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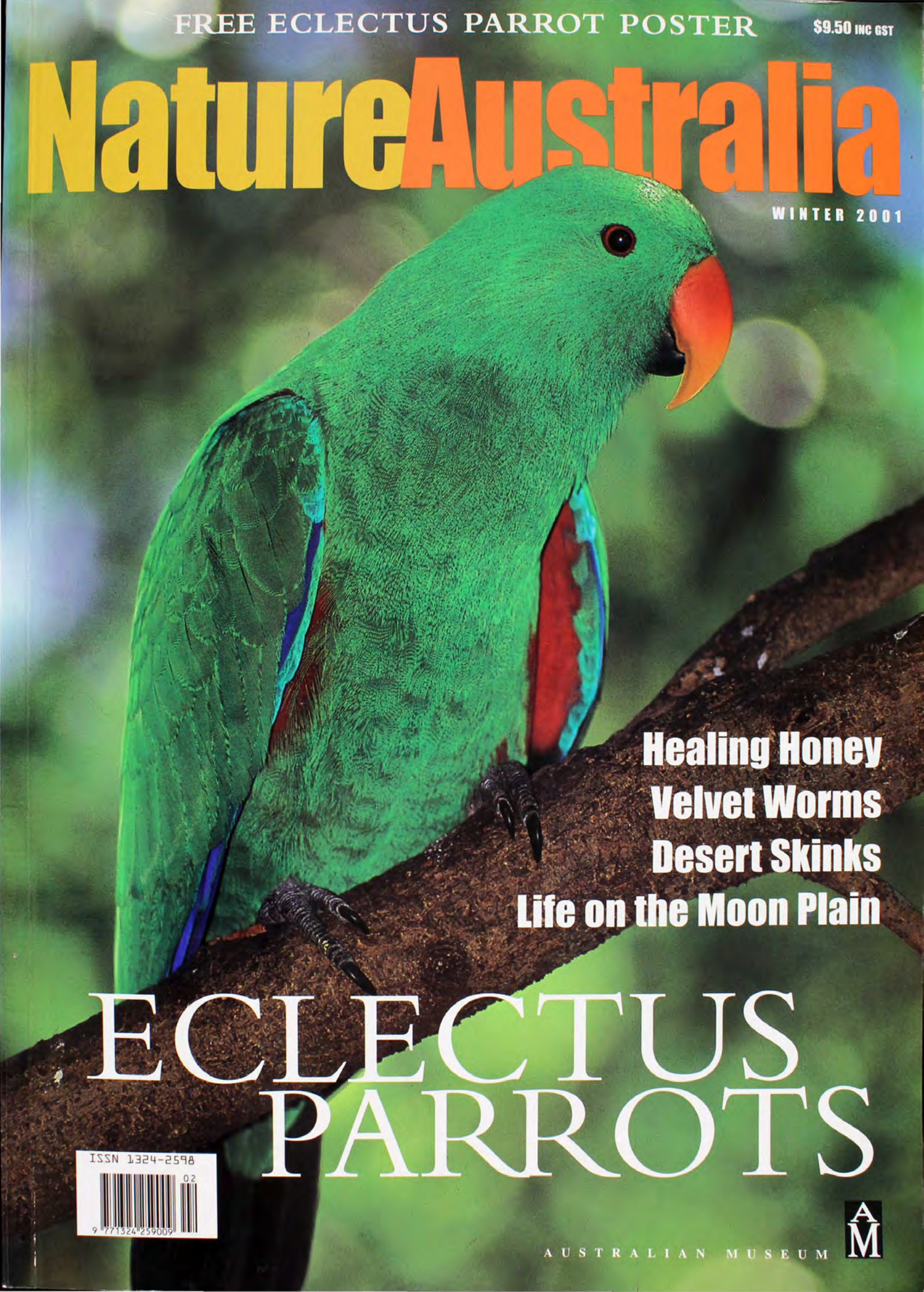

Healing Honey
Velvet Worms
Desert Skinks
Life on the Moon Plain

ECLECTUS PARROTS

ISSN 1324-2598

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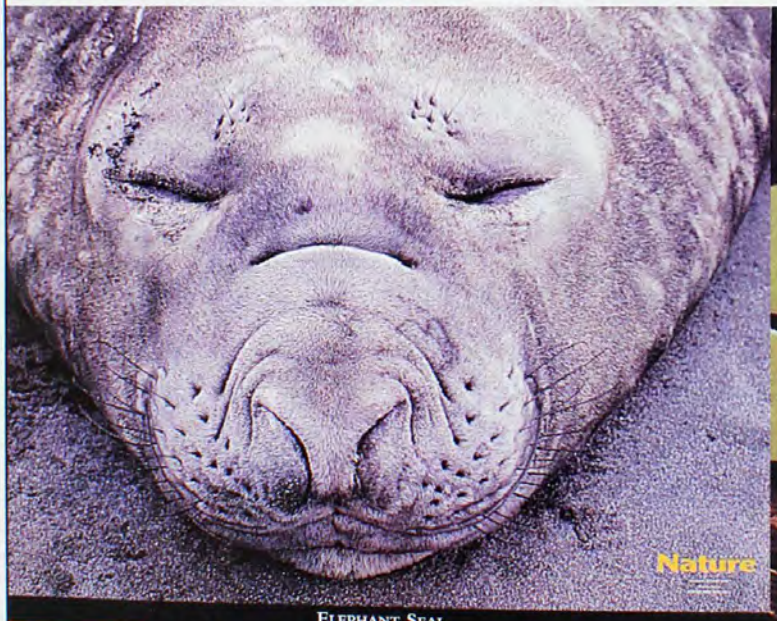

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Web: http://www.amonline.net.au
Trust President: Brian Sherman
Museum Director: Michael Archer

Managing Editor
JENNIFER SAUNDERS, B.Sc.
email: jennys@austmus.gov.au

Scientific Editor
GEORGINA HICKEY, B.Sc.
email: georgieh@bigpond.com

Photo Editor
KATE LOWE
email: klowe@austmus.gov.au

Design & Production
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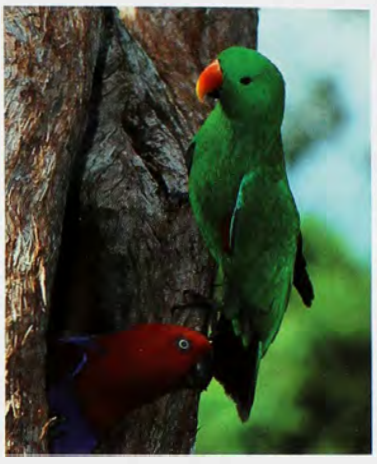
FRONT COVER
A male Eclectus Parrot (*Eclectus roratus*). Both male and female Eclectus Parrots are beautiful, but in different ways. The question is why? Photo by T. & P. Gardner/ Nature Focus.

up front

SCIENTISTS HAVE AN INFINITE FASCINATION for the minutiae of their chosen subject and it's just as well or we'd never know what life was like inside a rotten log. And this is definitely something worth knowing because among the animals you'll find there are velvet worms. As far as authors Paul Sunnucks and Noel Tait are concerned, velvet worms, or peripatus as they are also known, are quite adorable. But what makes these unusual animals so appealing? Well for one thing, they have seriously weird sex lives, and recent DNA studies by Paul and Noel have once again supported the notion that the only thing you can expect when studying velvet worms is the unexpected. To find out more about the complex and wonderful biology of velvet worms turn to page 60 for "Tales of the Unexpected".


HANS & JUDY BESTE/ LOCHMAN TRANSPARENCIES

A male and female Eclectus Parrot at their nest hole.

It's hard to imagine how anything could survive in one of the harshest deserts on Earth, where temperatures regularly soar to 60° C and the landscape resembles the rocky surface of the Moon. Astoundingly, this habitat doesn't just support your regular arid-adapted reptiles, but a thriving community of mammals. But the trick to finding them is knowing where to look. "Life on the Moon" takes us through the bulldust and into the lives of these amazing desert dwellers.

Of course knowing where to look for your subject is one thing but actually being able to reach them is quite another. Eclectus Parrots live high in the canopy of Australia's tropical rainforests, so studying them becomes a logistical nightmare. Undeterred, Rob Heinsohn and Sarah Legge have spent many hours perched high up in the canopy trying to discover what role colour plays in the lives of these stunningly beautiful parrots.

Australian honey may be the solution to the menacing problem of antibiotic-resistant bacterial infection. For thousands of years, different cultures have recognised honey's medicinal qualities and now the latest research confirms that honey is indeed quite miraculous. But before you start scraping the honey off your crumpet and onto that cut, you'd better read "A Spoonful of Honey".

Also in this issue you can explore the nature of flowering bark, evolution's dodgy designs, a skink that benefits from torched landscapes, and the magnificent coastline of South Australia. —JENNIFER SAUNDERS

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letters

For the Sake of Humans

It distresses me to think that there is a whole army of researchers out there destroying our wildlife to produce "the answers to many of the problems that plague human populations", as per Kirsten Benkendorff's "Molluscan Medicines" article (*Nature Aust.* Winter 2000).

"Of greater concern is the disappearance of organisms, and the destruction of habitats, before anyone has had the chance to explore them." How many times do you hear that? Doesn't she mean exploit them? Kirsten finishes the article with the usual apologies for the scientific onslaught. She even shows concern about a proposed open-water boat harbour in Shellharbour, but it seems only because it may lead to the loss of a "priceless biological resource".

The other day I watched in horror on TV as dozens of millipedes were ground up to be tested to see if they could benefit humans in any way. I read of bear gall bladders being administered to patients suffering from liver, stomach and intestinal disorders. How many bears and other animals were destroyed before they discovered this? I believe in Japan and Korea demand for this 'cure' has killed off most of the Asiatic Black Bears. And all for a belly ache? Probably caused by excessive lifestyle.

Why, if one way or another most of our illnesses are brought upon by ourselves, should we look to the Animal Kingdom to solve our problems? Why should animals suffer even more than they do now for the sake of humans? Is it all really necessary?

—Barbara Brownlow
James Creek, NSW

Frog Correction

In your "City of Frogs" article by Tim Low (*Nature Aust.* Summer 2000–2001), which I must say was excellent, you incorrectly labelled an image of Peron's Tree Frog (*Litoria peronii*) as a Brown-striped Frog (*Limnodynastes peronii*), which Tim correctly describes the call for in the article as an "incessant pok pok pok". Incidentally, Peron's Tree Frog is often referred to as the 'Maniacal Cackle Frog' because of its cackling, laughter-like call. No doubt the confusion in the caption arose because of the frogs' shared specific name.

Keep up the good work and congratulations on the continued evolution of one of the greatest Australian natural-history magazines available.

—Jeremy Morante
Port Macquarie, NSW

Fungi Have Names Too

The lovely images of fungi by Brian Chudleigh in Photoart (*Nature Aust.* Spring 2000) were a delight to peruse. I was, however, dismayed by the lack of captions, which you normally provide for other Photoarts on birds, butterflies, frogs, sea

G. HOYE, NATURE FOCUS

A correctly identified Peron's Tree Frog.

Should Rabbit Haemorrhagic Disease calicivirus be used as a biological control for Rabbits in Australia?

© ANDREW HENLEY/NATURE FOCUS

life etc. There is much to learn about fungi, with many thousands of species yet to be formally named, but there are plenty of species (and certainly genera) well enough known to be readily recognisable. This is particularly so among the larger fungi, such as toadstools. Their beauty of form and colour attract our attention, but also allow identification from the fruit body often without recourse to microscopic characters, as is obligatory for most microfungi.

The fungi depicted, in order of appearance, were the magnificent sky-blue *Entoloma virescens*, the red-capped Fly Agaric (*Amanita muscaria*), Sulphur Tuft (*Hypholoma fasciculare*), the long-stemmed *Crinipellis procera*, massed fruiting of Orange Pore Fungus (*Favolaschia calocera*), a trio of *Mycena parsonsii*, an earth tongue (*Geoglossum*), a beautiful green *Hygrocybe* (in the *H. graminicolor* group) and the white *Mycena austrororida*. The Fly Agaric and the Orange Pore Fungus are exotics, and of concern due to their invasion of native forests, the former in Australia and both in New Zealand.

—Tom May
Royal Botanic Gardens
Melbourne

Spell Check

For many years scientists have been criticised for their lack of writing skills. I was sorry to see the critics provided with ammunition in the Spring 2000 issue of *Nature Australia*. In the caption on page 34 our attention is drawn to the "shear" size of the Wedge-tailed Eagle, and in that on page 39 we are told that the eggs are "layed".

—K.R. Levingston
Charters Towers, Qld

Rabbit Calicivirus Immunity

I congratulate Alvin Smith for daring to challenge the CSIRO on the use of the Rabbit Haemorrhagic Disease (RHD) calicivirus as a biological control agent in Australia. In his Last Word article (*Nature Aust.* Winter 2000) he argues that the biology and ecology of this highly mutagenic virus, which emerged 'out of China' in 1984, is so poorly understood that it should never have been released in Australia.

In his article he points out the potential for this virus to adapt to new hosts, including humans. The Nipah virus incident, which killed over 100 people in Malaysia in 1999, reinforces Smith's statement that "rampant viral plagues in any mammalian species increase the risk of exposure and infections in alternate species (including humans)".

And after the promotion RHD received, interest and intrigue continue to surround Australia's experiment with the release of the virus. In August last year the South Australian Animal and Plant Control Commission announced that another similar calicivirus, present in Australian Rabbits prior to the accidental release of the RHD calicivirus from Wardang Island in 1995, was cross-protecting wild Rabbits against the lethal effects of RHD. This recent revelation might explain what's been known for several years—namely, a significantly reduced impact of the RHD calicivirus in Rabbit populations over much of south-eastern Australia. It might also explain the positive test reactions to RHD in blood samples collected from Australian Rabbits before 1995.

What it doesn't explain is why the CSIRO didn't research this possibility before they released the RHD calicivirus. It also doesn't explain why the CSIRO didn't tell the Australian public that in 1996 virologists and veterinarians were already aware that a related calicivirus was immunising Rabbits against the lethal effects of RHD in other parts of the world. Perhaps Smith is correct when he warns, "be suspicious when a profusion of eloquence is used by any official to describe the success of their own personal and bureaucratically mandated programs".

—David Obendorf
Trevallyn, Tas.

Sound Observations

I was interested in Jeff Leis' article "Out of the Blue" (*Nature Aust.* Spring 2000) where he suggested that larval coral reef-fish might use reef sounds in navigation. During the early '80s I was experimenting with underwater sound-recording and playback at Heron Island in the Capricorns. There were some observations that may be of interest.

For a start, I found that I could pick differences in ambient sounds from different parts of the reef. Shark Bay, for example, was quite distinct from other areas of the reef flat. Another observation concerned the noise made by boats. The Island launch was particularly noisy

TOM & PAM GARDNER/NATURE FOCUS

Could the advance of Cane Toads (*Bufo marinus*) be halted by toad-wise crows?

and readily detectable by hydrophone at a distance of several kilometres. When this launch started its engines it led to an audible response from sound-producing animals, even at distances of a kilometre or more from start-up. Another source of noise was Scuba divers. They were so noisy that I imagine a larval fish with two divers close behind would hear nothing else. Even in the absence of divers, judging direction would be difficult. I found no sharp sound-level gradient as I moved closer to or farther from a reef. Other ways of judging sound direction are to compare the intensity and the time of arrival of sound at each ear. As sound travels about four times as fast in water as in air, judgment becomes more difficult especially in larval fish where the distance between ears is small.

—Alastair Traill
Wonga Park, Vic.

Toad-wise Crows

Recently there has been much media coverage on the colonisation of Kakadu National Park by Cane Toads (including *Nature Aust.* Winter 2000).

On two visits I observed the first influx of Cane Toads into a western Queensland property. Initially there were Cane Toads and their tadpoles everywhere, no visible native tadpoles and no visible sand goannas. On the second visit at least a year later, there seemed to be slightly less toads and tadpoles, a few native tadpoles and a few goannas, and lots of dead, eviscerated toads. Could the local crows have 'learnt' how to safely kill Cane Toads?

Is there any merit in translocating 'toad-wise' crows to strategic areas to help slow the influx of Cane Toads? Allen Greer's Last Word article on translocation (*Nature Aust.* Summer 2000–2001) outlines the dangers of translocating individuals, but perhaps the devastation that Cane Toads cause may balance this.

—Carmel Kerwick
Camp Hill, Qld

Zero-Tolerance

Thank heavens poor old Joe Public has more common sense than the boffins, who are trying to perpetuate an error that their predecessors made when they formulated the Gregorian calendar. Like these people, Alan Moskwa (*Nature Aust.* Summer 2000–2001) fails to recognise the part that zero plays in mathematics.

Zero is a human concept used as a point of reference—a concept that leaves off the zero at the beginning of counting because it has no value unless smaller segments are given as decimal points. The Gregorian calendar began counting from one instead of from zero and it has been causing confusion ever since. It went from 1BC to 1AD without separating them with a zero.

Alan Moskwa's example is in error because the counting of money also begins

from zero. If we are completely 'broke', we have zero dollars and zero cents. If the $2,000-loan he used as an example, without fees or interest, were paid back with one dollar at the end of each year, the end of the day that the loan was taken would be 'day one, year zero'. The first dollar would be paid back 365 days later at the end of year zero and then the second year, year 0001, would commence. The last dollar would be paid back 730,000 days after the loan commenced at the end of year 1999, and when the year 2000 commenced all of the $2,000-loan would have been repaid.

The confusion is enhanced even further because of how common usage of the calendar has evolved. If the date of the birth of Jesus Christ, 25 December, is correct, the Year 0001 was inserted when he was just six days old, and not when he was one year old. This date was used as AD—an abbreviation of the Greek words *anno Domini* meaning in the year of our Lord and therefore technically correct. No zero should be used because it was the *first* year of our Lord and not a reference to his age. However, to be correct it would have to be written as 1st, not just as 1.

In the interests of science, and to prevent the continuation of this confusion, we should do one of three things: (1) either put the 'year-of' abbreviations after the year on the calendar (2000th, 2001st, 2002nd etc.), (2) change the year number of the calendar back by one year so that it is the same as the age of Jesus Christ, or (3) move the year 1BC back by one year and insert a zero as a correct reference point, leaving the calendar the way it is.

The first two are unlikely to happen because of common usage and would only create more confusion. But seeing that most people have already carried out the third option in their own minds, as demonstrated by the worldwide celebration of 1 January 2000 as the logical beginning of the new millennium, the last is the best option. It is unlikely that dates older than 2,000 years can be given with an accuracy better than 365 days, so moving 1BC back and inserting a zero would have no effect on history books etc. The calendar would then equate with other forms of counting, and we can think of the 'A' in AD as meaning 'after' Domini, that is after our Lord.

—Eric Sorensen
Helidon, Qld

Frog Laws

Tim Low's "City of Frogs" article (*Nature Aust.* Summer 2000–2001) reveals his ignorance of the Queensland Nature Conservation Regulations as they apply to native amphibians. For the cost of a local phone call, Low could have contacted the Queensland Parks and Wildlife Service and discovered that it is illegal to take, keep, move or deal in the eggs or tadpoles of native frogs without a permit. In this regard, the law in Queensland is much the same as that in New South Wales.

—Jenny Holdway
Queensland Frog Society Inc.
Brisbane, Qld

Jenny is right. Because of a change in the law in 1994, people who move tadpoles in Queensland are unwittingly breaking the law. I was misled by pond owners who said it was legal.

—Tim Low
Chapel Hill, Qld

Garden Polly-tics

I wish to comment on the power 'polly-tics' in my garden. Crimson Rosellas are always the first and the last after sunset to visit my seed pods. They were at first shy and easily startled even by gentle doves, but over the years these birds stiffened in resolve and began to stand their ground against mynas and lorikeets. However, the last thing I would have called Crimson Rosellas is "quarrelsome extroverts", as Elsie Krebs does in her article (*Nature Aust.* Summer 2000–2001). This description more aptly fits the Rainbow Lorikeets, which bring their fledglings to feed from my hand each year. Rather, the Crimson Rosellas are elegant patricians of the garden, disdaining vulgar fights over human food.

Of course Elsie Krebs' study was done in Canberra where the rosellas could pick up some bad habits from the 'pollies'.

—Nigel Stoneman
Carlingford, NSW

Nature Australia **requests letters be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in this issue will receive a copy of** ***Stinging trees and wait-a-whiles.*** **The winner this issue is Alastair Traill.**

nature strips

COMPILED BY GEORGINA HICKEY

DANIELLE CLODE, RICHARD FULLAGAR, KARINA HOLDEN, JASON MAJOR, KAREN McGHEE, RACHEL SULLIVAN AND ABBIE THOMAS ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Language of Love

Whispering the wrong name during an intimate moment can have disastrous results. But Arla Hile and her collaborators at the University of California at Irvine suggest that slips of the tongue are even riskier for the talkative Budgerigar (*Melopsittacus undulatus*). Budgerigars are renowned for their powers of imitation and Budgie fanciers have long known that males, rather than females, are better talkers, but why?

When the researchers placed unfamiliar birds together in pairs, they found that their calls became more similar. Such synchronising of calls might reinforce pair bonds, particularly amidst the noise and ruckus of thousands of breeding Budgies in the wild. This convergence of calls is primarily due to the male adding the female's calls to his repertoire, while the female rarely changes hers. Hile's group suggests that a female might use the frequency of her own calls in her partner's song as an indicator of his fidelity. With imitated female calls accounting for up to 90 per cent of the male's repertoire, there is little opportunity for him to 'sweet talk' another. Previous research (see *Nature Aust.* Winter 1998) has found that male Budgies only court other females when their regular mate is out of sight. So after any absence, the female would do well to listen to his every phrase for signs of disloyalty.

—D.C.

Neanderthal the Hunter

We know Neanderthals ate meat, from the indirect evidence of associated animal bones. But how much meat did they eat? Did they hunt, really hunt, like top carnivores? Or were they just scavengers, relying more on plant material for their 'daily bread'?

There is much debate on the relative role of meat versus plants in early hominid diets. This is because direct evidence of what they ate has been pretty thin on the archaeological ground. But a new wave of research, which looks at the chemical composition of bones, is changing all that.

The levels of certain stable isotopes (variants) of carbon and nitrogen reflect the source of dietary protein over

DAVE WATTS/NATURE FOCUS

Could the female Budgerigar (left) be listening for signs of her partner's infidelity?

The Red Deer stag is no brave heart.

JOHN CANCALOSI/AUSCAPE

the last few years of an animal's life. From these values it is possible to tell whether the protein came from plants or animals, and even where the food lived or grew (such as open or forested areas). By comparing the isotope values of 28,000-year-old Neanderthal bones from Vindija Cave (Croatia) with known herbivores (such as cattle and deer) and carnivores (Arctic Foxes, wolves) of the day, Michael Richards (University of Oxford) and colleagues were able to show that the Neanderthals filled the role of top-level carnivores, obtaining the bulk of their protein from animal sources. Another study on older Neanderthals (up to 40,000 and 130,000 years old) showed similar results, which suggests that Neanderthals were seriously dependent on meat for a very long time.

The researchers say it would have been impossible for Neanderthals to obtain that much meat by scavenging alone, and that they would have had to actively hunt their prey. Such a restrictive diet, the authors believe, may have made some groups of Neanderthals especially vulnerable to environmental change, and may well have contributed to their demise.

—R.F.

Scaredy Stag

When a winter gale is howling over the windswept isles of Scotland; when the skies are dark with rain clouds and all good folk are tucked up inside—the Red Deer on the Isle of Rum will still be out grazing as the storm rolls in. Yet if you were to take a closer look, you'd see there are only bonnie females out in the gale. The male deer are no brave hearts—once it's a blowing, they're a going.

Scientists studying the Scottish Red Deer (*Cervus elaphus*) have puzzled over why the males are such scaredy stags. Although they present a fierce demeanour with their roaring bellow, at the first sign of rain the males retreat from communal pastures to the sheltered glens of heather. Larissa Conradt from the University of Leeds and colleagues devised a theoretical model based on net energy gain to see if they could explain these sexual differences in sheltering behaviour.

It appears the stags' sensitive dispositions are related to their impressive size. When exposed to chilly gales, the males quickly lose heat, yet they can't eat fast enough to outweigh their energy losses. This forces them to give up good foraging in favour of better shelter. Females, however, are small enough to soldier on as they can eat enough to see out the storm.

This is the first time the weather has been found to drive males and females apart. The 'weather-sensitivity hypothesis' has the potential to explain habitat segregation in a number of ungulate species in sub-Arctic and temperate climates, where it seems the big chill makes big males the more delicate sex.

—K.H.

JEFF FOOTT/AUSCAPE

Cub-swapping in Polar Bears—a case of mistaken identity?

Polar Bears Swap Cubs

Something strange is going on in the Arctic Circle. Researchers following Polar Bears (*Ursus maritimus*) in the Canadian Arctic have noticed there's some cub-swapping going on. Mother bears are caring for baby bears that are not their own. To understand why, Nick Lunn from the Canadian Wildlife Service and colleagues investigated the genetic relatedness between the mothers and the cubs.

One explanation for cub-swapping is 'kinship theory'. That is, a female may foster or help care for the young of a relative, thereby preserving some of her own shared genes. Yet, by comparing microsatellite markers in the bears' DNA, the researchers found that in six 'families' the mothers were caring for completely unrelated cubs.

Why females would adopt strangers doesn't make evolutionary sense. However, the researchers suggest that each mum may be none the wiser. It's possible that kin recognition in Polar Bears is poorly developed because of their solitary social system. Polar Bears rarely encounter one another because of their low population density, nor do they keep home ranges or defend territories. Because they are loners by nature, they might not realise they have the wrong cubs.

Although contact between families is uncommon, Polar Bears may run into each other at places where resources are abundant such as a whale carcass or garbage dump, and during these occasions the swap may occur. A sudden aggressive encounter between adults may cause enough chaos and confusion to send cubs scattering with the wrong female. It seems that adoption among Polar Bears is merely a case of mistaken identity.

—K.H.

Ozzie Origins

Again...where did we come from? Did fully modern humans march out of Africa 100,000 years ago and outcompete more archaic forms around the world (the Complete Replacement Theory)? Or are modern humans the result of mixing between populations of ancient hominids (the Multi-regional Model)?

Several years ago, the matter appeared settled, with studies of ancient DNA 'pointing the bone' at the Complete Replacement Theory. But since then, measurements of European fossils have provided compelling evidence of interbreeding between archaic and modern humans (see *Nature Aust.* Spring 2000). The latest evidence in the ongoing debate now comes from Australia.

John Hawks (University of Utah) and colleagues propose that the Complete Replacement Theory predicts close morphological similarity between all modern humans and potential ancestors from Africa and the Levant (Near East), while there should be less similarity between modern humans and archaic hominids. As a test, they compared measurements on a 15,000-year-old (that is, modern human) skull known as WLH-50 from Willandra Lakes, western New South Wales, with much older fossil specimens from Africa, the Levant and Ngandong

COURTESY MILFORD WOLPOFF & JOHN HAWKS

Hominid skulls from (left to right) Indonesia, Australia and the Levant. Which of these skulls is not like the others?

