FREE GECKO POSTER

WHITLEY AWARD WINNER 2004

Nature Australia

AUTUMN 2005
$9.50 INC GST

- Snake Sounds
- New Guinea Agriculture
- Red-crowned Toadlets
- Silverfish
- Pitcher Plant Spiders
- Solar-powered Bats
- Circumcision

BUSH STONE-CURLEWS

ISSN 1324-2598

www.natureaustralia.net

AUSTRALIAN MUSEUM

REWARDING OUTSTANDING SCIENCE!

The 2005 **Australian Museum Eureka Prizes**, Australia's premier science awards, reward outstanding achievements in Australian science, industry, innovation, education and science communication. Prizes worth almost a quarter of a million dollars – including new prizes for leadership in science and for bioinformatics research. See www.amonline.net.au/eureka for full details.

Entries Close 13 May 2005

AUSTRALIAN MUSEUM EUREKA PRIZES
REWARDING OUTSTANDING SCIENCE

AUSTRALIAN
MUSEUM

NatureAustralia

Autumn 2005 Volume 28 Number 4

Published by the Australian Museum Trust
6 College Street,
Sydney, NSW 2010.
Phone: (02) 9320 6000
Fax: (02) 9320 6073
Web: www.natureaustralia.net
Trust President: Brian Sherman
Museum Director: Frank Howarth

Publishing Manager
JENNIFER SAUNDERS, B.SC.
email: jennys@austmus.gov.au

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

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

Design & Production
RUSSELL GIBSON COSTELLO

Advertising
KEN HILL/BUSINESS MAGAZINES
Phone: (07) 3399 1885
email: ken.hill@businessmagazines.com.au

Subscriptions
Phone: (02) 9320 6119
Toll-free (1800) 028 558
Fax: (02) 9320 6073
email: subscribe@austmus.gov.au

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

Proudly printed in Australia by Penfold Buscombe

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

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

nsw arts The Australian Museum is a statutory authority of, and principally funded by, the NSW State Government

Published 2005 ISSN–1324–2598

NATURE AUSTRALIA is proud winner of the 1987, '88, '89, '90,'91,'92,'93,'99,2000,2002,2003 and **2004 Whitley Awards** for Best Zoological Periodical, and the 1988 & '90 Australian Heritage Awards.

FRONT COVER
An adult Bush Stone-curlew (*Burhinus grallarius*) shows off its legs, which led to its former common name of Bush Thick-knee.
PHOTO BY RAOUL SLATER/ LOCHMAN TRANSPARENCIES

up front

A single's scene that leaves many desperate and dateless. It's a state of affairs that all too many of us have been familiar with at some stage in our lives. But have any of us ever been desperate enough to decide that a motorbike might be a reasonable choice as a loving partner? It seems that the current plight of our lonely Bush Stone-curlews is leading some of them to decide just that. Across south-eastern Australia where they were once regarded as common, isolated pairs and single birds are now being reported. And a single bird has little chance of mating and producing offspring. So, in order to head off this species' lonely slide into extinction, landholders, community groups and government agencies are working together and may just be able to bring a little love back into a lonely curlew's life.

Do all snakes hiss? Do snakes have mating calls or territorial calls? Most people would be surprised by the answers because it seems that most of the 2,800 species of snakes in the world produce no sound at all. And there are no documented cases of mating calls, territorial calls or any calls except for defence. Yet, snakes do have a well-developed hearing apparatus and sound is important to them. Bruce Young explores this fascinating topic and reveals a side of snakes that we know all too little about.

KEN GRIFFITHS

Copperhead snake.

Also in this issue we meet a frog for whom the wrong decision seems to be the right one, examine the development of agriculture in New Guinea that is challenging conventional beliefs, look at how tree-roosting bats survive the cold, and delve into the practice of circumcision.

— JENNIFER SAUNDERS
Publishing Manager

GEOFF TAYLOR/LOCHMAN TRANSPARENCIES

Bush Stone-curlew.

contents

REGULAR FEATURES

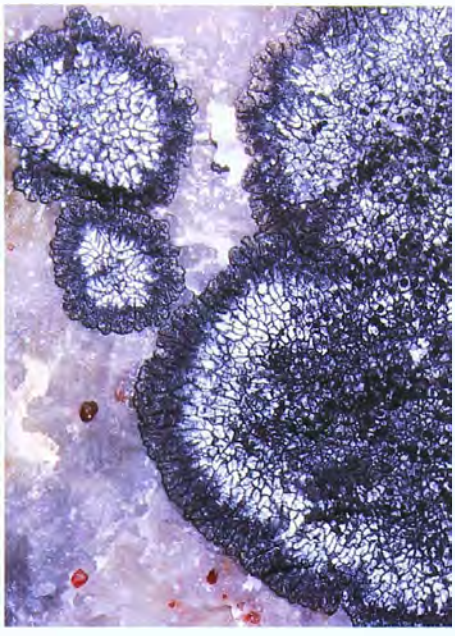
ARTICLES

RARE & ENDANGERED

Tammar Wallaby

Moves across the Tasman may bring the South Australian mainland subspecies back from 'extinction'.

BY ANDY SHARP, JASON VAN WEENAN & JULIA BIGNALL



WILD THINGS

Growing Old in the Cold

Antarctica's lichens survive extraordinary extremes.

BY TIM LOW

PHOTOART

ANZANG Nature and Landscape Photographer of the Year 2004

View a selection of the spectacular images that were part of this international photographic competition.

GLOBAL SPOTLIGHT

Bugs in Jugs

Malaysian pitcher plants are home to an extraordinary crab spider that takes both food and refuge from the plants' fluid-filled jugs.

BY SIMON D. POLLARD

BEING HUMAN

Making the Cut

The practice of male circumcision goes back at least 4,000 years, and the documented reasons for it are diverse.

BY RICHARD FULLAGAR

THE SECRET LIFE OF PLANTS

All in the Family

No longer just false cousins, Australia's 'native heaths' are now fully fledged members of the 'true' heath family.

BY TIM ENTWISLE

THE LAST WORD

Taxonomy: Biology's Infrastructure

Just as governments are judged by their ability to maintain roads, sewers and courts, so too will they be judged by their maintenance of museum collections.

BY ALLEN E. GREER

COLUMNS

letters

Tough Penguins

The Nature Strip item "Penguin Mothers Show True Grit" (*Nature Aust.* Summer 2004–2004) was of particular interest to me, having just returned from Argentina. While there I visited two breeding colonies of Magellanic Penguins (*Spheniscus magellanicus*) and puzzled at their success in breeding in such harsh conditions. The thick shell of the eggs explains a lot. It was a wonderful sight to see so many birds raising chicks of all sizes, some with eggs still to hatch.

—Judith Russell
Peakhurst, NSW

Tasmania's Hell

Readers may be interested in the broader environmental context of "The Devil's New Hell", the Devil cancer described by Nick Mooney (*Nature Aust.* Summer 2004–2005).

Tasmania is currently suffering the fastest proportional rate of native forest destruction in the developed world, with 39,000 hectares logged last year.

Accompanying this onslaught is the largely unmonitored aerial spraying of forestry herbicides and pesticides in most major catchments in the State. These include potent endocrine disrupters, such as atrazine and other triazine chemicals. An independent report on marine life kills on the east coast of Tasmania noted a correlation between Devil Facial Tumour Disease hotspots with areas of intensive plantation establishment.

Complementing the spraying is the routine use by forestry of 1080 poison to kill browsing mammals, exposing many Devils to serial episodes of gorging on poisoned carcasses. Devils have a high resistance to 1080, but the poison is known to leave residual damage to organs, including the reproductive system, at sublethal doses.

Given the political muscle of both the logging and agri-chemical industries, it is difficult to imagine the green-bashing Tasmanian Government vigorously supporting any enquiries into the long-term effects of these chemicals or their synergies.

The grudging level of support for Mooney and his colleagues is reflected in his article's reading references. On a unique, virulent cancer first noticed in 1996, there is one very short 2003 article in *Wilderness News*.

—John Hayward
Weegena, Tas.

COURTESY JUDITH RUSSELL

A Magellanic Penguin and chick.

Thankyou for your timely article on the devastation of the Tasmanian Devil population from facial tumours ("The Devil's New Hell", *Nature Aust.* Summer 2004–2005). The cause is presently unknown but it appears reasonable to conjecture that the habitual use of 1080 poison by Forestry following reseeding of clear-felled logging coupes could play a part as a chemical 'promoter'. The Devils being prime

scavengers no doubt feed on the poisoned carcasses, thus concentrating the toxins in their system, similar to the Indian Vultures, also featured in this issue ("Scavengers at Death's Door"). However, is discussion of this potential promoter of the disease too politically sensitive?

Mention is also made in the article of the recent malicious introduction of Foxes to Tasmania. I understand that previous Fox introductions have fortuitously been unsuccessful due to their predation by Tasmanian Devils, and competition for burrows and carcasses. Surely the answer is to invest in a concentrated effort to discover the causes of Facial Tumour Disease and eradicate them so that the recovery of a healthy population of Tasmanian Devils can assist in eliminating Foxes.

