING HIS PH.D. ON SPECIATION IN FROGS OF THE WET TROPICS.

Genes for beans

Over the years many a plant breeder has turned to our native vegetation in the quest to enhance a major crop.



Australian native Mung Beans are unappealing as foods compared with their larger cultivated counterparts, but contained within their chromosomes may be genes that help create better cultivated beans.

AUSTRALIA HAS CONTRIBUTED VERY little to the range of world crops, with only the delectable Macadamia nut, from the Australian rainforest (*Macadamia integrifolia*, *M. tetraphylla*, and their hybrids), achieving any foreign fame.

That's not much to skite about, yet there's a little more to the story than this. Australian plants have a more subtle contribution to make to world agriculture, by yielding up genes to improve existing crops. Over the years many a plant breeder has turned to our native vegetation in the quest to enhance a major crop.

In a striking example from the 1960s the Australian flora saved one industry from disaster. During the 1950s a disease that infects Australian native tobaccos—Blue Mould (*Peronospora tabacina*)—spread abroad and blighted tobacco crops in America and Europe. Because this disease originated here, some of our native tobaccos (*Nicotiana* species) are highly resistant. In complex breeding trials, commercial tobacco plants were cross-bred with several native species to create disease-resistant cultivars. This means that every 'cancer stick' you see is partly a native product, the DNA in the cured leaves containing genes lifted from native tobaccos—traditional drugs of Outback Aborigines.

Breeding work on our plants can be traced all the way back to the early years of the 20th century. In 1909 a citrus breeder in America crossed an Australian rainforest Finger Lime (*Citrus australasica*) with a dwarf orange, although nothing useful came of that. In more recent trials in Florida (in the 1970s and 1980s), cultivated citrus were crossed with wild Australian citrus in a bid to improve their cold tolerance. But the plants either did not cross, or the hybrids died in the cold.

More often than not the Australian relatives of crops, although in the same genus, are not close enough to hybridise freely. Several projects have faltered or failed because progeny were not forthcoming. When native Wild Flax (*Linum marginale*) could not be crossed with commercial Flax or Linseed (*L. usitatissimum*), in the quest for edible-quality linseed oil, all interest was lost.

But some native plants contain such highly prized genes that advanced work is underway to extract them. Soybean Rust (*Phakopsora pachyrhizi*), the most serious disease of Soybeans (*Glycine max*), reduces yields in fields by up to 90 per cent. Australia has plenty of Soybean relatives and several show high disease resistance. Because that resistance is controlled by a single dominant gene, there is ample incentive to breach the genetic barriers. The plant set to yield the gene is a dainty little twiner (*Glycine tomentella*) found in eucalypt forest in eastern Australia. Monsanto is interested in this work.

Native sorghums (*Sorghum* species) show great promise for their resistance to drought, ergot and mites, and Texas A & M University has begun work with the Queensland government to surmount the fertility problems. When cross-pollination trials yield no offspring the next step is to elucidate the

BY TIM LOW

fertility barrier.

Sturt's Desert Rose (*Gossypium sturtianum*), the floral emblem of the Northern Territory, happens to be closely related to cotton (*Gossypium* species), and not only does it fare better in the cold than any cotton variety, it also offers resistance to a virulent new disease. Scientists are very interested. Stay tuned.

The Mung Bean (*Vigna radiata*) is an ideal candidate for cross-breeding because native Australian Mung Beans hybridise freely with crop plants—they are the same species. In the 1980s Bob Lawn (now at James Cook University) established beyond doubt that the wild Mung Beans growing in Australia are native plants, not escapees from farms. At the British Museum he examined a Mung Bean specimen collected in northern Queensland by Joseph Banks in 1770, proving that the native range of the Mung Bean extends from Asia to Australia. Lawn hopes to breed hard-seeded Mung Beans better suited to Australia's erratic climate than existing Asian forms.

In each of these examples any new cultivar is years away, but one striking new crop is ready for the world right now. The CSIRO's Steve Sykes works on disease resistance and tree size in citrus, and he started crossing mandarins with native limes back in 1981. That project is progressing slowly, but as a sideline he crossed a red colour-form of the Finger Lime (which hybridises easily) with a foreign lime and with little further effort produced a striking red fruit he christened 'Blood Lime'. The bush tucker industry has seized upon this product (even though it is only half bush tucker), and interest has also come from abroad. Citrus growers want new colours to promote, to match the varied palette available for stone fruits, and Blood Lime may have a big future overseas.

Apart from the crops mentioned here, Rice, Sweet Potatoes and Bananas may also benefit one day from a native infusion. Advances in gene technology increase the prospects of Australian genes finding their way into cultivated foods. Australia's contribution to the global crop base can only grow and grow. □

PHOTO: TIM LOW

The native tobacco *Nicotiana excelsior* is an important chewing tobacco for Pitjantjatjara people in central Australia, and one of several native species used in breeding trials to create disease-resistant cultivated tobacco.

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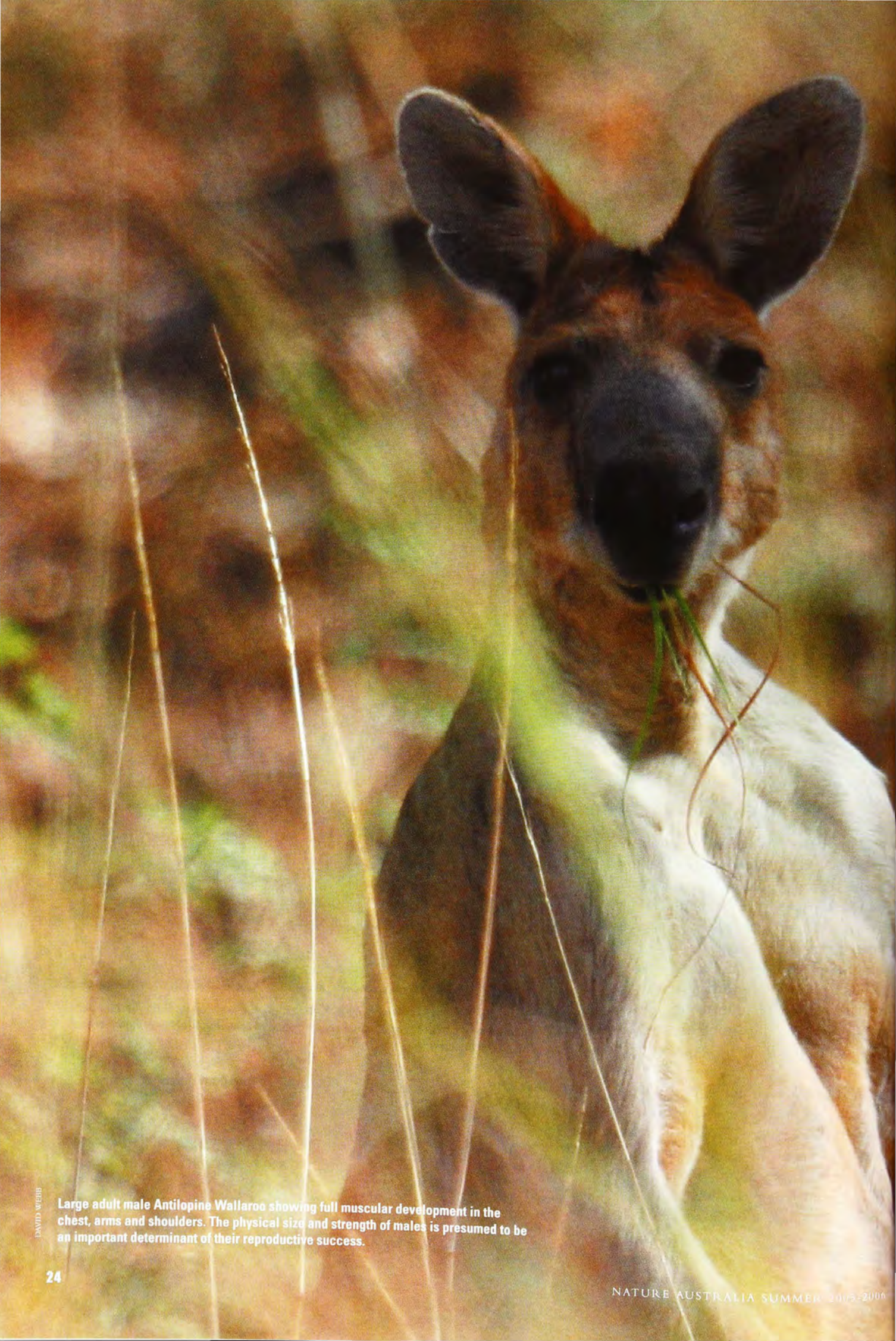
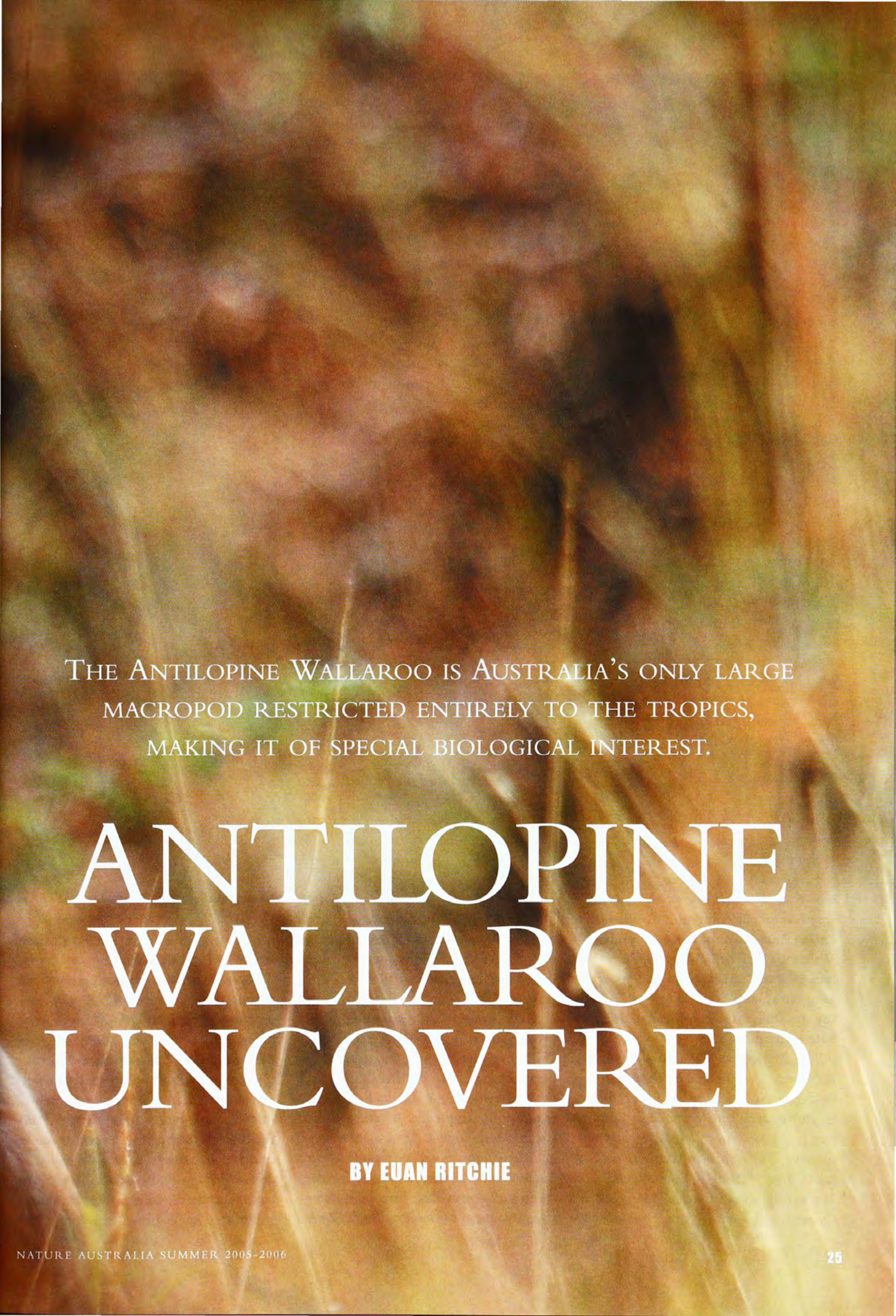
TIM LOW IS A BIOLOGIST AND AUTHOR OF SIX BOOKS, INCLUDING *FERAL FUTURE* AND *THE NEW NATURE*.



Large adult male Antilopine Wallaroo showing full muscular development in the chest, arms and shoulders. The physical size and strength of males is presumed to be an important determinant of their reproductive success.

DAVID WEBB



THE ANTILOPINE WALLAROO IS AUSTRALIA'S ONLY LARGE MACROPOD RESTRICTED ENTIRELY TO THE TROPICS, MAKING IT OF SPECIAL BIOLOGICAL INTEREST.

ANTILOPINE WALLAROO UNCOVERED

BY EUAN RITCHIE

WHAT IS YOUR IMAGE OF Australia's tropical savannas? Fiery sunsets, vast areas of golden grasslands, and a spectacular, rugged and remote wilderness? A reasonable and common view, but you may also harbour the romantic notion that this immense and relatively inaccessible expanse, covering nearly a quarter of mainland Australia, is shielded from the impacts of humans. Unfortunately, this view is incorrect. We are presently witnessing a broad-scale decline in numbers of the north's diverse mammal assemblage, most of which is endemic to the region. This poses a significant threat to preserving Australia's biodiversity.

One mammal reported as being in decline is the Antilopine Wallaroo (*Macropus antilopinus*). Most large macropods, in contrast to Antilopines, are thought to have increased in range and abundance since European settlement because of an increase in the availability of grazing pastures and access to water. This makes the apparent decline of Antilopine Wallaroos puzzling. Antilopine, meaning 'antelope-like', refers to the head shape and coat colouration of this wallaroo. And what makes it a wallaroo? Wallaroos are distinguished from wallabies by their larger body size (over 20 kilograms), and from kangaroos in having typically more rounded ears and bare rhinariums.

The Antilopine Wallaroo is Australia's only large macropod restricted entirely to the tropics, making it of special biological interest and particularly important to preserve from a biodiversity perspective. It occurs in a narrow band stretching from north-west of Townsville to northern Cape York in Queensland, across the top of the Northern Territory and into the north-western Kimberley region of Western Australia. It is commonly found in low, undulating savanna woodlands, and is ecologically most similar to the Eastern Grey Kangaroo (*Macropus giganteus*). A distinctive feature of the Antilopine Wallaroo is its gregarious nature, with group sizes averaging three to four animals. Indeed groups of six to ten, and even aggregations of 20 or more, are known to occur. Arguably Antilopines are the most social of all macropods. The species also displays strong sexual dimorphism (difference in body size) with adult males weighing over 50 kilograms and adult females averaging 20–30 kilograms.

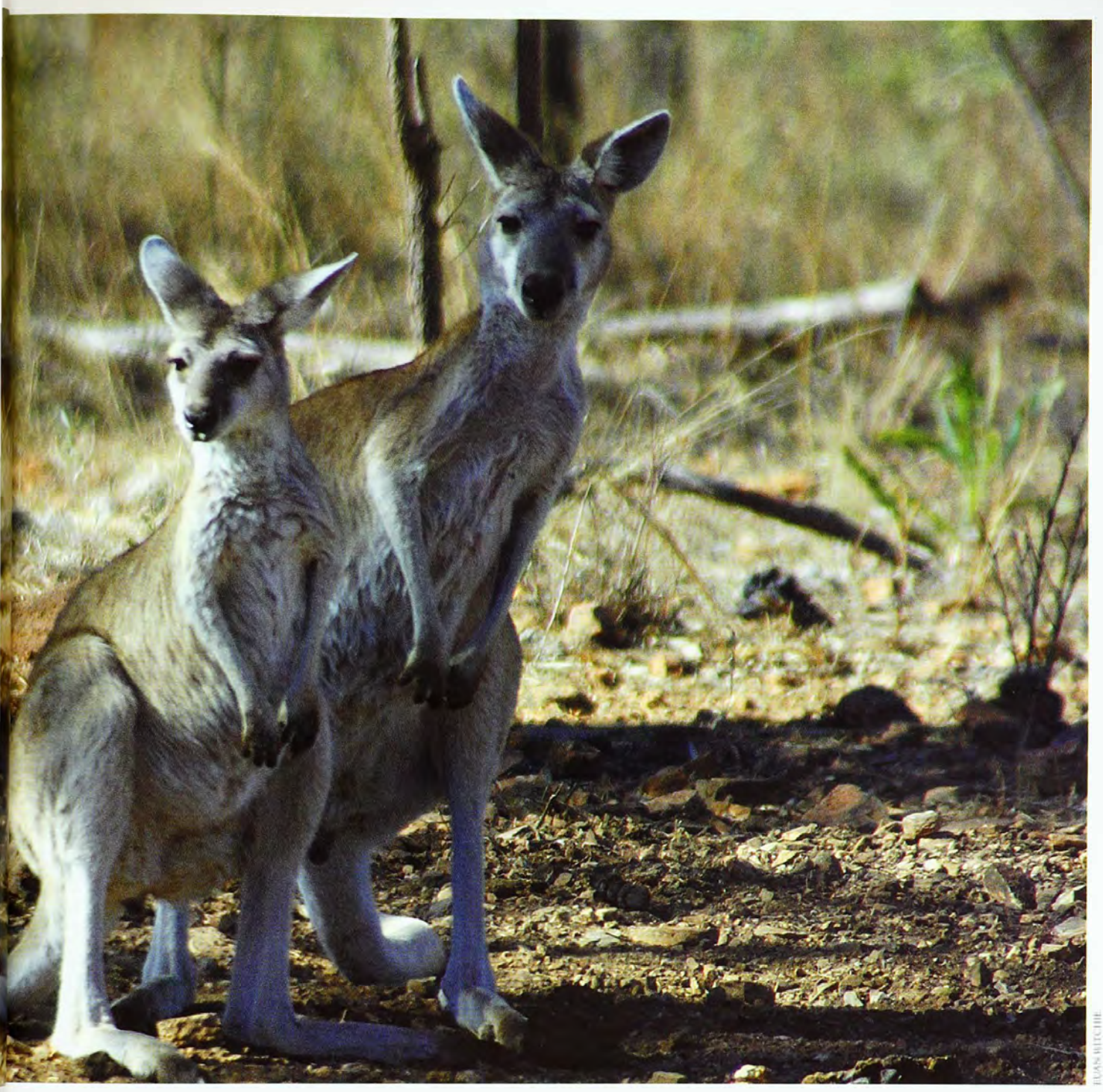
ANECDOTAL REPORTS OF

Antilopine declines are widespread and come from a broad spectrum of the community.