(Indonesia). The Ngandong fossils are thought to be *Homo erectus*, and off the modern human line, in contrast with the African and Levant fossils, which are all accepted as being direct ancestors of modern humans (*Homo sapiens*). Using statistical analysis, the researchers showed that WLH-50 was more similar to the Ngandong fossils than any of the supposed direct ancestors from Africa and the Levant, concluding that the Complete Replacement Theory must be wrong.

Not everyone agrees. Some archaeologists maintain that WLH-50 is unusual for several reasons and simply unrepresentative of populations in Australia or elsewhere. The skull may have been distorted, for example, as a result of some disease.

Another potential nail in the coffin for the Replacement Theory comes from the finding, by Gregory Adcock (Australian National University) and colleagues, that part of the mitochondrial DNA of 'Mungo Man', a skeleton also found from the Willandra Lakes region and claimed by the researchers to be over 60,000 years old, is unlike that of any modern humans. They believe this supports the Multiregional Model of human evolution—in other words, that Mungo Man may have inherited some of his DNA from earlier humans such as *Homo erectus*.

AMOS NACHOUM

Killer Whales slap for their supper.

The devil is in the detail and, given the entrenched positions on both sides of the archaeological debate, the matter of where we came from is far from settled.

—R.F.

Slap-happy Whales

How do big Killer Whales (*Orcinus orca*), with their relatively poor acceleration and manoeuvrability, manage to catch flighty little fish like herrings? By giving them a spanking.

Paolo Domenici (International Marine Centre in Italy) and colleagues made video- and sound-recordings of whales feeding on Atlantic Herrings (*Clupea harengus*) in a Norwegian fjord. The whales first mustered the herrings into tight schools just below the water surface. They would then lunge through the middle of them, and give them an underwater slap with their tail. Successful slaps were accompanied by a loud bang, after which herrings were seen floating to the surface. The whales then ate these fish one by one.

The researchers calculated that the whale's tail could move up to 13.6 metres per second, which is much faster than the swimming speed of either the herrings or the whale itself. They also estimated that a well-directed slap was capable of yielding 16 herrings—far more than the whale could hope to catch by individual chases.

The authors suggest that the fish are stunned mainly through physical contact of the tail, rather than pressure waves created in the water by the tail's movement. This is because fish only became stunned when the slap was accompanied by a loud noise (interpreted to be the sound made from the physical contact), and many of the 'floaters' bore tell-tale signs of abuse. 'Misses' (in which tail slaps did not result in stunned fish) never went off with a bang.

—A.T.

Born to Drink

Many people look forward to an alcoholic drink after a long day; indeed it may even be good for us. Some people, however, look forward to it a little too much, to the point that alcoholism is now a major challenge to public health. But we are not alone. Our fondness for the drink is shared with a bunch of other animal species. Vinegar flies (*Drosophila*), butterflies, elephants, monkeys and apes, for example, have all been observed in various states of inebriation after feeding on fermented fruit or nectar. After five years of studying the 'drinking habits' of fruit-eating primates, Robert Dudley (from the University of Texas at Austin) believes there may be an evolutionary explanation for human alcoholism, which stems from when our ancestors first started eating fruit millions of years ago.

Robert Dudley believes there may be an evolutionary explanation for human alcoholism.

Ethanol (the same alcohol in our beer, wine and spirits) is a volatile compound that is released from ripe and decaying fruit—a precious commodity in the tropical forest and for which competition is often fierce. Just as ethanol attracts vinegar flies, the whiff of ethanol in the air may have alerted our frugivorous forebears to the presence of ripened fruit. Evolution may have selected individuals that were particularly sensitive to the scent of ethanol and its promise of high-energy rewards. The smell may have become entrenched into our ancestors' range of olfactory stimulants, predisposing us to alcohol ever since.

STEVEN DAVID MILLER/NATURE FOCUS

Our 'fondness for the drink' is shared by many fruit-eating animals, such as the Orang-utan (*Pongo pygmaeus*).

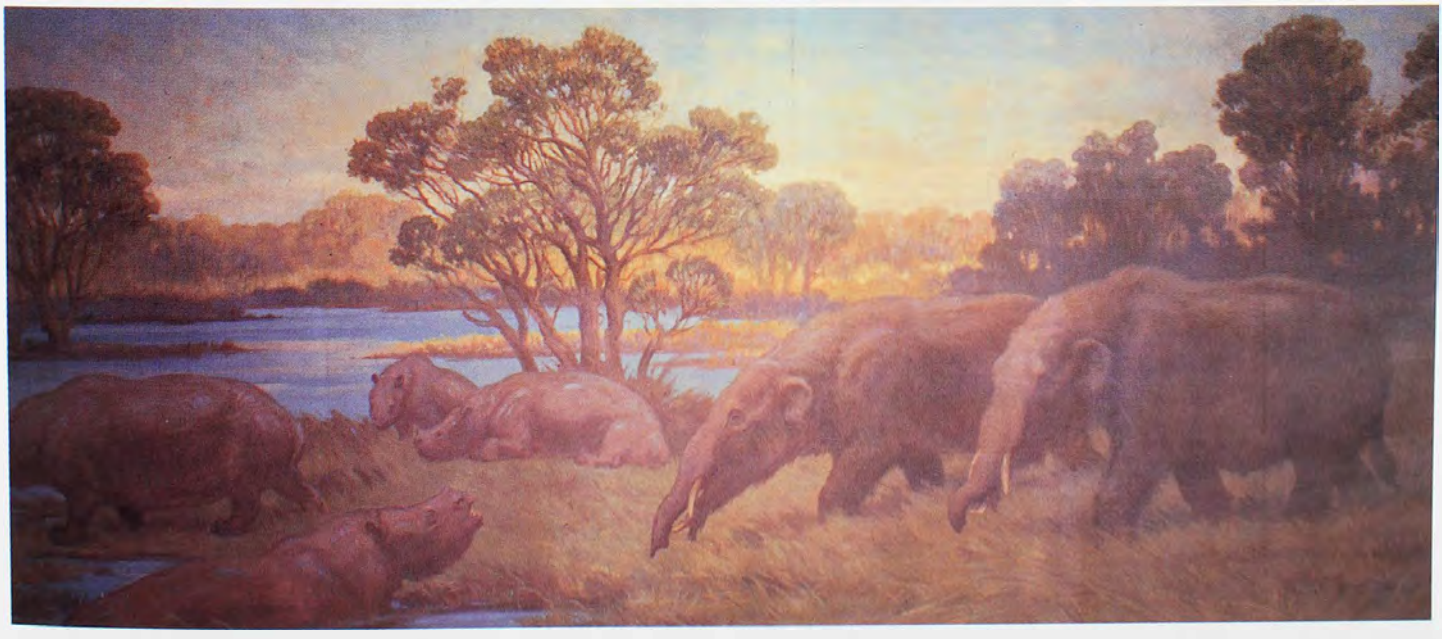
In the past, getting drunk may simply have been an occupational hazard—the consequence of feeding on an especially overripe batch of fruit. While the attraction to alcohol would have been advantageous in the ancestral environment when fermenting fruit was a limited resource, in the modern world where alcohol is literally available on tap, the behaviour has become maladaptive. In this way, alcoholism (like diabetes and obesity) can be viewed as a disease of nutritional excess.

—G.H.

Tusks Tell of Tragedy

Just as tree rings record information about the environment, so can the rings of enamel and dentin found in the tusks of elephants. Growth rings signify the growing season of a plant or animal, and therefore indicate resource abundance at certain times of the year and length of seasons. Taking this one step further, the growth rings in fossil tusks of extinct species can help us piece together information about past climates and how they have changed.

Palaeontologist David Fox, from the University of Michigan, has recently analysed tusks of *Gomphotherium*—an elephant-like creature—from fossils found in Nebraska, Oklahoma and Texas. The seven specimens used in his study represent changes in the Miocene climate, from 15 million to five million years ago. After factoring in changes of growth associated with age and sex, Fox demonstrated that the tusks from the Middle Miocene revealed patterns of high growth throughout most of the year, followed by only a few months of slow growth. However, tusks from the Late Miocene showed that the annual period of high growth was only 11–24 weeks. This implies the



THE FIELD MUSEUM, #GR437

Past patterns of climate change are written in the tusks of *Gomphotherium*.

KEVEN DEACON/OCEAN EARTH IMAGES

The chambered nautilus *Nautilus pompilius* sniffs down its food in stereo.

growing season had become shorter and more distinct. Fox believes this was due to a gradual increase in aridity and the development of a single distinct wet season late in the Miocene.

The growth patterns in these tusks are consistent with other geological evidence for climate change. Such a dramatic shift in climate is thought to have been responsible for the mass extinction of many North American mammals at the end of the Miocene. As extinction also came for *Gomphotherium*, these tusks tell a sad tale of the end of an era.

—K.H.

The Nautilus Nose

Rarely seen, and unchanged for millions of years, chambered nautiluses (*Nautilus* spp.) live in deep dark waters, eking out a living on the carrion they scavenge during nocturnal forays up nearby reef slopes. Equipped with only primitive eyes, scientists have long suspected that *Nautilus* species rely on their sense of smell to find food, helped by small, nipple-like structures (called rhinophores) located beneath each eye.

But in the ocean, odours are dispersed by currents and turbulent water, making the source of a smell more difficult to detect. To find out just how the nautilus 'nose', Jennifer Basil and colleagues from the Marine Biological Laboratory in Woods Hole, Massachusetts, captured 12 *Nautilus pompilius* and videotaped their responses to a smelly shrimp cocktail injected into the flow of their aquarium. Simultaneously, they tested the effect of the rhinophores by temporarily blocking one or both pores with a blob of Vaseline.

With one or both pores blocked, the animals could detect, but had difficulty homing in on, the source of the scent. With both organs clear, however, they could track an odour from more than ten metres away, zigzagging their way through the odour plume, using their rhinophores to smell 'in stereo'. But once they came within 20 centimetres of the odour source, their behaviour changed completely, slowing down and extending their 90 thin tentacles until they reached the source of the odour. Although taste-bud-like cells have been reported on the tentacles, no studies have been done on their sensory function. This study, however, supports the idea that they do indeed detect chemicals and are used to fine-tune the nautilus' nose.

The researchers suggest that a similar type of stereo sensory system probably guided ancient cephalopods, like ammonites, to their food sources.

—R.S.

Snakes Fish with Forked Tongue

Snakes normally use their forked tongues as sense organs, flicking them in and out of their mouths to collect chemical signals from the surrounding air. The Pacific Coast Aquatic Garter Snake (*Thamnophis atratus*), however, appears to have developed an additional use for its tongue.

Over the last decade, Hartwell Welsh and Amy Lind (US Forest Service) have been studying this snake along a five-kilometre stretch of a Californian creek, and have shown that the way it obtains food changes as it matures. Adults mainly forage on the bottom of the creek bed for larval Pacific Giant Salamanders (*Dicamptodon tenebrosus*), while young

A young Pacific Coast Aquatic Garter Snake lures fish with its tongue.

COURTESY A. LIND

snakes ambush tadpoles and juvenile fish from the water's edge.

Most recently, Welsh and Lind described how juvenile snakes use their tongues, which are red with black tips, as lures to attract prey. The snakes cautiously approach the edge of the stream, positioning themselves so that their heads are one or two centimetres above the water. They then hold their tongues out rigid and fully extended with the tips quivering over the water surface, until a prey item comes within striking distance. This differs from the typically rapid in-and-out movement of chemosensory tongue flicking.

Some snake species twitch their tails to attract prey (caudal luring), but this is the first clear report in the scientific literature of snakes using their tongues in this way. Similar 'lingual-luring' behaviour has been reported in the Alligator Snapping Turtle and Snowy Egret.

—K.McG.

Dishonest Crabs

The costs of producing and displaying elaborate sexual signals, like long tails and enlarged claws, are high, but are thought to act as honest

DAVE WATTS/NATURE FOCUS

indicators of an animal's genetic health. The trade-off is that the animal is more likely to mate, and carry his genes forward to the next generation. But new research has shown that not everyone is playing the mating game fairly.

Patricia Backwell (Smithsonian Tropical Research Institute) and colleagues studied fiddler crabs in Mozambique (*Uca annulipes*) and found the first known example of a dishonest sexual signal.

When male fiddler crabs lose the big claw that they use to attract mates and defend territories, they grow a new one, but it is lighter and therefore cheaper to wave around than its predecessor. It is also a less effective weapon than an equivalent-length original claw.

What is surprising, say the researchers, is that these supposedly less-fit crabs do not seem to suffer in any way from their disability. Even though males with original claws are more likely to win encounters with 'second-hand' males, they do not go out of their way to fight these males; nor are females deterred from choosing 'second-hand' individuals for mates. Assessment of crab fitness, it seems, is based on claw-length alone.

With up to 44 per cent of the population displaying regenerated claws, Backwell and colleagues suggest that cheating may be a lot more common than we thought. Its apparent rarity may simply be an artefact of the difficulty in detecting cheats, designed by nature to go unnoticed.

—R.S.

Owl Chick-Chat

When birds return to the nest to feed their chicks, there is usually a cacophony of noise as the baby birds compete for the tasty morsel being delivered. But Barn Owl chicks (*Tyto alba*) play a different tune—they call to each other even when parents are not present. What's the point of squawking when the parents are out of earshot? Alexandre Roulin and colleagues from the University of Bern in Switzerland wondered whether chicks might be negotiating among themselves who should get the next meal.

Owl parents only deliver about one mouse per hour to their chicks but, with up to nine chicks per nest, inevitably the babies are left in different states of hunger. The researchers temporarily removed all chicks except two. They gave one chick extra food during the day, leaving the other one hungry. They secretly filmed and recorded the chicks, noting

How does a parent Barn Owl decide which of its chicks to feed?

the duration and volume of their chirps before and after the parents arrived with food, and noting which chick got fed. The results showed that the hungrier chick not only made the most noise before the parents arrived, but almost always got the mouse. After the parents left, it immediately quietened down and the other chick piped up with the louder call.

Experiments with larger broods showed that, contrary to some other bird species, the more chicks in the nest, the lower the noise level. The researchers suggest this is because each owl chick uses the intensity and frequency of its siblings' calls to assess their willingness to compete for the next meal. If the other chicks' needs are greater than its own, rather than calling for hours on end, the chick

shuts up and waits for the next round of negotiations. In this way it saves energy and possible injury from ravenous siblings. With fewer chicks in the nest, the probability of getting the next meal increases, as does their willingness to compete for it and the overall noise level of the brood.

Previous research has shown that owl parents continue feeding their chicks at a steady rate, whether or not the chicks are already satiated. Therefore, it may be that these wise young owls can afford the luxury of kicking back, in the knowledge that they will eventually get dinner from their hard-working parents.

—A.T.

Lovers or Fighters?

The Argentine Ant (*Linepithema humile*) behaves almost as if it's a different species when away from home.

In its native range, it lives in single-nest colonies that it aggressively defends against other members of its own species. This seems to self-limit population size and, as a result, the Argentine Ant manages to coexist with a wide range of other native ant species.

However, in California and other places where it has been introduced, it lives in large 'supercolonies' in which individuals from different nests mix freely with each other. As this lifestyle helps it outcompete and dominate local ant species, the Argentine Ant has become a serious pest.

According to recent research by Neil Tsutsui (University of California at San Diego) and colleagues, different levels of genetic variability could determine whether Argentine Ants are lovers or fighters. In the ant's native home, where aggression between nests is high, the researchers found comparatively high levels of genetic variability. In the introduced populations, where different ant nests cooperated rather than fought, the ants were more genetically similar. The ants use genetic similarity to assess whether other ants are friends or foe. Thus in their introduced range, genetically similar Argentine Ants act as one big happy family. This is one of the few known examples in which reduced genetic variability can lead to ecological success.

With aggression towards members of their own kind seemingly operating as a check on population size, the findings suggest that increasing the genetic variability in introduced populations could offer an effective form of biological control for Argentine Ants.

—K.McG.

The Shroud of *Nephila*

In New Zealand's Canterbury Museum there is an artefact from the New Hebrides (Vanuatu) that resembles a flaccid, wool-coloured dunce's hat, just under a metre long. The label, written in the early 1900s, describes it as a "spider-web cap" that was used for smothering adulterous women. The cap was made by passing a cone-shaped piece of wood backwards and forwards through numerous spider webs until it was covered with a thick felted mass of silk. The wooden cone was then withdrawn so the conical cap could accommodate a human head. However, it seems that the anthropologist who wrote the label literally had the spider-web cap pulled over his eyes. Rather than being used to procure death, these caps were used to mourn death in funerary rituals (as they still are today). Kirk Huffman (Honorary Curator of the Vanuatu Cultural Centre) believes the mistake was made by the white collector incorrectly interpreting the gestures and pidgin English of the local people. However, the unwitting providers of the raw material for these caps do have some smothering tricks of their own.

The webs are spun by golden orb-weaving spiders (*Nephila* spp.), probably the Giant Wood Spider (*N. pilipes*) or the smaller *N. plumipes*. *Nephila* are enormous spiders and common throughout the tropics. Females of some species can have a body seven centimetres long and a leg span up to 20 centimetres. Compared to

KIRK HUFFMAN 1997

SIMON POLLARD

The 'spider-web cap' held in the Canterbury Museum, New Zealand, was used in funerary rituals such as this one photographed on Malakula Island, Vanuatu, in 1997.

COURTESY ROY L. CALDWELL

Mating in the Greater Blue-ringed Octopus is a touchy, feely affair.

females, however, the males are puny—up to 400 times lighter.

The webs of *Nephila*, which are built by the female, may be up to two metres in diameter and are very strong. Reports of hats being snatched off people's heads are not uncommon. I accidentally walked through a *Nephila* web, while hatless, in Sri Lanka. The silk stretched across me, and the skin on my face was pulled back towards my ears, as if by an invisible cosmetic surgeon. As I took another step, the silk strings pinged and my face popped forward. Hats and face-lifts aside, the webs are designed to snare flying insects, although small birds and bats are also sometimes caught.

Because females are so huge and have cannibalistic tendencies, mating can be a risky pastime for male *Nephila* (see *Nature Aust*. Autumn 1998). While some males manage to escape in tact after mating, others lose limbs, and still others end up with their sperm where it should be but with the rest of their body inside the female's stomach! Even less fortunate males are cannibalised as virgins. To add insult to real injury, females may mate with many males, before laying eggs.

Males captured by adulterous female *Nephila* are wrapped in a shroud of silk. Ironically, this fate echoes the myth associated with the spider-web cap being used to smother adulterous women.

—Simon D. Pollard
Canterbury Museum
Christchurch, New Zealand

Feeling the Blues

To the beach-wise Aussie kid, the luminescent blue rings of blue-ringed octopuses clearly signal danger. But do these striking patterns communicate information between octopuses? Other cephalopods, like cuttlefish, are renowned for their mesmerising displays during the mating season, so it might be reasonable to suspect that blue-ringed octopuses also convey information about their sexual inclinations via their highly expressive skin.

Surprisingly, research by Mary Cheng and Roy Caldwell from the University of California, Berkeley, has found that looks mean very little to the Greater Blue-ringed Octopus (*Hapalochlaena lunulata*). In fact, from a distance, these blue-ringed octopuses can't even tell the sex of their *inamorato*. In the first detailed study of the sexual behaviour of a blue-ringed octopus, Cheng and Caldwell found that males were equally likely to copulate with other males as females. Copulation involves inserting a specially modified arm with a spermatophore (sperm packet) into the other octopus' body. Once in such close proximity, however, it seems that the sexual identity of the partners becomes obvious. Most male–male copulations ended rapidly in amicable separation and the spermatophore was rarely transferred. In male–female copulations, the spermatophore was always transferred and the male was less enthusiastic about departing. Copulations usually took more than an hour and a half, but even then only broke up after an intense struggle by the female. Presumably such prolonged matings are a form of mate-guarding, or allow the male to ensure that fertilisation occurs before he departs.

Octopus mating behaviour is little-studied and different octopus species may certainly use different methods to communicate sexual information. But in the world of the blue-rings it seems that a gentle feel will tell you more about your partner than the flashiest looks.

—D.C.

New First out of Africa?

The Republic of Georgia has yielded a surprising new human contender for the title of 'First out of Africa'. Like most good finds, this one happened by chance, when an archaeology student in charge of a school excursion to Dmanisi noticed some strange bones after heavy rains. These turned out to be a partial and nearly complete skull of an ancient human.

The first surprise was that their age was older than expected. A large international team of scientists considered all the evidence (fossil morphology, stone artefacts, associated animal bones, sediments, stratigraphy, isotopic dates and palaeomagnetic data) and concluded that the bones are 1.7 million years

old. This takes us back in human evolution when *Homo erectus* fossils begin to take on larger brains, smaller teeth and other less primitive features. And it is *Homo erectus* that most scientists believe was the first to step out of Africa into Asia. Debate continues on what happened next: either subsequent migration of more modern humans out of Africa, or a mixed human ancestry with *Homo erectus*.

The second surprise was that the Dmanisi fossils are not really like *Homo erectus* at all! A bevy of measurements demonstrated a much closer resemblance with an earlier human species, *Homo ergaster*, well known from the Koobi Fora fossils in Africa and thought never to have had the brain power nor technology to leave Africa.

How could this be? One explanation is that *Homo ergaster* was really the first out of Africa and that Asian *Homo erectus* evolved from these early immigrants. Contrary to previous arguments that sophisticated stone technology was a prerequisite for early human dispersal, the stone tools from Dmanisi are more similar to even earlier African tool kits (called Oldowan). If technology was not the driving force, the researchers speculate that relatively larger body mass (suggested by measurements on African *Homo ergaster* fossils) required more animal protein, and that these first Asian immigrants were driven out of Africa by a need to hunt meat.

—R.E.

Pigeons Go Boom

Throughout history Homing Pigeons (or Rock Doves, *Columba livia*) have been used to deliver human messages because of their ability to find their way back to their lofts from up to thousands of kilometres away. Many researchers fancy they know how the birds navigate, with theories ranging from sense of smell, to good sight, to an inbuilt magnetic compass. One interesting theory is that pigeons rely on their ability to detect infrasound (low-frequency acoustic waves) to hear their way home. Infrasound waves—too low for us to hear—are generated when the moving ocean exerts pressure on the seabed and makes the land shake. Now there are fears the sonic boom from the Concorde aircraft may be interfering with the navigation of pigeons and other animals.

Jon Hagstrum from the US Geological Survey suspected that the Concorde's boom could potentially interfere with the pigeons' hearing, after four disastrous pigeon races held in Europe and America between 1997 and 1998, when many pigeons never returned. In one race from Soustons in France to the Netherlands, for example, 60 per cent of pigeons still had not returned after six days. There was one thing

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Were Homing Pigeons thrown off course by the Concorde?

DON W. HADDEN/NATURE FOCUS

Just how far do Wandering Albatrosses wander?

common to all the races, Hagstrum noted, and it wasn't bad weather. In each race, the Concorde's route passed over the path most likely taken by the birds. The Concorde creates a 'boom carpet' about 100 kilometres wide beneath the aircraft. This, he argues, may have temporarily or permanently deafened the pigeons.

If the theory is true, the Concorde may pose serious problems not only for Homing Pigeons, but for any animal that might use infrasound signals to migrate, such as the Monarch Butterfly or perhaps even sea turtles. Of course, this may not be an issue if the Concorde fleet is permanently grounded as a result of last year's crash. However, it may provide some insight into why some animals go crazy just before large earthquakes; they, unlike us, might hear the faint beginnings of what is to come.

—A.T.

Non-wandering Albatross

The sliver of silver lures the wandering seafarer in for a closer look. Diving, the bird plucks a fish from the water. A sharp pain flashes along its beak. Minutes later the albatross is dead—drowned after taking the bait from a long-line fishing hook. Longlining is now classified as a key threatening process under Australia's endangered species legislation.

To help protect Wandering Albatrosses (*Diomedea exulans*), researchers need to establish their movements and behaviour during the non-breeding season. A Wandering Albatross pair spends one year hatching and raising a single chick before heading to sea for a well-earned rest. After a year they return to breed again. Scientists had always assumed the birds wandered aimlessly during these year-long sabbaticals. New research now suggests otherwise.

Henri Weimerskirch (Centre d'Etudes Biologiques de Chize, France) and Rory Wilson (Institüt für Meereskunde, Germany) tagged nine Wandering Albatrosses from the Crozet Islands, using a modified geolocation device for tracking fish. The devices revealed that the birds travelled 1,500–8,500 kilometres, and that each bird had a preferred stomping ground for its winter sabbatical. The team suspects the albatrosses learn over the years where the profitable feeding grounds are and return to these each year. One bird, captured and tagged in 1960 while 'on sabbatical' near Sydney, was recaptured 40 years later at the same site.

But, as the saying goes, men are from Mars and women are from Venus. Tagged males appeared partial to the colder climes, spending their time around the Antarctic ice pack. The females, however, chose to bask themselves in the tropical and subtropical waters around Madagascar.

—J.M.

Blister Beetles Mimic Bees

The parasite's lot is not an easy one, and many species have evolved complex host-finding behaviours. Take the blister beetle *Meloe franciscanus*, for example. Its larvae hatch in the ground at the base of vegetation but they can only continue their development

inside the nests of solitary bees, which provide them with pollen to eat. How do they get inside these nests? According to John Hafernik and Leslie Saul-Gershenz (San Francisco State University) who studied the blister beetles in the Mojave Desert, the larvae hitch a ride by clumping themselves on a twig and waiting for an amorous male bee to carry them off.

When a male bee lands, the clump moves as one to grasp the bee's undercarriage. Then, when the bee encounters a real female and attempts to mate, the clump is passed intact onto her back and taken to the nest. If another male attempts to mate with her, some of the larvae may be transferred to his 'belly' and passed on to the next female he encounters. In this way, the larvae can be viewed as a venereal disease.

The researchers believe that male bees mistake clumps of larvae for female bees, which perch on bushes in similar positions. However, likening the process to pseudocopulation in orchids, they say that olfaction must also play a role, a theory borne out by the bees' total lack of interest in painted models of the aggregations.

—R.S.