—Alastair Stevenson
North Sydney, NSW

Molar Muddle

I always enjoy attempting the Nature Strips quiz questions, and can usually answer some of them. But I am a little puzzled at the answer given for question 3 in the Summer 2004–2005 issue: "How many molars do placental mammals have?" As a retired dental academic, I felt sure I knew the answer, which, without discussing genetic variations, is 12. 'Three' is correct only if the question includes the supplemental words 'in each quadrant'.

But even with that addition, there is still a problem. To be accurate, the question should also include the word 'usually'. I am in a strong position to suggest this addition, as I am one of the small but growing percentage of humans that have only four upper molars; that is, two in each upper quadrant.

Congenitally absent third molars ('wisdom' teeth) are becoming more common in modern humans, and it is a good thing not to have them, as there is then little chance of developing the dreaded 'impacted wisdom tooth'. I suppose that this is the way evolution occurs.

But even with the above suggested changes, the answer is still not complete. Many placental mammals have two sets of teeth, 'deciduous' teeth (including eight molars, usually), which are shed to make way for the 'permanent' teeth.

—Barrie Gillings
Turramurra, NSW

For the Record

The illustration of the Columbian Mammoths on page 10 of the Summer 2004–2005 issue of *Nature Australia* should have been credited to Karen Carr. And the full Crown-of-Thorns Starfish specimen pictured in From the Collection was not the Museum's oldest one referred to in the text (which is only half a specimen). We apologise for the errors.

—G.H.

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

Autumn

Compiled by Geordie Torr and Martyn Robinson

BOB DRUMMOND

Silvereye.

THE HORDES OF AUTUMN

Silvereyes are on the move. These birds (*Zosterops lateralis*) are familiar visitors to suburban gardens over much of the east, south and south-west, their reedy 'tsee-tsee' calls filling the air as they flit from bush to bush. In autumn the birds gang together in large flocks that scour the land for food.

The birds typically head north at this time, and southern populations sometimes replace the more northern ones. So Silvereyes can be present all year round in some areas, it's just that they're not the same birds.

The Silvereye's diet is varied, taking in insects and fruit, as well as pollen and nectar. This can lead to the birds being both a pest, damaging soft fruit such as grapes, and a pest-controller, feeding on insects such as the Woolly Apple Aphid.

When the weather warms, the birds return to their original haunts, pair up, build their little cup-shaped nests from grass, hair and cobwebs, and start the seasonal cycle all over again.

For more on Silvereyes, visit **http://www.amonline.net.au/factsheets/silvereye.htm**

Deciduous Beech, Cradle Mountain, Tasmania.

TASMANIAN GOLD

Autumn clothes the forests of the Northern Hemisphere in red and gold, but here in the Great Southern Land, the majority of our trees retain their cloak of green. There is, however, one species that puts on a particularly remarkable autumnal display.

Growing in dense stands in mountainous, high-rainfall areas of central and western Tasmania, the Deciduous Beech or Fagus (*Nothofagus gunnii*) is a small tree, rarely reaching more than two metres.

The species, like the genus to which it belongs, is an anachronism left over from a time when Australia was still part of Gondwana. There are Deciduous Beech fossils going back 35 million years in Tasmania and the Antarctic, and it appears that the tree has changed little in that time. Back then, the landmass that is now Tasmania was about 20° farther south and was plunged into darkness during winter. Hence, being deciduous was a very good idea.

Although individual trees can live for more than 350 years, the species' survival is threatened. The trees have extremely thin bark and so are very sensitive to fire. And because Deciduous Beech seeds don't survive for very long in the soil and don't spread over very large distances, the species has difficulty regenerating after a conflagration.

If you want to see the tree at its fiery best, one of the most accessible viewing areas is around Lake Fenton in Mount Field National Park. Those willing to go a bit farther afield should visit Crater Lake in Cradle Mountain National Park, which boasts a spectacular display. But if you can't get that far, try visiting **http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/BHAN-54A3PL?open**

SO MANY JELLIES

In autumn, the estuaries and harbours of eastern Australia can become filled with aggregations of Common Jellyblubbers (*Catostylus mosaicus*) so dense that they clog cooling pipes and commercial fishing nets. No-one is quite sure why the aggregations take place, but they are thought to be due to temporary local conditions such as wind, currents, temperature and salinity.

The blubbers start life as larvae that attach to the seafloor and become polyps. About two weeks after settling, these bud off into a series of medusae—the familiar jellyblubber shape. The young medusae grow rapidly at first, as much as five millimetres a day, probably so they can quickly become strong enough swimmers to avoid being swept into deeper waters.

This species is brown or white in many places in New South Wales, but frequently blue farther north. The different colours come from the different species of photosynthetic algae that live in the blubbers' see-through tissues, providing them with oxygen and nutrients. This species of jellyblubber is served as a delicacy in certain Asian cuisines, and there is also an Australian fishery.

For more blubbery facts, visit **http://faunanet.gov.au/wos/factfile.cfm?Fact_ID=17**

NEIL VINCENT

Common Jellyblubber.

FROM THE COLLECTION

AUSTRALIAN MUSEUM

*This is the Australian Museum's earliest specimen of what used to be called the Spine-tailed Swift and is now known as the White-throated Needletail (*Hirundapus caudacutus*). Presented to the museum by A. Clarke, it was registered in May 1884 and collected in Bulga, in the Hunter Valley, New South Wales.*

This species is migratory, arriving in Australia in spring, towards the end of October, and leaving in autumn, usually before the middle of April. Some birds will hang around until August, but these are all non-breeders. Early autumn is when the birds are at their most visible, as they feed voraciously on flying insects just prior to leaving our shores.

The bird's common names refer to the unusual spines that project from the ends of its tail feathers. These are formed by the central shaft extending beyond the vane or flight surface of the feather.

As would be expected of a species that spends so much time on the wing (it even mates while flying!), its legs are relatively poorly developed. It nests in tree hollows, and with its small legs and feet, one would expect it to have some difficulty manoeuvring about. But this is where the tail spines come into their own. When clambering in and out and perching in the cavity, the bird uses its spiny tail as a brace to prevent it slipping backwards.

Visit **http://www.amonline.net.au/factsheets/needletail.htm** *for more about these fascinating little birds.*

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

nature strips

COMPILED BY GEORGINA HICKEY

RUTH BERAN, RICHARD FULLAGAR, KARINA HOLDEN, MICHAEL LEE, KAREN MCGHEE, RACHEL SULLIVAN, GEORDIE TORR AND PAUL WILLIS ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Strange Bedfellows

Normally you would expect that a prey animal would put as much distance between itself and its predator as possible. So imagine the surprise of two researchers working in the Aleutian Islands, Alaska, when they performed a routine inspection of a Bald Eagle's nest and found not only a healthy eaglet, but also a gull chick—normally a staple of the eagle's diet—happily coexisting.

Robert Anthony (US Geological Survey) and John Faris (Aleutian Islands Maritime Wildlife Refuge) say that the much smaller and younger Glaucous-winged Gull chick (*Larus glaucescens*) was on good terms with the six-week old eaglet (*Haliaeetus leucocephalus*), and was healthy, suggesting it was either being fed, or scavenging enough food to survive (*Wilson Bull.* 115: 481).

The question remains how it got there in the first place. It is unlikely that the nest was parasitised by a gull, because gulls aren't brood parasites, and anyway, the egg would have to have been laid during the first week of the eaglet's life when its parents would be at their most aggressive.

Another possibility is that the parents preyed on an adult female gull with a well-developed egg in her oviduct, and incubated the egg after consuming the female, but that is also unlikely because eagles also eat gull eggs.

The third alternative is that one of the adults captured the gull chick but failed to kill it during the initial attack—a case of non-lethal predation. The gull probably escaped a death sentence by pretending to be dead. But how the relationship developed from there is anyone's guess!

—R.S.