Anecdotal reports of Antilopine declines are widespread and come from a broad spectrum of the community including pastoralists, Indigenous people and park rangers. For example, Tim Flannery, in his book *Country* (2004), makes reference to a conversation with Thompson Yulijiri, an Aboriginal elder of Arnhem Land, who speaks of the decline of the Antilopine around Oenpelli (Western Arnhem Land) and tells how his people must now go far to hunt this species. And a recently completed CALM (Department of Conservation and Land Management) mammal survey of the West and East Kimberley failed to record any Antilopine Wallaroos where they were once plentiful.

The declines are of major concern, coming on top of the existing extinctions of some 12 per cent of Australian macropods (typically smaller-bodied species) in recent times. However, anecdotal reports are obviously a precarious and unreliable way to assess a species' conservation status. An extensive assessment of the Antilopine Wallaroo is clearly required, a need that my Ph.D. is currently addressing.

My research aims to improve our understanding, and ultimately the conservation status, of this little-known species. I am studying the ecology of the Antilopine Wallaroo across its entire Queensland distribution—a logistically challenging task, considering this represents an area larger than Victoria! My field program therefore requires me to undertake the enormous (but enviable) task of driving all over Cape York in the north and the Einasleigh Uplands in the south, to track down this enigmatic



EVAN HITCHE

An alert mother and young: the ears are turned outwards to enhance hearing.

macropod.

Specifically, my study addresses the current distribution and abundance, diet, habitat preference, reproductive biology, social behaviour, phylogeography, conservation and management of the Antilopine Wallaroo. There are three main factors influencing the Queensland environment where Antilopine Wallaroos are found: cattle grazing, fire, and extreme rainfall seasonality; characteristics shared by most of the monsoonal tropics. My research aims to determine the relative importance and influence of each of these factors on Antilopine Wallaroo ecology.

HALFWAY THROUGH MY STUDY, 70,000 kilometres of driving and 3,500 Antilopine Wallaroos later, what have I discovered? First, and most pleasing from a management perspective, Antilopine Wallaroo populations appear to be relatively stable in Queensland. Most sites in Queensland where declines had been reported appear to currently support good populations of Antilopines. However, based on anecdotal reports, this does not appear to be the case for populations in the North-

Pouch-cleaning behaviour by an adult female Antilopine Wallaroo with small pouch-young.

Antilopine Wallaroo

Macropus antilopinus

Classification
Family Macropodidae.

Identification
Short fur, large black nose, white ring around inside and edge of ears; males red on back and white on underside; females similar but with grey through head, neck and shoulders to mid back; males = 50 kg, females av. 20 kg.

Distribution and Habitat
Common but patchily distributed throughout low undulating tropical savanna woodlands in northern Qld, NT and the Kimberley in WA.

Biology
Seasonal breeder giving birth in wet season; highly gregarious; sexes segregate outside breeding season; activity crepuscular and nocturnal; feeds almost exclusively on grass.

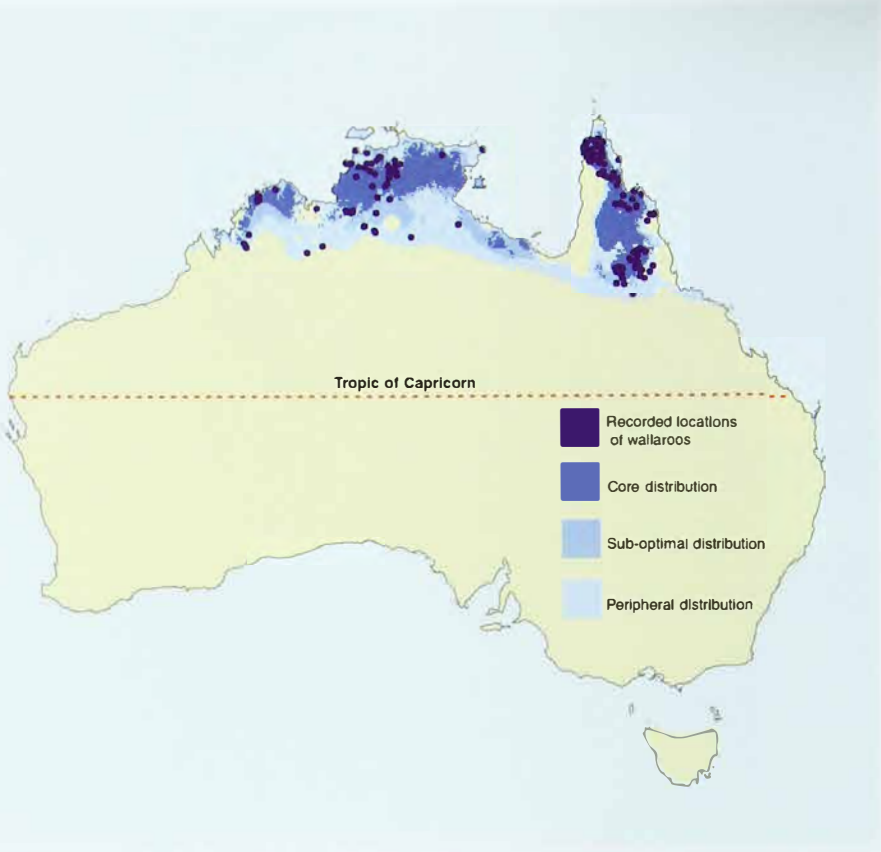
ern Territory and Kimberley. This may be associated with inappropriate fire regimes, and I now plan to assess the apparent difference in stability of Antilopine Wallaroo populations across Australia by surveying these areas as well.

In relation to fire ecology, the highest abundance of Antilopine Wallaroos I've recorded in Queensland occurs on a cattle station near Mt Surprise (north-west of Townsville) in the Einasleigh Uplands. It has not been burnt for over ten years, and the owner practises rotational grazing (where paddocks are regularly rested), a management practice atypical for the region. This suggests that the Antilopine Wallaroo may be a fire-sensitive species, preferring less frequent fires. Considering that much of northern Australia is characterised by regular, intense and late-season fires, this is an important finding from a management perspective.

From a biological perspective, it is

the behaviour of Antilopine Wallaroos that is most intriguing. They display a behavioural phenomenon known as sexual segregation, currently a hot topic in the field of behavioural ecology. It refers to a situation in which males and females of a species separate into single-sex groups when not breeding. In Antilopine Wallaroos, groups of five to ten females, and bachelor groups typically consisting of three to five larger-sized males, are a common occurrence.

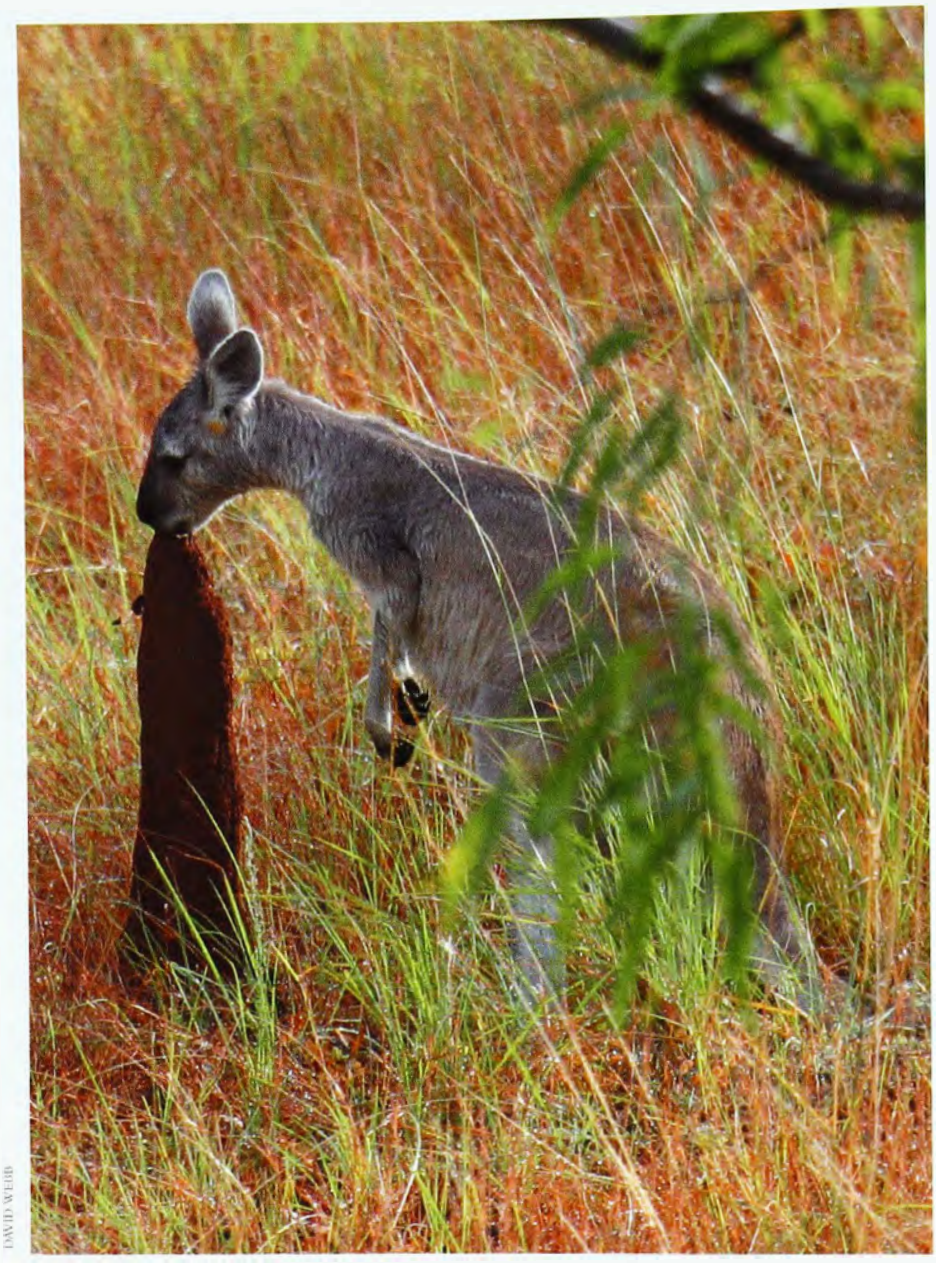
To identify the reasons behind sexual segregation in Antilopine Wallaroos, I decided to carry out a year-long analysis of the behaviour, activity patterns and diet of males and females near Mt Surprise, in the southern part of its range. Physiological theory predicts that females should have higher metabolic demands than males, due to their smaller body size and the energetic costs associated with reproduction (for example, lactation). Because grass is a relatively low-nutrient food, large quantities and large digestive times are



Distribution of the Antilopine Wallaroo in Australia.

JENNY MARTIN

Ritualised fighting between two young male Antilopine Wallaroos. In adult males this behaviour assists in establishing a dominance hierarchy.



DAVID WEBB

Salt is often lacking from the natural diet of many large herbivores, and Antilopine Wallaroos routinely supplement their diet by using cattle licks. This adult female may be gaining minerals by licking a termite mound.

required, meaning that smaller animals are disadvantaged.

In collaboration with Peter Fossan, a James Cook University masters student, we found, as predicted by the diet hypothesis, that male and female Antilopine Wallaroos feed on different types and amounts of plant material. Grass makes up 85 per cent of the diet of males and 74 per cent of the diet of females, but females feed on significantly more non-grass items (forbs) than males (11 per cent compared with three per cent). Forbs are higher in nutrients than grass, and may be preferentially eaten by females due to their greater energy demands. Within our study site, forbs were less abundant and more patchily distributed than grass. The female preference for forbs may at least in part explain sexual segregation, as it leads to separation of male and female groups. Interestingly, on the topic of nutrient availability, I have observed a female Antilopine licking a termite mound, presumably trying to access the mineral salts that had accumulated through evaporation.

However, diet is not the only possible explanation for sexual segregation in Antilopines. Other mechanisms, such as differences in the risk of predation (particularly by Dingoes and Wedge-tailed Eagles), social affinities between similar sex and age classes, or activity patterns, may offer equally plausible hypotheses and remain to be tested. Females with young may be more vulnerable to predation than larger males and therefore seek safer areas to feed. In addition, because female Antilopines are smaller than males they must feed more often, resulting in higher levels of activity and a split between the sexes within the same habitat.

One result of sexual segregation is that males spend long periods of time with each other, possibly impacting on their reproductive success. My observations indicate that a dominance hierarchy tends to become established within bachelor groups. This hierarchy may establish the strongest male in the group, and the one most likely to succeed in male–male competition for females, and ultimately to mate in the breeding season. Ritualised fighting occurs regularly, involving clawing of the ground, head flicking, wrestling and wallaroo kickboxing. One of the more unusual examples of dominance assertion I witnessed was an attempted copulation that lasted more than ten minutes, between a small and a medium-sized male, with a larger male observing.

On the topic of reproduction, my study has also defined the breeding season of Antilopine Wallaroos in Queensland. Early in the wet season (late December), when grass is most abundant and nutritious following heavy rains, young vacate the pouch. Adult males then begin fighting and displaying mate-guarding behaviour towards oestrous females, following them for extended periods. Births occur towards the end of the wet season (March–April), with young then remaining in the pouch over the extended dry season (May–November) as food resources become depleted. This pattern appears to be very similar for Antilopines in the Northern Territory and Western Australia, from the limited information we have.

THERE REMAINS MUCH TO BE LEARNED about the Antilopine Wallaroo, and I feel privileged to be able to make a contribution to our understanding of this poorly understood macropod. An unexpected benefit of the project has also been the relationships I have estab-

Thermoregulatory behaviour by a subadult male Antilopine Wallaroo involves licking the arms to facilitate evaporative cooling.

lished with a broad range of individuals and communities, including graziers, Indigenous people and park rangers. I have been inspired by the genuine interest that people from these diverse groups have shown in my work, and the help and cooperation that they have extended to me. I am thankful that this is the case as these are the people who will shape the future of our tropical savannas.