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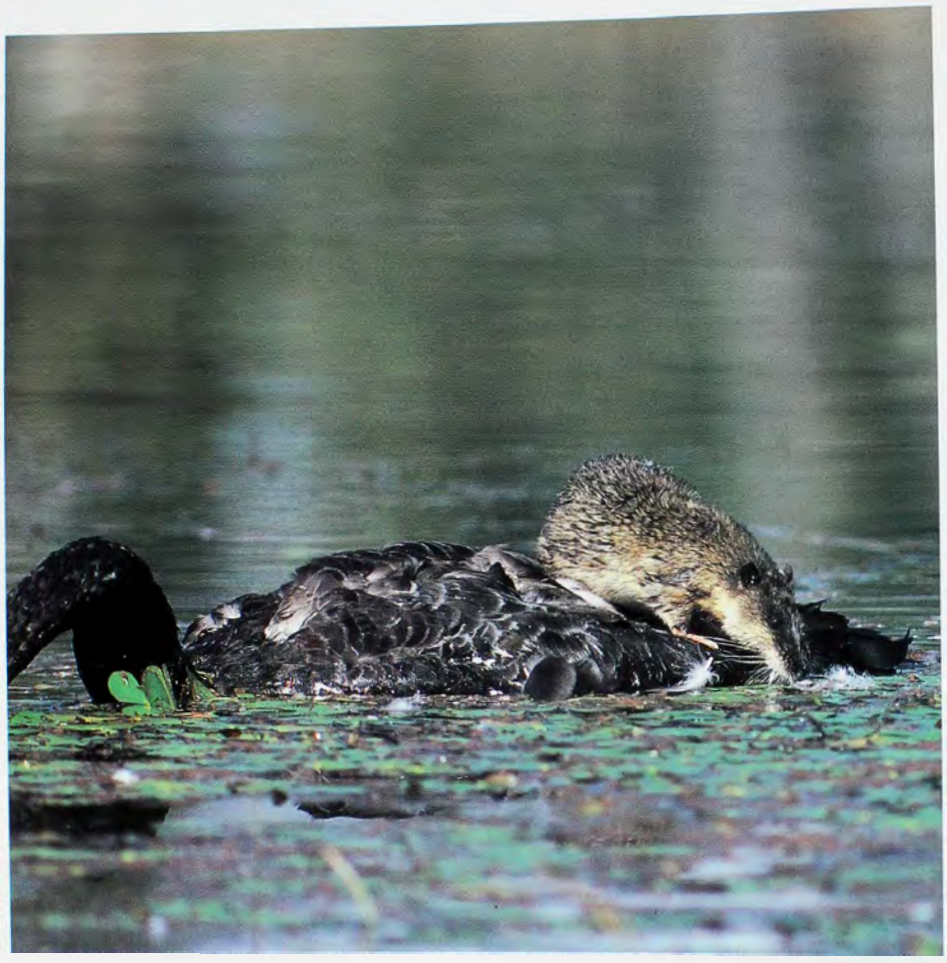
QUICK QUIZ

1. *Which shark was the first to become a protected species?*
2. *What metal does the symbol Pb stand for?*
3. *Chilopodophobia is the fear of what?*
4. *Which country 'owns' the 5,300-year-old Ice Man known as Ötzi?*
5. *What does a pluviometer measure?*
6. *Name the most venomous marine creature in the world.*
7. *Which endangered animal species does the superfine wool known as shahtoosh come from?*
8. *What is the principal component of 'cave bitumen' or amberat?*
9. *Which is the smallest planet in our galaxy?*
10. *What type of animal was* Genyornis*?*

(Answers on page 82)

What-a-rat!

Water-rats have a pungent natural odour that is eclipsed only if a polecat in a nearby cage has died and gone unnoticed for two weeks.



T & P GARDENER/NATURE FOCUS

A Water-rat dines on a dead Black Swan.

THE CLOSEST MY MOTHER EVER got to owning a mink coat was a skunk stole that had had its stench and white stripes removed to disguise it beyond recognition.

Before I was out of nappies, I had been sworn to secrecy regarding the animal origins of the prized bushy mane. But our wire-haired terrier, crackerjack ratter and chooker, wasn't fooled and had to be straight-jacketed whenever the camouflaged skunk was hauled out of mothballs to go a-dining and dancing on my mother's shoulders.

It is a strange coincidence that the most sumptuous fur coats are fashioned from bits and pieces of the world's most notorious pongers. Foxes, civets, minks, weasels and the Muskrat are as famous for their fine fur as they are infamous for their humming BO.

Whoever said that silk purses could not be made from sows' ears could not have known that luxurious fur coats once came from rats' bellies, and for a while Australians were responsible for supplying the rats in question.

During the Depression, the Federal Government tried to boost the local economy by banning the import of all furred skins. Australian Water-rats (*Hydromys chrysogaster*) were seen as the perfect substitutes for American Muskrats. Our skins were just as large, the fur was dense, soft and sleek, and the colour was a rich golden brown with long shiny black guard hairs over the top. The ban on imports made the price of a Water-rat pelt jump from four shillings in 1931 to ten shillings in 1941. To Aussie battlers this astonishing price (approximately $45 each on today's scale of values) would have been like a short-cut map to Lasseter's Reef. So, with legs and backs buckling under the weight of every imaginable trap in the business, off rushed thousands of get-rich-quickers, hot on the scent of the poor old 'beaver rat' as they knew it.

WHOEVER SAID THAT

silk purses could not be made from sows' ears could not have known that fur coats once came from rats' bellies.

Those who could afford them used bone-crunching, steel-jawed Rabbit traps baited with lard or fish heads. Others with more cunning than cash made do with used jam tins from the rubbish tip. These they masterfully set on creek banks and swamp crossings. They dropped in some melted fat as bait, pushed the lid back inside the tin, and tied the can to a sapling or tree root. The brutal mechanism behind the deadly marmalade tin will be crystal clear to all who have lost patience, skin or knuckles trying to lever out a jagged lid accidentally pushed into the jam. It was little wonder that few Water-rats

BY STEVE VAN DYCK

saw the light of day after cramming their heads into those dark, irresistible, one-way tins.

But as usual, in such ventures where the stakes are high, everything came unstuck when hard-headed hunters started using poison to bring down their rats. In many places this wiped out all the rodents, young and old, and eventually led to legislation protecting the Water-rat.

One of my most emphatic and early-learned animal husbandry lessons was that, under bedroom conditions, there can be no more unsuitable pet than a Water-rat. These animals are large, shy and powerful, and can ringbark slow schoolboy fingers to the bone in seconds. They growl when cornered and, being primarily fish- and game-eaters, have a pungent natural odour that is eclipsed only if a polecat in a nearby cage has died and gone unnoticed for two weeks.

But on the waterfront, in cross-currents and creeks, these rats are the Captain Hooks of Down-Under rodents—mariners extraordinaire and butchers when it comes to cleaning up their prey. As a terrestrial species they are exceptional in being able to paddle in the coldest of Tasmania's icy streams, or flop around in the warm waters of Torres Strait, diving with ears, nostrils and eyes shut tight and feeling for food with their whiskers. But as thermoregulators they have been shown to be pretty inefficient at maintaining their body temperature when the temperature of the surrounding water drops lower than 15° C. To compensate for this, in the cold months Water-rats eat big vertebrate prey whenever they can catch it, spend as little time as possible in the water, and shiver a lot on the bank.

Some individuals can be a terror around poultry and goldfish farms, and one rat at Innisfail, Queensland, managed to dispatch 62 ducklings in the space of five days. The grisly discovery of caged poultry with their throats and heads roughly skinned can often be attributed to a Water-rat's poor table manners. But to their credit, Water-rats have come to grips with the toxic Cane Toad and don't think twice about flipping them over and pirating the contents of their fat paunches.

Water-rat

Hydromys chrysogaster

Classification
Family Muridae, tribe Hydromyini. One of only 2 water-rats in Aust.

Identification
Very large rat, adults otter-like and almost as big as a small Cat. Head–body length up to 30 cm, tail 27 cm, weight up to 700 g. Upper body usually dark brown, underside orange-grey to white. Ears small, partial webbing between hind toes (no webbing on forefeet). Tail usually white-tipped.

Distribution
All States of Aust., in fresh- or saltwater habitats (mangroves, waterfronts, rivers, creeks, drains, lakes, dams, swamps) from rainforest to arid interior (although more coastal habitats in WA). Also in PNG and adjacent islands.

Food
Mostly carnivorous, eating crustaceans (yabbies), molluscs (mussels), insects, frogs, fish, birds, mammals. Middens of mussel and crustacean shells common.

Reproduction
Usually Aug.–May, but throughout year in some areas. Nests at end of tunnel in creek bank etc. Normally 3–4 young per litter, 1–2 litters/year. Young weaned at 4 weeks, independent at 8 weeks, reproductively mature about 8 months.

These days Water-rat numbers seem to have recovered since the big trapping boom of the '30s and '40s but, although now reasonably common and active both day and night, they are just as difficult to observe as our notoriously shy Platypus. Oddly enough, it seems easier to stumble upon them by accident than to purposely set out to observe them and succeed.

In this context I always remember the time when Ian Forbes, one of our more colourful neighbours, was walking along the creek and his Dog disturbed a Water-rat. The rat dived into a big log and Ian lay along the top of it to look inside. Unbeknown to him, the Water-rat emerged from the other end and was about to set off when the Dog noticed it. As the Dog lunged at it, the Water-rat swung up onto the log and ran back towards Ian who was still looking over the far end. With cover heavily on its mind and the Dog hot on its heels, the rat opted for the darkest cavity it could see...the gap between Ian's hairy back and the loose shirt tail pulled up out of his pants. No doubt Ian could have shrugged off the memory of the Water-rat corkscrewing its way around his torso and out through the neck of his T-shirt...had not the Dog decided to follow! My mother, having worn skunk close to her neck, would have been more forgiving of the wolfhound's bristles and halitosis than Ian. Only on account of its ability to repel visitors and thieves did the Dog escape an early afterlife as a coir mat. The rat also escaped and lived on to eat all of the Forbes children's chickens.

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

Great Desert Skink

From an Aboriginal perspective the Great Desert Skink has always been around and is an important component of economic, social and spiritual life.

THE GREAT DESERT SKINK (*Egernia kintorei*) occurs in the 'western deserts region' (central western Australia). From a European perspective, the skink is considered rare, based on the limited number of museum specimens and known localities. The first museum specimen was collected in the Great Victoria Desert in 1891. Since then only 33 other localities have been recorded, with just one population known to occur in a conservation reserve (Uluru–Kata Tjuta National Park).

From an Aboriginal perspective, however, the Great Desert Skink, or Tjakura as it is known by several tribes, has always been around and is an important component of economic, social and spiritual life. Much of what we know about the biology and ecology of the Great Desert Skink derives from research at Uluru, which combines traditional ecological knowledge of the Anangu people with Western scientific research techniques. Numerous senior Aboriginal people throughout the western deserts region have a detailed knowledge of the Great Desert Skink. They have strong memories of hunting the skink while living on their traditional lands. Many anecdotal reports suggest that the skinks have vanished from some former localities and this, combined with the paucity of museum records, has contributed to the species' 'vulnerable' listing.

There is strong evidence that traditional hunting techniques actually benefit the Great Desert Skink. Some of the largest and apparently healthiest populations occur in the Gibson Desert and are subject to human hunting pressure. Traditional hunting includes the frequent use of fire as well as digging the skinks up from their burrows. Small-scale, constant patch-burning in areas where Aboriginal people have ready access, has created an intricate mosaic of different fire-aged vegetation. This benefits species such as the Great Desert Skink that seem to prefer areas burnt from three to 15 years previously. The skinks are not present in nearby, much larger areas that have no access roads and are only burnt every 15–20 years, usually by wildfires. Plant succession following fire produces skink food such as the Bush Tomato (*Solanum centrale*). The most common dietary items, however, are termites. Following early summer storms, termite alates (winged individuals) swarm in incredible numbers, providing an enormous food resource for an array of desert reptiles as well as mammals and invertebrate carnivores.

Sandplains vegetated by spinifex (*Triodia*) clumps and scattered shrubs are the most commonly utilised habitat of the Great Desert Skink. These sandplains are often adjacent to rocky hills or low ranges that may provide a flow-on of additional moisture to the plains. In the Gibson Desert, undulating gravelly sandplain, known as 'rirra' to the local Aboriginal people, is a key habitat type.

The Great Desert Skink weighs up to 350 grams and reaches just over 40 centimetres in total length, the tail being slightly longer than the head and body. Adults construct extensive burrow systems, up to ten metres in diameter and sometimes over a metre deep. Burrow systems may have over ten entrances, several of which have mounds of red sand, built up from the excavations, and utilised to angle the body during basking. A feature of burrow systems is the latrine or toilet, where dozens of large scats accumulate adjacent to one of the burrow entrances. The latrine may be important for group identity and recognition.

In the warmer months, Great Desert Skinks have two main activity periods. The lizards are active from about one hour before sunrise until mid-morning. During this time they bask in the sun and run out to consume passing prey. But the most intense activity period is the first two hours after sunset. At this time they forage out from the burrow, eating beetles, spiders, cockroaches and any other creatures they can swallow, including small lizards and snakes. They also consume leaves, flowers and fruits of various plants, when available. The skinks are most prone to predation by Cats and Foxes during this nocturnal activity period.

A Recovery Plan has just been completed for the Great Desert Skink. Aboriginal communities and government agencies are now combining to implement fire-management and predator-control programs, which hopefully will increase populations and once again make the Great Desert Skink an important and well-known component of western desert ecosystems.

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STEVE MCALPIN HAS UNDERTAKEN RESEARCH ON THE GREAT DESERT SKINK THROUGH THE NORTHERN TERRITORY UNIVERSITY AND WORKS AS A CONSULTANT TO THE ARID LANDS ENVIRONMENT CENTRE AND ENVIRONMENT AUSTRALIA.

BY STEVE McALPIN

STEVE McALPIN

Flowers from wood

Some species bear fruits or flowers almost anywhere—on the upper stems among the leaves, along lower branches, and straight from the trunk.

PHOTOS: TIM LOW

Bumpy Satinash is a wonder to behold when the flowers sprout right down to ground level.

TREES THAT SPROUT FLOWERS and fruits straight from their trunks are a curious feature of tropical rainforests, and often evoke surprise, for we are not used to seeing tree trunks in bloom. Flowers may sprout right down to ground level. Cauliflory, as it is known, has evolved independently in many trees, the Cocoa Tree (*Theobroma cacao*) of Latin America, the source of chocolate, providing a well-known example.

Australia has relatively few cauliflorous trees. They include at least ten species of figs (*Ficus*), three lillypillies (*Syzygium*), two red bopple nuts (*Hicksbeachia*), and a smattering of other unrelated trees. Most are confined to northern Queensland, although a few grow in southern Queensland and northern New South Wales, and one, the Crowned Sandpaper Fig (*Ficus coronata*), occurs right down the east coast to Gippsland.

Biologists have pondered this phenomenon ever since Alfred Russell Wallace suggested in 1878 that cauliflorous flowers were easier for pollinators to find in the gloom of the rainforest. In the late 1960s, Leedert van der Pijl suggested that cauliflory helps bats find fruits. Bats disperse many rainforest seeds but they are less agile among foliage than birds, and fruit clusters on trunks are easily found.

Cauliflory is made more puzzling by all the variation that goes on. Northern Queensland's Bumpy Satinash (*Syzygium cormiflorum*) comes in two forms—one a cauliflorous understorey tree found mainly on mountains, the other a taller non-cauliflorous tree of lowlands. (The lowland form, incidentally, yields good timber, whereas the cauliflorous form is too irregular in vein and form because the flowers sprout from bumps.) Some cauliflorous species, including the Crowned Sandpaper Fig and Red Bud Satinash (*Syzygium erythrocalyx*), bear fruits or flowers almost anywhere—on the upper stems among the leaves, along lower branches, and straight from the trunk. Also, there are trees such as Durobby (*Syzygium moorei*) that don't produce flowers and fruit on their trunk, but only on bare branches well below the foliage. (This is called ramiflory.)

As a phenomenon, cauliflory has rarely been studied. A survey in Trinidad found that, in two cauliflorous tree species that also produce canopy flowers, the trunk flowers attracted the most insect pollinators. This lends support to work done in Australia by naturalist Garry Sankowsky, who contends that cauliflory in four species of small northern Queensland trees attracts pollinating insects or birds. Below the canopy, flowers on trunks show up better than flowers among leaves.

One of the best studied of all cauliflorous trees is Bumpy Satinash. Its flowers attract many visitors—moths, cockroaches, flies, honeyeaters, rodents and Striped Possums (*Dactylopsila trivirgata*)—but Common Blossom-bats (*Syconycteris australis*) appear to be the best pollinators. Their fur collects large amounts of pollen when they lap up the copious nectar, and they are very mobile, visiting many trees over a wide area. The Bumpy Satinash seems to be designed mainly to attract pollinating bats, although not to the exclusion of birds, which are probably good pollinators as well.

Figs are probably cauliflorous for a different reason. Their special pollinating wasps are extremely efficient at locating figs wherever they occur; indeed, in a previous article (*Nature*

BY TIM LOW

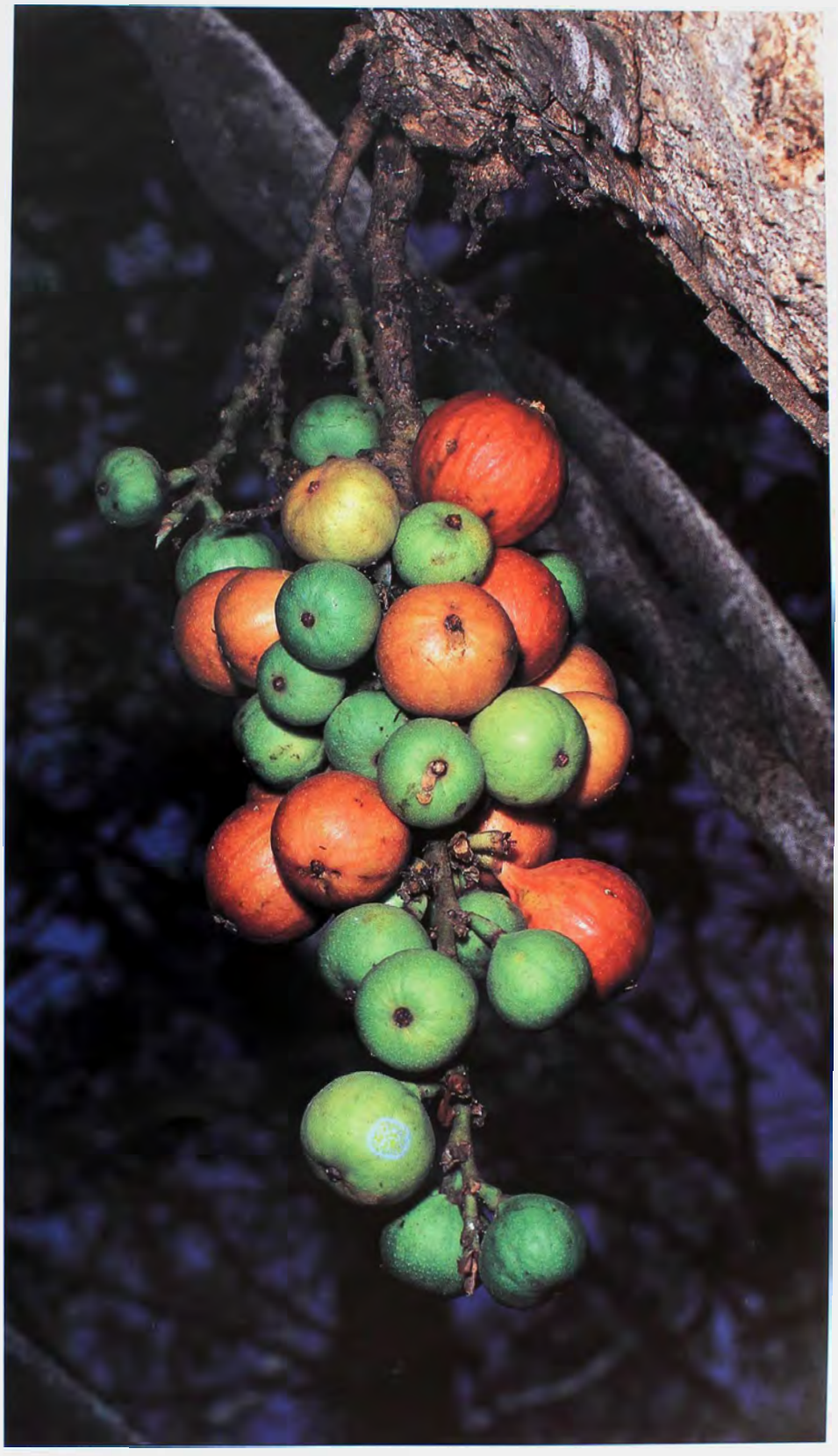

Fig clusters dangle enticingly from the Cluster Fig tree, inviting bats to feed.

Aust. Autumn 2001) I mentioned that Australian fig wasps have found their way over to fig trees in New Zealand after blowing across the sea. Cauliflory in figs probably helps bats find the fruits (and hence disperse the seeds). The Cluster Fig (*Ficus racemosa*) and other cauliflorous species are eagerly eaten by Common Blossom-bats, Eastern Tube-nosed Bats (*Nyctimene robinsoni*) and flying-foxes (*Pteropus* species).

It is also possible that cauliflorous fruits gain better access during development to the resources stored in tree trunks. In the Bumpy Satinash and Red Bud Satinash this may be important, for they bear very large fruits eaten by Southern Cassowaries (*Casuarius casuarius*). Other cauliflorous species with sizeable fruits include the Brush Walnut (*Dysoxylum parasiticum*), Davidson's Plum (*Davidsonia pruriens*) and red bopple nuts. In South-East Asia the cauliflorous Jackfruit (*Artocarpus heterophyllus*) produces one of the world's biggest fruits, cultivated forms sometimes reaching the size of watermelons. These fruits would break branches and stalks were they not cauliflorous.

Cauliflory is something to wonder about today, but to Queensland Aborigines in the past the fruits were often important foods. Cluster Figs, Davidson's Plums and Bumpy Satinash fruits are both tasty and large. Ludwig Leichhardt, exploring the Suttor River in central Queensland in 1845, observed that Cluster Fig trees were "readily detected by the paths of the natives leading to them: a proof that the fruit forms one of their favourite articles of food".

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TIM LOW IS A NATURE WRITER AND ENVIRONMENTAL CONSULTANT BASED IN BRISBANE. HIS MOST RECENT BOOK IS *FERAL FUTURE* (PENGUIN).

Natural selection didn't come up with the best design; it just made the best of what was available.

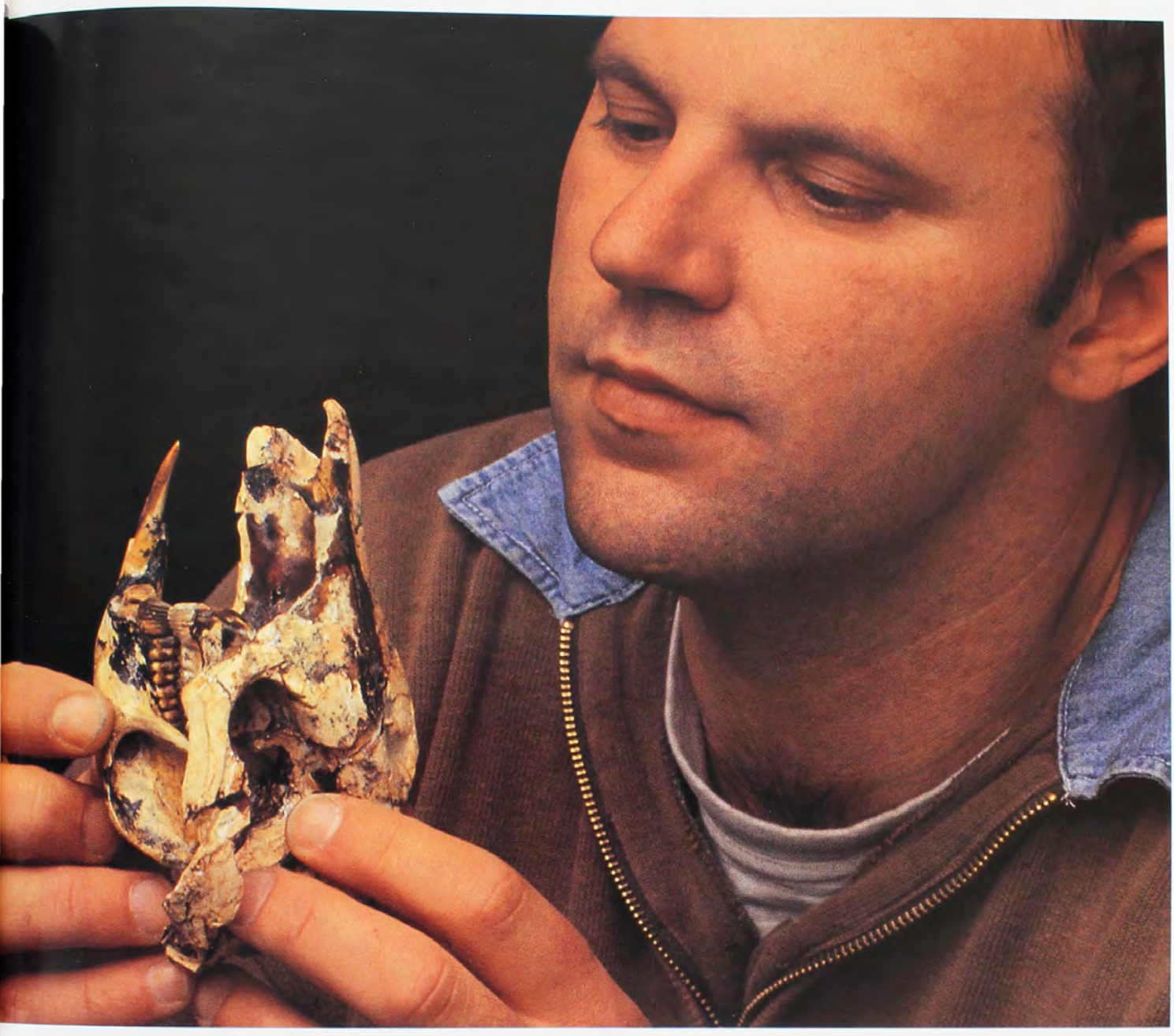
THE KILLER RAT-KANGAROO'S TOOTH

BY STEPHEN WROE

THE 'HAND' OF THE GIANT PANDA (*Ailuropoda melanoleuca*) has six 'digits'. In processing its staple diet of bamboo, the Giant Panda drags the stalks between its sixth 'digit' and its paw to strip off the leaves. This sixth 'digit' or 'thumb' is a curious device. It is not, as one might expect, simply an additional finger of the type sometimes produced through congenital defect. In fact, the Panda's 'thumb' is not a real digit at all, but a greatly enlarged and specialised wrist bone called the radial sesamoid that lacks much of the flexibility of true digits. Why, one might wonder, did the Panda evolve a 'thumb' out of a wrist bone when it already had a 'real' thumb?

Evolution can be a fickle and opportunistic process. Often the end result can appear surprisingly imperfect, even 'sloppy'. The bottom line is that, at any juncture in its evolution, a species is constrained by accidents of history. When 'fashioning' new adaptations, natural selection can only work with what it's got. Because the real thumb (the first digit) of the Giant Panda was already modified and in use for another task (for walking on), evolution could only work with what was available, in this case, a radial sesamoid bone. It is this very fact of imperfection that underpins the reality of natural selection.

As pointed out by Stephen J. Gould (Harvard University) in *The panda's thumb*, text books paradoxically cite examples of 'optimal design' in misplaced efforts to illustrate the evolutionary process. But it is these same examples that are often cited by creationists in defence of the notion of a Divine Creator (how can the complex 'perfection' of, say, an eagle's eye not be the product of anything other than conscious design?). A graphic way to expose the soft



CARL BENTO/NATURE FOCUS

The author peers into the empty eye sockets of the extinct Powerful-toothed Giant Rat-kangaroo (*Ekaltadeta ima*).

underbelly of this argument is to flag examples of 'imperfect design'. The Giant Panda's thumb is one. Another, more home-grown example, and the subject of this essay, is the second premolar of the Powerful-toothed Giant Rat-kangaroo (*Ekaltadeta ima*).