Stone Age Pussy

How long have cats been rubbing themselves and arching their backs up against human legs? The Ancient Egyptians certainly enjoyed and revered their felines

JOHN SHAW, ALSC AIPL

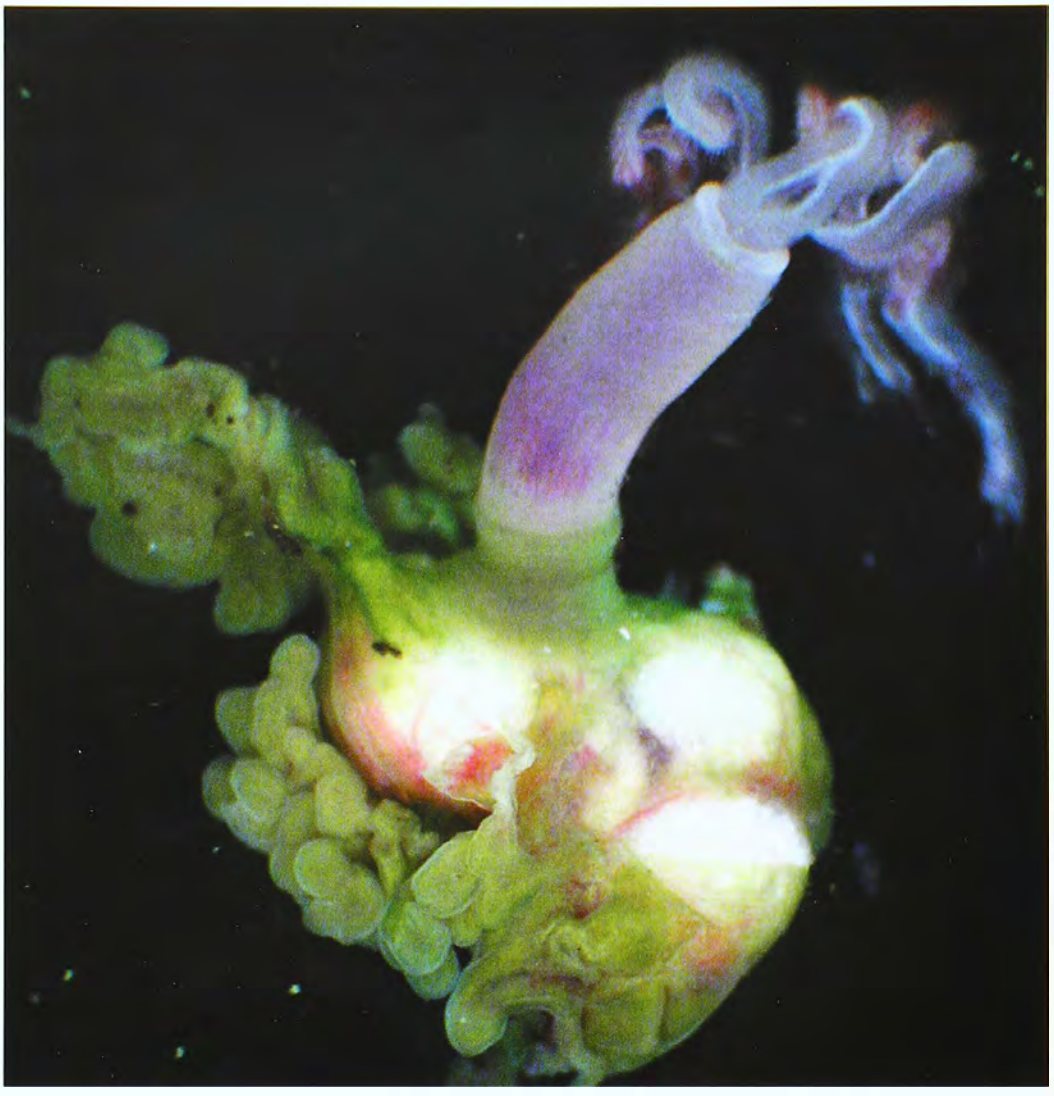
A Bald Eagle with its young about to fledge. Apparently Bald Eagles may end up raising, rather than eating, their prey.

4,000 years ago. Buried skeletons, mummies and paintings of cats are testament to the special role they played in that society. However, a cat skeleton has been found inside a 9,500-year-old human grave on the island of Cyprus, pushing back the earliest known evidence of cat-taming by 5,500 years.

Jean-Denis Vigne (CNRS–National Museum of Natural History, Paris) and colleagues discovered the articulated cat skeleton less than half a metre from the burial remains of a 30-year-old human (*Science* 304: 259). Both bodies were oriented the same way, with their heads pointing west. That they were found so close together, in the same level of sediment and with the same degree of preservation strongly suggests the two skeletons were buried together intentionally. This in turn suggests that the cat was special and most likely a pet. There are no clues as to how the cat died, but it may well have been sacrificed to accompany its owner into the afterlife.

The cat belonged to the Wild Cat species (*Felis silvestris lybica*), from which the smaller Domestic Cat (*F. catus*) is derived. No cats are native to Cyprus, so the original human inhabitants of the island—Neolithic cereal farmers—must have brought them over from the mainland, most likely Turkey, encouraging them to live alongside them to help protect their grain stores from mice.

—G.H.



GREG ROUSE

Whaleworms

Two bizarre new worms described by Greg Rouse (South Australian Museum) and colleagues emphasise how much we still have to learn about biodiversity in the deep sea. Both species of *Osedax* (Latin for 'bone-eater') feast exclusively on sunken whale skeletons, living in tubes that cover most of the exposed bones (*Science* 305: 668). Feathery, retractable red fronds, used for gas exchange, protrude from these tubes. The worms have lost their mouths and usual digestive systems, instead obtaining food by sending ramifying roots deep into the marrow. Nutrients are absorbed through these roots with the help of symbiotic bacteria.

***Osedax* worms feed exclusively on the skeletons of sunken whales.**

The life cycle of these bone-eating worms is similarly bizarre. Each 'worm' is really a colony consisting of a large female and up to 111 microscopic parasitic males, which are little more than bags of sperm attached to the female's oviduct, ready to fertilise developing eggs. The larvae disperse into the water column, and the researchers suspect those that settle on fresh whalebone develop into females, and those that settle on females develop into males.

DNA sequences reveal that *Osedax* evolved shortly after whales arose, and the dense populations of these

ROBIN SMITH

The Hippo's red skin secretion acts as a sunscreen and antibiotic in one.

worms indicate that they have successfully exploited sunken whale carcasses: rich but highly localised and transient resources.

—M.L.

Hippo's Pink Zinc

An ancient belief that Hippos sweat blood came from observations of red mucous oozing from their skin. Blood it isn't, but it is only recently that the true nature of this mysterious red has been revealed.

Yoko Saikawa (Keio University, Japan) and colleagues swabbed the backs and faces of Hippos (*Hippopotamus amphibius*), and found the slimy secretion to be a natural form of sunscreen produced by glands in the skin (*Nature* 429: 363). It consists of two acidic pigments. The red pigment is hipposudoric acid; and the other, which is actually orange, norhipposudoric acid. Considering their bristly naked skin and the amount of sun exposure Hippos are subjected to as they loll around in the waterhole, it's a good thing they come with their own protection.

The researchers discovered that the red skin secretion also acts as an antibiotic. When they tested it on a culture of bacteria, it inhibited the growth of the harmful microbes.

Hippos are notoriously cranky creatures and when fights break out they can do serious damage to one another with their giant incisors. Anti-bacterial skin provides the Hippos with an effective way of fighting wound infection in a swampy environment. It might not be the most pleasant-smelling substance, but Hippo slime provides all the slip, slop, slap needed to make the most out of naked bog-dwelling.

—K.H.

Bed Bugs on the Rise

Bed-bug bites are an inevitable part of the 'third-world' travelling experience. But few people expect to share their mattress in Australia with these voracious little blood-suckers. In fact, infestation levels here and in other developed nations fell significantly during the 20th century due to developments in sanitation and insecticides.

The bad news, however, for all those who expect and enjoy scratch-free sleep, is that the decline has reversed in recent years and countries such as Australia, Britain and the United States have been recording dramatic rises in bed-bug numbers. The pathology service at Sydney's Westmead Hospital, for example, has experienced a massive 400 per cent jump in the number of bed-bug samples submitted since early 2001 (*Environmental Health* 4: 22).

The pest-control industry has also noted the trend and reported a significant increase in demand for bed-bug treatments. Interceptions of the insects by the Australian Quarantine and Inspection Service have risen

significantly as well. The insects are being found mostly in the luggage of travellers, which gives a clue to at least one underlying reason for this troublesome entomological resurgence.

Stephen Doggett and colleagues from Westmead's Department of Medical Entomology believe that, although the increase is most likely to be underpinned by several factors, the rise in world travel is probably the main cause.

Bed-bug saliva can cause irritations and allergic skin reactions in victims, and a small proportion of people may even experience anaphylactic shock. Researchers believe a better understanding of the problem and how to treat it, particularly within the accommodation industry, is essential if infestation levels are to be brought back to pre-21st-century levels.

—K.McG.

COURTESY STEPHEN DOGGETT

Common (left) and Tropical Bed Bugs (*Cimex lectularius* and *C. hemipterus*) are making an unwelcome comeback in Australia.

Oldest Modern Beads

South Africa's Blombos Cave is already famous for its remarkably early evidence of human art (see "The Start of Art?", *Nature Aust.* Summer 2003–2004). Now it's latest claim to fame is the world's oldest jewellery.

Christopher Henshilwood (University of Bergen, Norway) and colleagues have described 41 beads made from the shells of the small snail *Nassarius kraussianus*, and dated to the Middle Stone Age (about 75,000 years old). Each shell has a hole in exactly the same position near the lip, and microscopic wear marks are consistent with rubbing against threaded string, clothing or other beads (*Science* 304: 404). The shell beads are larger than, and distinct from, the more modern beads found in higher, younger levels of the site (less than 2,000 years old).

Some archaeologists remain sceptical that the art of bead manufacture can be so old. Beads are for decorative display and indicate the ability to construct symbols, which (like art and language) are diagnostic indicators of modern human behaviour. The discovery of Middle

Stone Age beads is important (and controversial) because they are over 30,000 years older than other beads found in Africa or anywhere else in the world (see "Original Hippies", *Nature Aust.* Spring 2002). Until now, beads have been associated with the argument for a late (about 45,000-year-old), rapid appearance of modern human behaviour. If 75,000 years marks the first appearance of beads, then modern human behaviour arose gradually—or just stalled for 30,000 years.