My project is just one example of the recent escalation in research effort that is now being directed to the tropical savannas of northern Australia. I firmly believe that, although we face many difficult challenges in maintaining the integrity of these environments, our collective successes indicate we are heading in the right direction. □

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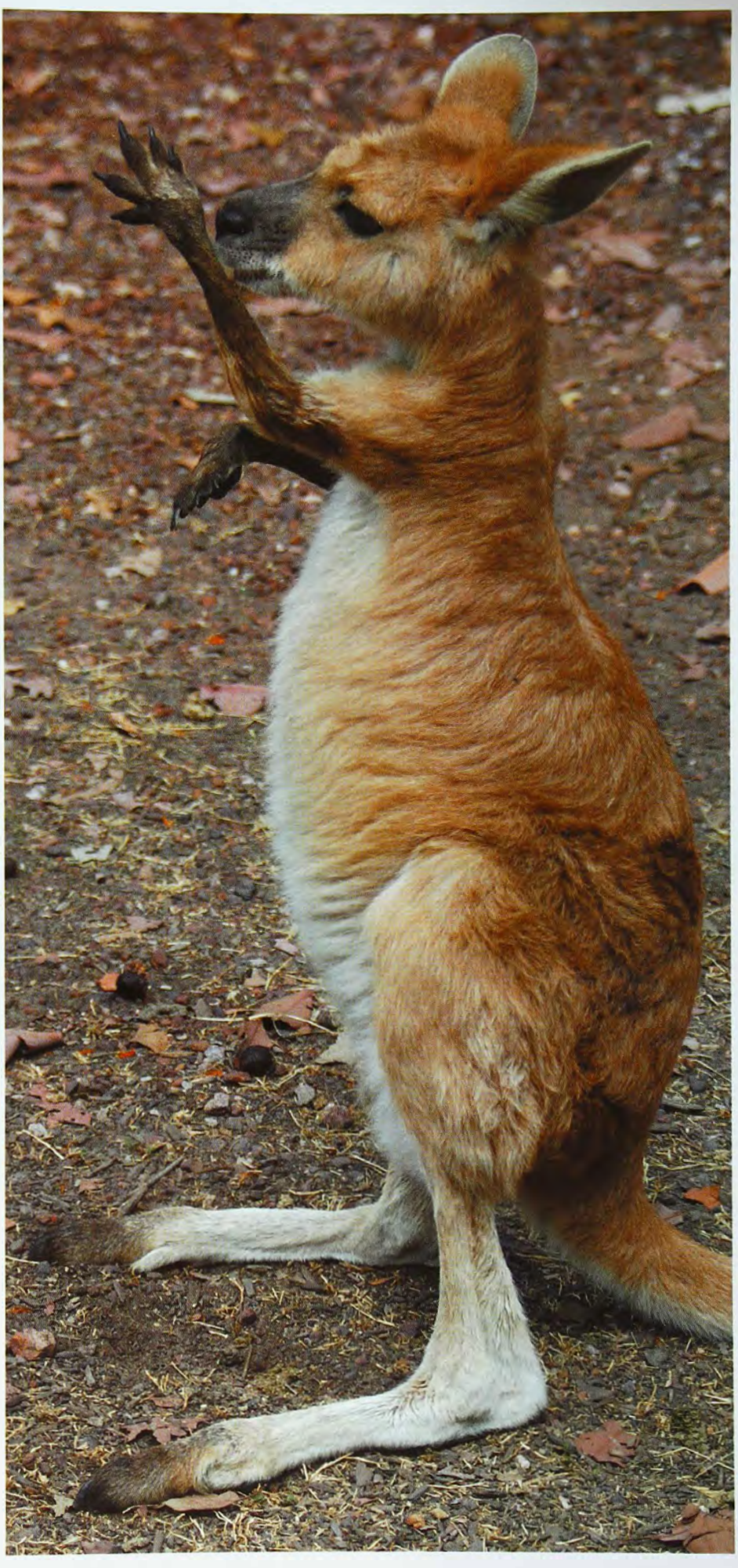
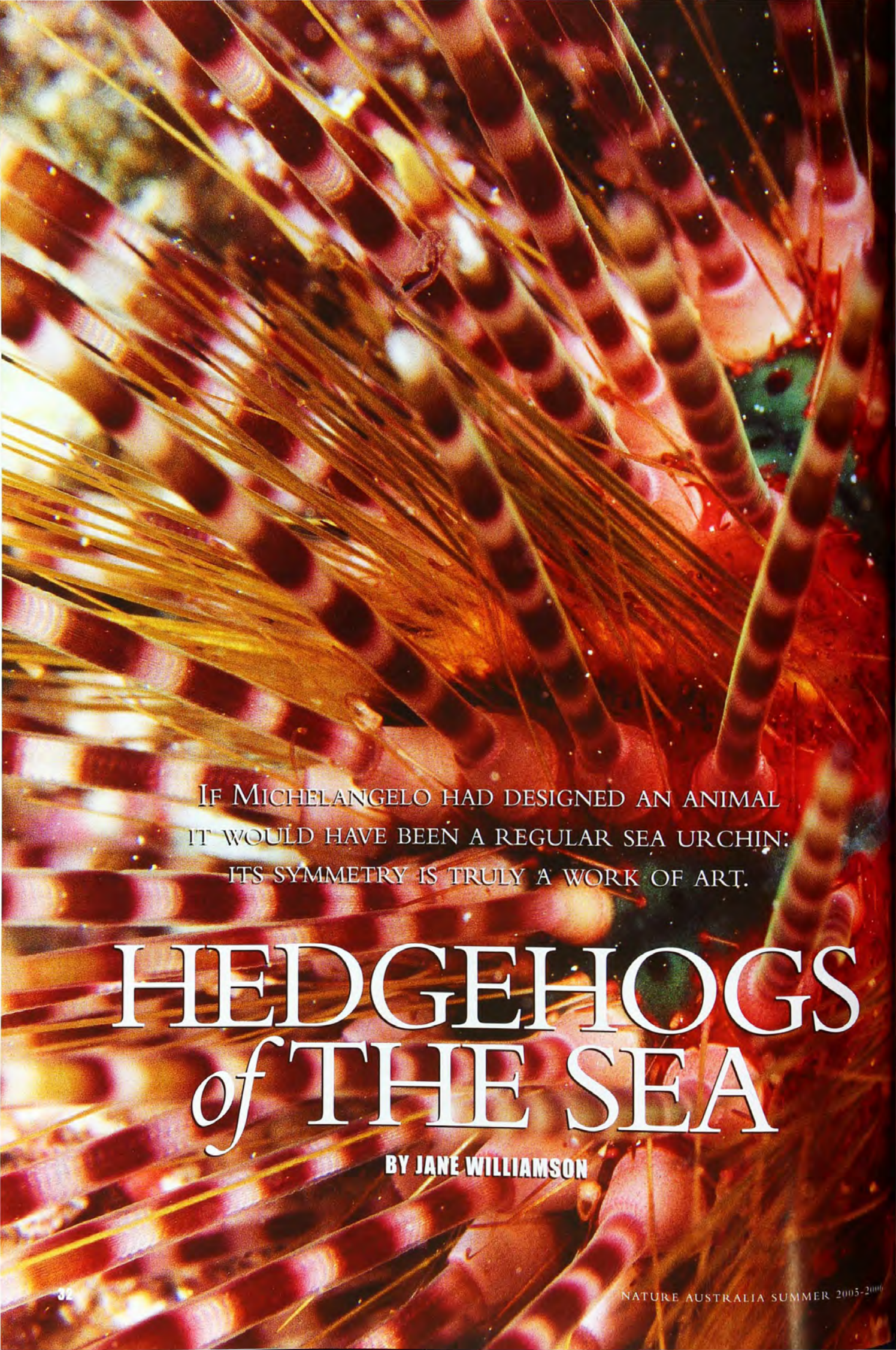


JENNY MARTIN



IF MICHELANGELO HAD DESIGNED AN ANIMAL IT WOULD HAVE BEEN A REGULAR SEA URCHIN: ITS SYMMETRY IS TRULY A WORK OF ART.

HEDGEHOGS *of* THE SEA

BY JANE WILLIAMSON

The Banded Sea Urchin (*Echinothrix calamaris*) is a tropical species that is commonly found underneath outcrops of coral.

CLAY BRYCE/LOCHMAN TRANSPARENCIES

OUCH! I REMEMBER IT WELL. I was eight years old the day I sat on a boulder at the edge of the sea extracting a barbed spine from my foot. As I held the broken spine up to the sun in wonder, I began to mull over the creature I had unwittingly trodden on. At the time I had no idea that a lifetime of research into sea urchins had begun.

As far as looks and reputation go, sea urchins are not top contenders. These balls of pointy spines are 'echinoderms', *echinus* meaning hedgehog and *derma* meaning skin, and could be mistaken for a curled up hedgehog or echidna at first glance. The spines on urchins, however, are completely different to those found on hedgehogs, echidnas or any other animal. Comprised of calcium carbonate, urchin spines rotate like a ball and socket in the same manner as our shoulder joints, giving them the flexibility to point in most directions. Spines are used in locomotion but can also be used to brace animals when wedging into crevices, to transfer food to the mouth, and in protection against predators. Some species even have specialised sacs at the base of their spines that eject toxins on demand. Spines range from the thick, blunt structures of pencil urchins to the long, thin needles (up to 30 centimetres) of the tropical diademids. Their texture can be smooth, thorny or grooved, they are either hollow or solid, and their colour range is extraordinarily diverse. Indeed, spine characteristics are so varied that many species are classified on this basis alone.

Among other distinguishing features of sea urchins are the pedicellariae. Found between the spines, these broccoli look-alikes are dynamic stalked structures terminating in three opposing 'jaws' that open or close via muscular control. Like spines, many pedicellariae have associated poison sacs. The jaws of the pedicellariae are constantly moving, and their job is to clean the urchin's surface of unwanted debris and organisms. The pedicellariae bear an uncanny resemblance to the carnivorous plants in the movie "The Day of the Triffids".

Urchins have a series of tube feet or podia that they use for locomotion. Fluid-filled canals extend through the hard skeleton (test), connecting an internal vascular system to each of the many (up to 2,000) external thin-walled tubular feet. (The pores through which these canals pass can be seen when you hold an empty, spineless urchin test up to the light.) Pumping water through a one-way valve into a tube foot causes the foot to elongate by hydraulic motion. Once the end of the foot touches a surface, it adheres through a combination of suction and chemical means. The tube foot retracts when longitudinal muscles contract and the fluid is forced back through the same one-way valve into the central vascular system. In addition to locomotion, the tube feet are used to excrete waste products, through diffusion across the thin membranous walls, and may also be involved in chemoreception and the manipulation of food. Such a simple and elegant structure does, however, have its drawbacks. Fish have a habit of nibbling on exposed tube feet, and in some urchins loss or damage to 20 per cent or more of the tube feet will cause irreparable damage to the vascular system and result in death. Urchins are also susceptible to disease through small tears in the vascular system.

FISH *have a habit of nibbling on exposed tube feet.*

Sea-urchin tests can be either radially symmetrical ('regular') as in the urchins that commonly reside in the intertidal zone, or bilaterally symmetrical ('irregular'), like sand dollars or heart urchins. I believe that if Michelangelo had designed an animal it would have been a regular sea urchin: its symmetry is truly a work of art. The test of a regular urchin is comprised of a mosaic of flat ossicles arranged in ten radial sections extending from the genital pores and anus at the top, and finishing at the mouth on the underside. There are five sections that contain the tube feet and these are called the 'ambulacral grooves'. These are interspersed with five 'interambulacral grooves' devoid of tube feet. Spines occur on both types of grooves.

The hard structure of sea-urchin spines and tests means that they preserve well. Indeed, fossil records show that sea urchins have existed relatively unchanged for at least 600 million years. At their peak of diversity there

KAREN GOWLETT-HOLMES-ONCORD SCIENTIFIC FILMS/AUSCAPE

***Holopneustes inflatus*, closely related to the Velcro Sea Urchin (*Holopneustes purpurascens*), uses the kelp *Ecklonia radiata* for both food and protection.**

were an estimated 20,000 species. Today there are about 6,500 species of echinoids (regular sea urchins, heart urchins and sand dollars). They have made their home in every marine habitat, from the intertidal to the deep sea, and at temperatures ranging from the warm tropics to the icy-cold polar waters. Such a ubiquitous distribution is probably due, in part, to the simplicity of their internal design. These animals have a simple nervous system with no obvious brain, and feature very few internal structures—just the jaws (called the 'Aristotle's lantern'), the intestine, and the reproductive organs.

Individual sea urchins are either male or female and most reproduce by shedding their gametes (sperm and eggs) into the surrounding water, a process

Australian Sea Urchins

Classification
Phylum Echinodermata, class Echinoidea; 42 species (8 families) of regular (radially symmetrical) sea urchins; 43 species (12 families) of irregular (bilaterally symmetrical from anterior to posterior) sea urchins.

Identification
Families separated by shape of test, positioning of peristome (mouth) and periproct (anus), internal supporting structures, ambulacra (podia-bearing sections of test), along with patterning and morphology of spines.

Habitat & Distribution
All marine benthic habitats, from estuaries to deep sea, and tropics to Antarctic polar waters.

Diet
Most are herbivorous, but some opportunistic, omnivorous and even carnivorous. Capable of biting through tough kelp, encrusting algae, and most sessile invertebrates.

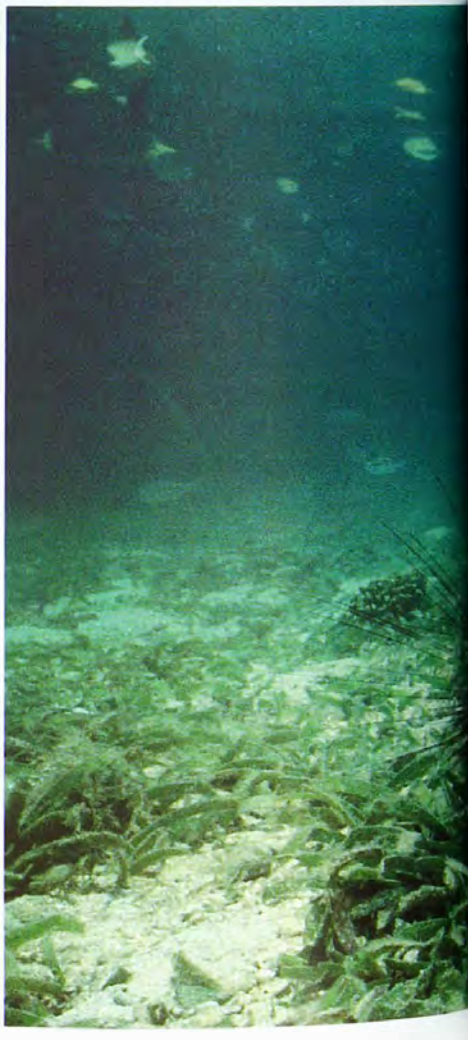
EVA BOGGARD/LOCHMAN TRANSPARENCIES

The Western Slate Pencil Urchin (*Phyllacanthus irregularis*) uses its thick spines to wedge into undercut limestone caves in areas of heavy wave action.

known as external fertilisation. Sea urchins of the same species often form aggregations just prior to releasing gametes in synchrony, thus maximising the chance of successful fertilisation. Synchronous spawning is frequently induced by specific external cues such as the beginning of a full moon, or to a particular sea temperature or photoperiod. Progeny are then dispersed to varying extents depending on the length and form of their larval stage. Some urchin species have larvae that subsist on internal nutrient reserves, while the larvae of others feed on plankton. These 'planktotrophic' larvae have the potential to disperse greater distances than 'lecithotrophic' larvae, which must find an appropriate place to settle before their reserves are exhausted.

AUSTRALIA HAS 42 SPECIES OF REGULAR (radially symmetrical) sea urchins. The biology and basic ecology is well known for several of these species but not for the majority. The most studied sea urchin in Australia is undoubtedly the Black Sea Urchin (*Centrostephanus rodgersii*). This is the dominant sea urchin on shallow subtidal reefs along south-eastern Australia. It hides in crevices and under boulders during the day, and emerges to feed mainly on large kelp and foliose (leafy) algae found on the surrounding substratum once night falls. This pattern of foraging causes dramatic 'halos' of areas cleared of large plants but dominated by crustose (encrusting) algae around their daytime hideaways. These heavily grazed habitats are known as 'white rock areas' or 'barrens', and are maintained if the density of Black Sea Urchins stays above a critical level. Once the urchins are removed or the density is reduced, the barrens shift back to areas dominated once more by foliose algae, and perhaps even kelp beds. A mosaic of barren areas interspersed with patches of kelp occurs throughout the shallow subtidal zone in New South Wales, and is in part defined by the location of the urchins' cryptic hiding places.

The roe (eggs) from sea urchins is considered a delicacy in many coun-



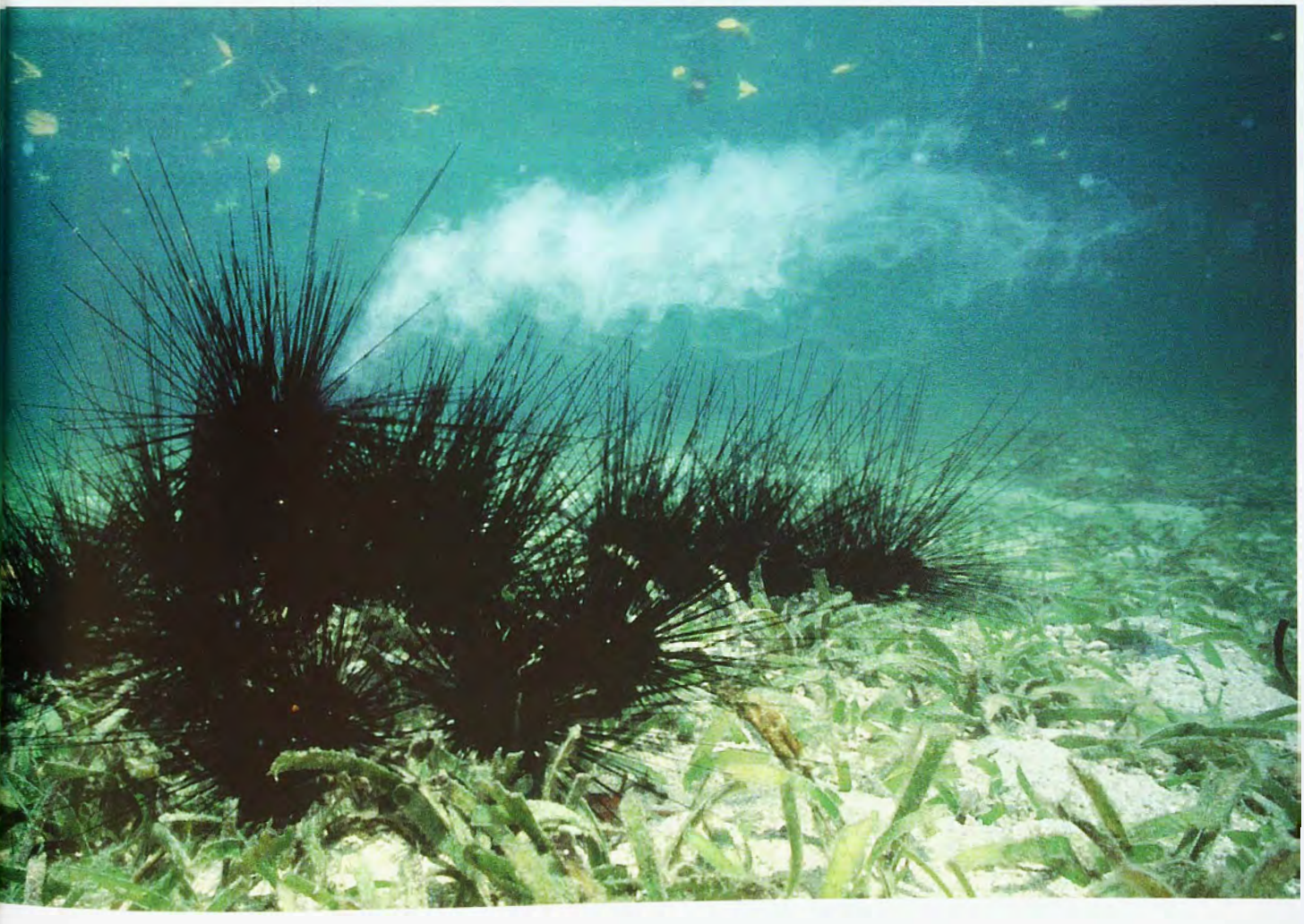
THE ROE FROM SEA URCHINS

is considered a delicacy in many countries, and a small fishery exists for the Black Sea Urchin in New South Wales.

tries, and a small fishery exists for the Black Sea Urchin in New South Wales, for local sale and export. SCUBA divers collect urchins in autumn to early winter when the animals are getting ready to spawn. They target medium-sized urchins as these have the most roe per volume (larger urchins are more variable and thus more unpredictable) and, because the quality of the roe is directly related to diet, they harvest urchins either in or on the edge of kelp forests rather than in barrens. Regular removal of urchins of a particular age-class and from particular areas has the potential to substantially alter community structure and may have cascading effects on the ecology of many other commercially important fishes and invertebrates, including lobsters and abalone. For example, the abundance of Black Sea Urchins is often inversely related to that of the Blacklip Abalone (*Haliotis rubra*) in south-eastern Australia, although the competitive interactions between both species are complex.