Giant rat-kangaroos (subfamily Propleopinae) are an extinct group of marsupials found in fossil deposits ranging from around 25 million to 50 thousand years or so in age. *Ekaltadeta ima* is the oldest of six known species, and it is also the best represented. Fossilised remains of this animal include the only two near-complete skulls known for the subfamily, as well as numerous upper and lower jaws.

EVOLUTION

can be a fickle and opportunistic process.

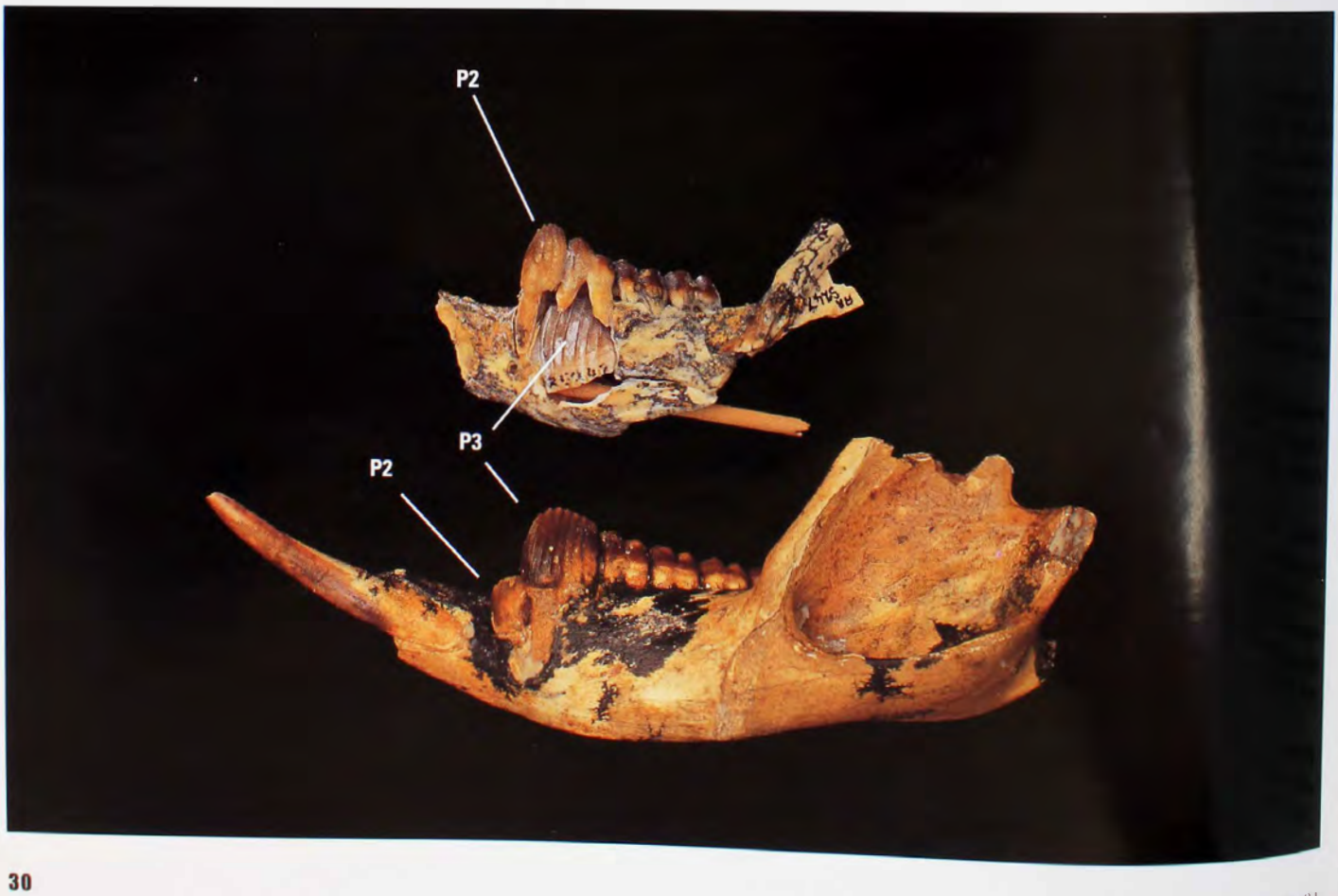
Propleopine biology has been the focus of considerable debate among palaeontologists, ever since 1888 when Charles W. De Vis, once Director of the Queensland Museum, described the first known species of giant rat-kangaroo, *Propleopus oscillans*. In particular, scientists have argued about

the food preferences of these fascinating beasts. In recent decades the weight of opinion appears to favour carnivory, or at least shows a leaning in that direction. This conclusion is based mainly on the size and shape of a large, buzz-saw-shaped cheek-tooth, the adult third premolar (P3), which is common to all propleopines. Whether or not this tooth was actually used in the butchery of carcasses is difficult to determine, but there can be little doubt that, when used in conjunction with powerful jaw muscles, the P3 of *Ekaltadeta* had the potential to bite through just about anything. However, it is not what this P3 was used for, but how it got there, and how it was held in place, that is of interest to us here.

Like other mammals, *Ekaltadeta ima* replaces its 'baby teeth' with adult teeth. Normally, tooth replacement involves the shedding (eviction) of a pre-existing deciduous (or milk-) tooth by an erupting adult tooth in the same position. These deciduous teeth are the ones kids tuck under their pillows in the hope of obtaining hard currency from tooth fairies. Marsupials are unusual in that only one premolar is generally replaced, the deciduous third premolar (dP3). Among marsupials, kangaroos are still more unusual in that the erupting P3 usually displaces not only dP3 but also the second premolar (P2). *Ekaltadeta ima*, however, is an exception here, not only among kangaroos, but among mammals in general. From the fossil record we know that in juveniles, the P2 performs the role of primary cutting blade. However, when P3 erupts, P2 is not ultimately discarded as in other roos. Instead, this P2 is withdrawn and reoriented to fulfil a completely different purpose—as a buttress for the whopping great P3.

A SINGLE ORGAN
has been used for two completely different roles in the course of the individual's life. This makes Ekaltadeta *unique among mammals.*

When you think about it, this is pretty strange. A single organ has been used for two completely different roles in the course of the individual's life. This, to the best of my knowledge, makes *Ekaltadeta* unique among mammals. It is also a glaring example of evolutionary opportunism that undermines the notion of 'optimal design'. Using a normally discarded tooth to act as a structural support for a succeeding tooth is not the best way to do the job. A far 'cleaner' and more aesthetically pleasing solution to the problem would have been to



The juvenile lower jaw (top) and the adult lower jaw (bottom) of *Ekaltadeta ima*. In the juvenile, the second premolar (P2) served as a slicing blade. In other kangaroos (both living and extinct), this tooth is evicted in adulthood to make way for the third premolar (P3), but in this 'killer rat-kangaroo' it was not lost. Instead it turned and moved down to serve as a support for the massive P3.

CARL BENTO/NATURE FOCUS

This is what *Ekaltadeta ima* may have looked like when it roamed Australia 25 million years ago.

completely eject the P2 and buttress the P3 with bone. In the case of the killer rat-kangaroo's tooth, as with the Giant Panda's 'thumb', natural selection didn't come up with the best design; it just made the best of what was available. And in that opportunistic imperfection, there is no clear vision of the hand of God.

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PHOTOS: CARL BENTO/NATURE FOCUS

The exquisitely well-preserved fossil skull and lower jaw of *Ekaltadeta ima*, smallest and oldest of the six species of giant rat-kangaroos.

Dr Stephen Wroe is a mammalogist at the Institute for Wildlife Research (University of Sydney) and at the Centre for Research into the Evolution of Australia's Total Ecosystems (CREATE) at the Australian Museum. He obtained his Ph.D. on marsupial carnivore evolution from the University of New South Wales.

When they are all at home, the 12 male and 5 female Eclectus Parrots light up the branches like a Christmas tree.

SEEING RED: A PARROT'S PERSPECTIVE

BY ROB HEINSOHN & SARAH LEGGE

One of the 20th century's great evolutionary biologists, the late Bill Hamilton (from Oxford University), used to show a slide in his lecture series of a male and female parrot sitting side by side. The male was a vibrant green and the female a stunning vermilion. Whereas evolutionary theory had plenty to say about sexual selection producing greater size or gorgeous colouration in one sex, it stumbled somewhat in establishing what had happened in this parrot species. Even nature, with its healthy disregard for theory, has failed to produce any other bird in which both sexes are 'beautified', but in such different ways. Hamilton ended his talk by saying "When I understand why one sex is red and the other green, I will be ready to die."

HANS & JUDY BESTE LOCHMAN TRANSPARENCIES

Thought for many years to be separate species, it was only when they were seen together that naturalists realised that male (green) and female (red and blue) Eclectus Parrots were the same species.

ONE OF OUR FIRST DISCOVERIES WAS THAT FEMALES
virtually never leave the vicinity of their nests, relying instead on the males to bring them food.

The troublesome species was the Eclectus Parrot (*Eclectus roratus*) and sadly Hamilton passed away before the mystery was solved. For many years, the Eclectus Parrot sat on its perch beckoning to evolutionary biologists, but the challenge went unanswered. This was for good reasons, as few birds present such logistic difficulties to the field worker. Eclectus Parrots live in the canopy of forests in New Guinea, west to the Moluccas, east to the Bismarck Archipelago and Solomon Islands, and south to the tip of Cape York. Apart from living in such remote locations, their nest hollows may be 20 to 30 metres above the ground, and they are notoriously shy birds that fly away screaming over the treetops when disturbed. The theoretical lure was strong, but it was a rash moment when we committed ourselves to solving the Eclectus puzzle.

THE FIRST NEST TREE we encountered was the remarkable "Smuggler's Fig"—a Green Fig (*Ficus albipilla*) in far northern Queensland's Iron Range National Park. This majestic old denizen, which still has rusted metal spikes sticking from its trunk as a testament to the bad old days of parrot-smuggling, represents a microcosm of Cape York wildlife. In its various hollows it supports 17 Eclectus Parrots distributed amongst three different breeding groups, two pairs of Sulphur-crested Cockatoos (*Cacatua galerita*), and roosting cavities for bats inside its trunk. Its crown is decorated with a magnificent colony of (native)

Male Eclectus Parrots appear to blend into their surroundings, but they also have strong ultraviolet colouration, visible to other Eclectus but not humans.

© ANDREW HENLEY (ARUS)

MICHAEL McCOY/NATURE FOCUS

Although breeding females are fed exclusively by males for many months, females do feed themselves when breeding is over.

Metallic Starlings (*Aplonis metallica*) with their multitude of nests that hang from the upper branches. Preying on all these creatures is a resident pair of Grey Goshawks (*Accipiter novaehollandiae*), and a large Slaty-grey Snake (*Stegonotus cucullatus*) haunts the ground below, waiting for the starling chicks to fall. When they are all at home, the 12 male and five female Eclectus Parrots light up the branches like a Christmas tree.

Although we approach nest trees cautiously, we are often met by the raucous cry of Eclectus females quickly exiting their hollows. During our visits they usually sit in nearby trees but those with eggs or chicks re-enter the hollows immediately upon our departure. Without such permissive behaviour our research would not be possible. One of our first discoveries was that, unless threatened, females virtually never leave the vicinity of their nests, relying instead on the males to bring them food. They sit in their holes with their resplendent red heads sticking out, and watch the world go by for at least a month before laying eggs (usually in September). The females do all the incubation and brooding of small chicks. Where they differ from most other parrots is that they refuse to leave the hollow when the chicks are older.

ROLAND SEITRE

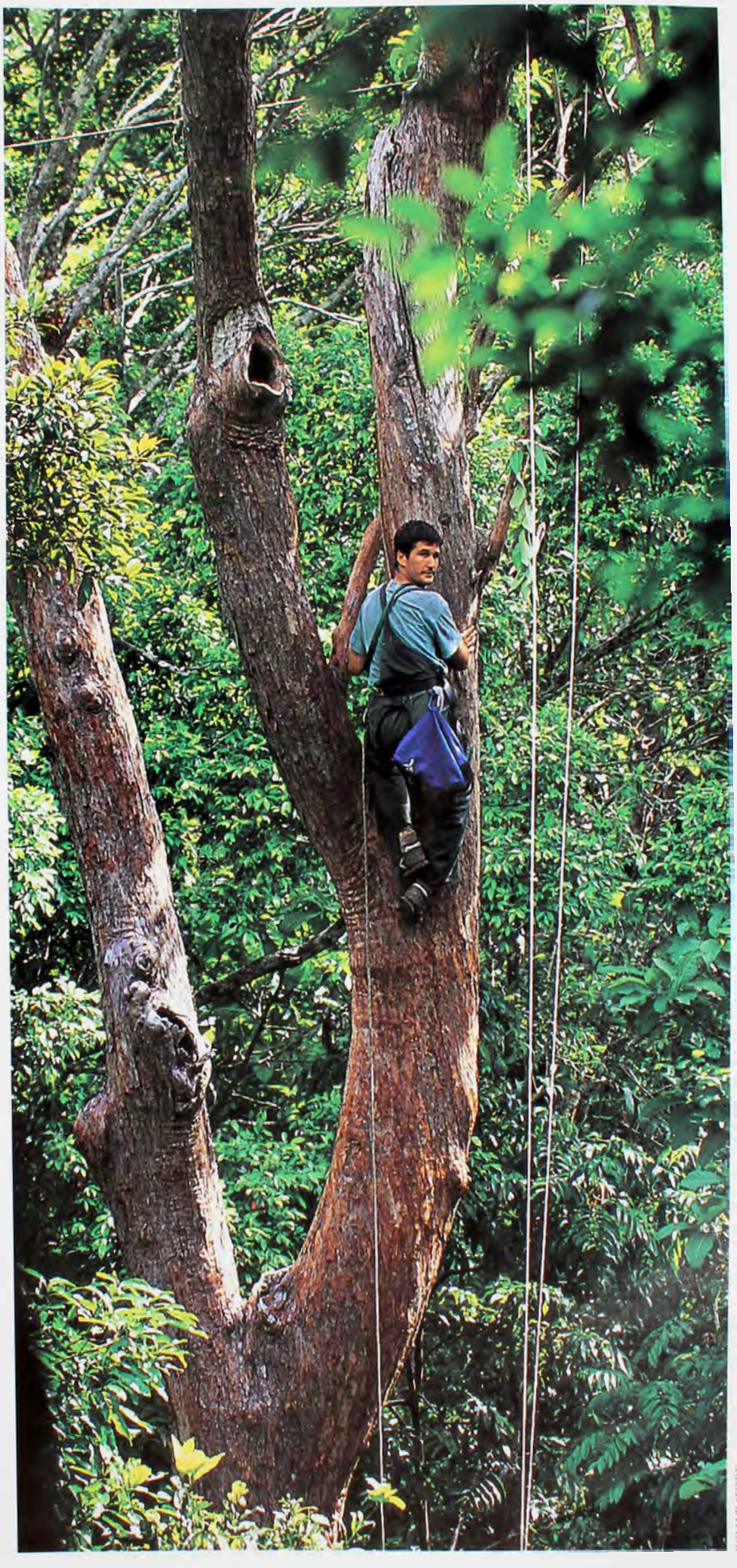
Why do male Eclectus Parrots differ so markedly from females?

Even after the chicks have fledged, the females still return to their hollow every day to make sure no intruders have usurped it. They attack any other Eclectus that venture too close, and even attack their own males if they try to enter the hole. The nest hollow is clearly a prize worth fighting for!

Herein lies the first clue to solving Hamilton's puzzle. Nest hollows are typically in very large emergent rainforest trees. In fact 75 per cent of our known hollows are in just three major tree types: figs (*Ficus* spp.), milkwoods (*Alstonia* spp.) and the Black Bean (*Castanospermum australe*). The trees used for nesting are clearly visible from the air as they tower prominently above their neighbours. Using a light aircraft, we conducted comprehensive aerial surveys for potential nest trees in the rainforests in and around Iron Range National park, and found that there are only a few hundred suitable trees in the whole region (which incidentally makes up over half of the Australian Eclectus habitat). Not only are potential trees rare, but holes vary remarkably in quality, with over half of those we monitor closely being prone to flooding in heavy rain. When that happens, even large chicks drown and the previously cosy hollow is unavailable for several weeks. A good hole is clearly one that stays dry for at least four months over the crucial breeding period (one month incubation plus three months from hatching to fledging). It seems then that scarcity, coupled with quality, makes a good hole hard to come by. This is born out by the behaviour of some females that guard tiny little holes that are clearly inadequate for breeding, but which gradually enlarge to something more usable over the years. We don't yet know whether these females literally wait years for hollows to form, or whether it is more normal to join the queue for an already formed hollow.

RED COLOUR IN PARROTS *comes from a poorly understood pigment that is probably manufactured by the bird rather than ingested.*

So how does this relate to the female's colour? All Eclectus nest-hollows are in bright light, and females sit at the entrance with their head and chest glowing like a beacon. It is hard



Climbing to a nest hollow. This tree (*Lofastemon* sp.) has three nesting hollows, two for Eclectus Parrots and one belonging to a pair of Sulphur-crested Cockatoos.

to escape the conclusion that their bright red colour is a signal to other females, one that says "this hollow is occupied", but it might also signal their ownership of a good hollow to prospective mates. We catch adult Eclectus by stringing strong mist nets high in the rainforest canopy, an activity that is gruelling, time-intensive and often unrewarding. But it is occasionally very worthwhile because capture of a bird opens up so many avenues of research. Most importantly, we can colour-band birds for individual recognition, and take blood samples for DNA analysis to determine relationships within the breeding group. To analyse colour, we examine captured individuals using a spectro-radiometer, an instrument that allows precise measurement of the colour spectrum of any patch of feathers. Our first discovery was that the head, cheeks and face are indeed the brightest of any red patch on the female, hardly surprising when it is these that are displayed at the hole.

Unlike many passerines (perching or songbirds) that enhance their red patches with carotenoids obtained from the diet, red colour in parrots comes from psittacofulvin, a poorly understood pigment that is probably manufactured by the bird rather than ingested. Some finches use the extent of carotenoid-based red in their plumage as a signal of their health and vigour when attracting females. The intensity of red in Eclectus Parrots varies between individuals, but it is too early to say whether the degree of colour is a trait that could provide a potential signal of a female's genetic (that is, heritable) quality or health.

Why then do males differ so markedly from the females? If we remember that females stay at the hollow and the males go out to forage, it begins to make sense. The males spend virtually all their time in the tops of widely dispersed fruiting trees and, unlike the females, they may prefer to blend in with their green surroundings for safety from aerial predators.

THEIR GREEN POSITIVELY GLOWS IN THE ULTRAVIOLET,

a colour beyond the blue end of the colour spectrum that is not visible to humans but is within the normal range for many birds. Could females use this colour to choose their mates?

However, our spectro-radiometer tells us that their green has an unexpected quality. It positively glows in the ultraviolet, a colour beyond the blue end of the colour spectrum that is not visible to humans but is within the normal range for many birds. Could females use this colour to choose their mates? Although we are closing in on Hamilton's puzzle, our studies of Eclectus colour are so far preliminary, and all such colour measurements must be interpreted in context of the background light environment, and a better understanding of their mating system.

FEMALE PROTECTION OF, and confinement to, their hollows has provided a wonderful lead on another front. Our studies have confirmed that Eclectus breed cooperatively in stable groups, a social system that is exceedingly rare among parrots. This mode of breeding, in which some birds help care for the young without contributing genetically, occurs in about three per cent of birds but has only been suspected in a couple of parrot species (for example the Vasa Parrot, *Coracopsis vasa*, from Madagascar). In Eclectus Parrots, males provide all the food for the female and her chicks. Many males regurgitate food to feed the one female at the nest-hollow, and she then passes the food onto any chicks. It's a beautiful sight when the female's red is contrasted with the shiny green of the males when she slips out of the nest to receive food from a number of males that have returned together. It seems that a shortage of hollows and hence breeding females, together with the extra workload of supporting the females for so long, have driven Eclectus to a system of permanent sociality in which males share the burden of supporting breeding females. They cannot all be fathers however, as females only lay two eggs per clutch, and we have observed up to 11 males (although usually

A two-month-old female chick has her colours scanned by a spectro-radiometer. As well as providing accurate measures of colour brightness and intensity, the spectro-radiometer picks up ultraviolet colour not visible to the human eye.

ROLAND SEITRE

around five) at one hollow from our carefully hidden observation hides built in neighbouring trees. We think that some of the males are mates, and some are offspring, and one of our major aims is to use molecular techniques to work out all of the relationships within the social group.

So nest-hollows seem to be an important force in Eclectus ecology, and may well be linked to both their colour patterns and social system. We spend a lot of our research time moving between widely dispersed nest trees and climbing to the hollows using single-rope techniques. It's a joyous experience rising up through the gloom and oppressive humidity, and breaking through the canopy into the breezes and brighter light. It's a different world up there looking down on passing birds, beetles and butterflies. It is also an incredible privilege to be part of the Eclectus' world, especially upon reaching the hollow and looking in to see the fluffy chicks.

Another unusual trait of Eclectus is that chicks 'reveal' their sex at a very early age. From only ten days old, we can tell males by their light grey down and females because they are considerably darker. The chicks then move straight into adult plumage colours. The first signs of their colour appear on their heads at about four weeks old, and from then on they only get brighter. By the time they fledge, they are virtually indistinguishable from adults. Very few birds show their sex so young, and few even grow directly into adult plumage. This tempts us to guess that developing colour is somehow adaptive for young Eclectus Parrots. Whether it helps their survival in the nest, or helps them when they emerge into their intense social world, we are not yet sure.

We may not know why they develop colour early, but we are sure that producing chicks of the right sex is important. In fact we have strong evidence that breeding females somehow control the sex of their offspring. In an analysis of the records from captive breeders, we found that a number of breeding females (but not all) produced highly improbable strings first of one sex and then the other, over

ROLAND SEITRE

A maturing female chick cautiously sticks her head out of the nest hole.

ECLECTUS PARROT

Eclectus roratus

Classification
Family Psittacidae; up to 10 subspp.

Identification
Large, stocky parrot with short, square tail and long, round-tipped wings. Male generally brilliant green, with bend of wing blue, and under wing and sides of body red. Female mostly red, with blue/purple lower breast and abdomen. Immatures difficult to distinguish from adults. Female entirely red in 2 subspp. (*E. r. cornelia* and *E. r. riedeli*). Cape York subsp. (*E. r. macgillivrayi*) the largest.

Distribution and Habitat
Found in lowland and lower montane forest in the Moluccas, Sumba, New Guinea, Solomon Islands and Cape York. Requires hollows in mature, usually emergent forest trees.

Diet
Fruits, seeds, leaf buds, blossoms and nectar.

Reproduction
On Cape York, lays two eggs Aug.–Sept. so that demands of feeding nestlings coincide with major fruiting periods of late dry/early wet season. Incubation 30 days. Up to 3 months from hatching to fledging. Female stays at hollow for up to 8 months of year. Multiple males feed her at hollow entrance; she regurgitates food to chicks. Many chicks lost to predators, especially Amethystine Pythons, and many drown when holes flood in heavy rain. Fledging success low, with approx. 1 egg in 10 resulting in a fledgling. Breeding females also vulnerable to predators while occupying nest hollow.

Status
Cape York subsp. 'near threatened' due to small population in limited habitat. Threat to some subspp. from poaching for avicultural trade may be reduced due to successful captive breeding.

ROLAND SEITRE

Unlike most birds, Eclectus Parrot chicks develop straight into their adult plumage.

(Right) Sexual selection has had the unusual effect of making the female Eclectus Parrot bright and beautiful.

their entire breeding lifetimes. The most extreme example was one female that over 12 or so years produced 20 consecutive sons followed by 13 consecutive daughters. We examined the sex sequences in a variety of ways and concluded that these patterns could not have occurred by chance (assuming that each sex is produced with 50 per cent likelihood). All the signs pointed to female control, but because these were captive birds, we could not say why or in what circumstances she wanted a boy or a girl.

It will take many years of studying wild Eclectus to be able to say which sex is produced when, but one guess is that it has something to do with their system of cooperative breeding. In Seychelles Warblers (*Acrocephalus sechellensis*) for example, breeding females produce the helping sex (females) when they need help, but the dispersing sex (males) when the territory is too crowded. Such examples of adaptive sex allocation in birds are still rare in the wild, and, although an exciting challenge, it is a touch frustrating to be working on a species with amongst the strongest control over the sex of their offspring, but with little idea of why they do it.

ECLECTUS PARROTS

offer a combination of challenge and intrigue rarely seen in the animal world.

All our leads keep coming back to hollow scarcity, and it would be tempting to link production of the desired sex to the female's needs in maintaining her hollow. Perhaps she needs an army of helper males to maintain her hollow in the face of would-be usurpers, and only switches to producing females once that goal is achieved. Maybe she is programmed to start producing female offspring when her own prowess begins to decline and she is ready to bequeath her hollow to a daughter. Or perhaps it is only breeding females in very good condition, or with a host of male helpers, that attempt to produce daughters because young females have to be strong, healthy and bright to acquire a good hollow. Most variations on these themes are plausible, and ours will be a complicated task sifting through long-term data to tease apart the possibilities.

Between their extraordinary colouration, unusual social system, and ability to alter the sex of their offspring, combined with the difficulties of working with them in the field, Eclectus Parrots offer a combination of challenge and intrigue rarely seen in the animal world. It would be nice if we could tell Bill Hamilton about our progress; how close we get to the definitive answers in our own lifetimes is another question.

STEPHEN DAVID MILLER/ NATURE IMAGE LIBRARY

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DR ROB HEINSOHN AND DR SARAH LEGGE ARE IN THE DIVISION OF BOTANY AND ZOOLOGY, AUSTRALIAN NATIONAL UNIVERSITY. ROB IS A QUEEN ELIZABETH II FELLOW AND SARAH RECENTLY COMPLETED HER PH.D. ON THE SOCIAL SYSTEM OF LAUGHING KOOKABURRAS. THEY STARTED THE ECLECTUS PARROT PROJECT IN 1997, AND HAVE A KEEN INTEREST IN THE BIOGEOGRAPHY OF CAPE YORK AND NEW GUINEA. THE AUTHORS ARE ESPECIALLY GRATEFUL FOR THE GENEROUS SUPPORT OF PETER AND EMMA HUYBERS, AND MICK AND CLARE BLACKMAN.

WHAT SORT OF ANIMALS COULD THIS MOONSCAPE POSSIBLY SUPPORT?

LIFE ON THE MOON

BY JOHN READ

JOHN READ

The Breakaway Ranges form a colourful backdrop to the Moon Plain. Temporary streams originating in these ranges provide sparse yet valuable flows of water and nutrients onto the plain following rain. The Gibberbird (inset) is the only bird species found more frequently on the Moon Plain than in adjacent habitats.