Either way, it is puzzling why Blombos Cave, on the southern tip of Africa, is so unique. For this reason, archaeologists await with much interest the dates of possibly even older ostrich eggshell beads from Tanzania.

—R.E.

When No Means Yes

When female Green Turtles (*Chelonia mydas*) suffer sexual harassment from overeager males they have no recourse to anti-discrimination boards. And during mating, male Green Turtles can be quite aggressive, biting females on the flippers, neck and head, and leaving wounds that may take several weeks to heal.

Why then would a female turtle mate multiple times when a single mating is often sufficient for fertilisation?

Until now, the standard answer has been that multiple paternity benefits the female by positively selecting for fitter offspring. (Nothing like a bit of healthy sperm competition!) However, Patricia Lee and Graeme Hays (University of Wales Swansea) studied female Green Turtles and their offspring at Ascension Island, and found that multiple mating did not significantly benefit offspring survival (*PNAS* 101: 6530). In fact, sand quality had a much greater impact on the proportion of young that successfully left the nest than whether or not the young were sired by one or more males.

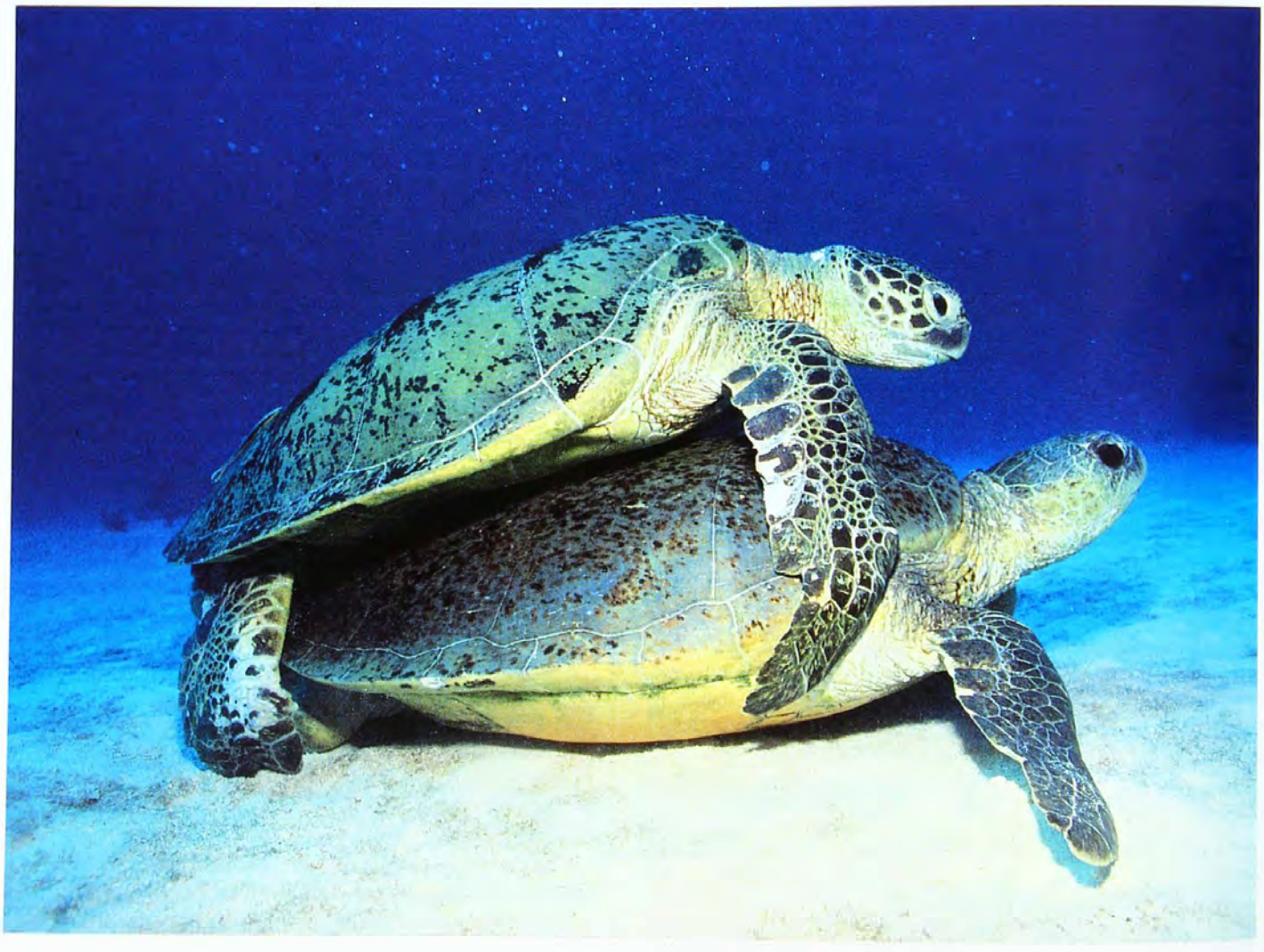
The researchers suspect that females will generally avoid mating more than once. But if the cost of resisting a male's sexual advances is greater than the cost of mating, females will "make the best of a bad job" and give in to male pressure. It seems that multiple paternity in Green Turtles is the result of male coercion, where females have found it easier to say yes than to put up a fight.

—R.B.

Screaming Squirrels

Only in my worst nightmares do I scream and no sound comes out. But some squirrels do this fairly frequently, and to apparently good effect.

Richardson's Ground Squirrels (*Spermophilus richardsonii*) produce audible alarm calls to alert others of danger, sometimes at considerable risk to



ADAM ZEBEDEE/NOMAD

Mating in Green Turtles can be a rough affair.

COURTESY JAMES HARE

Silent but deadly: a Richardson's Ground Squirrel emitting an ultrasonic warning call.

themselves. But David Wilson and James Hare (University of Manitoba) became curious when they noticed some squirrels with mouths wide open, looking like they were giving off an alarm call, yet only emitting faint rushes of air. So they recorded both the audible and so-called 'whisper' calls, and found that, unlike the audible call with a frequency of 8 kilohertz, the whisper call was made up entirely of ultrasonic frequencies (above the level of human hearing) with the dominant frequency just under 50 kilohertz (*Nature* 430: 523).

To investigate the possible function of the ultrasonic call, the researchers recorded and played back whisper calls to squirrels, as well as three control calls (general background noise, the audible call, and a pure tone that matched the dominant frequency of the whisper call). Both the audible and ultrasonic calls produced an increase in vigilant behaviour, but the audible call evoked the strongest response, causing many squirrels to run for cover. Ultrasound, besides being inaudible to humans and also many rodent predators, peters out very quickly and is highly directional. Perhaps ultrasonic calls are used only to warn specific animals close by, without drawing attention to the caller.

—G.H.

Extinction's in Your Genes?

Extinction, it seems, is part of life. Almost all species that have ever lived have become extinct. Now a controversial new idea suggests that extinction may be controlled by an internal clock in every species, and that a species' time is up when the protective caps at the ends of the chromosomes—called telomeres—get too short.

Scientists have been grappling with the issue of 'background' extinction for more than a century: dramatic mass-extinction events like the one that killed the dinosaurs account for only four per cent of now-extinct species, so what killed the rest? Reinhard Stindl (Institute of Medical Biology in Vienna) thinks he has the answer (*J. Exp. Zool.* 302B: 111).

Each time cells divide, telomeres are not copied completely and gradually become shorter. However, according to current ideas, the enzyme telomerase rebuilds the telomeres in germ cells (eggs and sperm), which means the offspring would inherit constant telomere length. Stindl questions this and proposes that telomeres do in fact erode steadily with every generation, thus acting like a species clock.

After many generations, diseases related to chromosomal instability or

Where Are All Our Big Carnivores?

To most people, it's a relief Australia has no big mammalian meat-eaters. But for biologists, the continent's celebrated shortfall of marauding carnivores has been one of prehistory's perennial puzzles.

Through his 1994 bestseller *The future eaters*, renowned mammalogist and palaeontologist Tim Flannery garnered popular support for a theory that blames it largely on poor-quality soils. The impoverished state of the Australian continent, it's been speculated, limited both diversity and body size of plant-eaters, which in turn restricted the types and size of carnivores that fed on them.

Support for an alternate hypothesis now comes from Stephen Wroe (University of Sydney) and colleagues, who compared the South American and Australian continents during the past 25 million years (*Proc. R. Soc. Lond. B* 271: 1203).

For tens of millions of years these two landmasses shared many significant features. Both were large and isolated with a carnivorous fauna dominated by marsupials. When they looked at body sizes and numbers of species, the researchers found that the diversity of warm-blooded carnivores in both continents was comparable. But allowing for South America's much greater area, diversity in Australia was, if anything, greater.

Things changed three million years ago with the collision of the North and South American plates and the formation of the Central American land bridge. A southerly migration of huge placental mammalian carnivores followed in an event known as the Great American Biotic Interchange. From that point the diversity and size of South America's carnivore complement rose rapidly. In Australia, argue Wroe *et al.*, the status quo was maintained primarily by geographic isolation. If correct, this means that attempts to explain Australian biodiversity must first properly account for our island status before invoking factors such as productivity.