Another commercially and ecologically important Australian species is the Purple Sea Urchin (*Heliocidaris erythrogramma*). This urchin occurs in shallow coastal waters from Caloundra in southern Queensland to Shark Bay in Western Australia, including all coastlines of Tasmania. The Purple Sea Urchin is generally more sedentary than the Black Sea Urchin. Although also a night feeder, the Purple Sea Urchin usually stays within its crevice and captures detached algae drifting past. It is thus less likely to cause the halo effects of barren areas interspersed with kelp forests as seen in areas inhabited by the Black Sea Urchin. In saying this, however, we sometimes observe high-density aggregations (over 100 individuals per square metre) of Purple Sea Urchins that result in intense grazing pressure. These aggregations can have important consequences for community composition and algal growth. Unfortunately, the

Sea urchins spawn externally and successful fertilisation is, in part, left to the vagaries of the currents.



D. PARER & E. PARER-COOK/AUSCAPE

The Black Sea Urchin (*Centrostephanus rodgersii*) is the dominant urchin in shallow subtidal reefs in south-eastern Australia.

public often mistakenly assumes that these large aggregations constitute plagues that should be eliminated, without thinking about the consequences of removal.

One of the more unusual species of sea urchins in south-eastern Australia is (*Holopneustes purpurascens*), which I refer to as the 'Velcro Sea Urchin' on account of its prominent tube feet that stick to your hand when you hold it. Unlike most urchins, large individuals live in the algae they consume. Therefore, their habitat distribution depends on the breadth of their diet. Apart from spending many hours musing on the intelligence of eating your own house, my co-workers and I noticed that, in areas around Sydney, small Velcro Sea Urchins occur predominantly in the fronds of the leafy red alga *Delisea pulchra*, whereas larger individuals live amongst the kelp *Ecklonia radiata*. Both plants are rich in different types of biologically active chemicals, and these appear to drive the pattern of host-plant use by the different sizes (and presumably ages) of the urchins. New recruits settle in response to chemicals exuded from the red alga and, because the red alga is unpalatable to urchins, they feed on diatoms and other algae on and around their leafy home. However, as they get bigger, they are then forced to move and secondarily colonise the kelp. This act of moving between algae can greatly increase their risk of being eaten and not many individuals make it to their final destination.

Why Velcro Sea Urchins initially respond to the red alga's metabolites when they don't even eat the plant remains a constantly perplexing puzzle for me. Some of my avenues for research have included investigating the possible added protection that the red alga may give to a tiny urchin (but I found this to be no more than that afforded by other algae), and whether the urchins are responding to chemical cues from the alga because it is a reliable indication of high-quality habitats nearby (there is a good possibility of this). What is clear though is that the Velcro Sea Urchin, like most urchin species, is a creature displaying highly complex ecological patterns—not bad for an animal with no real brain.

Sea urchins play a pivotal role in regulating community structure in a diverse range of marine habitats, and are also important sources of food for many predators, including blue gropers, octopuses, Port Jackson Sharks and large starfishes. Predators do, however, have to overcome those spiky spines before getting to the good stuff, and often suffer in the process. A few years ago there was a large Eastern Blue Groper (*Acho-*

erodus viridis) at one of my regular research sites that clearly had a penchant for urchin roe and, having discovered that I routinely uncovered urchins during my dives, followed me closely whenever I was in the water. This groper quickly earned the name 'Merv' because of the substantial moustache of spines protruding from its upper lip.

CONSIDERING THE IMPORTANT ecological role sea urchins have in temperate marine ecosystems, it makes sense not to greatly impact on their abundance and distribution. But as more and more people discover the joys of consuming urchin roe, this fine balance has the potential to topple. Global demand for urchin roe is steadily increasing, yet in most regions where urchins are fished overseas, populations are either economically extinct or in a state of decline. The market for edible sea urchins is unlikely to decline in the near future and sea urchins, especially shallow inshore species like the ones we have here in Australia, will be particularly vulnerable to overharvesting.

To alleviate some of the pressure on wild sea urchin populations, there is considerable interest in echiniculture (aquaculture of sea urchins). Currently, there is no commercial echiniculture in Australia but my colleagues and I are researching ways of optimising life-cycle stages and improving quality of roe for local sea urchin species, which will hopefully be good candidates for echiniculture in the future. Based on overseas predictions, this could prove to be an extremely profitable industry if we get it right. □

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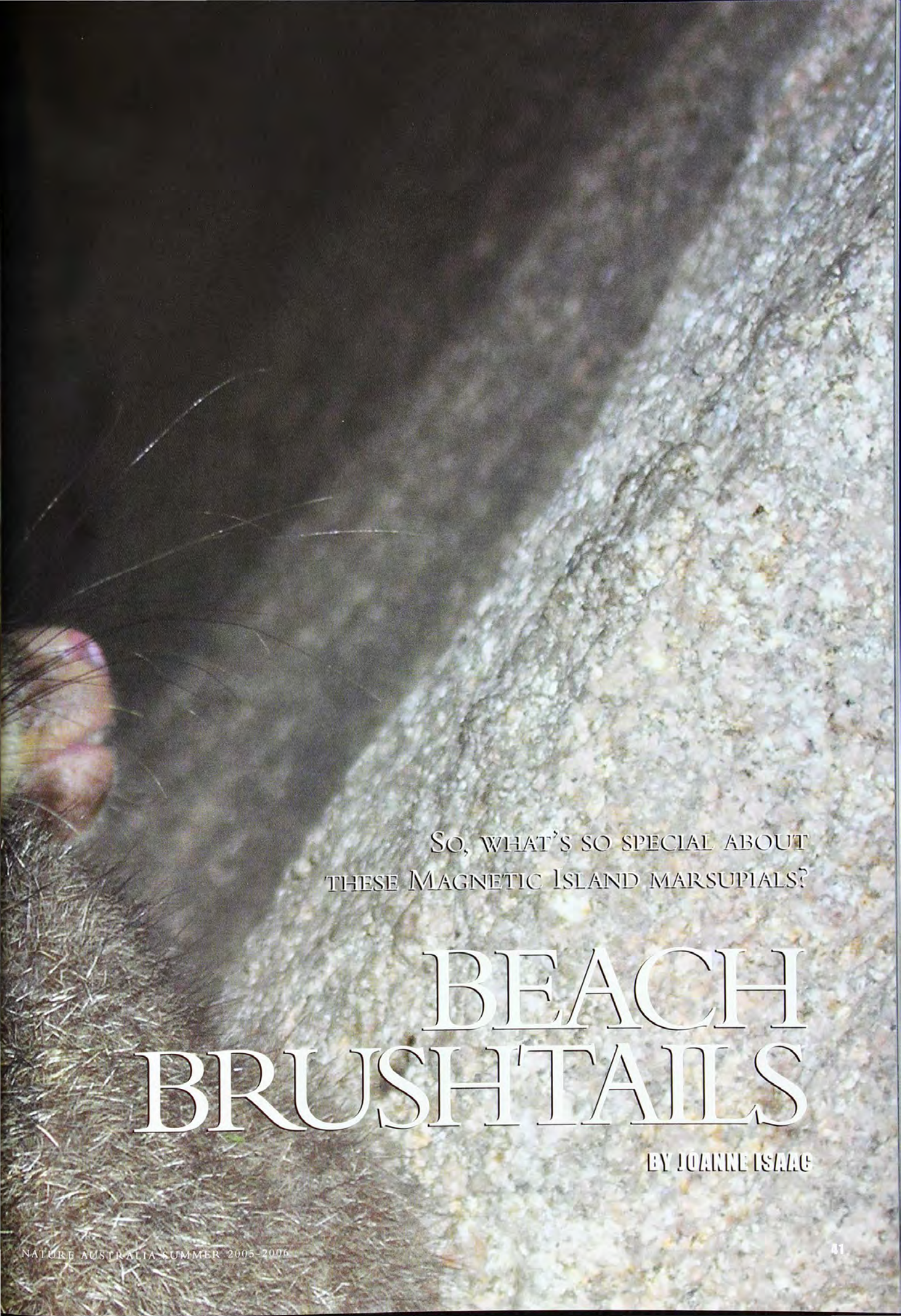
CLAY BYRCE/LOCHMAN TRANSPARENCIES

Mathae's Sea Urchins (*Echinometra mathaei*) are commonly found in high densities on open intertidal areas in tropical regions. Here they are eating small epilithic algae covering dead coral rock.

A young possum clings tightly to its mother as she squeezes through a rock crevice into their den.



So, what's so special about these Magnetic Island marsupials?

BEACH BRUSHTAILS

BY JOANNE ISAAC

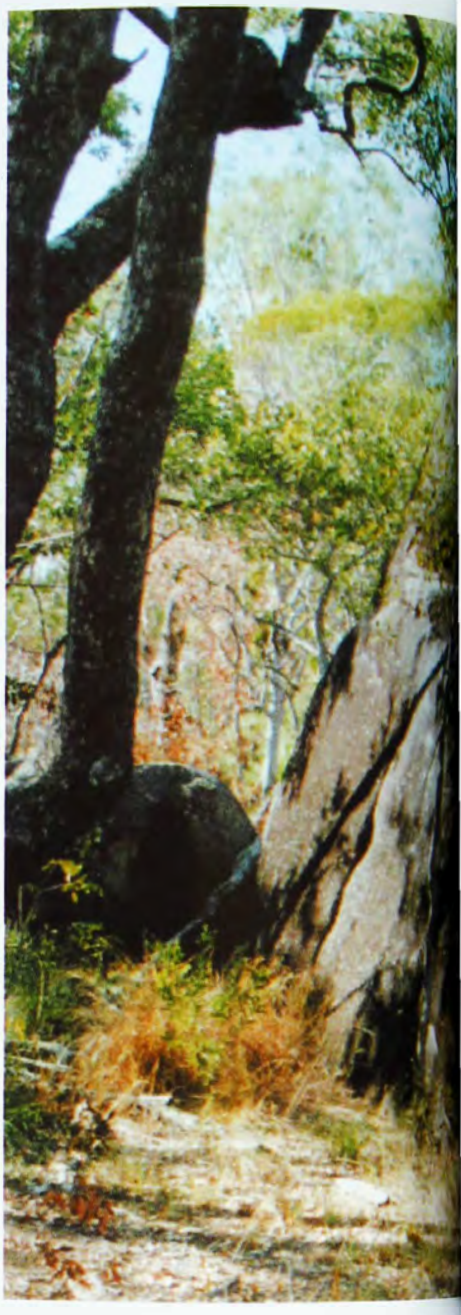
LOVE THEM OR HATE THEM, there are few Aussies (or Kiwis for that matter) who don't have an opinion on the Common Brushtail Possum (*Trichosurus vulpecula*). Seemingly ubiquitous in our towns and cities and a frequent visitor to our gardens, it will come as no surprise that the Common Brushtail has one of the widest distributions of any native Australian mammal. The success of the species lies in its ability to adapt to a wide variety of habitats and food sources. Common Brushtails will den in roofs, garages, nest boxes and rocks, as well as in the more traditional tree hollows. These supposedly folivorous (leaf-eating) marsupials have also been documented to eat everything from fruit and flowers, spicy Mexican beef burritos (my own observation whilst moonlighting as a waitress!), to the eggs and fledglings of endangered New Zealand birds. However, despite this apparently adaptable nature, the Common Brushtail Possum is also in decline in a number of areas, including Western Australia, the Northern Territory and Cape York Peninsula, most likely due to habitat modification and clearance.

From 2001 to 2004, I studied the life and times of a population of Common Brushtails on Magnetic Island. Magnetic Island is a small continental island, with an area of 5,184 hectares, about eight kilometres off the coast of Townsville, in tropical north Queensland. The island was so named by James Cook because, as he was sailing past in 1770, the ship's compass acted strangely, leading him to the (erroneous) conclusion that the island had magnetic properties. More than half of the island is zoned national park and the vista is dominated by large hills and spurs, with elevations of up to 540 metres, and covered with extensive granite outcroppings. The climate on the island is tropical and highly seasonal, with a dry winter season from May to October and a wet summer season from November to April. The vegetation is predominantly grassy eucalypt woodland.

My study site was located on the west side of the island in an area of open woodland, complete with the large granite boulders typical of the rest of the island. The main tree species there were

WENDY KING

Measuring a small pouch young of a Common Brushtail Possum on Magnetic Island.



ANDREW KROCKENBERGER

Habitat typical of the author's study site and much of Magnetic Island. The possums den in the large rock crevices, which are abundant.

eucalypts, but also wattle (*Acacia*) and paperbark (*Melaleuca*) species, the native Yellow Kapok Tree (*Cochlospermum gillivraei*), and Burdekin Plums (*Pleiogynium timorense*), which the possums were very partial to.

I began trapping in early May 2001 and I remember the first possum I caught very well. She became known as female 723 (taken from the number on the microchip that I injected under the skin of each possum). From the wear on her first upper molar, 723 was about four years old and, at the time, had a tiny pink pouch young. Possum 723 was still alive when I finished my study —I caught her nearly every month for the whole three years—as was her daughter, called 3038, whose territory overlapped with her mother's (as is typical for female offspring). Possum 3038 had her first young, a male, when she was two years old. He stayed around with her until he was nearly 12 months old, before setting off to find a territory of his own. Most males disperse by about nine months of age, so this one seemed to have been a bit of a mummy's boy! Possum 723 and her extended family were one of many such families at my site, which at the end of the study I knew to contain about 30 resident females and 25 males.

SO, WHAT'S SO SPECIAL ABOUT THESE Magnetic Island marsupials? First of all, the habitat and conditions on the island are quite different to those on the mainland. There are many rocks on the island but relatively few large trees with

ANTHONY HILL

(Top) Magnetic Island possums are generally quite lucky, as there are relatively few predators about. However, occasionally an unlucky individual can get taken by a snake, such as this Carpet Python. (Right) This young possum is about eight to nine months old. Offspring are able to cling onto their mother's fur amazingly well as she jumps from tree to tree.

hollows, forcing most of the possums to den in rock crevices, not trees. Also, like many islands, Magnetic Island is less biodiverse in terms of animal species, compared with the mainland. In particular there are few native mammal or bird predators present, such as Dingos (*Canis lupus dingo*). Carpet Pythons (*Morelia spilota*) are probably the only native predators of Magnetic Island possums, although it is possible that barking owls (*Ninox connivens*), which are currently increasing on the island, may take the odd unlucky individual. And there is also only one other arboreal, folivorous marsupial present to compete for food—the Koala (*Phascolarctos cinereus*). Koalas are present at relatively low densities (it's thought they were introduced to the island from nearby mainland populations) and are also much fussier eaters than the possums and therefore probably don't present much competition. Perhaps as a combined result of these factors, the possum population on the island is very high—in fact, only one brushtail population that has been studied in Australia has had a greater density, and that was recorded on another island, Tasmania.

KOALAS ARE *much fussier eaters than the possums and therefore probably don't present much competition.*

Female possums on Magnetic Island can produce up to two offspring each year; all sexually mature females produce one young in the main breeding season in autumn and some females go on to have a second in early spring. My research has shown that these 'double breeders' are often older females that give birth to their autumn offspring earlier than other females, giving them time to fit in a second young in spring. I also discovered that young female possums breeding for the first or second time are much more likely to give birth to a son than other females. As daughters remain close to their mothers' home ranges for the rest of their lives, young females probably produce sons in order to avoid life-long competition with female offspring for resources like food and den sites.

The high density of possums on Magnetic Island seems to have led to another strange phenomenon—some possums live exclusively in the man-

groves. As you might imagine, tidal mangroves are not ideal possum habitat; the leaves of mangrove trees are full of salt and difficult to digest, and there are also very few suitable den sites. Possums in the mangroves are often found with wounds and it seems that they may be subordinate individuals, forced out of the woodland by bigger, more dominant possums into the suboptimal mangrove habitat.