FEW HABITATS ON EARTH appear as barren as the Moon Plain. From the comfort of an air-conditioned car en route from Coober Pedy to Oodnadatta, with ground temperatures regularly exceeding 60° C, the landscape is breathtakingly desolate. Fist-sized rocks, reminiscent of those photographed by the Mars Explorer, are the dominant feature of this northern South Australian landscape. Shards of gypsum shine like shattered windscreens over the 'lunar landscape', which has formed the backdrop to popular feature films such as "Mad Max", "Beyond Thunderdome" and "Ground Zero". Perennial plants can't survive in the cracking clay soils, which rapidly desiccate after what little and erratic rain falls. What sort of animals could this moonscape possibly support?

In recent years an astounding community of animals has been recorded in this apparently hostile environment. OK, I hear you thinking, there's probably an assortment of indestructible lizards that can survive in these conditions with their tough skin and minimal food and water requirements. After all, the Lake Eyre Dragon (*Ctenophorus maculosus*) lives in one of the world's harshest habitats out on the dry salt crust of nearby Lake Eyre. And you're right, but only in part.

Central Bearded Dragons (*Pogona vitticeps*), which are known locally by their Aboriginal name 'Cadney', occasionally wander out into the barren landscape or perch up on the Dingo Fence, which dissects the Moon Plain. Four-pored Earless Dragons (*Tympanocryptis tetraporophora*) are also reasonably common, as are Gibber Dragons (*Ctenophorus gibba*). Unlike their close relatives, the netted dragons, which use burrows to shelter from predators and temperature extremes, Gibber Dragons are generally not burrowers out in these puffy soils. The soil is too heavily cracked and friable to support burrows, so the Gibber Dragons have developed another technique for avoiding predators and the sun. When charging off on their back legs doesn't work, they dive through the thin clay crust and literally swim through the soft, underlying bulldust. From above there is no way of discerning how far they have 'swum' because, with the exception of the entrance hole, the thin clay crust remains undamaged.

MICHAEL CERMAN

HOWEVER, IT IS NOT the robust, heat-tolerant lizards that dominate the fauna of the Moon Plain. After a comprehensive fauna survey of the different habitats in the Lake Eyre South region, Helen Owens and I found that the cracking gypseous soils of the Moon Plain supported the least diverse assemblage of arid-zone reptiles and birds in

A Central Bearded Dragon makes its way out on the plain to take advantage of the flush of annual vegetation that follows a rain.

STEVE WILSON

The seldom-seen Gibber Dragon is unusually abundant on the Moon Plain. This one is basking and searching for insects from its elevated vantage point.

the region, but the most diverse community of mammals. The lack of trees explains the scarcity of birds, which are typically most diverse in structurally complex habitats. However, the low number of reptile species on the Moon Plain is at first surprising in what is usually considered to be 'the land of reptiles'. Although mammals dominate the desert faunas in Africa and America, our deserts typically support many more lizards (in terms of species and numbers) compared with mammals. A likely reason for the low reptile numbers on the Moon Plain is that termites and ants—key food resources for many lizards—are scarce, being unable to form permanent galleries in the crumbly, self-mulching soils. As a result, rather than being removed by termites and ants, most of the seeds from the ephemeral vegetation on the plain are accessible to rodents foraging within the cracks. In addition, crickets, which thrive on the abundance of organic debris that accumulates in the absence of large termite populations, provide an ideal food source for carnivorous mammals.

Concealed within the cracks and 'crab-holes' of the Moon Plain is a rich assemblage of small mammals that only venture out at night. Tiny Paucident or Giles' Planigales (*Planigale gilesi*), which weigh only about eight grams, are fearless and ferocious predators of crickets and spiders, some of which are nearly the same size. Other carnivorous marsupials on the plain include the Stripe-faced (*Sminthopsis macroura*) and Fat-tailed Dunnarts (*S. crassicaudata*). Although at first it seems unusual that two similar-sized, closely related dunnarts can coexist on the plain, closer inspection reveals that the Fat-tailed Dunnart generally occupies habitats that are even more sparsely vegetated than those preferred by Stripe-faced Dunnarts.

Marsupial 'mice' are not the only small mammals that take advantage of the cracking soils. The most significant placental mammal that thrives on the Moon Plain is the Plains Rat (*Pseudomys australis*), which is considered vulnerable to extinction. The Plains Rat is actually a large soft-furred native mouse or rodent, and is considerably more placid than the larger and more aggressive true rats (*Rattus* species). Like many other arid Australian mammals, the Plains Rat has declined considerably in abundance and range since European settlement. Once they occurred from the Nullarbor Plain and Coorong regions of South Australia across to western Queensland and the southern Northern Territory. However, Katherine Moseby (National Parks and Wildlife Service) and colleagues believe that the Moon Plain and adjacent similar plains on the western margin of the Lake Eyre Basin are now the stronghold for the Plains Rat. Predation by introduced Cats and Foxes, and competition by Rabbits, are thought to have played an important role in the species' decline. However, luckily for the rats, Cats and Foxes are rarely found on the Moon Plain because the crumbly soils and dry vegetation are not suitable for Rabbits, their main prey.

Smaller than the Plains Rat, but considerably more aggressive, is Forrest's Mouse (*Leggadina forresti*). *Leggadina* species are distinguished from most other arid-zone mice by having a shorter tail than their body. Although they sometimes coexist with Plains Rats, Forrest's Mice typically occupy smaller, shallowly cracked drainage depressions, which are less suitable for their larger and more gregarious cousins. Other rodents found in the area include the introduced House Mouse (*Mus musculus*) and the Desert Mouse (*Pseudomys desertor*). House Mice are not thought to competitively exclude native rodents because they are only abundant for short periods after rain and quickly disappear when the going gets tough. Desert Mice are particularly interesting in that they were not recorded in South Australia for 19 years until 1989.

Tiny yet tenacious Paucident Planigales often subdue large, dangerous prey items like this centipede.

CATS AND FOXES ARE RARELY FOUND

on the Moon Plain because the crumbly soils and dry vegetation are not suitable for Rabbits, their main prey.

Although they have since been recorded in a variety of localities and habitats, including the Moon Plain, Desert Mice are more abundant in wetter habitats of the outback, such as sedgeland and samphire shrubland.

In dry times, which are typical for the Moon Plain, these mammals, and particularly the rodents, are restricted to low numbers in small patches of seasonally denser or damper vegetation. Although the plain looks flat and uniform, slight undulations form run-off regions that direct water to the comparatively rich 'run-on' patches. Even more important are the small, ephemeral streams, which divert water off the surrounding breakaway ranges and gibber pavements into the plain. Although these areas are also normally devoid of perennial vegetation, they are essential for the persistence of rodents on the plain.

THE REMAINDER OF THE PLAIN IS home to the occasional Richard's Pipit (*Anthus novaeseelandiae*), Little Crow (*Corvus bennetti*) or Gibberbird (*Ashbyia lovensis*). The pale orange Gibberbird and the bulldust-swimming Gibber Dragon, both named after the polished round gibber stones, can be found perching on the grey shale boulders, which often contain fossils of marine life. These fossils attest to the period when the centre of Australia was an enormous inland sea. The Gibberbird and Gibber Dragon are largely restricted to these stony flat plains, which accounts for their apparent scarcity. In contrast, Richard's Pipits and

Flocks of Budgerigars and other granivorous birds such as Cockatiels and Flock Bronzewings descend upon the Moon Plain to take advantage of seeding grasses after rain.

Little Crows are among the most widespread birds in open habitats throughout arid Australia.

Following heavy rains, grasses, daisies and peas erupt from the sodden earth, rapidly attempting to flower and seed before the soils dry out to their characteristic harsh, cracked form. This brief growth period is particularly important for two recently described plants, *Nicotiana truncata* and *Stemodia haegii*, which are largely restricted to the Moon Plain. Rodent populations explode as seeds become abundant. Flocks of Budgerigars (*Melopsittacus undulatus*) and Cockatiels (*Nymphicus hollandicus*) dart across the plain looking for seeding grasses. Small numbers of Flock Bronzewings (*Phaps histrionica*), which once formed huge flocks in central Australia but have declined since Cattle and feral predators invaded their grasslands, move out to the plain from their stronghold in the Barkly Tablelands of the Northern Territory and the channel country of Queensland.

This exuberance of life also attracts predators. Black Falcons (*Falco subniger*), which swoop like fighter planes, and Spotted Harriers (*Circus assimilis*), reminiscent of lumbering bombers, patrol the plain for birds, particularly nomadic species that move into the area to capitalise on the profusion of insects and seeds. Letter-winged Kites (*Elanus scriptus*) and owls move silently through the night skies, searching for rodents and small marsupials. Discovering a roost of owls or kites is a great boon for biologists surveying the mammal fauna of the region. These birds regurgitate pellets of indigestible bones and hair. By sorting through the pellets, which may each contain the remains of up to ten animals, Graham Medlin (South Australian Museum) has been able to piece together the diet of these birds. In turn, the local presence and relative abundance of a range of mammal species can be assessed. To collect the same information by standard trapping methods would take many more days of time and effort. Using the same technique with older owl pellets, Graham has also shed considerable light on the former range of many small mammals, some of which are now extinct or critically endangered in the arid zone.

But birds are not the only predators out on the plain. Arguably the best-adapted predator of all is the world's most venomous land snake, the Inland Taipan or Fierce Snake (*Oxyuranus microlepidotus*). The Inland Taipan was rediscovered in 1974 after being 'lost' to science for nearly 100 years. Until recently it was thought to be restricted to the channel country of south-western Queensland, south-eastern Northern Territory and north-eastern South Australia where it preys, almost exclusively, upon the Long-haired Rat (*Rattus villosissimus*). However, in 1992 this snake turned up near the opal-mining town of Coober Pedy, just a short slither from the Moon Plain. Long-haired Rats briefly colonised the Coober Pedy region in the mid 1970s but have not

BILL BELSON/LOCHMAN TRANSPARENCIES

Richard's Pipit is a frequently encountered bird throughout arid Australia. It is one of the few species that can still be found on the Moon Plain during droughts.

The world's most venomous land snake, the Inland Taipan, makes its way across the Moon Plain in search of Plains Rats and other small mammals.

JOHN READ

been recorded there since. Therefore, scientists were initially unsure whether the Inland Taipan permanently inhabited the Coober Pedy region or was a misplaced hitchhiker from the Birdsville area. The subsequent collection of a further eight specimens, and closer investigations of the habitat and food supplies in the region, suggest that Inland Taipans are indeed residents on the Moon Plain. Unlike the avian predators that retreat from the district, Inland Taipans hole up in the most productive areas on the plain during dry times and move into surrounding areas following good seasons when mammal populations increase.

Inland Taipans probably escaped detection for so long because they are rarely active in hot weather. Most of their life is spent concealed in the cracks where they shelter from the heat and predators such as eagles and Dingoes. In these cracks they can also find their food (the small mammals hidden below the surface), so there is little need for them to move above ground, except when searching for a mate. Although they have unfairly been called 'Fierce Snakes', my encounters with these beautiful creatures suggest they are shy, intent on saving their incredibly toxic venom for their prey.

Far from being the sterile wasteland that it appears at first glance, the Moon Plain hosts a rich assemblage of mammals and their specialist predators in a unique enclave within the land of the lizards.

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DR JOHN READ IS AN ECOLOGIST AND LAND MANAGER WITH WMC RESOURCES AT OLYMPIC DAM, SOUTH AUSTRALIA. HIS PRINCIPAL RESEARCH INTERESTS INCLUDE THE ECOLOGY OF ARID-ZONE VERTEBRATES, BIO-INDICATORS AND LAND-MANAGEMENT ISSUES IN NORTHERN SOUTH AUSTRALIA. JOHN WAS RESPONSIBLE FOR COORDINATING A BIOLOGICAL SURVEY OF THE LAKE EYRE SOUTH REGION, INCLUDING HABITATS SUCH AS THE MOON PLAIN, FOR A PROJECT CONDUCTED BY THE ROYAL GEOGRAPHICAL SOCIETY OF SOUTH AUSTRALIA AND WMC RESOURCES.

HONEY HAS BEEN USED THERAPEUTICALLY THROUGHOUT THE HISTORY OF THE HUMAN RACE.

A SPOONFUL *of* HONEY

BY SHONA BLAIR

NEXT TIME YOU SPREAD HONEY ON YOUR TOAST, think about spreading it over yourself instead. No, this is not the advice of a perverted scientist who has spent too many hours locked up in her lab, but an ancient remedy that has recently been scientifically proven. Honey has been used therapeutically throughout the history of the human race, but until now has been largely ignored by modern medicine. This sticky

BRIAN CHUDLEIGH

A hive of activity as the queen bee is surrounded by her workers. The workers clean the cells in preparation for the baby bees as well as feed and tend their queen.

concoction, produced by bees to feed the hive, is an incredibly effective antibacterial agent. My own research has found that one particular type of Australian honey is a potent killer of the deadly Golden Staph bacterium (*Staphylococcus aureus*). This insidious microbe has been responsible for many deaths around the world and is becoming particularly menacing because of its increasing resistance to conventional antibiotics.

IF YOU WERE

so inclined, you could eat honey that had been exhumed from ancient Egyptian tombs.

As part of my Ph.D. project, I tested a special sort of thick or 'jelly-bush' honey against some antibiotic-resistant Golden Staph specimens obtained from a Sydney hospital. The bacteria were grown in solutions containing various amounts of the honey. A solution containing just one per cent jelly-bush honey was enough to stop the growth of these microbes for three hours. A two per cent solution stopped growth for five hours, and a three per cent solution for ten hours. At four per cent, the organisms were unable to grow for over 24 hours. Miraculously, just six per cent jelly-bush honey killed them all!

Honey is an effective antibacterial agent for a number of reasons. As we all know, honey is very sweet because it contains large amounts of sugar. The sugar molecules bind tightly to any water molecules that may be present, leaving very little free water available. Like all living things, microbes need water to survive. Consequently, pure honey is not a suitable environment for the growth of micro-organisms. This is the main reason that honey long forgotten in the back of the cupboard never spoils (and also why, if you were so inclined, you could eat honey that had been exhumed from ancient Egyptian tombs).

When bees collect the nectar they use to make honey, they mix it with an enzyme called glucose oxidase present in their saliva. If water is added to honey, this enzyme reacts with the glucose present, producing hydrogen peroxide. Hydrogen peroxide, besides being a well-known bleaching agent (once used liberally by surfies in their hair), is also a known antibacterial agent. This property accounts for most of the reported antibacterial activity of honeys from around the world.

The high acidity of honey also contributes to its antibacterial activity. The pH of honey ranges from 3.2 to 4.5, which most pathogens find intolerable.

But these factors alone can't account for the particular potency of some sorts of jelly-bush honey. When I tested the effects of an artificial honey (made by mixing the four main sugars of honey with some acid) against the drug-resistant Golden Staph, I found that at least six times more artificial honey was needed to achieve similar results to those obtained using the jelly-bush honey. I then added an enzyme called catalase to a range of honey solutions, which neutralises any hydrogen peroxide present. This resulted in the loss of antibacterial activity in most honeys, but not the jelly-bush honey. These experiments indicate that some 'mystery factor' other than high sugar content and hydrogen peroxide production is responsible for the observed antibacterial effects of jelly-bush honey. The acidity of jelly-bush honey was also ruled out, because the growth medium used in these experiments actually buffers the low pH of honey, nullifying its effects.

The European Honey Bee (*Apis mellifera*) is responsible for the production of most of the world's honey. Therefore, the extra antibacterial activity we see in some jelly-bush honey (and also manuka honey from New Zealand) is unlikely to be attributable to anything added by

SHONA BLAIR

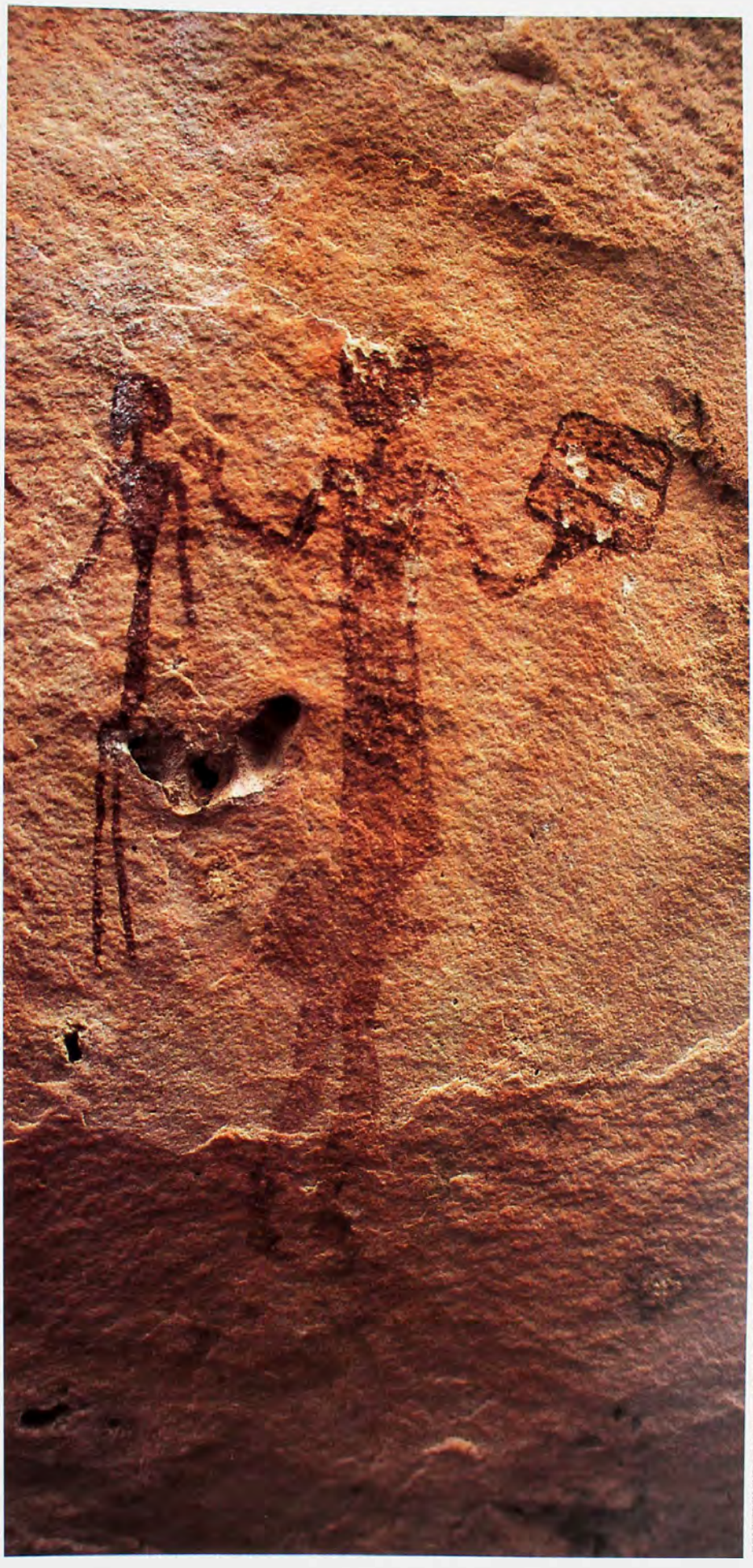
A petri dish of Golden Staph on solid growth media. However, note the clear zones around the wells that were filled with active jelly-bush honey. These zones of inactivity are the result of the honey diffusing through the media and inhibiting the growth of this nasty pathogen.

the bees. It is more likely to be a plant component directly carried over in the nectar or somehow altered as the nectar is turned into honey. The floral source for jelly-bush honey is an Australian *Leptospermum* species, probably *L. polygalifolium*. But even though this plant is found nationwide, jelly-bush honey with the extra antibacterial factor has only been collected from coastal regions in northern New South Wales and southern Queensland. And, even in these areas, some hives may produce active jelly-bush honey for several years in a row, and then 'normal' honey (that is, without the extra antibacterial activity) the next. New Zealand's manuka honey derives from another *Leptospermum* species, *L. scoparium*. So far, only these two species of *Leptospermum* are known to produce active honey. We are clearly at a loss to explain how active jelly-bush and manuka honeys achieve their remarkable properties. Identification of the exact component(s) responsible for 'superhoney' remains the Holy Grail in medicinal-honey research.

NUMEROUS ROCK PAINTINGS across the world show that many ancient cultures prized and revered bees and honey. For example, in southern African San rock paintings, bees and honey occur in contexts that suggest they were among a restricted range of topics believed to have *n/um* or 'supernatural potency'. Also, some San prefer to perform their Medicine or Trance Dance when the bees are buzzing, so they can 'tap into' the bees' potency, thus helping to heal the sick, make rain, control movements of game, or combat malevolent forces.

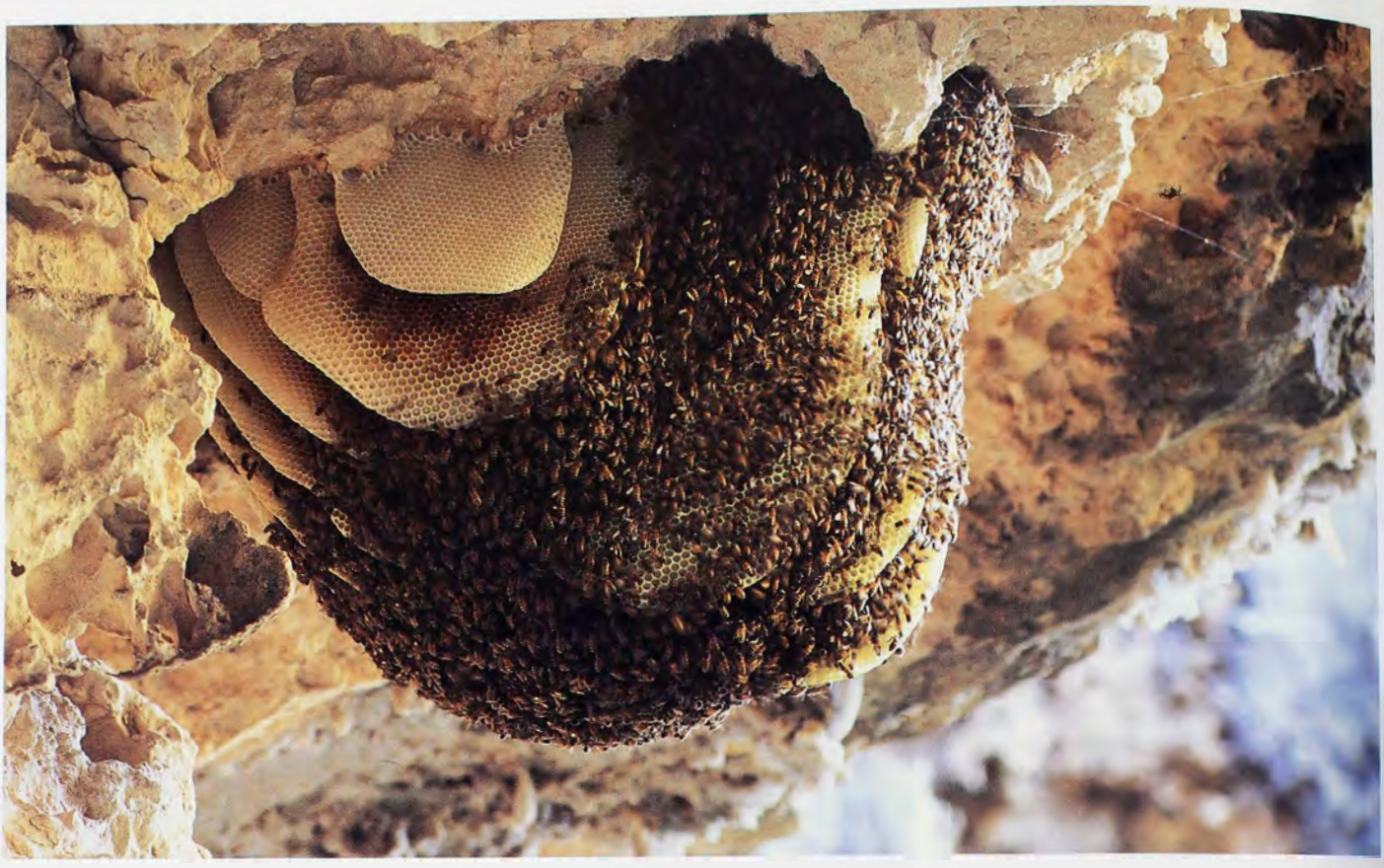
Almost all cultures that had access to honey held it in high regard and used it medicinally. The Chinese, Greeks, Romans, Arabs, Indians, Aztecs, and Indigenous Australians (see box), are just some of the peoples who believed in the therapeutic use of honey. The ailments treated with honey were as diverse as the cultures that used it and include anything from insect bites to war wounds.

The ancient Egyptians were incredibly efficient beekeepers. They produced thousands of tonnes of honey



COURTESY SVEN OZZMAN, ROCK ART DEPT, NATIONAL MUSEUM OF SOUTH AFRICA

Cave art from northern South Africa. A procession of people is depicted, with the front person holding some honey comb. This painting was found in a shelter that contained much shamanic imagery.



JIRO LOCHMAN/LOCHMAN TRANSPARENCIES

A bee hive sheltered under a cliff. Made from folds of hanging wax many bee hives such as these have been depicted in ancient rock art.

every year, moving their hives up and down the Nile on barges following the nectar flow. Their medical practices were highly sophisticated and effective, with honey being included in over 500 of their 900 prescriptions. Burns, skin sores, eye infections and sexually transmitted diseases were among the numerous conditions they treated successfully with honey. Apparently, they even used a mixture of honey and crocodile dung as a contraceptive (I imagine it would be rather hard to attract a mate using this recipe—perhaps this is why it was so effective!).

Apart from clearing infections, there is much anecdotal evidence indicating that honey may actually promote wound healing. For example, in ancient India honey was applied after surgery, the ancient Greeks believed honey to be beneficial against ulcers and sores, and the Romans found honey effective in treating ulcerated ears. The *Leechbook of Bald*, an English text for medical practitioners from 925 AD, recommends honey for removal of scabs, sores of the eye, burns and as a dressing for wounds after amputation.

Wound healing is an incredibly complex process that we still do not fully understand. However, we do know that molecules called cytokines are fundamental to the process. When cytokines are released from our cells, they act as mediators that influence other cells to regenerate and restore tissue, as well as to fight infection. Macrophages are an important type of cytokine-releasing cell. These cells are key players in our body's defence system and are usually found in high numbers at a wound site.

BURNS, SKIN SORES, *eye infections and sexually transmitted diseases were among the numerous conditions treated successfully with honey.*

In an attempt to validate the ancients' faith in the healing powers of honey, I investigated the effect of three different honeys (active jelly-bush and manuka honeys, and a mixed-pasture honey from New Zealand) on human cells. I found that, when human macrophages were exposed to any one of the honeys, various cytokines were released at significant levels. These were tumour necrosis factor-alpha (TNF-α), interleukin-1 (IL-1) and interleukin-6 (IL-6). To ensure that the cytokine stimulation was not due to the sugars in honey, I exposed a set of macrophages to artificial honey as well, but this did not induce cytokine release. Acidity is also unlikely to account for cytokine release (because of the buffering effect of the growth medium). Although I did not control for hydrogen peroxide activity, this is just one of over 150 components in honey that could be working, either singly or together, to stimulate wound healing. Also, it may well be that the antibacterial properties of honey have nothing to do with the wound-healing properties, and that an

This European Honey Bee has been busy collecting pollen, as we can see from the yellow mass on its hind leg. Back at the hive the pollen will provide essential protein.