—K.McG.

FRANÇOIS GOHIER, ARDEA

The large bones in *Tyrannosaurus rex*'s skull were only loosely connected.

QUICK QUIZ

1. *Which were domesticated first: Dogs or Cats?*
2. *What do you call sound waves that have a frequency of over 20,000 Hertz?*
3. *In which Australian State do Bennett's Wallabies live?*
4. *What type of animal is the venomous Gila Monster?*
5. *How many species of crow are native to Australia?*
6. *Which national park has the single-known wild population of Northern Hairy-nosed Wombats?*
7. *What happens to the nose of a Lion as it gets older (besides getting bigger)?*
8. *Do seahorses have scales?*
9. *Name the green pigment used by plants to photosynthesise.*
10. *Which two planets flank Jupiter in their orbit about the Sun?*

(Answers on page 79)

limited tissue regeneration, like cancer and immunodeficiency, would become common, ultimately resulting in a population crash.

Stindl says such a process of attrition would explain why telomere lengths vary so greatly between species: some bird telomeres are up to a million DNA base pairs long, while humans feature only 10,000 or so base pairs. All of which begs the question, how long have we got?

—R.S.

Testing the King's Head

You might think that the King of the Dinosaurs, which made a living by chomping on other dinosaurs, would have a pretty strongly built skull. But many of the larger bones in the skull of *Tyrannosaurus rex* were loosely connected to each other, with flesh binding the skull rather than rigid bone-to-bone contacts.

Damage to prey indicates that *Tyrannosaurus rex* was a 'puncture-pull' feeder. First the teeth were slammed deep into the prey in a bone-crunching bite, then the head was pulled back, ripping the prey apart. This would have exposed the skull to enormous stresses in the 'puncture' phase, followed by equally enormous forces in the opposite direction while 'pulling'. So could *T. rex*'s loosely connected skull have withstood the rigours of 'puncture-pull' feeding?

Emily Rayfield (Cambridge University) saw this as an engineering problem and so she decided to apply 'Finite Element Analysis' (FEA) to the King's head—a method normally used to analyse stresses and strains on bridges and other structures (*Proc. R. Soc. Lond B* 271: 1451).

It turns out that the palaeopugilist *had* to have fleshy, impact-absorbing connections between the bones of its skull. While some bones such as the nasals were particularly heavily built to withstand compression and shearing, the connections between bones were necessary to resist tensions and dissipate bone-shattering loads.

In short, *Tyrannosaurus rex* passed the FEA with flying colours. Its seemingly fragile skull was actually superbly adapted to the murderous forces encountered during dinner.

—P.W.

Fairy Circles

Since the early 1970s scientists have been puzzled by the appearance of 'fairy circles' on the western coastal edge of Africa's Namib Desert. These shallow circular depressions of completely bare sandy soil are between two and ten metres across and surrounded by lush perimeters of tall grasses.

Earlier work had discounted fungi as a possible cause of the bare patches, and, seeking a definitive answer to the question of what causes the fairy circles, Gretel van Rooyen (University of Pretoria) and colleagues put the three remaining theories—radioactive soil, toxic plant by-products and termites—to the test (*J. Arid Environments* 57: 467).

Radioactive soil was quickly dismissed after samples were lab-tested and found to be negative.

Then van Rooyen's team collected earth from underneath the poisonous milkbush plant *Euphorbia damarana*, which often grows in the vicinity, as well as from the barren centres and lush edges of several circles. When grass seeds were sown

COURTESY GRETTE VAN RENSWEN

A 'fairy circle' in the Namib Desert. What causes these mysterious bare patches?

in the soil samples back in the lab, the plants withered on the soil taken from within the circles, yet flourished on samples from the perimeter and beneath the milkbush, eliminating its toxins as a cause.

Finally the team excavated deep trenches in a bid to determine whether termite activity had anything to do with the circles. It had been thought that perhaps termites consume all of the seed within the circles, leaving nothing to germinate, but although termites were found nearby, there was no direct evidence linking the two.

The study attracted a flurry of attention and one suggestion, that the circles could be the result of residual effects of toxic ash, may bear further investigation. But for now, the researchers say, we'll just have to blame them on the fairies.

—R.S.

Drumming up Sex

The lusty atmosphere on Mexico's Isla Isabel reaches fever pitch as hundreds of Magnificent Frigatebirds (*Fregata magnificens*) come to roost for the annual mating season. As females circle low over the rookery, the males crane their heads to the sky to show off their scarlet-coloured throat pouches, inflated like heart-shaped balloons. The raucous males vibrate their wings rapidly

and woo the females with loud clicking and drumming sounds.

Females hold the balance of power as they make up the minority of the breeding colony. With so many males to choose from, they can afford to be fussy. Vinni Madsen (Universidad Nacional Autónoma de México) and colleagues have been studying the island's frigatebirds and found that only 55 per cent of males are successful at finding a mate (*The Condor* 106: 156). Because the birds are monogamous, this has major consequences for those who miss out. As a result, males must make every effort to advertise their vigour with an attention-grabbing audio-visual presentation.

It appears that females select males predominantly on the size of their throat pouch. The bigger the pouch, the sexier the bird. To make sure females know just how enormous their inflated pouches are, the males produce a sequence of deep, loud drumming sounds that resonate in the air-filled sac. Madsen and her team have been able to record these signals and compare them to pouch size. The results show birds with larger pouches produce lower-frequency drumming.

The researchers believe the birds are using sound to enhance the visual signal, just in case the flying females can't make out the size of their assets. A reverberating and bulging red pouch means the female both sees and hears her suitor's message, loud and clear.

—K.H.

Globe-trotting Dinos

As the Mesozoic Era drew to a close, the ancient southern supercontinent Gondwana resembled a pizza being pulled into irregular-shaped pieces. The question that has bugged geologists and palaeontologists for years is the sequence of that break-up into the separate continents and islands now known as Africa, South America, India, Antarctica, Australia and Madagascar.

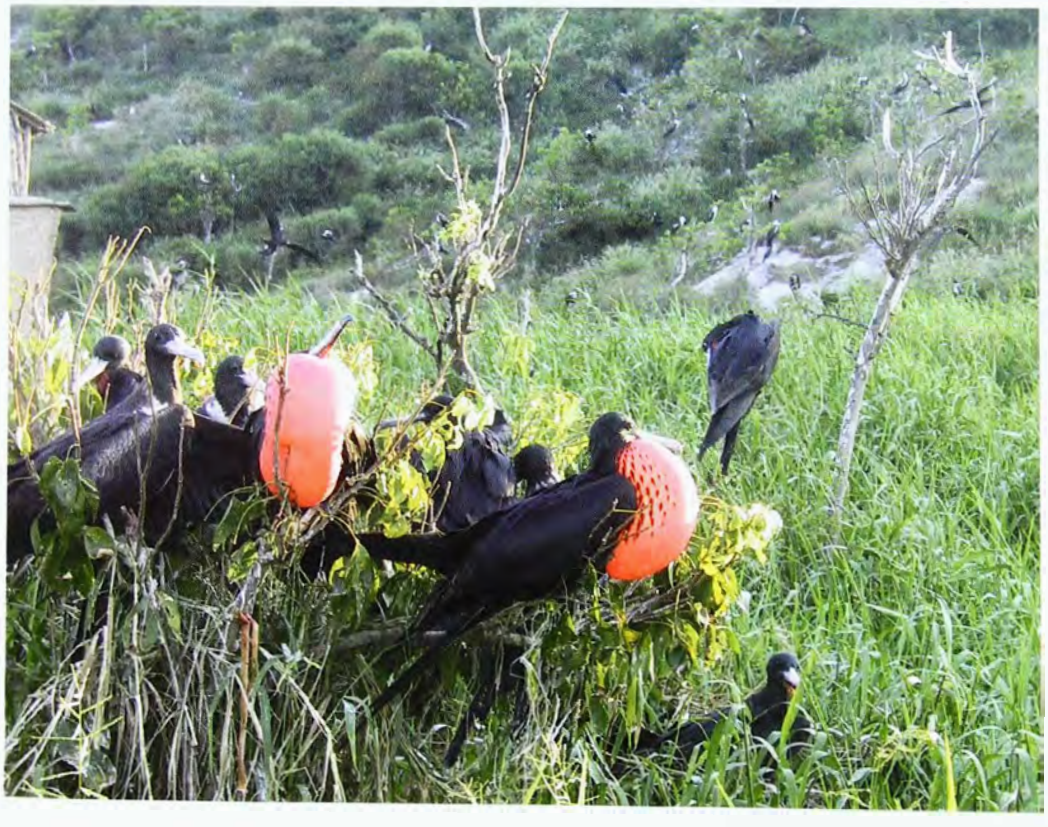
One group of dinosaurs, the predatory abelisauroids, suggested that Africa was the first piece of the pizza to be isolated from the rest. Fossils of abelisauroids had been found in Cretaceous-aged deposits in India, Madagascar and South America, suggesting that they could roam between these now separate landmasses via Antarctica. Their absence from Africa supported an 'Africa First' model of the supercontinental split—abelisauroids weren't in Africa because it had become isolated by seaways by the start of the Cretaceous.