In July 2002, a prescribed fire burnt half of my study site. Luckily I was able to move all the equipment out in time, and all the possums were present and accounted for after the fire. It seems they probably sheltered (or slept!) in the rock crevices during the fire. Interestingly, in the following months, many new individuals moved into the burnt area, indicating that perhaps the fresh growth of vegetation had made the area more attractive to dispersing possums. On a less happy note, early in 2004 I found one of my yearling females, number 4563, dead on the road. Unfortunately, road traffic accidents are probably a fate that befalls many of the possums on Magnetic Island.

APART FROM HAVING A GREAT TIME on a tropical island studying a wonderfully charismatic animal, what use was my study in a wider context? The Common Brushtail Possum is very similar, in terms of its ecology, to other medium-sized arboreal marsupials that are less common, such as the closely related Mountain Brushtail Possum (*Trichosurus cunninghami*) and Short-eared Brushtail Possum (*T. caninus*), both of which have patchy distributions, and the threatened Western Ringtail Possum (*Pseudocheirus occidentalis*). This means that any factors that have a negative impact on the reproductive success and population growth of Common Brushtails are also likely to have an amplified effect on similar, but less adaptable, species. The Common Brushtail can therefore be used as what is known as an 'indicator species'. For example, information on how the prescribed fire affected the Common Brushtail population on Magnetic Island can be incorporated in future fire-management plans in areas where more endangered marsupials occur.

More directly, the results of my investigations into the reproductive strategy and success of Common Brushtail Possums on Magnetic Island can be used in management plans to help eradicate the species from New Zealand. Common Brushtails were introduced to New Zealand in the 1800s to establish a fur trade and have since become a huge pest by defoliating valuable native forest and impacting on the fragile New Zealand ecosystem. With its high population density and scarcity of predators and competitors, the Magnetic Island population seems to experience conditions more similar to introduced pos-

Common Brushtail Possum

Trichosurus vulpecula

Classification
Family Phalangeridae.

Identification
Characteristic 'bushy' tail; 1.5–3.5 kg (smaller in tropical north, larger in temperate south); fur colour varies from orange-grey, silver-grey to mostly black.

Habitat and Distribution
Once widely distributed across most of Aust., now absent from large parts of arid, semi-arid and tropical woodlands and thought to be declining in other parts of WA, Cape York Peninsula and NT.

Diet
Mainly folivorous, yet will eat almost anything. *Eucalyptus* leaves can vary from composing up to 95% of diet to being almost absent. Also commonly eats flowers and fruits.

Reproduction
In warmer areas where food available all year, can breed year round, with birth peaks in autumn and spring. In colder, more seasonal southern areas, most births occur April–May or May–June. Litter size one, twins rare. Some females produce 2 offspring in a year, in autumn and spring.

BEN MOORE

An adult male Common Brushtail Possum in the typical rocky habitat of Magnetic Island.

sum populations in New Zealand, than to other Australian mainland populations.

Finally, if the worrying decline of Common Brushtails in many parts of Australia continues, the results of my study will be useful in securing a safe future for these populations as well. □

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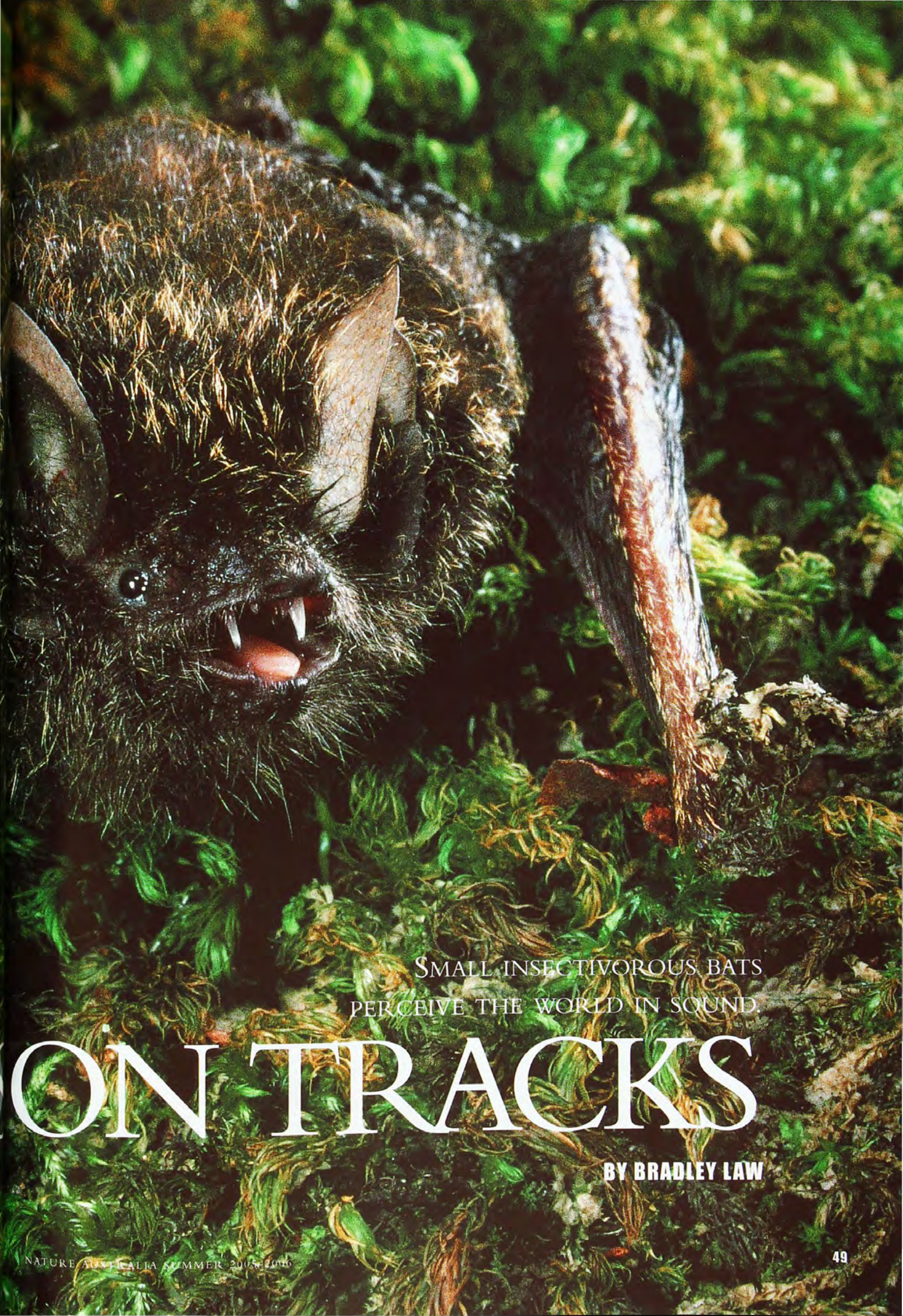
JOANNE ISAAC RECENTLY COMPLETED HER PH.D. AT JAMES COOK UNIVERSITY, TOWNSVILLE. HER STUDY FOCUSED ON THE LIFE HISTORY AND REPRODUCTIVE SUCCESS OF THE COMMON BRUSHTAIL POSSUM ON MAGNETIC ISLAND.

BATS

The Golden-tipped Bat (*Kerivoula papuensis*) specialises in plucking small spiders from their delicate webs, often amongst tangled vegetation. This requires both exceptional manoeuvrability and sophisticated echolocation.

DAVID CHRAGAN



SMALL INSECTIVOROUS BATS PERCEIVE THE WORLD IN SOUND.

ON TRACKS

BY BRADLEY LAW

ONE OF THE JOYS OF THE bush is experiencing the peace and quiet at night, broken only by the occasional shriek of a nocturnal animal. Thank heavens I don't have ears like a bat, I think to myself. When I reach down and turn on my bat detector, the silence is suddenly filled with a cacophony of sound. The bat detector has converted the ultrasonic (high-frequency) calls of bats into a frequency that humans can hear; that is, below about 20 kilohertz. Although normally inaudible to us, bat calls are very loud with intensities over 100 decibels (the equivalent of a jet flying over at 300 metres). I'm grateful for my limited aural senses.

Small insectivorous bats (suborder Microchiroptera), while not blind, usually have tiny eyes and so don't see fine detail. Instead, they perceive the world in sound. Ultrasonic calls are mostly made in flight, with some bats emitting sound through their nose and others through their mouth. Returning echoes of this sound are received by sensitive ears and used to form an image of the bat's surroundings—hence the term echolocation.

But bats do more than just perceive their surroundings with sound. Their echolocation system is sensitive enough to track and hone in on the movements of tiny insects, for some bats even in areas tangled with vegetation. To bat biologists, vegetation or other obstacles that impair a bat's ability to hunt is termed clutter, because it produces unwanted echoes. The level of sophistication required to tease out the movement of small prey from the clutter is mind-boggling.

A spectacular example is when some bat species use Doppler shift to assess distance from an object. Doppler shift will be familiar to most people as the effect noticeable when an ambulance siren rapidly approaches and passes. As the siren approaches, sound waves bunch up, which means the sound rises in pitch or frequency. When the siren passes, the sound waves spread out and we perceive a drop in frequency. To be able to make use of Doppler shift, bats need to produce a constant frequency of sound. This is exactly the technique used by horseshoe bats (family Rhinolophidae), for example. They emit calls of constant frequency (tone), lasting up to 80 milliseconds, and are able to judge the closing distance to their prey by calculating the degree in frequency shift of the returning echoes. Constant-frequency (CF) calls are especially useful for detecting prey in clutter, because returning echoes from fluttering insects contain a peak in amplitude that is absent from background clutter echoes. The bat's sensory system is sensitive enough to detect these minute acoustic glints.

The individual pulses of ultrasound produced by most other insectivorous bats are not of constant frequency but sweep from high to low, like a chirp. These bats are often referred to as 'frequency-modulated' (FM) bats. This system is well suited for accurate localisation of targets, because the rapid sweep in frequency provides a spectrum of sound that delivers time markers to frequency-sensitive auditory neurons. Bats use the time delay between the emitted signal and returning echo to estimate

Harp traps set on forest tracks can be effective at capturing large numbers of microbats. Such tracks provide ideal habitat for many species of clutter-sensitive bats.

PHOTO BY BRAD LAW

The Eastern Falsistrelle (*Falsistrellus tasmaniensis*) is clutter-sensitive and so spends much time cruising back and forth along tracks or natural gaps in the forest.

the speed and direction of their prey. The bats also dynamically alter the number of pulses emitted per unit time, from one pulse per wing beat (usually about 10 per second) while searching or cruising, up to 200 calls per second to ensure precision when finally attacking an insect. It is truly amazing that they detect their small flying targets at distances of just one to five metres, leaving themselves only a fraction of a second to adjust their flight and intercept. Unlike CF bats, most FM bats, however, have a limited ability to detect prey in clutter, because prey echoes are masked by background echoes.

Bats as a whole are an incredibly diverse group, with about 1,000 species worldwide and about 90 species in Australia. Of the Australian species, they range in size from the Little Forest Bat (*Vespadelus vulturnus*), which at just three grams is Australia's smallest mammal, to one of the world's largest microbats, the 150-gram Ghost Bat (*Macroderma gigas*). Although bats are very diverse, we can learn much about the ecology of individual species by studying their call type and frequency. This is because low-frequency sounds travel long distances, but do not have very good resolving power for discriminating small flying objects. The reverse is the case for high-frequency sound, which can't travel far through air due to atmospheric attenuation.

WE CAN LEARN

much about the ecology of individual species by studying their call type and frequency.

PAVEL GERMAN

The constant-frequency call of the Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) is emitted through its intricate nose-leaf. It is able to judge distance from its prey using the degree to which the frequency of returning echoes are Doppler shifted.

The White-striped Free-tail Bat (*Tadarida australis*) produces low-frequency calls (10–13 kilohertz), making it one of the few bats audible to us. Not surprisingly, it flies and hunts in wide open spaces where large objects can be detected at relatively long distances. This bat has long narrow wings that allow it to fly fast, sacrificing manoeuvrability, but suiting it to flight in open areas. The Golden-tipped Bat (*Kerivoula papuensis*) is at the other end of the spectrum. It is Australia's only bat to specialise on a diet of spiders. This requires an ability to detect that finest of structures, spider silk, typically in areas of

PAVEL GERMAN

The White-striped Free-tail Bat (*Tadarida australis*) is notable for producing an echolocation call audible to humans. Such a low-frequency call is suited to foraging in open areas, usually above the canopy of forests.

dense vegetation where spiders and their webs are common. Its call has both a very wide frequency range (sweeping from 150 down to 70 kilohertz) and very short duration (one millisecond or less). Although FM bats are not suited to detecting prey in clutter, it is thought that the unique call characteristics of the Golden-tipped Bat enable it to discriminate small objects at close range. This would seem to be possible only at slow speeds and indeed Golden-tipped Bats have short broad wings, giving them great manoeuvrability at slow speed...apparently just what you need if you are hunting for spiders in dense vegetation.

WHILE ALL OF THIS IS FASCINATING stuff, my real interest in bat echolocation relates to understanding how different species use their habitat and how bats respond to habitat change. I have been researching such matters for the past ten years, with a particular interest in the habitat requirements of different bats and their response to disturbance from logging, fire and weed-infestation in bushland. The field ecology of microbats is poorly known because bats were put into the too-hard basket until relatively recent advances in technology (including the bat detector) came about. Yet there is a compelling need for this work as bats are an important component of a functioning ecosystem, representing up to 50 per cent of native mammal species in some forests and even more in degraded landscapes. The conservation status of bats is also not good, with 16 species listed as threatened in New South Wales.

Researching the response of bats to changing forest structure began for me in the forests surrounding Eden in southern New South Wales. I decided to use bat detectors to record and iden-

PAUL GRIFFIN

Weighing as little as three grams, the Little Forest Bat (*Vespadelus vulturnus*) is Australia's smallest mammal. It is abundant in many habitats throughout south-eastern Australia.

tify the ultrasonic calls of flying bats in forest that had regrown for 20 years after logging compared with adjacent patches of unlogged forest. I wanted to know to what extent different species would use patches of regrowth when there was unlogged forest nearby. With the help of research assistant Mark Chidel, we surveyed eight blocks each of mature and regrowth forest and, back in the lab, identified over 2,200 call sequences to 11 different species. Although bats were using the regrowth, activity levels were only half of that in unlogged forest. The main difference between the two forest age-classes for a foraging bat was that the regrowth was still in a very active phase of regeneration and so the vegetation was very dense. Different echolocation abilities and wing shapes seemed to constrain where certain bats could forage.

Some species used the regrowth as much as the unlogged forest and these species demonstrate another distinct adaptation for feeding in clutter. Long-eared bats (*Nyctophilus* spp.), for example, have short broad wings that allow manoeuvrable flight and a sweeping call beginning at high frequencies that provides the senses with detailed information (high resolution) for foraging in clutter. In marked contrast to the Golden-tipped Bat, long-eared bats don't need to echolocate when detecting prey; instead they use their 'big ears' to listen for sounds generated by the prey themselves. This not only avoids masking of prey echoes by background echoes, but is also probably an adaptation to deal with insects that are capable of eavesdropping on bat ultrasound—an example of an evolutionary arms race.

Each night we also set harp traps on trails (dirt access roads) throughout the forest. These traps, which are specially designed for catching bats, consist of a frame with two banks of vertical fishing lines, each line separated by about two centimetres, and a collecting bag at the base. Interestingly, our harp traps caught large numbers of bats using the trails in both the regrowth and unlogged forest. Could it be that trails represent good habitat for bats in forests and allow them to better exploit dense regeneration?

We set out to explicitly look at the use of trails in northern New South Wales where the vegetation is even denser than in the south due to the presence of rainforest species in the understorey of wet sclerophyll forests. Our study site was located in Chichester State Forest, near Barrington Tops, and we used the bat detectors to survey areas of mature forest and also areas that had been logged 16 years earlier. After collecting and analysing more than 3,700 calls, it became pretty clear that most bats didn't like to fly in the dense vegetation that typifies a forest regenerating after logging and the rainforest understorey of unlogged forest. But they were not averse to flying and feeding along tracks and trails that pass through both dense regrowth and unlogged forest. To a lesser extent bats also used the creeks as flight paths, although the ones we sampled were relatively small and cluttered with overhanging vegetation. Some of the bats that don't mind flying in dense regrowth, such as the Golden-tipped Bat, call too softly to be recorded with our bat detectors, so we still have little information about how they respond to changes in vegetation structure.

THERE ARE OTHER FACETS TO THIS story we have been exploring. If trails are prime bat habitat in forest, because they provide a long strip of open space adjacent to an edge, could the space above and below the canopy represent another such edge? Maria Adams is a Ph.D. student who is interested in the dizzying heights of the forest canopy. She has been using bat detectors suspended at different heights within the forest to record activity levels of both bats and their insect prey. Traditionally, most bat workers have angled their bat detectors up from the forest floor. While this does a reasonable job of recording bats that normally fly above traps, no-one really knows how many are missed and which species like to fly in the canopy. Maria is working towards answering this question for forests with a range of disturbance histories.

Also, how important are larger, more open creeks as flyways and foraging habitat for bats? Anna Lloyd has recently completed her Honours degree on this topic by surveying streams of different sizes. She found that bat activity increased as stream size increased, which corresponds to the width of the stream and associated decrease in clutter. But rather than a gradual change, Anna identified a threshold where a flyway needed to be of a minimum size to support high bat activity. This was about 150 square metres, as measured in cross-sectional area; something like a small 4WD dirt track. Because bat activity over creeks did not differ between recently logged forest and mature forest, the results indicate that protection zones

around creeks in New South Wales State forests are effective in maintaining edges and hence bat activity after logging.