BRIAN CHILDSON

entirely different set of factors is involved. The hunt for the super-healing components of honey continues.

DESPITE THE HISTORICAL success and growing scientific evidence of honey's therapeutic attributes, modern Western medicine has largely ignored it. A few doctors, however, are beginning to incorporate honey into their treatment regimes.

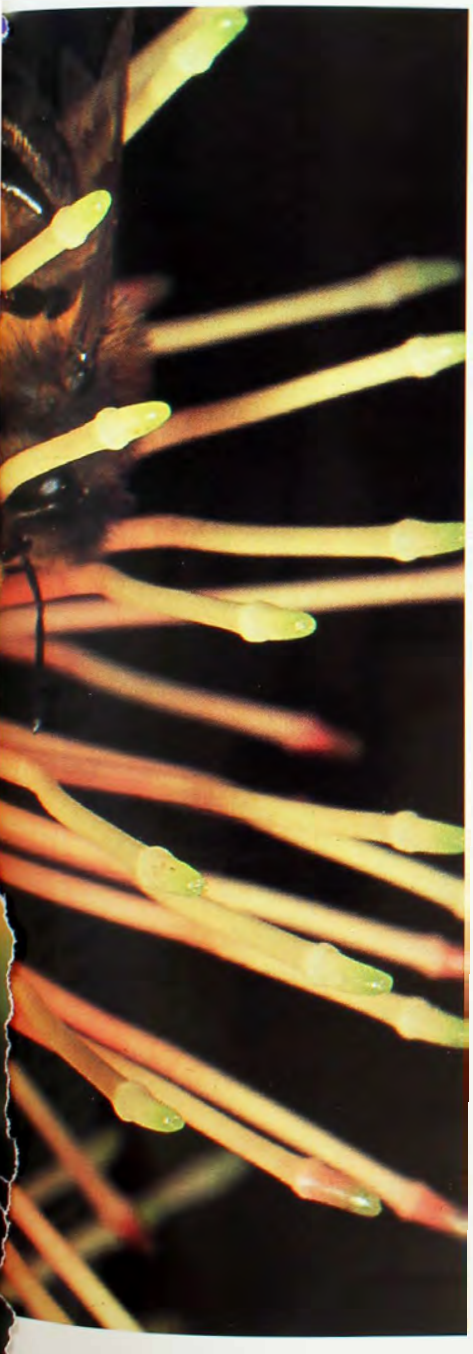
Ulcers, for example, are painful sores caused by disintegration of tissue, and are notoriously difficult to treat. On a recent study trip to the United Kingdom, I met a patient who was suffering from an ulcerated ankle. The ulcer had plagued the patient for over six months, and it was not responding to conventional treatment. The problem was compounded by a drug-resistant Golden Staph infection. Within two weeks of daily honey dressings, the infection had cleared and the ulcer was significantly reduced. Within a month, the ulcer had completely healed. I have heard many similar reports. Honey was even effective on an ulcer that had previously persisted for over three years, despite highly sophisticated modern dressings and skin grafts.

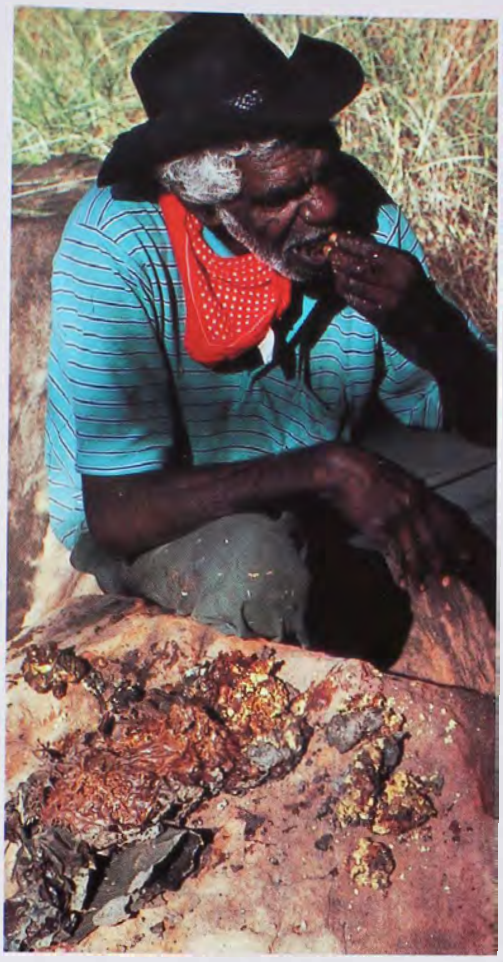
Skin is your first line of defence against microbial infection, and most of the time it does an incredibly good job

Although introduced to Australia, the European Honey Bee is more than happy to collect nectar from many of our native flowers—a phenomenon that keeps many of our beekeepers employed!

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

at keeping out the potential pathogens that constantly surround us. However, burn victims lose this crucial barrier. Consequently, burns are not only painful but they are also very susceptible to infection. An Indian physician, M. Subrahmanyam, has published numerous reports on controlled clinical trials of honey being used to dress burns. Compared to conventional dressings, honey was found to not only eradicate and prevent infections and promote faster healing, but to reduce scarring and pain. Interestingly, Subrahmanyam also successfully stored human skin in honey for up to 12 weeks. The tissue remained viable and was able to be





RICHARD FULLAGAR

Honey continues to be an important medicinal and food resource for Australian Aborigines. Dusty Legune from the Kimberley has broken into a native bees' nest at the base of an old termite mound and eats the 'sugarbag' or honey.

Aborigines and honey

Indications from ancient rock paintings suggest honey may have been a long-sought-after food and medicine for Aboriginal Australians. For instance, there are paintings in Kakadu National Park and Arnhem Land, thought to be at least 10,000 years old, that show people using hafted stone axes to break into the hives of log-nesting bees. Bees are also associated with the all-powerful Rainbow Serpent, which is said to live under ground. In a number of Aboriginal myths, for example, the Rainbow Serpent attracts its human prey by imitating the buzzing noise of wild bees. As people search for the beehives under rocks etc., water gushes out and the Rainbow Snake swallows them up. In other myths, the buzzing noise warns people of the Rainbow Serpent's presence. Bees, hives and honey continue to feature strongly in ceremony and paintings.

In northern Australia today, honey from native bees is a highly desired staple food that may be eaten immediately, with people scooping up honey, wax, eggs, larvae and pollen balls as soon as the nest has been opened. Honey, along with pollen, was also mixed with water to cure stomach upsets, colds or flu. As author and naturalist Jennifer Isaacs has put it, "People 'clean their guts out' by eating large amounts of honey or by drinking vast quantities of pollen mixed with water." Following the Aborigines' lead, I sometimes drink a honey–water mixture when I feel 'off' and can personally attest to its positive effects.

Aborigines have also claimed that honey is good for sore eyes, and in the mid-1980s I observed an Aboriginal elder from Kakadu heal a tropical ulcer on his foot by applying a mixture of honey and wild plant extracts. Western doctors had prescribed various substances for his foot for weeks but to no avail. One day, out of frustration, he wandered into the bush to collect the ingredients of his remedy. It was only after he applied his own medicine that the sore finally healed over. In a few days it was virtually gone.

—PAUL S.C. TAÇON
AUSTRALIAN MUSEUM

ANNE & JACQUES SIX/AUSCAPE

European Honey Bees form a vertical chain to build the wax cells that are the essential frame work of the hive.

used in skin grafts.

In a dramatic case from the United Kingdom, a 14-year-old boy contracted a meningococcal infection. Caused by a bacterium that releases a skin-destroying toxin, the boy sustained horrific lesions on his arms and legs. Doctors had to amputate both legs just below the knees and also some of his fingers. Unfortunately, the lesions on his upper legs failed to heal despite repeated skin grafts and extended specialist care. These lesions also became heavily infected with a variety of secondary bacteria. Due to the extreme pain suffered by the boy, a general anaesthetic was required during dressing changes. After nine months in hospital, there was little evidence of healing. Within a few days of honey dressings, however, the wounds showed signs of healthy tissue growth and a reduction in infecting pathogens. A few weeks later, no anaesthetic was needed, and after ten weeks all lesions had completely healed.

Apart from its antimicrobial and healing properties, honey used as a dressing keeps the wound moist, preventing it from sticking to the bandages and thus causing further injury during dressing changes. Honey draws pus, dead cells, foreign materials and discharges out of the wound. It deodorises putrid wounds, which are normally very distressing for the patient. Honey is also an anti-inflammatory agent that reduces the swelling and pain of many wounds (which may also be why many beekeepers swear by it for bee stings). And for those in charge of the budget, honey is cheap, especially when compared to modern pharmaceuticals.

People through the ages have used honey not only as a food source, but also as a magical and medicinal gift from the gods. Modern research is now catching up and providing us with some strong scientific justification for the traditional belief in honey's healing powers.

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SHONA BLAIR IS A PH.D. STUDENT IN THE DEPARTMENT OF MICROBIOLOGY, UNIVERSITY OF SYDNEY. SHE IS INVESTIGATING THE MEDICINAL PROPERTIES OF AUSTRALIAN HONEY. AND WHILE SHE ALWAYS USES HONEY ON HERSELF FOR MEDICINAL PURPOSES, SHE PREFERS TO USE VEGEMITE ON HER TOAST. HER WORK WAS FUNDED BY A RURAL INDUSTRIES RESEARCH AND DEVELOPMENT CORPORATION (RIRDC) GRANT.

Which honey?

All honeys possess some form of antibacterial activity, but some can be up to 100 times more effective than others.

Generally speaking, unprocessed honey is more active than the varieties we get from the supermarket shelf. This is because 'supermarket' honey has usually undergone some heating during filtration and packaging. Heat (and also long-term exposure to light in clear jars) can destroy the enzyme responsible for the production of hydrogen peroxide—the main factor behind the antibacterial properties of most honeys. Raw honey is available from most health-food shops or, if you are lucky enough to know any, beekeepers.

COURTESY SHONA BLAIR

Ancient remedy meets modern science as the author tests honey's potency in the laboratory.

There is no real way of predicting which honeys will be most active. The only way to determine the level of activity is to test it in a lab. This is not an option for most people. However, there are some honeys commercially available that have a guaranteed level of antibacterial activity (due to some 'mystery factor', see main text). Medihoney (supplied by Capilano and available through most chemists), is a pure, active *Leptospermum* honey that has been sterilised using gamma irradiation. Gamma irradiation kills any bacterial spores (such as the botulism-causing *Clostridium*) that may be present, while not destroying the antibacterial activity. (It should be noted that nearly all of the modern references to the medicinal use of honey just use raw honey that has not been irradiated, and there has never been a case of wound botulism reported. However, the theoretical risk is there. In fact, the potential presence of *Clostridium* spores in honey is why babies under one year old should not be fed honey.)

Manuka honey, supplied by companies such as Apimed, is another *Leptospermum* honey that can have super antibacterial properties. However, once again, the level of antibacterial activity can vary greatly from one manuka honey to the next. The honey research unit, at the University of Waikato in New Zealand, devised the term 'UMF' (Unique Manuka Factor) to rank the level of antibacterial activity of the honey—the higher the UMF, the more potent the honey. For medicinal use, a honey should have a UMF of at least 10, which is equivalent in antibacterial activity to 10 per cent phenol. There is a lot of manuka honey on sale in Australia, however only those with a certified UMF are guaranteed to have medicinal benefits.

So the best honey to use on wounds is one that is sterilised and comes with a guaranteed level of antibacterial activity. Next best is raw honey. But, if you're stuck in the middle of nowhere and the only honey you have is a jar from the supermarket, this would be better than nothing.

Although I regularly use and swear by honey for medicinal purposes, I am not a qualified medical practitioner and suggest people talk to their doctor before treating any serious complaints with honey.

—SHONA BLAIR
UNIVERSITY OF SYDNEY

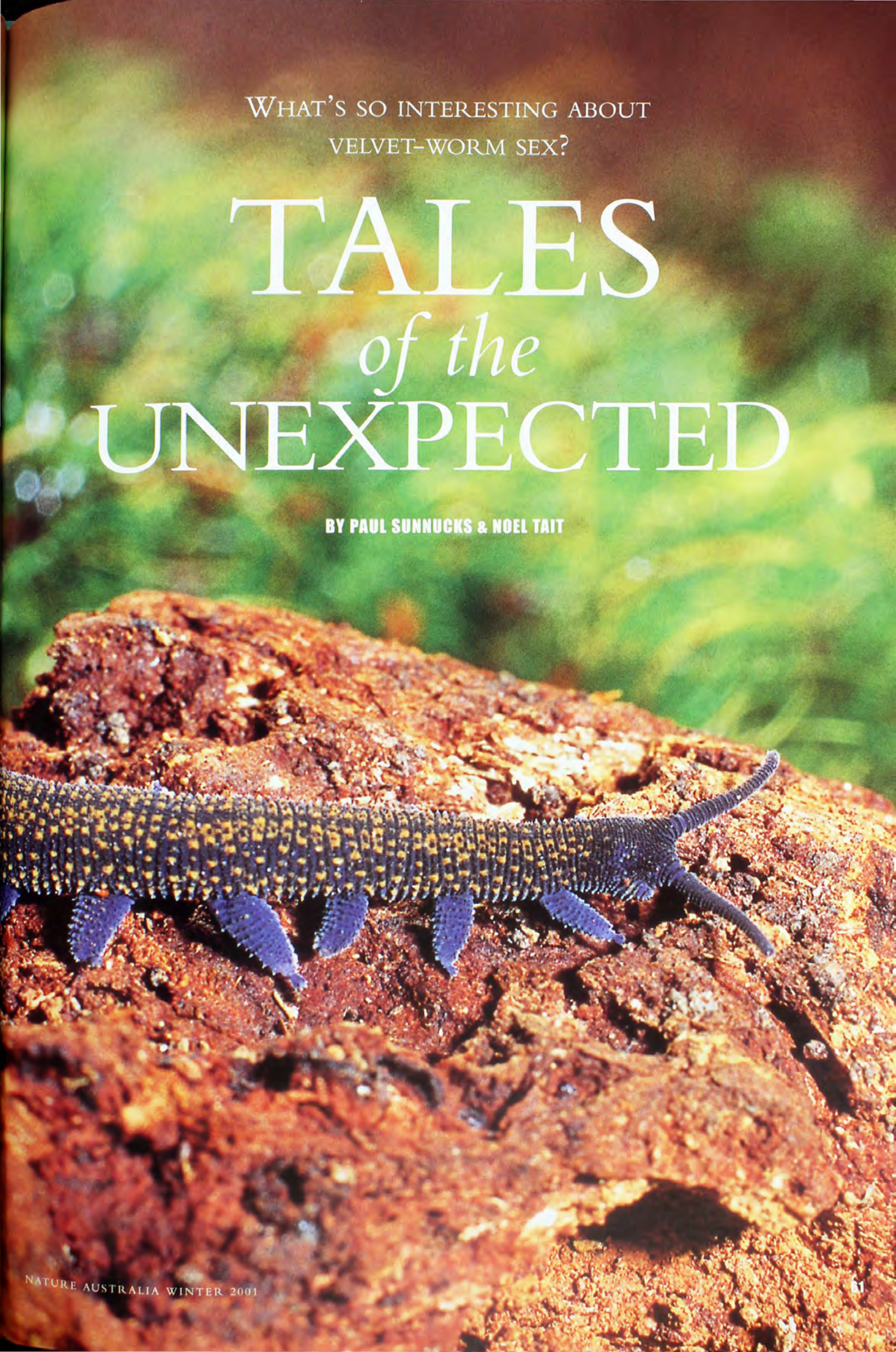
KATHIE ATKINSON

This specimen from Tasmania shows the sensual out-of-phase rhythm of the limbs during locomotion that inspired the name peripatus, from peripatetic, meaning wanderer or itinerant.

WHAT'S SO INTERESTING ABOUT VELVET-WORM SEX?

TALES *of the* UNEXPECTED

BY PAUL SUNNUCKS & NOEL TAIT



PEOPLE ARE SLOWLY becoming familiar with velvet worms, thanks to their weird and wonderful sex lives, which have featured in various popular articles and even the daily press. What's so interesting about velvet-worm sex? We thought we were starting to know it all, until recent research confirmed once again that, when it comes to these adorable 'worms with legs' (phylum Onychophora), you should expect the unexpected.

Reproduction in velvet worms—also known as peripatus*—is remarkably diverse. Some lay thick-shelled eggs, in which the embryos develop outside the mother's body (oviparity). Some lay thin-membraned eggs that develop and later hatch in the uteri of their mothers before being born live (ovoviviparity). And others are livebearers, whose developing embryos are nourished by the mother's placenta in the uteri just as in humans (viviparity).

The act of mating is equally as varied. Sperm are delivered to the females by a bizarre smorgasbord of methods, each characteristic of different groups of velvet worms. Males of some species have elaborate and often ornate structures on their heads that are used to place sperm directly into the genital opening of the female. Other species are more conventional and mate genitals-to-genitals, and yet others employ a technique called 'dermal insemination'. This last, ostensibly sado-masochistic (and to our taste, rather unromantic) form of copulation begins with the male placing a gift-wrapped package of sperm (spermatophore) almost anywhere on the skin of the female. With her complicity, her body wall ulcerates, the spermatophore wall breaks down, and sperm swim into her general body cavity. They navigate through jungles of muscles, cross oceans of body cavity fluid, circumnavigate organs, and finally reach their destination—either the ovary where they fertilise the eggs within, or, if females have them, the sperm storage organs (spermathecae), which sperm somehow enter.

Spermathecae too are structurally diverse, ranging from being entirely absent through to plush five-star hotels in which sperm can luxuriate for many years. But perhaps spermathecae are not really so hospitable: in many species they have structures that look suspiciously like they are for manipulating their wiggly guests, including funnels rimmed with wafting hair-like cilia, and small sacs where sperm may be broken down.

Velvet worms are extremely difficult to study in the wild. Most species spend

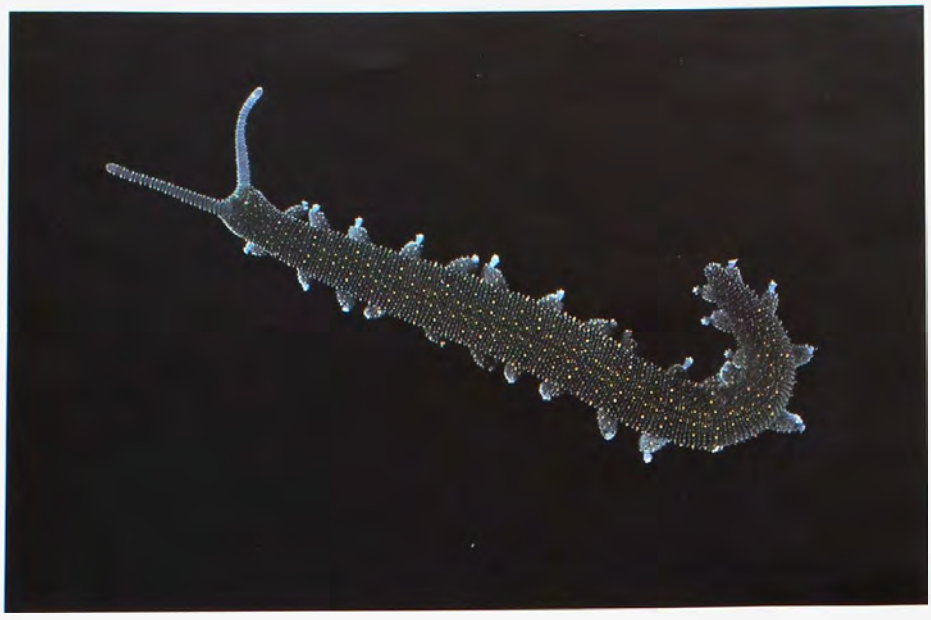
* *Peripatus comes from the word 'peripatetic', meaning an itinerant or wanderer, and was the name given to the first described genus of onychophorans.*

Euperipatoides rowelli **is ovoviviparous with embryos developing inside the mother from large yolky eggs. When newborns emerge from their thin enveloping membranes, they are white but rapidly acquire a juvenile colour pattern that gradually gives way to adult colouration.**

KATHIE ATKINSON

MICROSCOPY UNIT, BIOL. SCI. MACQUARIE UNIVERSITY

The only practical way of obtaining samples of log-dwelling velvet worms is to laboriously dismantle logs by hand (permits are required). Here Ray Cameron, Paul Sunnucks and David Briscoe (left to right) are working on a typical log that took several hours to sample.



MICROSCOPY UNIT, BIOL. SCI, MACQUARIE UNIVERSITY

the bulk of their lives buried deep in rotting timber, and the only practical way to observe them at all entails dismantling logs by hand, which undermines attempts to examine them in a natural context. Fortunately, advances in molecular biology over the last decade have provided an extensive toolkit of genetic markers that can help unravel the biology of even uncooperative organisms like velvet worms. While the details of these methods are complicated and diverse, the main underlying principles are gratifyingly simple. Most importantly, individuals within all species have slight differences in their DNA and proteins when compared to other individuals. These variants are heritable—that is, they pass essentially unchanged from parents to offspring. By following the trail of information held in the DNA through populations and species, it is possible to track facets of biology from mating patterns through to species formation. Just as a jury in a sexual-assault case may accept a 99.9999 per cent assurance that a semen sample came from a given suspect, so too we can use genetic techniques to illuminate biological patterns in wildlife.

We started applying genetic techniques to population biology of velvet worms more than 15 years ago. The first approach was allozyme electrophoresis (analysis of heritable differences in proteins; see *Nature Aust.* Autumn 1989). This led to the surprising finding that some supposed 'species', as identified from their physical appearance (morphology), were in fact made up of large numbers of species that had separated tens or even hundreds of millions of years ago. Despite the large allozyme differences between the species, there were not enough differences within species to say anything about aspects of population biology. For this we needed to use more sensitive DNA genetic markers: microsatellites and mitochon-

The 'terracotta' form of *Euperipatoides rowelli* (top) is genetically distinct from forms as little as ten kilometres to the south in Tallaganda State Forest. This distinctiveness can be seen in their physical features as well as their DNA. The 'terracotta' form has only terracotta spots and is measurably smaller. (Below) This form of *Euperipatoides rowelli* from Tallaganda State forest is genetically distinct from the 'terracotta' form, and has a dominant white spot above each leg.

KATHIE ATKINSON

Cephalofovea tomahmontis **from the Blue Mountains near Sydney is one of many Australian velvet worms that have a head structure in males used for mating. This male has a glistening white spermatophore (sperm package) loaded onto its everted head structure.**

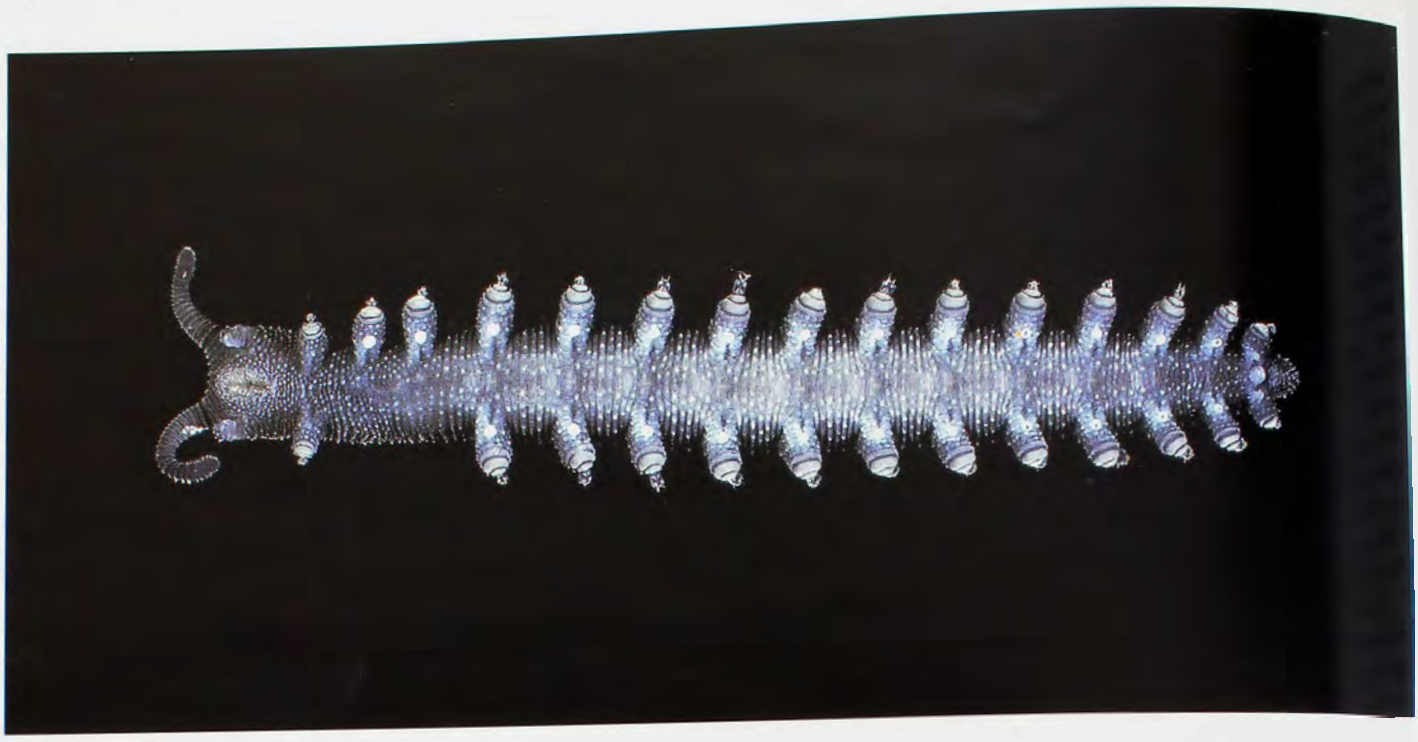
drial DNA. These are mainstays of modern molecular population biology because they can resolve relationships among populations, and illuminate mating patterns and sex-specific migration. The species we targeted was *Euperipatoides rowelli*—an ovoviviparous velvet worm from forests of south-eastern New South Wales. This species was itself newly reclassified from within *E. leuckartii*, which had been shown to be made up of several species based on allozyme analysis, and subtle morphological features.

THE ONLY PRACTICAL *way to observe them at all entails dismantling logs by hand.*

Application of the DNA markers led to astounding results. We screened specimens of *E. rowelli* from a 40-kilometre transect through a single forest in the Great Dividing Range (Tallaganda State Forest) and found that even on this scale there were two genetic groups sufficiently distinct to be separate species. Remarkably, genetic divergence of the mitochondrial DNA was as great as that between a bee and a fly.

Apart from differences in mitochondrial DNA, we also found consistent differences in the patterns of spots on the animals' backs. Individuals from the northern group ('Northern') have many straw-coloured, orange and terracotta spots, giving them an overall brownish appearance, while the southern group ('Black') are velvety purple-black, sometimes with a white spot above each leg. These colour forms had previously been ascribed to variation within the species.