Now three abelisauroids (or their possible antecedants) have been described from Niger, putting Africa back in contact with its Gondwanan siblings (*Proc. R. Soc. Lond. B* 271: 1325). The finds span three different stratigraphic levels of the Cretaceous Period (145–65 million years ago), from close to its beginning until almost its end.

Paul Sereno (University of Chicago) and colleagues suggest a land bridge across the embryonic South Atlantic Ocean (connecting The Ivory Coast and Ghana to the north coast of Brazil) remained for some 30–50 million years longer than previously thought. This connection allowed animals, including the abelisauroids, to migrate between Africa and South America until it finally collapsed around 90–100 million years ago in the middle of the Cretaceous Period.

Two other land bridges connecting India and South America to Antarctica are thought to have broken up at around the same time. So, rather than an 'Africa First' break-up sequence, Sereno suggests a new 'pan-Gondwanan' model for the final demise of the Great Southern Land.

—P.W.



COURTESY VINNI MADSEN

Male Magnificent Frigatebirds inflate their throat pouches to attract females.

I Can't Believe It's (Bog) Butter

We all know that leftovers can end up in the fridge longer than they should. The same applied to peat bogs. These cool, oxygen-poor swamplands were used as a kind of prehistoric refrigerator where locals buried food on wooden trays or wrapped in leather parchment. One such foodstuff was a waxy substance called 'bog butter', which, like an old cheese, reputedly improved with age. According to

The discovery of Cretaceous labelisauroid dinosaurs, including *Rugops primus*, in Niger means that Africa was not the first continent to break away from the Gondwanan landmass.

Samuel Butler (1612–1680), in his bawdy satire *Hudibras*, "butter to eat with their hog was seven years buried in a bog". But the actual recipe was apparently lost, for until recently no-one knew for sure just what animal products went into it. Was it literally butter (milk fat), or was it tallow (body fat) from animal carcasses?

A team of researchers led by Richard Evershed (University of Bristol) investigated nine bog butters from the National Museum of Scotland, the oldest of which was about 1,800 years old. They looked at the structure of the fatty components and their carbon-isotope composition and length of the carbon chains, and compared these with artificial bog butters made in the lab under anaerobic conditions from either mutton fat or mutton butter. The results show that six of the archaeological specimens were derived from dairy products, while the other three were composed of body fat (*The Analyst* 129: 270).

So now we know both butter and body fat from the bog were served up on Scottish tables, but were also sometimes forgotten—left in the fridge way beyond their use-by date!

—R.E.

Turkey Tactics

Through the well-documented phenomenon of 'imprinting', most birds learn to recognise their own kind by observing their parents upon hatching.

However Australian

This large alder keg of bog butter, 1.4 metres high, was found at Glen Gell in Scotland, and dates from the early 1800s.

CYRIL WEBSTER

An Australian Brush-turkey chick emerges, alone and unassisted, from its incubation mound.

Brush-turkey chicks (*Alectura lathami*), like other young in the unusual megapode family, enter the world without any relations around to teach them life's fundamentals. Mothers decamp soon after laying eggs into a mound of rotting organic matter, where incubation is driven by the heat of decomposition. Fathers stay longer to tend nests but they have nothing to do with the chicks once they hatch. And chicks normally don't encounter siblings straight after hatching because they emerge at different times and quickly leave the nest to hide from potential predators.

They survive despite the lack of postnatal attention by entering the world considerably more

Birds Make Lizards Hornier

Barring those with religious objections, I think we're all pretty much in agreement that Darwin got it right. But because evolution takes place over such long time spans, and much of it happened well before we were intelligent enough to appreciate it, we still have surprisingly few examples of traits to which we can categorically assign a causal agent. Sure, we know that Giraffes have long necks so they can reach the leaves other browsers miss, but we can't prove it.

Similarly, it's generally accepted that the bony horns that give American horned lizards (*Phrynosoma* spp.) their name are a defence against bird predation. Kevin Young (Utah State University) and colleagues set out to prove it (*Science* 304: 65).

COURTESY BUTCH BROOME

The horns on this particular horned lizard were not long enough to protect it from shrike-strike.

The Flat-tailed Horned Lizard (*Phrynosoma mcalli*) has a mortal enemy—the Loggerhead Shrike (*Lanius ludovicianus*). Lacking the strong talons of birds of prey, the shrikes impale the lizards on thorns, twigs and even barbed wire before picking off the soft tissue. The lizards are usually speared through the neck, and when a bird has finished its meal, it leaves the skull hanging on its hook.

The researchers collected these grisly leftovers and compared the length of horns of lizards that had been killed by shrikes with those of live lizards. They found that the latter were, on average, 10 per cent longer. Mathematical models of the effect of horn length on survival suggested that longer horns did indeed increase survival and that, once the horns reached a certain length, the lizards become effectively shrike-proof.

The study was unable to demonstrate whether or not there were other selection pressures on horn size, but it did clearly show that defence against shrike attack is one factor driving an increase in horn length.

—G.T.

TERRY HEATHCOTE – OXFORD SCIENTIFIC FILMS/AUSCAPE

Long symmetrical tails might be sexy for Barn Swallows in Europe, but not necessarily in North America.

developed and capable of self-care than most other birds. But they eventually form groups with chicks of a similar age, indicating they can recognise their own kind. To understand how, Ann Göth and Christopher Evans (Macquarie University) exposed hatchlings to the controlled behaviours of life-like robotic chicks wearing feathers and skins from birds that had succumbed to natural deaths (*J. Exp. Biol.* 207: 2199).

When the mechanical chicks were pecking, the real chicks joined them, mimicking their behaviour and even trying to steal their food, but they largely ignored robots performing other actions. And it wasn't only the eating action that attracted the chicks. When UV light was removed from the pecking robots, they failed to incite much interest.

The researchers believe megapodes may be born with an innate ability to recognise a special UV signal emitted by fellow chicks. This may be invisible to potential predators and only recognised by other chicks when combined with the action of eating.

—K.McG.

Sexual Selection and the City

Typical. You put all that effort into growing a beautiful long, symmetrical tail, only to discover that tails are, like, so last season!

The elongate tail streamers of the European Barn Swallow (*Hirundo rustica rustica*) have long been held up as a classic example of sexual selection. Longer, more symmetrical tails offer both male and female swallows a reproductive advantage. But apparently this is one more case where European fashion hasn't translated very well across the Atlantic.

Rebecca Safran and Kevin McGraw (Cornell University) studied North American Barn Swallows (*H. r. erythrogaster*) in New York. They captured male and female swallows during the first two weeks of the breeding season and measured the length and symmetry of their tail streamers. They also removed a few of the rust-coloured feathers from each bird's throat, breast, belly and vent, and measured how bright they were. They then determined when pairs began breeding, how many times they nested, and the number of chicks they fledged.

When they analysed the data, they found that, unlike in European swallows, tail length and symmetry had little effect on the onset of breeding or reproductive success. Feather colouration, on the other hand, was correlated with both—more colourful birds tended to breed earlier and more often and to have more offspring (*Behav. Ecol.* 15: 455).

The researchers suggest that this sort of geographic variation in sexual signalling—animals in different regions finding different things sexy—could lead to the divergence of populations, which in turn could lead to speciation.

—G.T.

FURTHER READING

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

www.natureaustralia.net

Silverfish for lucky lips

Silverfish as a group are about 100 million years older than the dinosaurs, making them seriously big-time living legends.

WHAT DO SIR CLIFF RICHARD, Dorian Gray and a silverfish have in common? If you were tempted to say 'the closet', you would be heading in the right direction, but the less scurrilous connection I had in mind was to do with the paradox of being ancient, yet looking young. Sir Cliff and Dorian Gray have clearly held their own in the perpetual-youth stakes, but where does the silverfish fit it?

Well, in spite of its slick-back appearance, the silverfish is really, like each of the other two, a living fossil. The entomologists tell us that silverfish (zygentomans) closely resemble the first insects that ever existed; that their order bridges the gap between wingless and winged insects. Their look-alikes are cast in rocks that go back to the Carboniferous Period (300 million years ago), and their actual bodies are not uncommon in 40-million-year-old amber—that exudate of pine trees responsible for fuelling the movie "Jurassic Park".

They will even feed on nylon stockings, low in starch but loaded with delicious residues of human oil and the flakings of leg and crutch skin.

These days, given the dinomania drummed up by that movie, if you found a small dinosaur living in your linen press, you'd probably put up with stains on the tea towels and some chew marks around the edges of the door. But what do you do when you see a silverfish between the doilies? You flip it onto the floor and squash it. Funny that, because silverfish as a group are, in fact, about 100 million years older than the dinosaurs, making them seriously big-time living legends.

And silverfish *look* so prehistoric. Take a trilobite, cover it with delicate silvery scales and stretch it, and you've got a silverfish. And it doesn't take much imagination to picture them skidding around the cycads and ginkgoes that form the backdrop of just about every dinosaur diorama ever created.