These studies provide snapshot pictures of how bats use their forest environments. Given that forests are such long-lived ecosystems, we have initiated long-term studies that delve into the dynamics of population changes over time. Nevertheless, we now know that trails and open creeks are incredibly important habitat for many bat species, especially where they pass through dense vegetation. It appears that clutter from dense vegetation places a real limit on where a bat is capable of foraging.

So the next time you find yourself on a 4WD trail through dense forest, remember that walkers and fire fighters aren't the only ones to use such tracks. Bats need them too and, without them, there would probably be a lot fewer to grace our skies at night. □

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PAVEL GERMAN

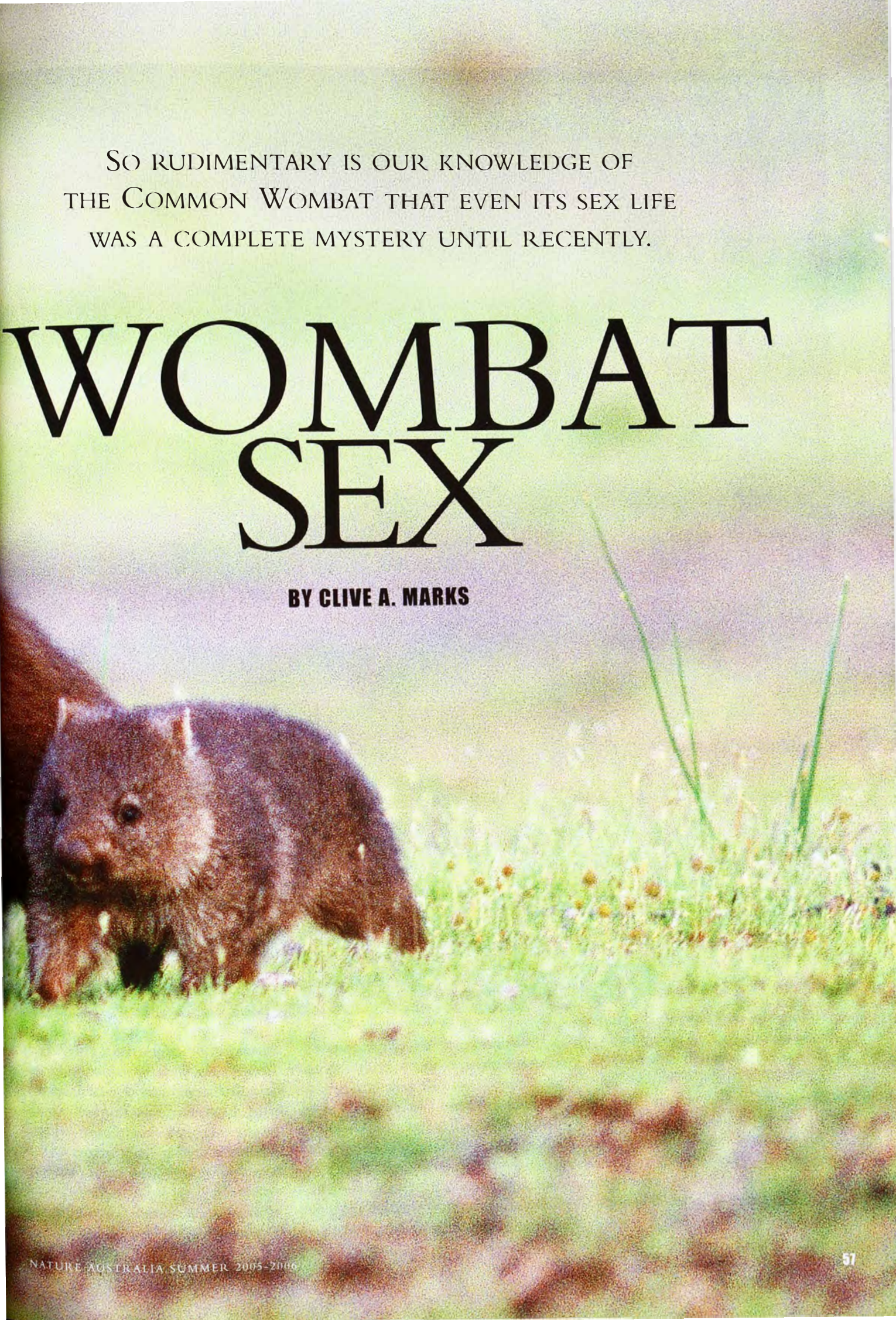
Big ears hear it all. Gould's Long-eared Bat (*Nyctophilus gouldi*) listens for sounds generated by its prey. However, it still echolocates when navigating through cluttered vegetation using a sweeping call beginning at high frequencies.

A female Common Wombat with young at heel—one of the most inspiring, but rarely seen, images of the Australian bush.

So rudimentary is our knowledge of the Common Wombat that even its sex life was a complete mystery until recently.

WOMBAT SEX

BY CLIVE A. MARKS



WHILE MORE NUMEROUS than the other two species of wombat, the title of 'Common' Wombat is nonetheless undeserved. It suggests that the biology and behaviour of this species is well known, yet this is far from the case. So rudimentary is our knowledge of the Common Wombat (*Vombatus ursinus*) that even its sex life was a complete mystery until relatively recently.

But in an obtuse if not flippant sort of way, Australians have always nursed a fascination for the sex life of wombats. If only I'd been given a dollar every time I was asked the question: "Is it true that a wombat eats, *roots* and leaves?" Yet until recently there were no recorded observations of courtship or mating in wild wombats. Obviously a comprehensive answer to this question was impossible!

A LOVE BITE

with chisel-like incisor teeth is the type of foreplay that removes hair and punctures skin.

In Australia, while some instances of copulation and 'mock' copulation during 'play' had been observed in captive wombats, there were no documented claims of successful breeding. Lack of knowledge about the structure of wombat burrows, and few attempts to construct appropriate artificial burrow environments in captive situations, seemed to contribute to their poor captive-breeding success. This, and the fact that neither courtship nor copulation had been seen in the wild, led biologists to suspect that mating may occur within the burrow. Such a cryptic and apparently dignified strategy may well have appealed to earlier naturalists who were imbued with a sense of Victorian modesty.

Attempts to mate wombats in captivity were often conducted with some trepidation, anyway. Frequently, newly introduced wombats were quickly separated as sexual interactions became quite aggressive. The male would attack the female, vigorously biting and raking her hindquarters. A love bite with chisel-like incisor teeth is the type of foreplay that removes hair and punctures skin. Sometimes the female would ardently resist with the sort of backward kicks that would send a Sumo wrestler flying. It was suggested that in the wild, the amorous male would have to 'trap' the female within the confines of the burrow in order to have his wicked way with her!

Just as some people become more sexually liberated when travelling

IRIS LOCHMAN-LOCHMAN TRANSPARENCIES

The Common Wombat is an iconic Australian marsupial, yet even basic details of its sex life have remained a mystery until very recently.

abroad, so too it seems do wombats. For it was in the German city of Hannover that the first successful captive breeding of wombats was recorded. In fact, careful observations at the Hannover Zoo gave the first insight into the breeding and subsequent growth and development of these Australian tourists. With absolute precision, details of the wombat's sex life were recorded and, surprisingly, it seemed anything but modest. It appeared to be a physically demanding process, complete with chasing, biting, grunting and loads of heavy breathing. But why had this display of uninhibited lubricious behaviour never been recorded in Australia before? Captivity can affect the behaviour of animals, sometimes quite substantially, and observations of wombats

COURTESY CLIVE MARKS

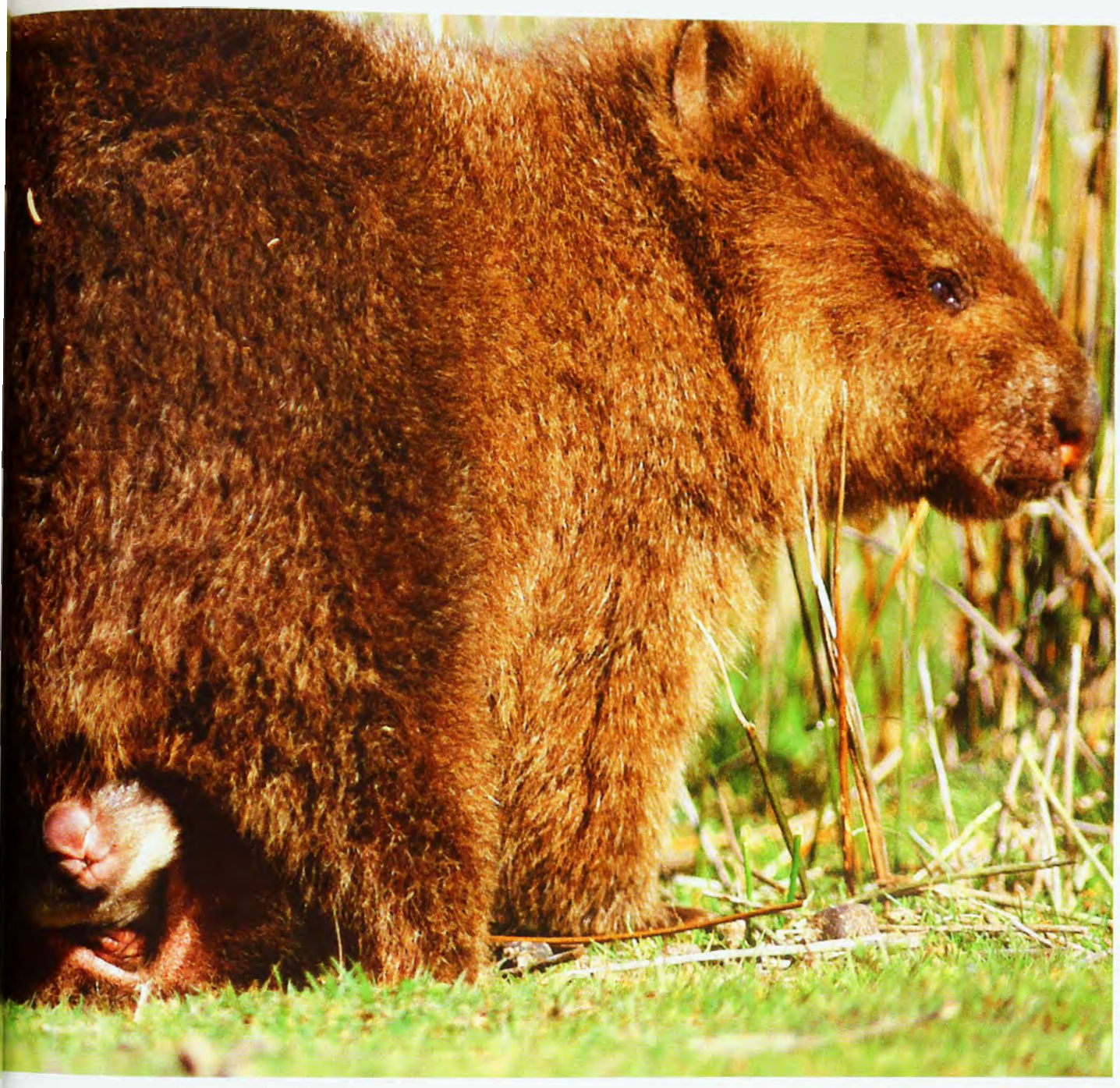
in a German zoo were not necessarily thought of as being 'typical' of free-ranging wombats in Australia.

IT WAS AS LATE AS 1990 THAT I observed and filmed Common Wombat courtship and mating at Tonimbuk Farm in Victoria. This 35-minute sequence of infra-red footage gave the first insight into their far-from-common sex life back home. Mating, as seen in captive wombats, occurred *above* ground with both wombats lying on their sides. The female, after a prolonged period of copulation in the same position, broke away and began to trot in a pattern of circles and figures of eight. The male chased her, following closely behind, and then bit her on the rump. She immediately stopped just long enough to permit him to roll her on her side and begin copulating again. If the male was slow to mount, she would kick back aggressively and not let him roll her on her side again until she had run round in more circles and figures of eight. This happened seven times. Clearly, in order to do the 'wild thing', wombats seemed to need loads of space. I wondered if captivity was cramping their style.

CLEARLY, IN ORDER TO *do the 'wild thing', wombats seemed to need loads of space.*

The events recorded at Tonimbuk very closely matched the observations in Hannover and did suggest that mating was not restricted to the burrow. Furthermore, they confirmed courtship and mating behaviour in Common Wombats to be a very physical and almost violent affair. The male biting the female appears to be normal and no doubt accounted for some of the scarring and hairless areas often seen on wombat rumps. The observation allows us to speculate why captive mating may result in abnormally aggressive encounters. If the female only permits mounting after a 'chase', small pens may prevent this. If the male uses a 'bite on the bum' as a cue for her to stop and permit mounting, it is possible that any sexual encounter will result in escalating aggression without copulation taking place as the female has little space to perform her 'hard-to-get' behaviour. In

Courtship behaviour in the Common Wombat. The male chases the female in circles and figures of eight, trying to bite her on the rear. If she's ready she will allow him to flip her on her side and mate, after which she gets back up and the chase-and-mate sequence continues several times.



IRIS LOCHMAN/LOCHMAN TRANSPARENCIES

Because of its burrowing habits, wombats possess a backward-opening pouch—a great vantage position for a well-developed young and a way to ensure that you are out of the way during serious earth moving!

this scenario, typical conditions of captivity may be inconsistent with the requirements of this species to breed. In the Hannover Zoo, the wombats were permitted the free run of the large elephant and rhinoceros enclosure at night so open space was not an issue.

Shortly after seeing some film footage of wombat courtship and mating, Androo Kelly at Trowunna Wildlife Park, Tasmania, was determined to sexually liberate his wombats. He had seen the signs of wombat sexual frustration before, resulting in a well-bitten female that did not fall pregnant. On the next occasion that he saw signs of wombat love, he released them from captivity into the grounds of the park. With freedom to lead the wombat '*dance d'amour*', the female permitted copulation and Androo saw the same sequence of behaviours as documented in the film. He also found a pouch young some months later!

Catriona MacCallum at the Western Plains Zoo in Dubbo has probably had the most spectacular wombat breeding success of all. Joining and modifying the pen systems to permit a chase, she not only found that wombat breeding was possible in captivity, but she found herself with the first recorded case of wombat twins. Perhaps sometimes, a change is as good as a holiday!

As the Common Wombat is increasingly held in captivity throughout Australia, there are compelling reasons to find out more about this cryptic marsupial. Let not the label 'common' deter us from this task or, worse still, lull as into a complacent attitude when it comes to the conservation status of this wombat. Habitat fragmentation increasingly impacts upon its populations. I hope that it will never be the task of any future biologist to more fully elucidate the sex life of the 'Uncommon' Wombat.

So, I am finally able to answer that great Australian wombat sex conundrum, but with an unexpected feminist twist. For it seems that, in the wombat dance of love, it is the female wombat that calls the shots: and eats, roots and *leaves*! □

Being the largest burrowing herbivore, it seemed probable that Common Wombats would mate within the confines of their extensive burrow system. But they turned out to be less modest!

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Common Wombat

Vombatus ursinus

Classification
Family Vombatidae.

Identification
Large, generally nocturnal burrowing marsupial with squat, round body and course pelt that varies from black, chocolate brown to blonde. Can grow to over 1 m in length and over 35 kg (mean 25 kg) in weight. Distinctive cube-shaped droppings.

Habitat and Distribution
Alpine forest, heath, coastal scrub and open forests with suitable burrowing habitat and forage. Once more widepsread across south-eastern Aust.; now largely restricted to Tas., and highlands in Vic. and NSW, extending to south-eastern Qld border. Patchy populations in western Vic. and eastern SA.

Biology
Diet of grasses, herbs and sedges. Digs a number of large burrows, some up to 30 m in length. May move many kms in an evening. Births occur at all times of year, almost always with single young.

(Left) Emperor Gum Moth caterpillar (*Opodiphthera eucalypti*).

Longicorn beetle *Piesarthrius* sp.

Insect Gallery

BY GUNTHER SCHMIDA

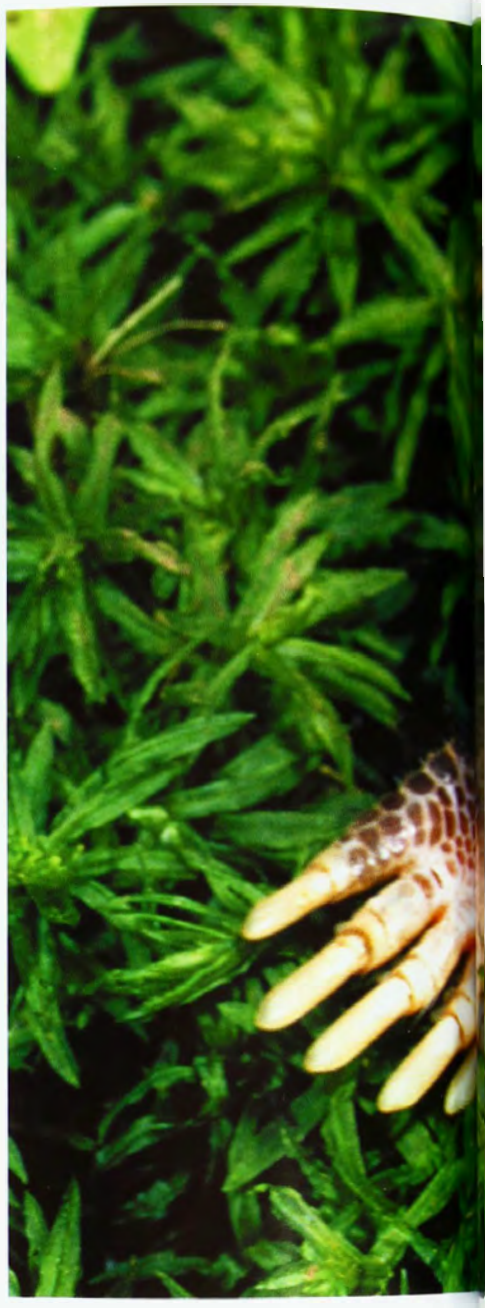
Emperor Gum Moth (*Opodiphthera eucalypti*).