Another reason to treat Northern and Black *E. rowelli* as separate species concerns an amazing if not unprecedented phenomenon. With other members of Macquarie University's 'Peripatus Team', we sampled specimens from where the Northern and Black forms potentially come into contact. This provides a direct test of the Biological Species Concept—that is, if the two are able to interbreed freely (exchange genes), then they are not different species, but if gene flow between them is restricted, they should be classed as



MR ROSCOPY UNIT, BIOL SCI, MACQUARIE UNIVERSITY

ALL IS NOT WELL IN THE HYBRID ZONE: FEMALE FERTILITY IS UNUSUALLY LOW, *and developmental abnormalities are common, including young that are missing a jaw, or show severely retarded development.*

The underside of a *Euperipatoides rowelli* showing a developmental abnormality (two missing legs) in an individual from the genetic contact zone between 'Black' and 'Northern' colour forms. The white disks (crural papillae) in this male's 'armpits' produce a scent attractive to both sexes. On either side of his mouth, turrets (glue guns) can be seen.

distinct species. The genetic markers showed that gene flow between the forms does occur, but is restricted in amount and nature. In this contact zone, many individuals cannot be unambiguously ascribed to Northern or Black forms, and are intermediate. However, all is not well in the hybrid zone: female fertility is unusually low, and developmental abnormalities are common, including young that are missing a jaw, have knotted guts, or show severely retarded development. Most extraordinarily, as many as five per cent of *E. rowelli* in the contact zone did not have the characteristic pattern of 15 body segments, each with one pair of legs. Instead, we found individuals with anything from 13–16 pairs of legs, and even some with different numbers of legs on each side of the body. These abnormalities indicate a breakdown in the genetic control of development, owing to incompatibilities between the two forms. This is the sort of barrier to gene flow that theoretically can lead to and reinforce speciation, although it has rarely been demonstrated.

Our genetic surveys also revealed a major difference in the spatial organisation of the sexes. Females showed genetic isolation-by-distance; that is, they were closely related to neighbouring females, but this decreased with distance. In contrast, males showed little such pattern. This suggests that, while females rarely move far from the logs in which they are born, males may move kilometres—conclusions that are consistent with ecological experiments carried out by Shaun Barclay and colleagues (Australian National University). This sex difference in genetic patterning is surprising at first, because it should not be stable if males breed after dispersal: on average half of their offspring will be female, and the pattern of sex difference would quickly break down. The implication is that, while males often disperse, they are very rarely successful at breeding in their new locations. To investigate this rather counter-intuitive possibility (why would males disperse, given the danger of desiccation, starvation and being preyed upon, if they were not even going to breed afterwards?), we decided to investigate patterns of parentage in *E. rowelli*. We hoped to be able to ascribe paternity of *E. rowelli* to local or to migrant males in the same logs. This work involved a blend of field sampling, delicate dissections and molecular analysis.

THE REPRODUCTIVE TRACT of female *E. rowelli* consists of a single ovary leading into a short oviduct that divides into two long uteri containing the developing embryos. In addition, at the ovary end of each uterus a sperm storage organ (spermatheca) attaches via two narrow ducts. We assume that eggs are fertilised as they pass a spermatheca on their way to a uterus. Each uterus of a mature *E. rowelli* female may contain as many as 35 developing embryos, end-to-end like a string of sausages. It is common for females to have one well-developed and one

undeveloped batch of embryos, in each uterus, with offspring in the two batches being born on average six or more months apart. During each birthing bout, females bear up to two offspring a day, for about six weeks. We dissected individual embryos from a sample of females, and collected sperm from the tiny spermathecae, being careful to record the order of the embryos in each uterus. Following DNA extraction from mothers, embryos and sperm samples, microsatellite analysis revealed the genetic contribution of fathers to the offspring, and their deposits in the females' sperm banks.

There are six places within each female in which we might find the genes of a given male: the spermatheca, young embryos and old embryos of the left-hand reproductive tract, and corresponding categories of the right. One result was somewhat expected, but exciting nonetheless, being a first for velvet-worm research: most females stored sperm from more than one male. Females also conceived with several different males per pregnancy, as young and old batches of offspring in a female were frequently not fathered by the same males. Another result was totally unexpected. Because the spermathecae are so close to each other and joined by common 'plumbing', we were surprised to find that sperm in a female's right-hand spermatheca did not always come from the same males as that in the left. Similarly the offspring on the left- and right-hand sides sometimes did not have the same fathers. Either the males can manipulate their chances of fatherhood (for example, by having particularly numerous or active sperm), or, more likely, females influence whose genes will make it into their offspring. It may be to this end that females store sperm from different males in separate spermathecae. By using their spermathecae independently to separate the sperm from different males, females leave open the possibility of future discriminate use of sperm. In contrast, if sperm from multiple males were mixed together, fertilisation would be dominated by male–male (sperm–sperm) competition.

Unfortunately the genetic analyses were unable to provide us with direct information on the proportion of offspring that are sired by local males rather than new migrants. However, indications of multiple paternity, sperm storage, and potential female manipulation of paternity, may all help explain our earlier inference that most paternity is by local males and that male breeding dispersal is generally unsuccessful. These factors could 'encourage' the rel-

PAUL SUNNUCKS

The ideal habitat for *Euperipatoides rowelli* is a eucalypt forest strewn with logs that have been rotting for several decades. The firm outer crust of the logs protects the internal meshwork of galleries that, like a sponge, retain a high moisture content.

KATHIE ATKINSON

Velvet worms are unique in capturing their prey in a squirt of glue, fired from turrets on either side of the head. The composition of this glue has recently been shown to be a sophisticated cocktail of biochemicals.

atively short-lived males of the species to disperse, but also operate against breeding success at their destination. For example, locally unsuccessful males may disperse in the 'hope' of better conditions, but find that they still have to compete with the stored sperm of many males, and even suffer rejection of their sperm by discriminating females. On the other hand, males that have mated locally may already have achieved most of the mating success that they can expect, because their sperm is stored in, and hopefully will be favoured by, available females. Having done their dash in their own backyard, these males may disperse in search of success elsewhere, but will tend to encounter tough competition in any new home. Future genetic and zoological studies will attempt to address these issues.

When we first suggested that female *E. rowelli* use their two reproductive tracts independently, we did not know their mode of mating. Based on the genetic evidence that sperm from a given male may not enter each spermatheca equally, we thought it most likely that mating was genitals-to-genitals. Females have a single vagina that splits to become the two uteri, and we thought that this arrangement could allow sperm from a given mating to be channelled from the vagina up one uterus or the other, and ultimately be sorted into one spermatheca or the other. This illusion was soon shattered by Muriel Walker and Bev Sherbon at the University of Leicester (UK), who have bred *E. rowelli* in captivity (incidentally no mean feat given the gestation of perhaps a year and the fact that velvet worms are difficult to feed and keep healthy). The Leicester group had observed shiny white spermatophores on the skin of females, and saw dermal insemination occurring. This leaves us with the mystery of how sperm from a given male can preferentially enter a particular spermatheca, despite the sperm having swum all the way from the disintegrating spermatophore near the female's body wall, through her body cavity, to the spermathecae that lie side-by-side in the same pool of fluid. Males are far from discriminating in spermatophore placement—even other males are recipients—so exquisite aim of Cupid's arrows does not resolve the paradox. *Euperipatoides rowelli* sperm have long, sharp and spiral heads, which could be useful in penetrating the thin walls of spermathecae. Perhaps females somehow influence the 'permeability' of the spermathecae, so sperm can enter only one spermatheca at a given time. Keeping sperm from different males separate would maintain a female's potential for selecting fathers of her offspring—a chance that may be lost if sperm are allowed to mix and fight it out. She might opt for particular characteristics, or simply a diversity of fathers. We are still in the dark about 'accessory pouches' in *E. rowelli* females—small sacs containing sperm, close to each spermatheca. Are these holding pens for sperm, or sites of (selective?) sperm destruction?

WE STARTED THIS research wanting to know why there are so many species of velvet worm. We found that local endemism (geographic concentration of genetic similarity) was even more marked than we first realised. It seems that (at least in the geologically and environmentally varied region of the Great Dividing Range) moving ten kilometres will usually bring you into the realm of a different velvet-worm species. If this pattern were true of all Australian velvet worms, actual species

diversity would be perhaps 100 times higher than the morphology-based estimate of only seven species that was held until 15 years ago.

Conservation efforts directed at invertebrates are in their infancy, and our work provides examples of some of the challenges that may be faced. Apart from the Northern and Black forms, we have also found many other cryptic species within *E. rowelli*. The genetic differences among cryptic species are far from minor, and signal important functional divergences: our results on infertility and developmental instability in an *E. rowelli* hybrid zone represent an example of natural 'outbreeding depression' (that is, loss of fitness through breeding of different forms). To maintain species diversity in *E. rowelli*, it is necessary to know and consider the geographic bounds of true species, and to ensure representation of core ranges. Further, artificial restocking without respect to cryptic species could lead to creation of hybrid populations dogged by infertility and developmental abnormalities. At present, it is unknown to what extent these ideas apply to other invertebrates, but they are likely to hold for many slow-moving organisms.

Our research was primarily about biodiversity but we ended up uncovering some of the complex and wonderful biology of velvet worms. This can only help us to further appreciate these most endearing invertebrates. Female *E. rowelli*, sophisticated ladies in figure-hugging purple velvet, seem to take the pick of the local genes by mating with lots of partners, perhaps even sequestering away sperm for future use as they see fit. The life of males is not so cushy. They get some reproductive success in the general vicinity of their birth, then set out on heroic but usually ill-fated, long-distance voyages, during which they may succumb to stresses or predators. Most will die before they reach one-third the size of their female counterparts. That said, some of them will receive the posthumous accolade of mating success via sperm tucked away in females' holding pens!

FURTHER READING

Barclay, S., Ash, J.E. & Rowell, D.M., 2000. Environmental factors influencing the presence and abundance of a log-dwelling invertebrate, Euperipatoides rowelli *(Onychophora: Peripatopsidae).* J. Zool., Lond. *250: 425–436.*

Barclay, S., Rowell, D.M. & Ash, J.E., 2000. Pheromonally-mediated colonisation patterns in the velvet worm Euperipatoides rowelli *(Onychophora: Peripatopsidae).* J. Zool., Lond. *250: 437–446.*

Curach, N. & Sunnucks, P., 1999. 'Molecular anatomy' of an onychophoran: compartmentalized sperm storage and heterogeneous paternity. Molec. Ecol. *8: 1375–1386.*

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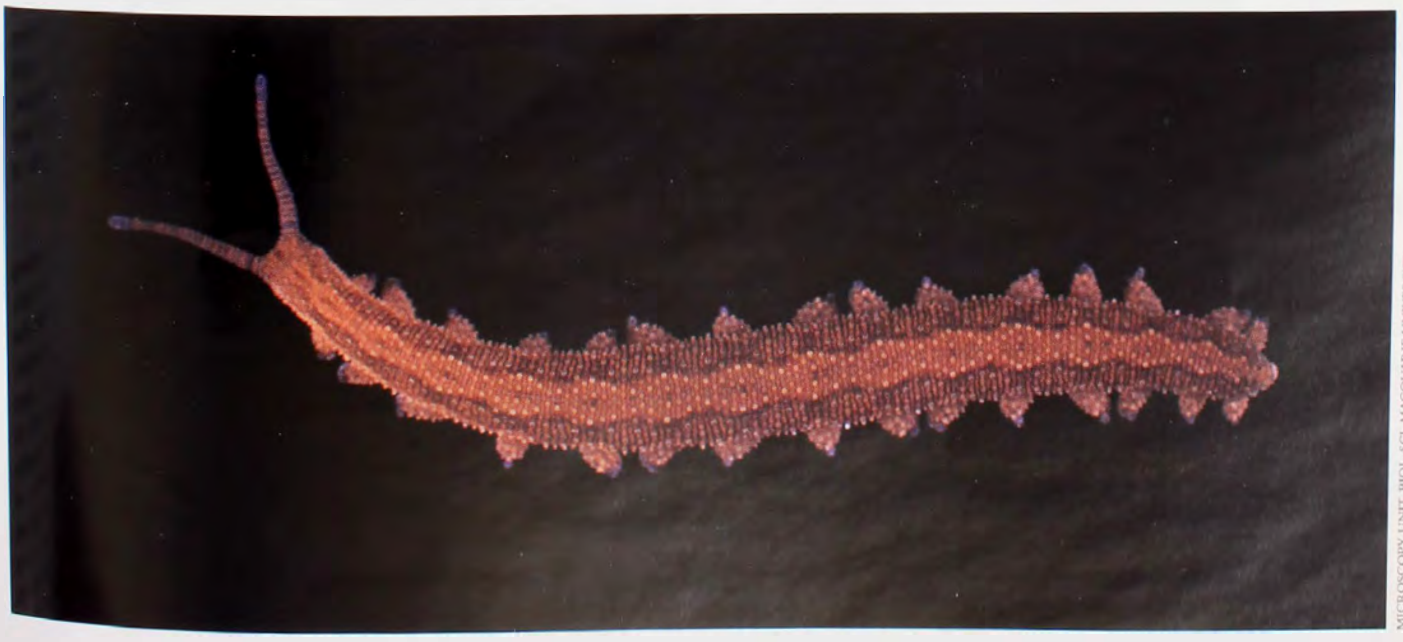
Sunnucks, P. & Wilson, A.C.C., 1999. Microsatellite markers for the onychophoran Euperipatoides rowelli. Molec. Ecol. *8: 899–900.*

DR PAUL SUNNUCKS WAS A RESEARCH ASSOCIATE AT MACQUARIE UNIVERSITY, SYDNEY, AND IS NOW A LECTURER IN THE DEPARTMENT OF GENETICS AT LA TROBE UNIVERSITY, MELBOURNE. HIS RESEARCH CENTRES ON THE APPLICATION OF GENETIC MARKERS IN POPULATION BIOLOGY. ASSOCIATE PROFESSOR NOEL TAIT IS IN THE DEPARTMENT OF BIOLOGICAL SCIENCES AT MACQUARIE UNIVERSITY. HE HAS A LONG-TERM PASSION FOR UNVEILING MYSTERIES ABOUT INVERTEBRATES IN GENERAL AND VELVET WORMS IN PARTICULAR, AND HARBOURS A SPECIAL LIKING FOR MUCUS AND SLIME.

THE AUTHORS WOULD LIKE TO THANK RAY CAMERON, NATALIE CURACH, DAVE BRISCOE, JORDAN FRENCH, DAVE ROWELL, ALEX WILSON AND ANTHONY YOUNG, WITHOUT WHOM THEY WOULD HAVE HAD A VERY DULL STORY TO TELL.



MICROSCOPY UNIT, BIOL. SCI. MACQUARIE UNIVERSITY

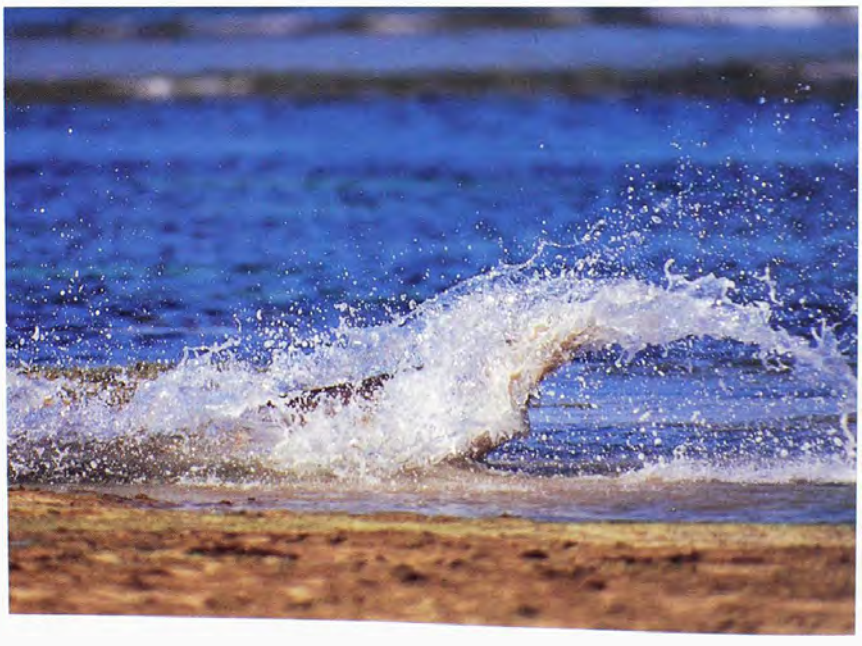
The beautifully patterned, egg-laying species *Ooperipatus hispidus* is very rare. Females have an external tube for laying eggs (ovipositor), the tip of which can just be seen at the posterior end of this individual.

Old telegraph station, Eucla, South Australia.

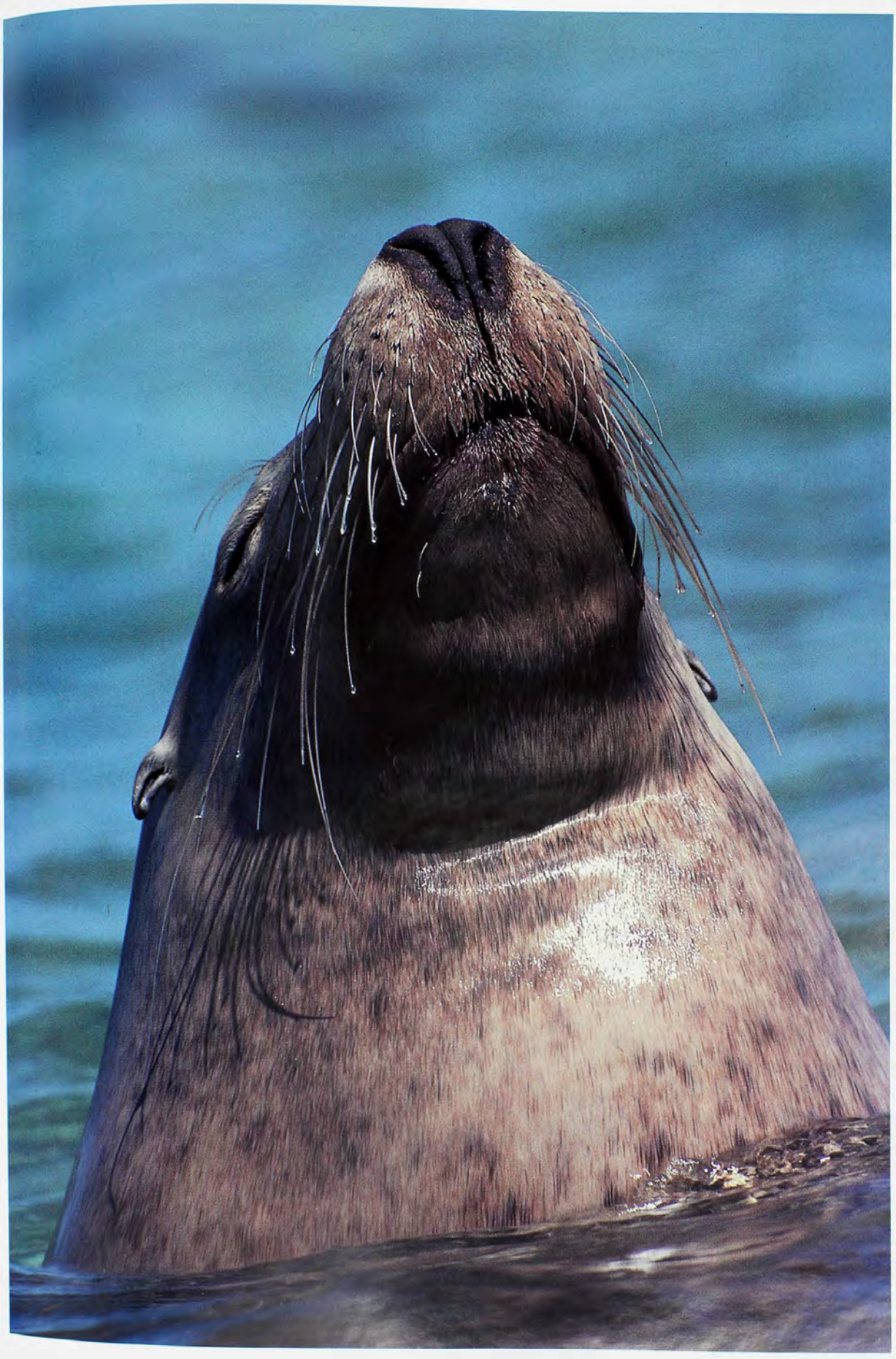
Southern Right Whale (*Eubalaena australis*).

coastwatch

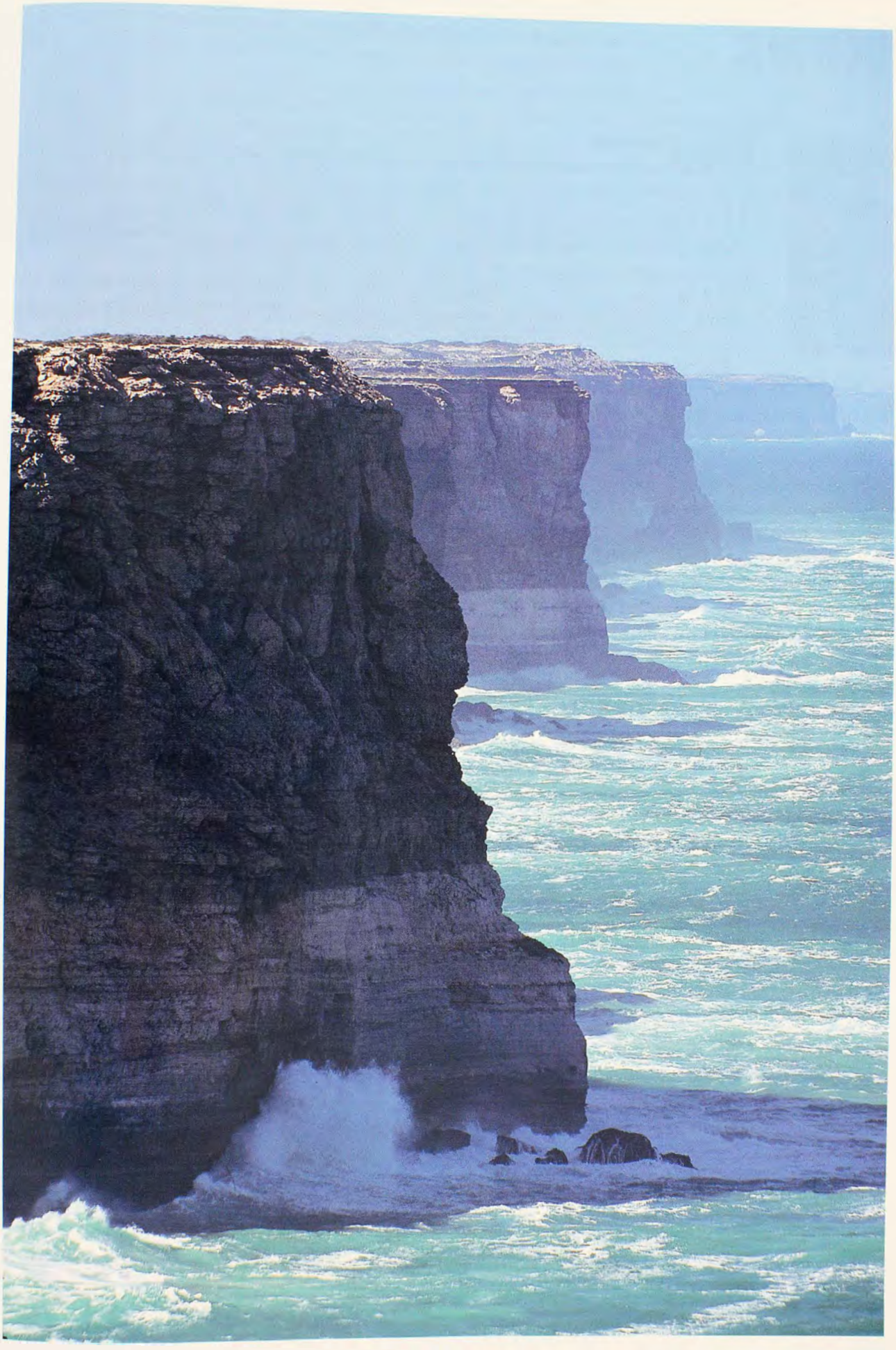
BY JASON EDWARDS



(Above and right) Australian Sea Lions (*Neophoca cinerea*).

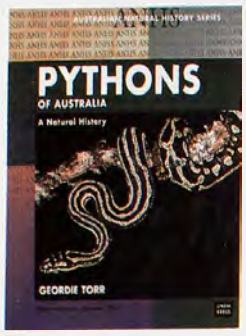


Australian Pelican (*Pelecanus conspicillatus*).



The Bunda Cliffs, South Australia.

reviews



Pythons of Australia

By Geordie Torr. Australian Natural History Series, UNSW Press, NSW, 2000, 103pp. $32.95rrp.

Pythons of Australia is the third and most recent book dealing with reptiles in the Australian Natural History Series published by University of New South Wales Press. It comprises eight chapters variably dealing with the history, biology, conservation and captive care of Australian pythons. There are also sections that give accounts of the distribution (including a map), habitat and miscellaneous information for each species, and a short bibliography for suggested reading. As with other recent editions in the Australian Natural History Series, the colour plates (16 pages) are presented as a centre block.

The book is a compilation and summary of the extensive information available in the scientific literature, much of which has arisen from the studies by Rick Shine and colleagues at the University of Sydney. Hence anyone wanting specific reference sources for the information presented here could probably trace its source in the references listed at the back. The book is easily read and the various aspects of python biology are illustrated by frequent reference to specific case studies, a bonus for students who might envisage a career in biology.

Snakes in general, and pythons in particular, have certain unusual characteristics associated with their highly specialised biology. How snakes shed their skin, use their tongue for sensing smell, or the way in which a python's jaw can be stretched to accommodate a prey many times larger than its head, are all simply and clearly explained. In this regard the book meets the broad objectives as defined by the series editor—to make accessible accurate scientific information to students, biologists, and readers with a serious interest in natural history. It is an excellent introduction to this particularly popular group of reptiles.

—Ross A. Sadlier
Australian Museum

Dinosaurs of Darkness

By Thomas H. Rich and Patricia Vickers-Rich. Published by Indiana University Press, USA, distributed in Australia by Alliance Distributors, NSW, 2000, 222pp. $39.95rrp.

Dogged perseverance, unrelenting, unstinting, backbreaking, hard work, and a bit of good luck to keep you going during the times you feel like quitting and going home. This is what palaeontology is all about, and it forms the primary thread running through the new book *Dinosaurs of darkness* by Tom Rich and Pat Vickers-Rich.