But in a bizarre twist, mention the world 'ginkgo' (those maidenhair trees of the Permian, 270 million years ago), and you'd see the silverfish scuttling for cover. For generations the incredibly acidic leaves of the sole-surviving Ginkgo species (*Ginkgo biloba*) have been pressed inside books with the express purpose of preventing silverfish from eating the pages and their binding.

That's because silverfish are browsers and a few enterprising cosmopolitan species have prehistoric appetites that make librarians' hairs stand on end. They are carbo freaks feeding on paper and fabric, heirlooms and works of art, onionskin and cellophane, and getting their protein from the glue on bookbindings and wallpaper. They will even feed on nylon stockings, notoriously low in starch but loaded with delicious residues of human oil and the flakings of leg and crutch skin. While what they really like is paper, it's what's on the paper (the glaze or sizing) that practically brings them unstuck with desire...starch, dextrin, casein, gum and glue.

Although Australia has 34 species of silverfish that most of us never see because they live under bark or inside ant nests, around 99 per cent of the literature on silverfish is devoted to getting rid of one or two introduced species (for example *Lepisma saccharina*). Traditionally, the slimy extract from the bulbs of English Bluebells (*Hyacinthoides non-scripta*) was used not only to starch Elizabethan collar ruffs and cure snakebite, but to make a bookbinding glue whose toxic nature repelled silver-

Silverfish

Classification
Order Zygentoma, 5 families, ~470 spp. worldwide, ~34 spp. in Aust.

Identification
Soft, semi-flattened, often cone-shaped, up to 2 cm long. Commonly covered with delicate scales. 'Tail' of 3 long bristles (abdominal cerci and terminal filament); 2 long antennae on head. Fast running; do not bite or sting.

Habitat and Distribution
Worldwide, with a few pest species. Found naturally in leaf litter, under logs, rocks, but around humans in furniture, books, sinks, cupboards, linen presses. Need dark humid hiding place during day.

Biology
No 'grub' stages (metamorphosis); all juveniles look very much like adults. Pest species eat paper, glue, clothing, book bindings, wallpaper past, photographs, sugar, flour, cornflakes. Themselves eaten by spiders.

BY STEVE VAN DYCK

fish. And Costmary (*Chrysanthemum balsamita*), an aromatic herb of the aster family, was also known as 'Bible Leaf' because when its tansy-scented leaves were used as bookmarks in bibles they protected the paper from attack by silverfish.

These days more aggressive insecticides are used, but while some people still maintain that Epsom salts, whole cloves, cedar-scented balls and strongly smelling soap work in the closet, others are just happy to leave a little bowl of irresistible icing sugar in the bath or sink, then run the hot water when they find silverfish trapped there (silverfish have clawed feet, not the 'sticky' feet of more advanced insects, so they can't crawl out).

But before you kill, think twice. You might be throwing away your only chance at immortality! If you can catch them, you might like to try a little experimentation that could see you in the same wrinkle-free camp as Cliff and Dorian. According to Idries Shah, author of *Oriental magic*, the Chinese believe that in silverfish may lurk the very source of the fountain of youth: "A silver-colored insect...is captured, and made to eat a piece of paper upon which the characters *Shen-Hsien* have been inscribed. This formula, signifying 'immortal-spirited', will, it is thought, cause the creature's body to take on multi-color hues. Anyone eating the prepared silverfish will then be protected from death for ever."

To be fair, the recipe comes with the warning that "it may take months of experiment before a suitable fish be found, whose bodies will react correctly, and will display several colors."

Just in case you were tempted to rush out and breed silverfish to speed up the turnover of the 'multi-hued', remember that, while they live for up to five years, they are very slow breeders. Females might lay only about 20 eggs over their entire lives and it's probably the hit-and-miss complications of silverfish sex that contribute to their low fecundity.

The male hides little takeaway packages of sperm (spermatophores) around the place and entices the female to walk past them. When one of them comes in contact with her genital opening it bursts, inseminating her. She then rips off the empty spermatophore and eats it.

And that's what's kept silverfish going for 300 million years! Clean, simple and old-fashioned, but with everlasting implications. For me, I'll be tricking a handful of the little silver wowsers to feast on the sealed section of a *Cosmo* mag upon which the characters *Shen-Hsien* have been inscribed. With any luck, that'll bring a rosy blush to one or two. And when it does, I'll eat my...well, not to give away any secrets, but it won't be glitter I'll be brushing off my lips! □

AUSTRALIAN MUSEUM

Silverfish are living fossils, resembling the first insects that ever lived.

FURTHER READING

Shah, I., 1968. Oriental magic. *Octagon Press: London.*

Smith, G. & Watson, J., 1991. *Thysanura (Zygentoma). Pp. 275–278 in* The insects of Australia. *Melbourne University Press: Melbourne.*

Smith, G., 1998. Zygentoma (Thysanura). Pp. 7–20 in Zoological catalogue of Australia. Vol. 23, *ed. by W. Houston and A. Wells. CSIRO Publishing: Melbourne.*

Tammar Wallaby

Thanks to the Victorian gentleman's penchant for collecting zoological oddities, an extinct Australian will soon be bouncing back from obscurity.

PRIOR TO EUROPEAN SETTLEMENT, there were at least four subspecies of Tammar Wallabies (*Macropus eugenii*) in Australia: two on the mainland (*M. e. derbianus* in Western Australia and *M. e. eugenii* in South Australia) and two on South Australian offshore islands (*M. e. decres* on Kangaroo and *M. e. flindersi* on Flinders). Today, only the Kangaroo Island and Western Australian forms remain, however moves are afoot to bring the South Australian mainland subspecies back from 'extinction'.

Tammars are one of the smallest of the wallaby family, weighing only five to seven kilograms. They have a dark grey-brown coat above, a pale buff grey coat beneath, reddish arms, feet and flanks, and a white cheek stripe. During the day they shelter among dense shrubby vegetation, to hide from predators (such as Wedge-tailed Eagles), and venture out into open grassy areas at night to feed. Across most of their current and former range, the wallabies inhabited dense coastal heaths and mallee thickets.

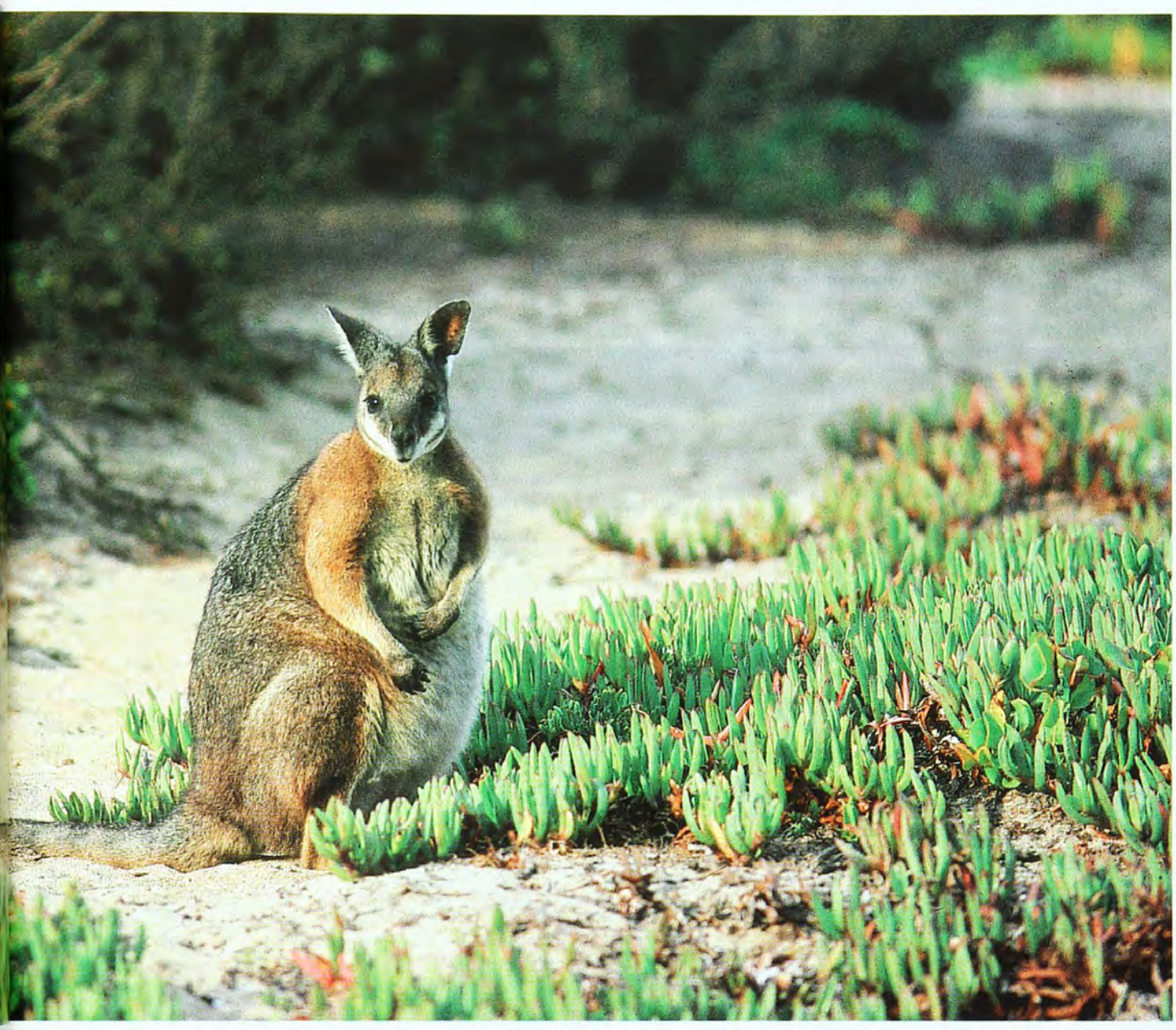
By the 1920s, the South Australian 'mainland' subspecies had become extinct. With the initial development of agriculture across South Australia, the mainland Tammar populations increased substantially, as the fragmentation of habitats increased the amount of their favoured 'edge' habitat. Although bounties were paid for Tammar Wallaby skins in many areas in the late 1800s, the animals remained abundant until the early 1900s, when they were still considered agricultural pests. However, the later expansion and intensification of agriculture resulted in the destruction of much of their remnant habitat. During the same period, the Fox (*Vulpes vulpes*) became established in South Australia and predation began to take its toll on the wallabies, leading to their demise on the South Australian mainland. In contrast, the Kangaroo Island subspecies continues to exist due to the presence of relatively large areas of remnant habitat and the absence of Foxes from the island.