Sparring male Golden Stag Beetles (*Lamprima aurata*).

March fly.

Squirming fleshy tentacles of doom

The Star-nosed Mole sees its world through pink-coloured tentacles.



BY SIMON D. POLLARD

THE WIND IN THE WILLOWS OPENS with the Rat taking his friend and fellow rodent the Mole on a picnic to the riverbank. Mole unpacks the fat, wicker luncheon-basket on a tablecloth and spreads out a number of small mysterious packets, which the Rat has explained contain food much loved by Moles. When it was ready the Rat said, "Now, pitch in, old fellow!" and the Mole unwrapped the food and began to eat in a manner befitting a talking Mole bestowed with English manners and picnic etiquette. However, if the Mole had the eating habits of a Star-nosed Mole, most of the food would have been eaten before the Rat drew another breath.

The Star-nosed Mole (*Condylura cristata*) has a soggy, subterranean lifestyle in marshes and wetlands from Canada down through the north-eastern United States. Coated in waterproof black fur and having heavily clawed forelimbs for digging, it blindly burrows through the damp soft soil and feeds on the abundant worms, small insect larvae and other tiny animals it comes across. As its name suggests it has a nose that looks like a star, but this is a rather bland description of what is the most extraordinary-looking sense organ. Twenty-two-tentacled Octopus-nosed Mole would be more apt.

Surrounding the nose is a fleshy array of 11 pairs of finger-like tentacles that are splayed across the mole's face. While some of us see the world through rose-coloured spectacles, the Star-nosed Mole sees its world through pink-coloured tentacles. These squirming fleshy tentacles are packed with 25,000 touch receptors that send information via 100,000 nerve fibres to the mole's brain. For us this would be the equivalent of having the sensitivity of our entire hand magnified six times and then concentrated into a single finger tip.

And what does the Star-nosed Mole do with all this information rushing to its head? When the tentacles of doom touch something that may be worth eating, the mole brings its lowermost central pair of tentacles into contact with the prey. These super-sensitive tentacles allow the mole to make even more precise decisions about what to do next, and if the brain says "Eat", the prey becomes fast food; really fast food. From the moment the mole finds prey, moves to prey, decides to eat prey, grabs prey, bites prey with its tweezer-like teeth and swallows prey, it takes just over one-fifth of a second.

Kenneth Catania and Fiona Remple at Vanderbilt University in the United States have found that the Star-nosed Mole is the champion of mammalian eating competitions. Using a high-speed video camera to film the mole's feeding behaviour, they found that it could eat ten mouthful-size pieces of earthworm in 2.3 seconds or 0.23 seconds per piece. Although the structure of the star, and the fact that a large part of the mole's brain is dedicated to processing information it receives from the star, was already known from earlier studies, the actual speed at which it could literally inhale food was unknown. Their results also suggest that the mole has pushed its brain and nervous system to its operating limits for moving quickly and processing information coming from the star. So it is not surprising that the mole often makes mistakes and misses a bit of food and then backtracks to make the right decision.

What are the advantages of super-efficient feeding? It seems intuitive that, in terms of time and energy spent foraging, it is cheaper for a large predator to catch one prey that weighs 100 kilograms than to catch 100 prey that each weighs one kilogram. However, if the predator expends very little energy locating each prey item, then it could survive on a diet of small animals. Catania and Remple suggest that the star evolved as an adaptation for high-speed feeding when the ancestors of Star-nosed Moles first moved into wetlands.

DWIGHT KUHN

The super-sensitive fleshy tentacles of the Star-nosed Mole.

By evolving an exquisitely sensitive appendage with its large surface area and flexible feelers, the Star-nosed Mole could make an efficient living by finding very small prey very quickly. In fact, the researchers have calculated that the size and mobility of the star allow the mole to find 14 times as many small prey items in a given time compared with its close cousin the Eastern American Mole (*Scalopus aquaticus*).

The Star-nosed Mole is the only mole to have evolved such an elaborate and delicate star. This may be because its fleshy muzzle is less likely to be damaged as it is pushed and shoved through the damp soft soil found in wetlands, unlike the drier soil of other mole habitats.

When Kenneth Grahame's Rat tells the Mole what food is inside the wicker basket, the list of goodies rolls off his tongue so quickly, it is easy to imagine that he was actually trying to whet the appetite of a Star-nosed Mole. "'What's inside it?' asked the Mole, wriggling with curiosity. 'There's cold chicken inside it,' replied the Rat briefly; 'coldtonguecoldhamcoldbeefpickledgherkinssaladfrenchrollscresssandwichespottedmeatgingerbeerlemonadesodawater—' 'O stop, stop,' cried the Mole in ecstasies: 'This is too much!'" However, life is no picnic for the Star-nosed Mole as it races against time to find wormsinsectlarvaecrustaceanstiny-insects...□

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Naked apes letting their hair down

We are not so naked that we won't wax or shave to improve the look and feel of even the most hard-to-reach places.

FORGET ARMPITS, PIGTAILS AND PUBES, just for a moment. The rest of our body is as hairy as the next great ape's, at least in the number of follicles per square centimetre. Humans, with dense, fine, short hairs, just look naked, so we can rightly be called 'naked apes', or 'third chimpanzees', or even 'silverbacks' (Gorillas aren't the only males to get long grey hairs on their back as they get older!).

Although anthropologists tell us we *look* naked, humans, it seems, can't get naked enough! We are not so naked that we won't wax or shave to improve the look and feel of even the most hard-to-reach places. There are 14 pages of beauty salons in the Sydney Yellow Pages, most offering waxing services for just about everything—eyebrows, upper lips, legs, backs, armpits, crotch.

On top of all this fuss over unsightly body tufts are beards and head hair. Fashion, health and even religion have a big impact. The Taliban (Islamic rulers of Afghanistan 1996–2001) banned shaving, and decreed that beards be longer than a man's fist. Barbers have since re-opened to high demand. But you don't have to be an Islamic fundamentalist to realise that we pay close attention to removing facial hair. Barbers and hairdressers command over 15 pages in my phone book, responding to demand for frequent trims and hairstyles to enhance facial attraction and to send out the right kind of signals—whether you're a job applicant, intellectual, company director, or lover.

Charles Darwin considered many tangled arguments about why hair is different on men and women, and why all humans have a mat of hair at the junctions of the limbs and torso. He wondered too if reduced body hair was naturally selected to free humans from ticks and other parasites, but thought this unlikely because he was unaware at the time of any specific adaptations for removing parasites in other relatively hairless, tropical landlubbers (elephants and rhinos). Nor did the loss of human hair to regulate body temperature appeal much to Darwin because it doesn't really explain retention of our head hair, most exposed to the sun. Darwin favoured sexual selection to explain different head and face hair on men and women.

Mark Pagel (University of Reading) and Walter Bodmer (Oxford University) combed new threads into these theories. They too rejected the hairless, bipedal, body-cooler argument (naked skin gains too much heat during the day and loses too much at night). And they doubted the 'aquatic ape theory', which purports hairlessness to have evolved during an aquatic or semi-aquatic phase of human evolution—the fossil evidence is just not convincing. They reckon that sexual selection could well explain human retention of face, head and pubic hair, but that relative hairlessness elsewhere on the body was largely driven by advantages conferred by eliminating ectoparasites like fleas and ticks. Darwin was wrong. A tendency to hairless and tick-free skin could easily have sparked a selective advantage through lower infections, which then kicked off the whole process of choosing mates that advertised clean skin ("Look! No fleas!").

The oldest hairdos depicted archaeologically were once thought to be on 30,000-year-old Venus figurines from Western Europe, but it turns out that these carvings are probably woven hats (see "Stone Clothes", *Nature Aust.* Autumn 2001), and thus the earliest evidence of covering up, if not removing, hair! Genetic studies of lice take us further back, and indicate that the Human Body Louse, which lives in clothing and only feeds on the body, evolved 50,000–100,000 years ago, presumably when we started wearing layered clothes (see "Lousy Clothes", *Nature Aust.* Winter 2004). So we must have been 'naked' at least since modern hunters walked—not streaking but dressed to kill—out of Africa. Maybe other early humans were a lot hairier. Could this explain the scant evidence of human interbreeding with hairy, cold-adapted Neanderthals? Perhaps they were just too flea-ridden and ugly. Could it explain Neanderthal extinction through infection?

Human retention of hair in or on the nose, ears, armpits, chest, genitals and other remote locations usually has a functional explanation. Hairs might be filters, cushions, signals of sexual maturity, or pheromone dispensers. Pluck some hairs from different parts of your body and have a sniff. Twirl them around. Pubic hairs are coarse and curly with an irregular diameter, which is handy because it means they can't get matted into dreadlocks when you walk to work. But human head hair stands up in a world of its own. How come head hair is so much longer than everywhere else?

Norbert Mesko and Tamas Bereczkei (University of Pécs, Hungary) suggest that long hair is linked with reproductive success. They tested several possible functions of long hair: to cover up or draw attention away from less attractive (more masculine) parts of the face; to advertise absence of parasites, assuming only individuals free of infection can afford to grow their hair long; or to send a 'costly signal' (like a peacock's tail) to advertise good genes. They got male subjects to examine computer images of six hairstyles (short, medium, long,

BY RICHARD FULLAGAR

COLIN MONTEATH/AUSCAPE

A Hindu Sadhu (holy man) from Kathmandu, Nepal. Long hair means different things to different people.

dishevelled, bun, and unkempt) on a set of female faces and to rank the effects of these hairstyles on attractiveness (femininity, youth, health and sexiness).

The results showed that unkempt or dishevelled hair, which might indicate parasites, has little impact on attractiveness, but that hair length is a pretty good indicator of general health and, presumably, genetic quality. Long hair certainly costs a lot in terms of production (head hair consumes more energy, grows faster and is shed more rapidly than body hair) and daily maintenance (long hair takes more time to care for than short hair). Hairstyle, particularly medium and long hair, is very important in enhancing attractiveness, whether you have something to hide or not. Longer hair makes less attractive women look more feminine and healthy, while it makes more attractive women more feminine and sexy. Obviously this study might only be true for a limited range of female hairstyles and for certain cultures, but the basic message probably holds: long hair will impress your mate, because to afford the costs of production and maintenance, you've got to have good genes. The next plan is to see how men make the cut, and what women want.

I read somewhere that transplanted pubic hair (that is, adding to it, not removing it) is becoming trendy in South Korea, but I can't see it catching on as a surgical cure for baldness in the West. Still, with all this artificial adding and removing, it's hard not to think that it's the end of evolution for human hair. The medium (hair) and the message (mate with me) might be the same, but what you see (or don't see) is no longer what you get. □

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Immortal plants

A tree can be viewed as a close-knit colony of many individuals, and this colony has the potential to live forever.

I WAS BOTH SHOCKED AND AWED BY the ideas offered by French tropical botanist Francis Hallé in his wonderfully titled book *In praise of plants*. I was certainly amused and captivated—it's a fascinating book. Hallé is particularly keen to show that most animals and plants are fundamentally different, and that we can't simply generalise from what we know about animal biology to plants. To my delight, Hallé also concludes that plants are far more interesting!

One of Hallé's key concepts is that a tree can be viewed as a close-knit colony of many individuals, rather than a single organism, and that this colony has the potential to live forever. What he means is that there is a repeated pattern, and each unit can continue to grow (whether part of the tree or as a cutting or graft) as long as it contains a bud. The bud, according to this interpretation, can be considered the true individual—it cannot be divided any further. (Even if we use genetic uniformity to define an individual, in a long-lived tree a slow build-up of mutations in vegetative cells can result in some branches having a distinct fingerprint.) So a tree is like an ant nest or sea anemone: individuals die, but the colony persists.

Apart from providing an interesting linguistic or philosophical exercise, does any of this matter? It does if you consider colonial organisms to be, to all intents and purposes, immortal. Clearly most trees are mortal: Australian wattles tend to flourish and die within a decade or two, and even our most majestic street trees have a maximum life span of one or two centuries. Structural problems develop. Food and water supplies can't be guaranteed. Fungal pathogens somewhat short-sightedly kill their host. Winds blow them down. And so on.

In fact, the longest-lived plants are not the grand trees. Granted a Bristlecone Pine (*Pinus longaeva*) chopped down in California in 1964, is often cited as the oldest tree. It was just under 5,000 years old when felled, although there are claims that other individuals of this species are 8,000 years or more old. And a massive Huon Pine, spread over 2.5 hectares (the size of a city block) in the Mount Read area of Tasmania, is estimated to be about 10,000 years old, but there is some debate over whether to call this an 'individual' tree or a 'colony of clones'.

So a tree is like an ant nest or sea anemone: individuals die, but the colony persists.

If we accept Hallé's view that most plants are colonial anyway, we shouldn't care too much if trees like the Huon Pine survive only because they spread vegetatively at their base by producing new stems to replace old (that is, sucker or layer). This brings into contention the Creosote Bush (*Larrea tridentata*) from California, now over 11,700 years old (see "The Lengthening Limits of Life", *Nature Aust.* Winter 1997). But this is a baby compared to a strange plant lurking in the Tasmanian World Heritage Area.

Some years ago, I took part in an *Australian Geographic*-sponsored expedition to Bathurst Harbour in south-western Tasmania. While I was wading through tea-coloured streams searching for new species of red algae, Jayne Balmer (Tasmanian Department of Primary Industries, Water and Environment) was collecting samples from one of Australia's oddest, perhaps its oldest, and certainly one of its rarest, plants. A member of the family Proteaceae and closely related to warratahs (*Telopea*), King's Holly (*Lomatia tasmanica*) was first discovered in 1934 by local identity Denny King. That plant is now assumed dead, but King found a second population, confirmed by Tasmanian botanist Winifred Curtis in 1965. It looks healthy enough, extending along creek gullies for over a kilometre, but none of the plants produces fruit or seed. Genetic testing by Jasmyn Lynch (who works with Balmer) and colleagues from the University of Tasmania showed no detectable variation across the entire population. This is usually good evidence of a vegetatively reproducing species (although some plants that grow from seed may be genetically indistinguishable from one another, such as the Wollemi Pine, and, like the branches on an old tree, vegetative off-shoots are not necessarily genetically identical).

Microscopic examination also demonstrated that King's Holly has three sets of chromosomes. When it comes to chromosome numbers, plants do mix it up a lot, and multiple copies are not uncommon. But triploids, as they are called, are rare. In *Lomatia*, and in fact in all its close relatives, a double (diploid) set of 11 chromosomes is standard issue. The fact that King's Holly has 33 chromosomes explained why it couldn't produce fertile seed—triploid plants rarely find a way to split this odd number up and produce viable gametes (the reproductive cells that have a single or haploid set of chromosomes). It's thought this odd set of chromosomes resulted from the successful fertilisation of a freak diploid gamete, with a normal haploid gamete, many years ago. Two plus one equals three!

Lynch and colleagues hypothesise that

BY TIM ENTWISLE

EVE LAZARUS

King's Holly: part of a 43,000-year-old clone?

every plant in the one-kilometre stretch was once connected, and that fire has probably fragmented the 'clone'. Based on a combination of its current extent, carbon-dated fossils, the lack of genetic diversity, absence of seed, and the unlikelihood of triploids occurring twice, they hypothesise that this clone may have started life over 43,000 years ago. Hard to confirm, but a tantalising proposition.

A few thousand kilometres north, plant ecologist Rob Kooyman has discovered another long-lived clone. He suggests, provocatively, that the Peach Myrtle (*Uromyrtus australis*) in New South Wales's Nightcap Range is, at least functionally, an immortal plant. That is, in the right circumstances it could live for ever. Kooyman and his research supervisor Peter Clarke (University of New England) are still trying to confirm the exact age and life history of this intriguing plant. Like King's Holly, the Peach Myrtle has found a way to survive without reproducing from seed. Each individual consists of a large group of stems up to 12 metres high, the biggest of which seem to be about 1,500 years old. The plant 'regenerates' itself by replacing old stems with new, and is likely to be at least 10,000 years old.

The real stayers, however, are giant fungal networks said to be the largest living organisms in the world (see "Largest Living Organism", *Nature Aust.* Summer 1993–94) and possibly functionally immortal as well. Plenty of algae, fungi, bacteria and other microbes reproduce almost exclusively by splitting in two (without any sexual fusion), and you could describe their extended families as exceedingly old but disjointed individuals. All this casts a dark shadow over the paltry efforts of most animals, which at best live for a few hundred years or, if you are a sea anemone, a couple of thousand years. Being a plant, or a microbe, has its benefits.

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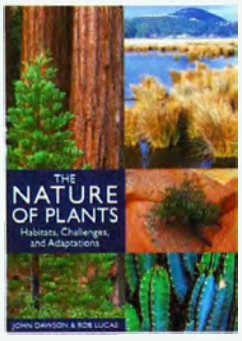
reviews



The Nature of Plants: Habitats, Challenges, and Adaptations

By John Dawson and Rob Lucas. CSIRO Publishing, Collingwood, Vic., 2005, 314 pp. $64.95 rrp.