Dinosaurs of darkness chronicles the ongoing, more-than-20-year period during which the Richs searched for dinosaurs along the rocky southern coast of Victoria. Actually, Tom and Pat were primarily interested in finding Cretaceous mammals and birds (their respective research interests), but dinosaurs kept popping up instead. This nevertheless formed the basis for a research program highlighting the somewhat counterintuitive idea of dinosaurs living in polar realms. During the Early Cretaceous (about 100–140 million years ago), the Victorian dinosaur localities of Flat Rocks and Dinosaur Cove were inside the Antarctic Circle.

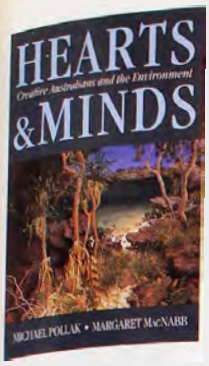
Dinosaurs of darkness reviews the scientific work done by the Richs over the years on the Victorian dinosaurs, and combines this with straightforward explanations of scientific concepts such as fossil dating and the ways in which palaeotemperatures and palaeolatitudes are determined.

But, the physical and mental costs of this work! Tom and Pat detail the arduous task of working along a rocky shoreline continually battered by waves and changing tides. The work at Dinosaur Cove involved blasting into the rock-face with dynamite and constructing a series of tunnels, in order to access the fossil-bearing rock. They take care to acknowledge the countless hours put in by a steady stream of volunteers.

The payoff for these years of work came in 1997 with the discovery of a small mammal jaw identified, controversially, as Australia's earliest placental. All other Australian Cretaceous mammals are monotremes, and the debate as to the identity of the Victorian mammal, *Ausktribosphenos nyctos*, continues. Nevertheless, the importance of these fossils cannot be overstated, and work at the Flat Rocks site continues with a new vigour and enthusiasm. Stay tuned!

The writing in *Dinosaurs of darkness* is clunky in places, but nevertheless it is a good read, to be enjoyed by anyone interested in Australian dinosaurs and palaeontology. My main complaint is that, although overseas colleagues are mentioned by name and their work and contributions described in detail, Australian colleagues are rarely identified.

—Zerina Johanson
Australian Museum



Hearts & Minds: Creative Australians and the Environment

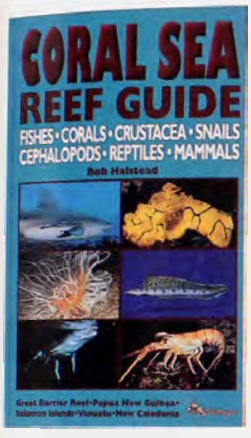
By Michael Pollack and Margaret MacNabb. Hale & Iremonger, NSW, 2000, 399pp. $34.95rrp.

THIS IS AN INTERESTING OVERVIEW OF THE AUSTRALIAN ENVIRONMENT seen through the eyes of the Arts. Pollack and MacNabb discuss the work of many creative Australians who express their passion for this land and country.

The task undertaken is large one, and the authors can therefore only dip into the work of artists as diverse as Xavier Herbert, Patrick White, Tim Flannery, Midnight Oil, Oodgeroo Noonuccal and Patricia Wrightson. The premise here is that art can move our hearts and minds, bringing about an environmental consciousness. The political background of the artists is diverse, but they are unanimously Australian and love the land.

In essence this is a reference book, a guide to creative work dealing with the environment. The authors interviewed many of the participants and have produced engaging cameos of their lives. The intended audience for this book was not immediately obvious but should be mandatory reading for politicians.

—LEONÉ LEMMER
AUSTRALIAN MUSEUM

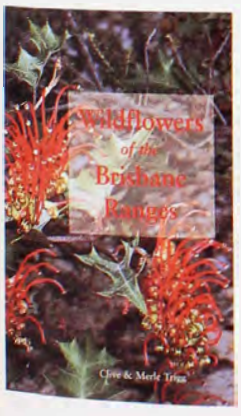


Coral Sea Reef Guide

By Bob Halstead. Sea Challengers Natural History Books, 35 Versailles Court, Danville, CA 94506-4454, USA (ph: 925-327-7750; fax: 925-736-8982; email: dave@seachallengers.com), 2000, 321pp. US$44.95.

BOB HALSTEAD WANTS DIVERS TO BECOME ACCURATE OBSERVERS of the Coral Sea fauna, and this nicely produced volume is a good start. Some 1,000 marine species are figured and identified, including several new to science. All are in colour and complemented by short but useful biological notes. The photographs are excellent and will be enjoyed by divers and non-divers alike. Fish dominate two-thirds of the book and perhaps more invertebrates should have been included in view of their massive diversity. Considering the wide scope of the work, however, this is a minor quibble. The author is obviously serious about marine life, but retains a sense of humour. Included among other things is a short list of Aussie slang and an amusing 'theory' explaining the extinction of the dinosaurs implicating the humble mantis shrimps. What am I talking about? You'll have to get the book and see for yourself.

—SHANE AHYONG
AUSTRALIAN MUSEUM



Wildflowers of the Brisbane Ranges

By Clive and Merle Trigg. CSIRO Publishing, Vic., 2000, 128pp. $19.95rrp.

I HAVE VERY FOND MEMORIES OF THE BRISBANE RANGES. It was here that I collected an unusual form of *Grevillea chrysophaea*. When I took it to the Herbarium at the Royal Botanic Gardens, Melbourne I realised I was destined for a career in plant taxonomy. It was also the closest place a homesick boy from New South Wales could visit heathlands that most closely resembled Hawkesbury sandstone heaths.

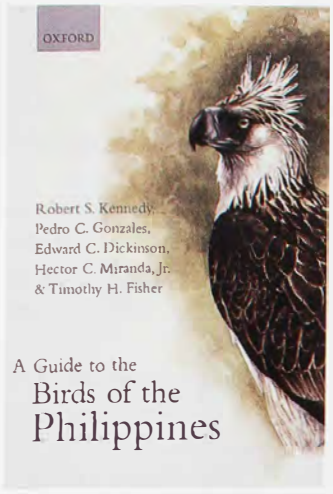
This is the kind of field guide I like. It has good clear photos, simply but well set out, and it's cheap and the right size to fit into any day pack. The layout is simple. It starts with ferns, then monocots and then dicots, with the families and species in alphabetical order. Eight of the more common families have brief biographies highlighting their morphological features, uses, size and distribution. Each species is given its common name, habit, preferred habitat and coded distribution.

Most of the photos are of excellent quality, particularly the close-up shots and the orchid pictures. The habit shots tend to be blurry however, and I would have liked to have seen habit shots of more of the larger shrubs and trees. Bark photos of the eucalypts would also have been useful as an additional identification guide. But these are small quibbles.

A useful guide to species using colour, and a basic glossary and comprehensive index are included. I also liked the fold-out maps at either end of the book. The front one is a park guide highlighting all the facilities and attractions, while the rear one divides the park into its various soil types and is the reference map for showing the distribution of each species.

So, next time you are embarking on a picnic to the Brisbane Ranges, be sure to include this handy little field guide and make the most of the spectacular wildflower display that's on the doorstep of Melbourne, Geelong and Ballarat.

—PETER JOBSON
NATIONAL HERBARIUM OF NSW



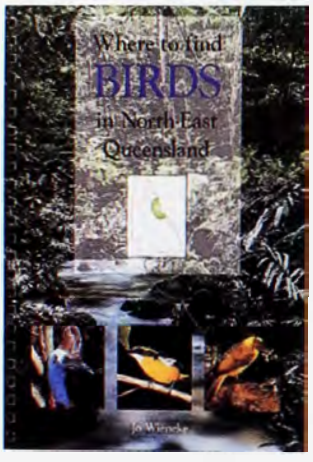
A Guide to the Birds of the Philippines

Ed. by Robert S. Kennedy, Pedro C. Gonzales, Edward C. Dickinson, Hector C. Miranda Jr. & Timothy H. Fisher. Oxford University Press, Vic., 2000, 369pp. $110.00rrp.

THIS IS A WORTHY ADDITION to the proliferating range of new field guides to appear in recent years. Most of these are welcome additions to the ornithological literature. While some fill gaps for geographical areas for which no guides have previously been available, others replace guides published many years ago that are either out of print or fail to reach current standards in their presentation.

This collaborative effort by Philippine and overseas ornithologists is in the second category: the first guide in 30 years to cover the birds of this area—the sprawling archipelago of the Philippine Islands. Nicely illustrated with 72 colour plates showing more than 500 species, it is a vast improvement on its predecessors in the quality of its text, illustrations and overall presentation. The plates are grouped together, preceding the main text, but conveniently have the relevant range maps on the pages facing the illustrations, together with the captions giving the species' major field marks. The species accounts in the main text cover all species known from the Philippines, and provide more detailed descriptions and distributions, plus information on habitats, voice, habits and other aspects of natural history. If you choose to go bird-watching in the Philippines, this attractively presented book is for you.

—WALTER E. BOLES
AUSTRALIAN MUSEUM

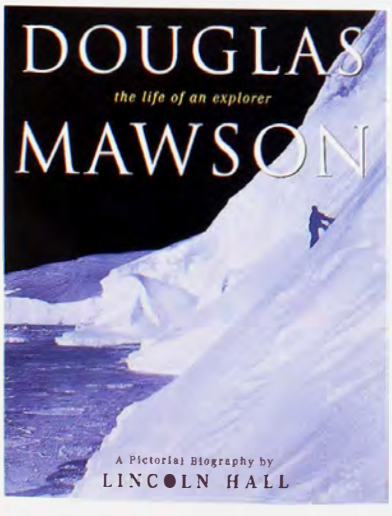


Where to Find Birds in North-East Queensland

By J. Wieneke. 3rd ed. Published by the author (bowerbird@msn.com.au), 2000, 132pp. $20rrp.

THIS THIRD EDITION IS A MAJOR REVISION OF A GUIDE that first appeared in 1992, which speaks well for its popularity and usefulness. It covers important birdwatching localities in the coastal region and ranges bounded by Bowen in the south, north to the Daintree area and west to, and including, the Atherton Tableland. The locality accounts range from sites suitable for a quick stop to ones that warrant a more extended visit, augmented by a series of maps that will greatly facilitate getting to a chosen spot. Also included are contacts for more information, local guides, suggested accommodation and other nearby attractions. The second part of the guide presents brief summaries of the many exciting species that might be found. The entry for each species is brief but gives the best habitats and seasons, and, often, specific sites at which they might be most likely encountered. Small and concise, yet highly informative, this guide will considerably enhance any visitor's birdwatching trip to this region.

—WALTER E. BOLES
AUSTRALIAN MUSEUM



Douglas Mawson: The Life of an Explorer

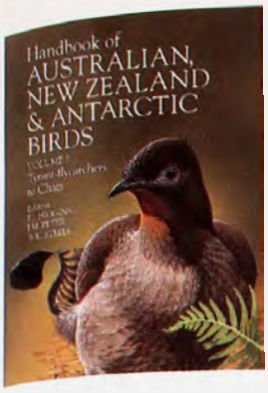
By Lincoln Hall. New Holland Publishers, NSW, 2000, 224 pp. $49.95rrp.

DOUGLAS MAWSON WAS THE FIRST PERSON to lead a small team of explorers to the south magnetic pole between 1911 and 1914. He was a contemporary of Robert F. Scott and Ernest H. Shackleton but he was overshadowed by their fame, even though his expeditions achieved more in terms of discovery than both men put together.

For Mawson and his colleagues, exploring Antarctica in the early part of the 20th century meant extreme hardship and almost certain death. So what motivated Mawson and how did he manage to survive? The answers to these questions make fascinating reading. Lincoln Hall, a mountaineer and adventurer himself, manages to give us an insight into Mawson's character and motivation by using excerpts from his diaries and letters. There are 170 black-and-white photographs, many of them taken by Frank Hurley and which are amongst his finest.

But overwhelmingly you'll find, as you read this book, that Douglas Mawson was much more than an explorer; he was first and foremost a geologist, a great team leader, and a forward thinker.

—K.L.

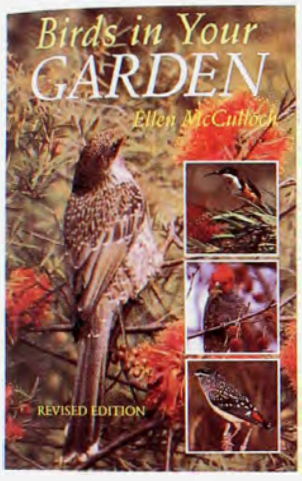


Handbook of Australian, New Zealand and Antarctic Birds. Vol. 5. Tyrant-flycatchers to Chats

Ed. by P.J. Higgins, J.M. Peter, & W.K. Steele. Oxford University Press, Vic., 2001, 1,269pp. $385rrp.

THIS IS THE LATEST VOLUME OF A SERIES that started in 1990. Previous volumes have been reviewed in earlier issues of *Nature Australia*; each received highly favourable comments at those times, and the current volume easily measures up to them. This massive work will be one of the most consulted of the series. Marking the start of the songbirds, it contains several of the best-known and most widely studied Australian families: the lyrebirds, fairy-wrens and honeyeaters. Other groups include the New Zealand wrens, pittas, scrub-birds and treecreepers—118 species in all. As such, this book will be of tremendous value as a reference, and there is no doubt that it will remain so for many years to come. The format of the species accounts remains the same as before, with the biggest difference from previous volumes being some changes in the artists. The current contributors have not let the side down, maintaining the high standard of illustration in the 42 colour plates. Once again, the price will prevent many people from acquiring personal copies; however, because of this book's exceptional and long-term value, anyone interested in these groups of birds will need to ensure that they have access to it.

—WALTER E. BOLES
AUSTRALIAN MUSEUM

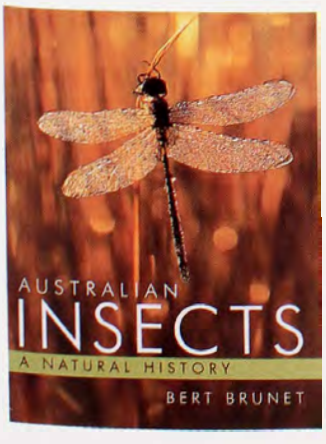


Birds in Your Garden

By Ellen McCulloch. Hyland House Publishing, Vic., 2000, 128pp. $24.95rrp.

BECAUSE OF THE SUPERFICIAL SIMILARITY between the cover of this book and one called *Birdscaping your garden*, I was expecting to read a reference book with practical suggestions on how to bring birds to my garden. However, although *Birds in your garden* is packed with the observations and knowledge of an extraordinary bird observer, it cannot be described as a reference book. It contains heaps of useful information but it is not organised into logical chapters, and its species-based index does not assist in concept retrieval. Instead, the book is a collection of stand-alone chapters that might initially have been published in a monthly newsletter or formed the basis of an entertaining slide show. Consequently the same bits of information are duplicated in different chapters and it is sometimes difficult to get a consistent picture of the author's position on subjects such as the desirability of native versus non-native plants, or the pros and cons of providing artificial food. The source of the information is the author's head and a very knowledgeable head it is too, but for my liking there was rather too much home-spun philosophy and little attempt was made to research the answers to rather simple questions. I was mildly irritated by comments such as "whether [*Pinus radiata* is] normally wind pollinated, I do not know". On the other hand it is a very chatty, personal account, which will appeal to a vast number of the people who enjoy having birds in their gardens. Readers will learn a lot, and many will empathise with both the birdie anecdotes and the throwaway asides such as "[the House Sparrow and Tree Sparrow] are amongst the species that have learned to scavenge in schoolyards for spilt chips and discarded lunches—I wonder how many children actually eat the lunch packed for them?" This is clearly a book for a niche market—for the ever-growing number of people who like to have a chat about birds.

—RICHARD MAJOR
AUSTRALIAN MUSEUM



Australian Insects: A Natural History

By Bert Brunet. New Holland Publishers, NSW, 2000, 288pp. $59.95rrp.

THIS FINE, LARGE-FORMAT BOOK IS THE BEST GENERAL INTRODUCTION to Australian insect life that I have seen. It is filled throughout with excellent colour photographs of insects in nature, and almost all are the work of the author, Bert Brunet. The illustrations are matched by a comprehensive text, divided into two sections. The first deals with insect body structure, life cycles, flight, behaviour and general ecology. The second section covers taxonomy, and reviews the orders and major families, providing basic biology and recognition characters. In addition, there is a section on the practical aspects of collecting and studying insects. For anyone who wants to find out about Australia's rich insect fauna, especially those who find the technical language of the CSIRO book *Insects of Australia* too daunting, Brunet's book is an ideal starting point. It would be an excellent gift for a budding naturalist, young or old.

—DANIEL J. BICKEL
AUSTRALIAN MUSEUM

SOCIETY PAGES

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

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Contact: Eleanor Hanger

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Threatened Birds Network
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Hawthorn East Vic. 3123
Ph: (03) 9882 2622
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Contact: Michael Weston

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Contact: Dr Paul Adam

Membership: $25 Single, $10 Students, $35 Library

Friends of Lane Cove National Park Inc.
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Web:www.malleefowl.com.au
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EDUCATION

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q&a

Red Triangles

Q: *A friend and I came across a brightly coloured slug-like creature during a walk in a cool temperate rainforest in north-eastern New South Wales. Would you be able to tell me if this species is, in fact, a slug, or is it another type of animal? The pictured individual is approximately ten centimetres long.*

—Shane Ruming
Armidale, NSW

A: This is a Red Triangle Slug (*Triboniophorus graeffei*), which is native to Australia and easily distinguished from the various introduced species, even in its younger, less colourful phases, because it has only two tentacles (as are clearly visible in your photo) while the exotic species have four. It is widespread, being found along eastern Australia's ranges and the coast from Victoria to northern Queensland in a variety of habitats. It also comes in a startling variety of colours. Your orange and red slug is most similar to the colour form found around the New England area. A reasonably consistent feature of all of them is the red-bordered mantle flap on the back (the part that would secrete the shell in a snail) along with the red-edged 'foot' (the bit the animal crawls on). With all their variety and their wide distribution, it has been suggested there may actually be several species listed under the one name but for the moment that's the way things stand. The species grazes on films of algae, fungus, and lichens growing on rocks, leaves and tree trunks. It is rare in urban gardens, but is unlikely to cause any problems if found due to their specialised diet. A meandering feeding track can sometimes be seen on smooth-barked tree trunks and rock outcrops, indicating where the slug has fed on previous evenings.

—Martyn Robinson
Australian Museum

COURTESY SHANE RUMING

The endemic and common Red Triangle Slug.

Mystery Funnels

Q: *On a recent walk in Sugar Creek Flora Reserve, we discovered some strange, long, narrow, funnel-shaped structures attached to seedling plants on the rainforest floor. The funnels were up to 40 centimetres high and appeared to be made from a closely woven, strong silk-like substance, similar to a spider's web. The funnels were about 25 millimetres wide at the top, tapering to about ten millimetres at the bottom. We counted over a dozen of these structures, dispersed sporadically on our walk. We could not find any animal that might have been responsible for the funnels and wondered whether you could tell us what made them.*

—Kevin McDonald
Balickera, NSW

A: These strange funnel or tube-like structures are built by tube spiders. They belong to the genus *Misgolas* within the family Idiopidae, a large group of mainly trapdoor-building species. *Misgolas* spiders are common in eastern Australia and New Zealand and are often called brown trapdoor spiders, despite the fact their burrows rarely have trapdoors. So far only two species of the tube-building *Misgolas* species have been described: *M. robertsi* and *M. mascordi*, and another has been reported from New Zealand. In Australia, tube spiders have been collected from New South Wales to southern Queensland, and are found mostly in association with eastern moist forest habitats and their margins.

Tube spiders have the peculiar habit

Answers to Quiz in Nature Strips (page 21)

1. *Grey Nurse Shark*
2. *Lead*
3. *Centipedes*
4. *Italy*
5. *Rainfall*
6. *The Box Jellyfish*
7. *Tibetan Antelope or Chiru*
8. *Urine*
9. *Pluto*
10. *A bird*

COURTESY HERBERT HEINRICH

These mysterious funnels were made by spiders.

of extending their burrows well above ground level, next to supports such as rocks, plant stems or trunks. The tubes can be 15–50 centimetres high at their open end, although one report has them extending "up to three feet" above ground. The longest tubes are built by the northern New South Wales species, *M. mascordi*. Each tube is supported from the adjacent structure by a silk attachment at the tube's mouth—the rest of the tube hangs against, or sometimes well clear of, the supporting structure. The tubes are made of tough parchment-like silk, often with a covering of soil particles, and in wetter areas lichen may adorn the tubes. They continue underground to a depth of 15–25 centimetres.

Why build these curious aerial tubes? There are several possible explanations. First, the tubes place the spiders into a unique feeding niche above the forest floor. This allows them to exploit insect prey that move through this area, reducing direct feeding competition with ground-dwelling spiders. When hunting, the spider sits just inside the tube or at its open mouth, and dashes out to seize passing prey. The movement of an insect walking onto the tube may alert the spider to its presence—so the tube itself may act as a prey-sensing device. Besides feeding advantages, an aerial tube may also reduce spider vulnerability to predators and parasites, and may provide temporary protection against burrow flooding and an above-water retreat for the spider during heavy rainfall and creek overflows. There's plenty of scope for observation and experimentation to test these hypotheses.

—Mike Gray
Australian Museum

Pic Teaser

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *Life in the tall eucalypt forests* from the Australian Museum Shop. Autumn's Pic Teaser was a bird-dung mimicking spider, *Archemorus curtulus*.

Mixing Mala

Mixing populations for mainland reintroductions may be the key to avoid the extinction of yet more of our endangered fauna.

SINCE EUROPEAN COLONISATION, Australia has seen a plethora of marsupials and native rodents become extinct. Many species that previously had enormous distributions across Australia have now been banished to islands and isolated pockets of their former range. Translocations of fauna have become an increasingly useful tool to re-establish populations. In contrast to the views of Allen Greer (*Nature Aust.* Summer 2000–2001), conservation efforts should not only make use of translocations, but also take the further step of mixing genetically similar populations within species to supplement translocated stock.

A recent review has identified no substantial increase in the success of reintroduction programs in the last 20 years, despite our improved understanding of what can cause these failures. Species reintroductions were found to be more successful if the cause of their decline (such as predation or competition) was controlled or eliminated, if animals were sourced from the wild, and if a large number of animals were released. Acquiring sufficient numbers of individuals to supplement breeding programs, or to source future translocations, becomes difficult if there are only a handful of surviving populations.

Mammal populations that are now found only on offshore islands represent important reservoirs of genetic diversity. But islands have also been recognised as genetic death traps, having low levels of genetic variation. Genetic variation is important to the long-term persistence of a population, particularly since it allows for adaptability to changing environments.

Studies by Mark Eldridge (Macquarie University) on the Black-footed Rock-wallaby (*Petrogale lateralis*) have shown that island populations tend to have much lower genetic variation than mainland populations of the same species, and that there are often genetic differences between islands (see *Nature Aust.* Winter 1998). Each island on its own may contribute little to the long-term persistence of a species. However, mixing individuals of the same species from different islands, together with individuals found elsewhere on the mainland, may improve the genetic representation of a founder population.

Consequently, we have three options when assessing wildlife translocations. One is to leave everything the same as it is, an option that will ultimately lead to the extinction of many populations and species.

A second option, the currently preferred method, is to translocate animals from populations that are known, or thought to be, genetically 'healthy'. In general, animals for captive-breeding programs and translocations typically derive from a single source population, in an attempt to minimise perceived problems associated with outbreeding depression (genetic mixing of animals that are too different from each other). However, these populations can usually only provide a few individuals each year without causing further endangerment to the population, so the new population nearly always ends up with less variation than the parental one.

A third option is to consider the genetic mixing (interbreeding) of closely related populations. This option recognises that most species currently isolated on islands once had widespread distributions on the Australian mainland. One example is the Rufous Hare-wallaby or Mala (*Lagorchestes hirsutus*), which today survives only on three islands off Western Australia and within a tiny enclosure in the Tanami Desert. Current translocation policies for Mala limit source individuals to those from within the mainland enclosure, because these have been shown to be more genetically diverse compared to the populations on each island. But why not include island individuals in future translocations? This management strategy would not only increase the number of source individuals (and the likelihood of success), but maximise the genetic diversity of the species, ultimately improving the long-term genetic stability of any translocated population.

We are not proposing to mix populations of different species, but rather to mix populations within species that were once continuous, with the proviso that the original (source) populations are not compromised. Island populations are, and should be maintained as, unique genetic identities, but for future conservation, mixing populations for mainland reintroductions may be the key to avoid the extinction of yet more of our endangered fauna.

FURTHER READING

Fischer, J. & Lindenmayer, D.B., 2000. An assessment of the published results of animal relocations. Biol. Conserv. *96: 1–11.*

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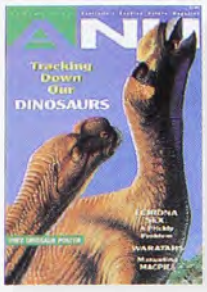

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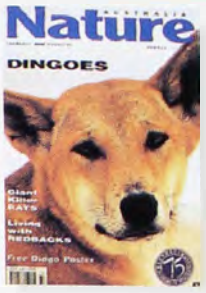

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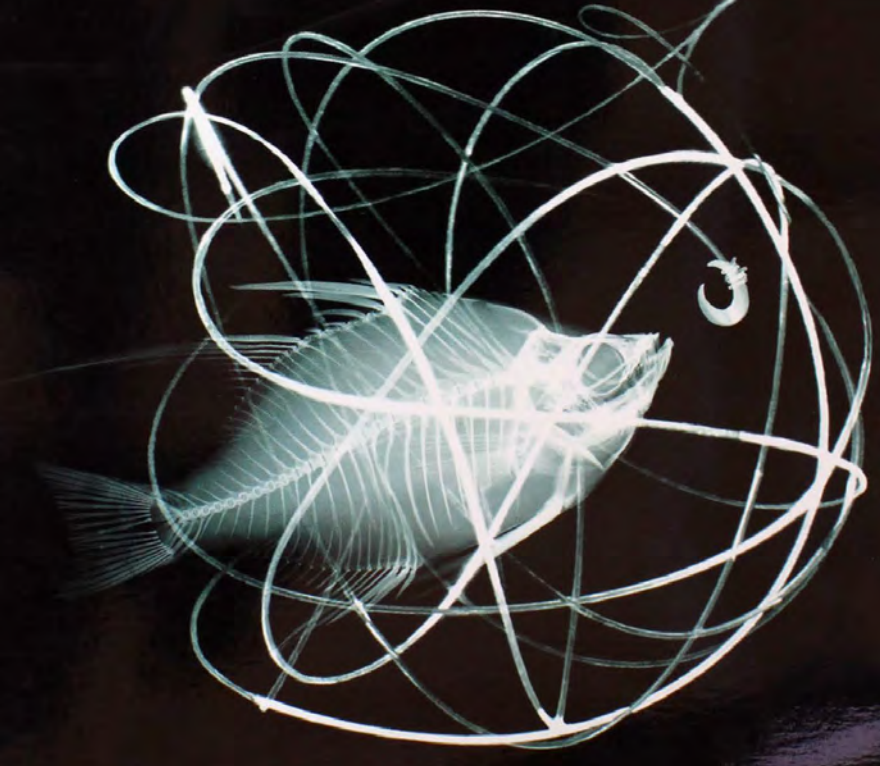

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