Books like this are usually written by Americans or Europeans, and the text and illustrations invariably emphasise northern-hemisphere examples. What is refreshing about this book is that its authors hail from New Zealand, and their text has a strong Australasian flavour. Many of the plants they describe and illustrate come from New Zealand, Australia and New Caledonia. As a detailed introduction to the world of plants this book is very good, and well pitched towards the category of reader who enjoys *Nature Australia*. In clear readable English the authors explain such phenomena as pollination and seed dispersal, and adaptations to fire, drought, cold, herbivory, and a life in water. The text can be read chapter by chapter, or be consulted when questions come up, such as 'How does sap rise?' The photos, mainly by Rob Lucas, are so outstanding that the book is almost worth buying just for these. The text appears to be pitched to an international audience, but its New Zealand bias ultimately becomes a minor weakness, with too many New Zealand examples used to illustrate the concepts.

—Tim Low

Seven Deadly Colours: The Genius of Nature's Palette and How it Eluded Darwin

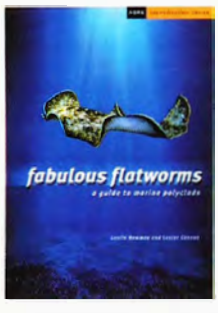
By Andrew Parker. Simon & Schuster, Pymble, NSW, 2005, 286 pp. $34.95 rrp.

The supporters of Intelligent Design argue that life is just too complicated to be the result of the directionless lottery of evolution, and to them the eye is too perfect to have evolved by chance. Charles Darwin also felt the eye was perhaps too perfect for evolution, but as Andrew Parker explains in *Seven deadly colours*, the eye is not quite as perfect as we tend to think.

This book deals with the physical aspects of colour, how it is 'made', and how much our 'perfect' eyes fail to see. While colour pigments are known to us all, what about structural colours, iridescence, and yellow fluorescence?

There is much fascinating information in this book, but sometimes the flow is interrupted by complicated explanations that might have been better in an appendix. I also would have liked answers to unanswered questions. For example, can parrots see yellow fluorescence? One of the aims of this book is to show that the eye is not perfect. Why then does Parker specifically exclude image-forming organs from his definition of an eye? Surely the 'proto-eyes' of snails and slugs and the light-sensing organs of other more primitive animals are part of the story of the eye's evolution?

—Bill Rudman
Australian Museum



Fabulous Flatworms: A Guide to Marine Polyclads

CD-ROM by Leslie Newman and Lester Cannon. CSIRO Publishing/Australian Biological Resources Study, 2005, $69.95 rrp.

Following on from the excellent book *Marine Flatworms* (reviewed in *Nature Aust.* Winter 2004), "Fabulous Flatworms" is an interactive CD-ROM covering similar but also new ground. Both works are profusely illustrated and cover evolution, classification, and all aspects of flatworm biology. Although a hardcopy book has obvious aesthetic appeal, the electronic medium enables features not previously available. For instance, video clips showing predation, reproduction, gliding and swimming are included, plus many more still images. A further departure from the book is that the CD-ROM is more strongly geared towards identification, making good use of both anatomy (internal and external) and living colour. Species can also be listed alphabetically, taxonomically or geographically, with each linked to the relevant images and descriptions.

"Fabulous Flatworms" is not an exhaustive guide to all species, and some can be difficult to identify from the photographs alone, thus requiring a careful reading of the description. However, with more than 400 world species depicted, most that are likely to be encountered can be readily recognised. Surprisingly, or perhaps not, about three-quarters of species included are yet to be formally described. Highly recommended.

—Shane Ahyong
Australian Museum

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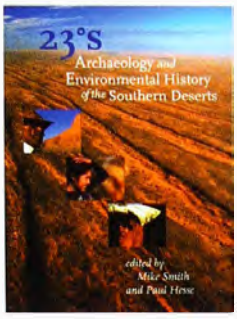


23° S: Archaeology and Environmental History of the Southern Deserts

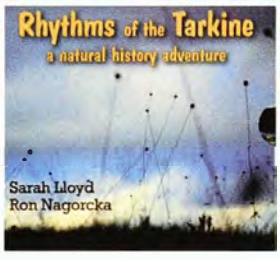
Edited by Mike Smith and Paul Hesse. National Museum of Australia Press, Canberra, 2005, 436 pp. $42.95 rrp.

TWENTY-FIVE ESSAYS BY 40 SCHOLARS PROVIDE ARCHAEOLOGICAL AND ENVIRONMENTAL perspectives on six deserts strung around the Tropic of Capricorn, 23° S of the equator. Despite some similar geological origins, deserts are diverse places. For example, the sandy Atacama Desert in South America is 150 kilometres wide and lacks obvious life forms, contrasting with a 2,000-kilometre stretch of Australian aridity, which has sustained Aboriginal populations for over 22,000 years.

23° S is an academic conference volume divided into five sections: Environmental History, Dynamics of Settlement, Rock Art and People, Hunters and Herders, and Historical Perspectives. Whereas the early environmental history is forensically complex and hazy, the recent past comes alive with Bushmen, Inca and Pintubi. Nicely illustrated rock paintings and engravings demonstrate the rich and diverse desert cultures.

Mike Smith is an Australian archaeologist who authored the recent exhibition on deserts at the National Museum of Australia, while Paul Hesse is a geomorphologist, well known for his research into climate change. It's a good combination, which has kept the chapters brief, despite complex arguments, scientific uncertainties and technical jargon (hence a useful Glossary). Highly recommended for anyone interested in the details of environmental history and desert peoples.

—RICHARD FULLAGAR
UNIVERSITY OF SYDNEY



Rhythms of the Tarkine: A Natural History Adventure

By Sarah Lloyd and Ron Nagorcka. Published by Sarah Lloyd, Birralee, Tas., 2004, 98 pp. and 99-track CD, $35 rrp.

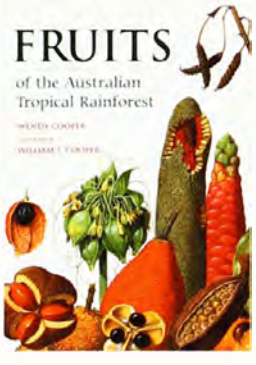
THE TARKINE AREA COVERS APPROXIMATELY 447,000 HECTARES OF THE NORTH-WEST OF Tasmania. The region hosts Australia's largest temperate rainforest, the largest area of unprotected wilderness remaining in Tasmania, and an astonishing variety of other cultural, biological, geological and landscape values. The authors spent several weeks exploring, recording the sounds, and documenting the natural history of the Tarkine.

The 98-page booklet is a descriptive diary account of 11 different places they visited in the Tarkine. The authors elaborately describe the different vegetation, birds and animals that inhabit the areas. The birds at each site are well documented and each species is accompanied by a number that relates to a track on the CD. The CD comprises 99 tracks that were recorded on their expedition. These are mainly bird calls but also other animals such as the Tasmanian Devil and some invertebrates. The booklet and CD together create a very strong image of the pristine beauty of the Tarkine. It almost made me feel like I was sitting on the forest floor.

Useful appendices listing the fauna sightings at each area, and the scientific names of the flora and fauna, are included.

The author sadly points out that, when travelling in Tasmania, breathtaking beauty is juxtaposed with massive destruction of the unprotected forests of the Tarkine.

—GEORGINA BROWN
AUSTRALIAN MUSEUM



Fruits of the Australian Tropical Rainforest

By Wendy Cooper, illustrated by William T. Cooper. Nokomis Editions Pty Ltd, Clifton Hill, Vic., 2005, 632 pp. $235 rrp.

REVIEWING BOOKS CAN BE A MIXED BLESSING AND MY ENCOUNTER WITH THIS ONE WAS NO exception. It's a big, detailed, specialist botanical work and as such somewhat daunting. Yet it's also a joy just to drool over the luscious illustrations—this book can hold it's own on any coffee table.

Still, it would be a waste if it spent its life on the coffee table, for it contains an inordinate amount of information on rainforest fruits and the plants that bear them. Thankfully everything is extremely well-organised in species accounts, glossary, key and bibliography, so you don't lost. It is a botanist's delight—the amount of information is truly mind-boggling.

And then there are the illustrations. What can I say? You could easily frame any of them and not be disappointed. But they aren't just beautiful; they do what the best natural-history illustration must do—they capture the essence of the subject matter. You really do get an accurate impression of what the fruits look like.

So I am torn between wanting to drag this book with me on my next rainforest walk and the impulse to put it on a pedestal in my lounge room. Should all my dilemmas be this good!

—GREG GOWING
AUSTRALIAN MUSEUM

SOCIETY PAGE

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

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Contact: Lana Allcroft

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Contact: Stan Wood

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Ph: 02 9417 6171
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q&a

STUART HUMPHREYS, AUSTRALIAN MUSEUM

Katydid eggs on a camelia leaf.

Katy Did It

Q: *Could you tell me what laid these curiously arranged eggs on my camelia leaf?*

—Lance Dover
Pennant Hills, NSW

A: This egg mass is produced by a katydid (a tettigoniid cricket), probably the spectacular Mottled Katydid (*Ephippitytha trigintiduoguttata*), which occupies a large range over much of Australia in a diversity of habitats. Females have a short, broad, flattened ovipositor (egg-laying organ) that they use to split the edges of leaves. They then lay and glue their eggs securely into place in the split. Black and yellow nymphs hatch in the spring months and then take six to eight months to reach adulthood. Very little is known about the life history of these katydids, but they are apparently quite easy to raise in captivity on a diet of leaves found in the local area.

—Dave Britton
Australian Museum

One-legged Ducks

Q: *I have a pair of Pacific Black Ducks (Anas superciliosa) that regularly visit my backyard and I noticed that both were resting on their left legs with their right legs tucked up into their bodies and bills tucked under their right wings. They stayed like this for at least half an hour. Why do ducks stand on one leg? Also, is there a 'handedness' to ducks, or do they alternate the standing leg?*

—Alan Moskwa
Kensington Park, SA

A: Standing on one leg is easy for ducks (and other birds) because special tendons in the leg lock it into place and it thus requires almost no extra energy to retain this position. Several explanations have been proposed for why birds do this. Most frequently suggested is that it helps birds regulate their temperatures by letting them hide one leg, with its exposed surfaces, in the well-insulated belly feathers. Birds can sleep with one half of their brain while the other side stays alert, so it may be that standing on one leg allows the other leg to 'sleep' as well. Another thought is that standing on one leg makes it easier for a resting duck (with its head pulled into the side of the body or laid on its back) to monitor its surroundings. This is because it takes less effort to rotate slightly on one leg to look at something than it would to shift position if standing on two.

Handedness is well known in parrots but little studied in other birds. There is no reason to believe that ducks would not have a natural preference for one side over the other. If it is simply like people crossing their legs preferentially, then there may be only limited alternation. If, however, the practice results from one or more of the reasons suggested, then changing feet would be expected. Observations on sleeping ducks might warrant a good school science project.

—Walter E. Boles
Australian Museum

Thirsty Koala

Q: *We live in Belair on the city side of the Adelaide Hills, and Koalas are common in our gardens most of the year. It is often stated that Koalas rarely drink, and that they get the water they need from the leaves they eat. Yet we saw and photographed a Koala come down to our garden pond and spend about 40 minutes deliberately drinking in broad daylight. How common is this behaviour?*

—Ian Gibbons & Judy Morris
Belair, SA

COURTESY ALAN MOSKWA

Why do ducks stand on one leg?

A: This behaviour is unusual. First, Koalas normally move at night and are seldom on the ground after sun-up. It's the drinking, however, that is particularly worrisome. Although Koalas do drink in the wild, they obtain most of their water from the leaves and dew. Drinking for 40 minutes indicates a serious problem with the kidneys. Researchers at the University of Adelaide are concerned about the number of Koalas in the Adelaide Hills that have damaged kidneys and have found aluminium deposits in all that they have examined (*The Veterinarian* June 2004). Oxalate crystals in Koala kidneys (oxalosis), caused by eating plants with high levels of oxalates, can also lead to a violent thirst. There is likely to be a relationship between oxalates and aluminium deposits but that link is currently not completely understood. Whatever the case, raging thirsts are a very bad sign of Koalas and the animals invariably perish.

—Rob Close
University of Western Sydney

COURTESY IAN GIBBINS & JUDY MCHUGH

Koala drinking from a garden pond.

Answers to Quiz in Nature Strips (page 16)

1. *She-oaks*
2. *Aboriginal painting styles*
3. *Eight or ten*
4. *Forest trees*
5. *Hobbits*
6. *1986*
7. *Sponges*
8. *Twenty-one per cent*
9. *Keratin*
10. *A Baobab Tree*

STUART HUMPHREYS/AUSTRALIAN MUSEUM

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win the DVD "Wilderness". Spring's Pic Teaser was a nose-leaf of the Eastern Horseshoe Bat (*Rhinolophus megaphyllus*).

Fertilising the greenhouse

Why are so many of us laid back about the possible impacts of this change?

HOKUSAI'S *THE GREAT WAVE off Kanagawa*, portraying three puny fishing boats defying a massive wave that frames Mt Fuji, is a beautiful depiction of humanity's tenacious spirit and use of technology in the face of the awesome power of nature. Presently there is an even greater wave threatening humanity—the steeply climbing concentrations of greenhouse gases, particularly carbon dioxide. The 'Keeling Curve', named after the American scientist who discovered it, describes the steady and ongoing increase in atmospheric carbon dioxide from 315 parts per million (ppm) in 1958 when measurements began, to the current levels of 379 ppm.

The Keeling Curve tracks the steady rise in post World War 2 economic prosperity, driven by the consumption of fossil fuels. It also proves beyond doubt that industrialisation has changed the Earth's biogeochemical cycles. The increase of 64 ppm of carbon dioxide over the last 46 years may not seem like much, but ice cores from Antarctica show that this in fact represents a sky-rocketing deviation from previous levels for at least the last 400,000 years and most probably millions of years, when carbon dioxide fluctuated from 280 ppm to 180 ppm. Such an increase is significant because of carbon dioxide's known capacity to trap heat and hence the apt name 'greenhouse gas'.

Another remarkable feature of the Keeling Curve is the seasonal drop of carbon dioxide by a few parts per million during the northern hemisphere spring and summer, when vegetation grows, and a slight rise when growth stops for the winter. (The comparatively small land area in the southern hemisphere is no match for the vast expanses of carbon-absorbing vegetation in the north.) Numerous studies have demonstrated that increased concentrations of carbon dioxide act as a plant fertiliser. The current high levels of carbon dioxide will therefore not only change the climate but also alter the functioning of the biosphere due to increased plant growth.

The failure of the USA and Australia to sign the Kyoto Protocol, designed to curb carbon dioxide emissions worldwide, signals a 'business-as-usual' mentality. However the magnitude and complexity of global change mean there is no such thing as 'usual' anymore. Why are so many of us laid back about the possible impacts of this change? I suggest one reason is that we have become distracted by the scientific squabbling regarding possible effects of increased greenhouse gases. Global and regional forecasts range from benign to cataclysmic changes in sea levels, air temperatures and rainfall patterns. Such uncertainty can give the impression that there is nothing much to worry about. However, such thinking is delaying adaptive responses to global environmental changes, considered by Sir David King, the British Government's chief scientist, to be a greater threat to civilisation than terrorism.

It is impossible, however, to make rock-solid predictions about our near-term environmental outlook. This point is demonstrated by ecological scientists' inability to accurately account for what has happened in the recent past. For example, my own group's research in northern Australia, and that of my colleagues around the world, is currently detecting the rapid expansion of native woody vegetation in marginal landscapes over the last 50 years. We are unsure if this expansion is a 'natural' ecological process due to changed rainfall patterns, the effects of overgrazing, the breakdown of Indigenous fire-management practices or some combination of all of these factors, or symptomatic of the 'fertiliser effect' associated with increased carbon dioxide concentrations.

Such uncertainty has tangible implications for environmental policy. For example, should the expanding woody vegetation be cleared for ecological restoration, as is often argued by pastoralists? Or should this phenomenon be celebrated as a passive form of carbon sequestration that is much cheaper than the Australian Government's currently championed engineering response to rising carbon dioxide, which involves pumping carbon dioxide deep into the ground? Answers to such questions are political because they demand making choices about socially acceptable economic and environmental costs and benefits.

I have no doubt humans will adapt to future environmental change, given that our species survived the global climate change caused by the last ice age, managing to colonise all terrestrial habitats and even creating enormous artificial ones (cities). Yet the cavalier application of science and technology has triggered global environmental change that potentially threatens our industrial civilisation. It is ironic that the development of an ecologically sustainable global civilisation must also be underpinned by science and technology. Managing the global greenhouse will teach us a lot about this new kind of science that is global in outlook yet humbly acknowledges uncertainty, complexity and the critical importance of human values.

BY DAVID BOWMAN

PROFESSOR DAVID BOWMAN IS DIRECTOR OF THE AUSTRALIAN RESEARCH COUNCIL KEY CENTRE FOR TROPICAL WILDLIFE MANAGEMENT, CHARLES DARWIN UNIVERSITY, DARWIN.

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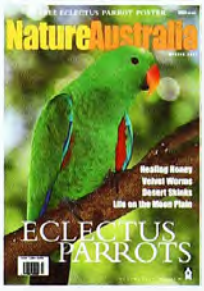

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