Tammars are one of the smallest of the wallaby family, weighing only five to seven kilograms.

Meanwhile, across the Tasman, a convoluted chain of events has given the 'extinct' subspecies a second chance at life. When George Grey was appointed Governor of New Zealand (for the second time) in 1862, he purchased Kawau Island, near Auckland, for his personal residence. In accordance with the acclimatisation movement of the time, Grey planted a vast array of exotic trees and shrubs, and introduced many bird and mammal species to the island from all over the world. Amongst his menagerie of species were zebras, antelopes, Laughing Kookaburras, Brush-tailed Rock-wallabies, as well as Parma, Swamp and Tammar Wallabies.

Many of the Australian species found on Kawau Island adapted well to their new environment and increased substantially in number, due to a lack of predation. These species are now considered pests, and the New Zealand Department of Conservation and the Regional Council of Auckland are about to embark on an eradication program for all introduced wildlife on Kawau Island.

BY ANDY SHARP, JASON VAN WEENAN & JULIA BIGNALL



JEAN PAUL FERRERO/AUSCAPE

There are no records of where Governor Grey obtained his original stock of Tammar Wallabies. So Andrea Taylor (Monash University) and Des Cooper (Macquarie University) decided to undertake some genetic detective work to uncover the source of the wallabies. By comparing genetic material from the Kawau Island and Kangaroo Island populations, and taking into account previous findings that showed New Zealand Tammars were not from Western Australia, they ascertained that the Kawau Island wallabies were indeed from South Australian mainland populations. This rediscovery of a subspecies once considered extinct prompted the Federal and South Australian Governments to initiate the repatriation of these wallabies before they are eradicated from Kawau Island.

A team from the South Australian Department of Environment and Heritage visited Kawau Island in 2004 and returned with 26 wallabies, bringing the total number returned to Australia to 86. These wallabies were held in quarantine at Monarto Zoological Park before becoming the focus of a captive-breeding and reintroduction program. A trial reintroduction of ten wallabies occurred at Innes National Park, on the southern Yorke Peninsula, in November 2004. Depending on the success of this trial, subsequent releases will be made at Innes National Park and another location in South Australia.

Thanks to the Victorian gentleman's penchant for collecting zoological oddities and present-day international cooperation in conservation, an extinct Australian will soon be bouncing back from obscurity. □

FURTHER READING

*Taylor, A.C. & Cooper, D.W., 1999. Microsatellites identify New Zealand tammar wallabies (*Macropus eugenii*) as an 'extinct' taxon.* Anim. Conserv. *2: 41–49.*

http://www.deh.sa.gov.au/biodiversity/tammar.html

ANDY SHARP, JASON VAN WEENAN AND JULIA BIGNALL WORK FOR THE SOUTH AUSTRALIAN DEPARTMENT OF ENVIRONMENT AND HERITAGE AND ARE INVOLVED IN THE TAMMAR RECOVERY PROGRAM.

Growing old in the cold

Some plants in Antarctica are restricted to the continent and may represent ancient lineages that survived the ice ages.

The colourful lichen *Pleopsidium chlorophanum* has a bipolar distribution, occurring widely in Antartica, and also in northern Europe and North America.

ANTARCTICA IS HAILED AS THE last great wilderness on Earth, yet most of it is utterly lifeless. It is wilderness in the same sense that the Moon, Mars and outer space are wilderness. What life there is survives only around the two per cent of land that is ice free in summer, mainly along the coast.

Here, seabirds and seals are the obvious living things, but small plants and animals occur as well. Antarctica has more than 200 species of lichen, plus 100 different mosses, although most of them keep to the Antarctic Peninsula, the tongue of land reaching towards South America, where temperatures are milder. This is also home to the only higher plants on the continent, a small grass (*Deschampsia antarctica*) and the cushion-forming Antarctic Pearlwort (*Colobanthus quitensis*).

Within Australian Antarctic Territory (40 per cent of the continent) plants do best around Casey Station in Wilkes Land, where rocky ridges block accumulation of smothering snow. One can find more than 30 different lichens, five mosses, a liverwort, around 150 non-marine algae and a similar number of microscopic fungi. Thick turfs of dark moss and lichen-encrusted rocks are visible from the station windows.

Mosses grow mainly in damp places, usually on the poor mineral soils. A few algae thrive around penguin rookeries, because they can tolerate the extra nutrients, and they impart lushness to the landscape. There are also microscopic algae that grow mainly in the snow and tint it red, orange, green or grey, depending upon the species. The Casey Station area supports around 20 different snow algae.

The micro-algae, particularly cyanobacteria or blue-green algae, are intriguing because of the prospect that similar life forms flourished on Mars. Evidence suggests that Mars went through four climatic epochs, two of them analogous to conditions found in Antarctica today. Although the fourth epoch was extremely arid and inimical to life, fossil cyanobacteria may lie preserved inside Martian rocks. Because of this enticing prospect, the Mars Viking Program, which analysed Martian soil, was tested first in Antarctica.

Lichens, however, are Antarctica's main plants. They colonise coastal rocks and outcrops, and sometimes grace mountains far inland. They survive amazing temperature extremes and changes to internal moisture. In summer they may warm to 40° C in the sun, plummeting in winter to –35° C. Some can photosynthesise at temperatures as low as 20° C below freezing point. To avoid extremes of temperature, wind and dryness, the most favourable habitat for terrestrial life in Antarctica is beneath a thin sheet of protective snow.

A few lichens fare especially well around penguin rookeries because they depend on or can tolerate the very high levels of nutrients. Feathers from moulting penguins, and their dung, are an important source of nutrients to many of Antarctica's plants, with colourful lichens often marking out penguin colonies and other seabird nesting sites. Snow Petrels (*Pagodroma nivea*) breed in some mountain ranges hundreds of kilometres inland, and their wastes support lichen oases in otherwise empty

BY TIM LOW

landscapes. Antarctic soils, away from birds, seals and water, can be as barren as the sands of the Sahara.

Lichens in Antarctica and other dry environments may grow incredibly slowly. *Buellia frigida*, which hugs rock faces so closely it looks like it has been drawn on with a felt pen, grows as slowly as a millimetre every 100 years, and large plants may be thousands of years old. Some lichens are barely visible, growing inside rocks in microfissures or in porous sandstone. In the Transantarctic Mountains, the driest, coldest desert on Earth, they hide up to a centimetre inside rocks. Algae and bacteria also grow within the porous rocks, especially sandstones, weathered granitic rocks or marble, and algae survive beneath translucent quartz stones.

Some plants in Antarctica are endemic (restricted to the continent) and may represent ancient lineages that survived the ice ages. Others appear on high mountains far away, and some are bipolar, growing in both polar regions but nowhere in between. The spores and other parts of fungi, lichens, algae and mosses, can be carried vast distances by wind, and many species may have colonised (or recolonised) Antarctica since the last ice age.

Antarctic plants face limited threats from people. Slow-growing mosses and lichens are easily damaged by clumsy walkers and scientists—a footprint may remain visible for decades, if the strong winds do not erode the damaged plants completely. In coastal regions, seals and seabirds may also trample plants. An explosion in Antarctic Fur Seal (*Arctocephalus gazella*) numbers has led to severe damage on Signy Island. On the island of South Georgia, Reindeer (*Rangifer tarandus*) freed long ago by Norwegian sealers have denuded lichen beds and triggered erosion. On the other hand, global warming is freeing more rock from the grip of ice, and some plants are slowly colonising these exposed areas. Lichen and moss growth may actually benefit from increased levels of UV and carbon dioxide.

The little plants down in Antarctica look normal enough. The lichens and mosses resemble Australian species, and some are closely related. But so extreme are their stratagems for survival, I came away from Antarctica thinking this might as well be life on Mars. □

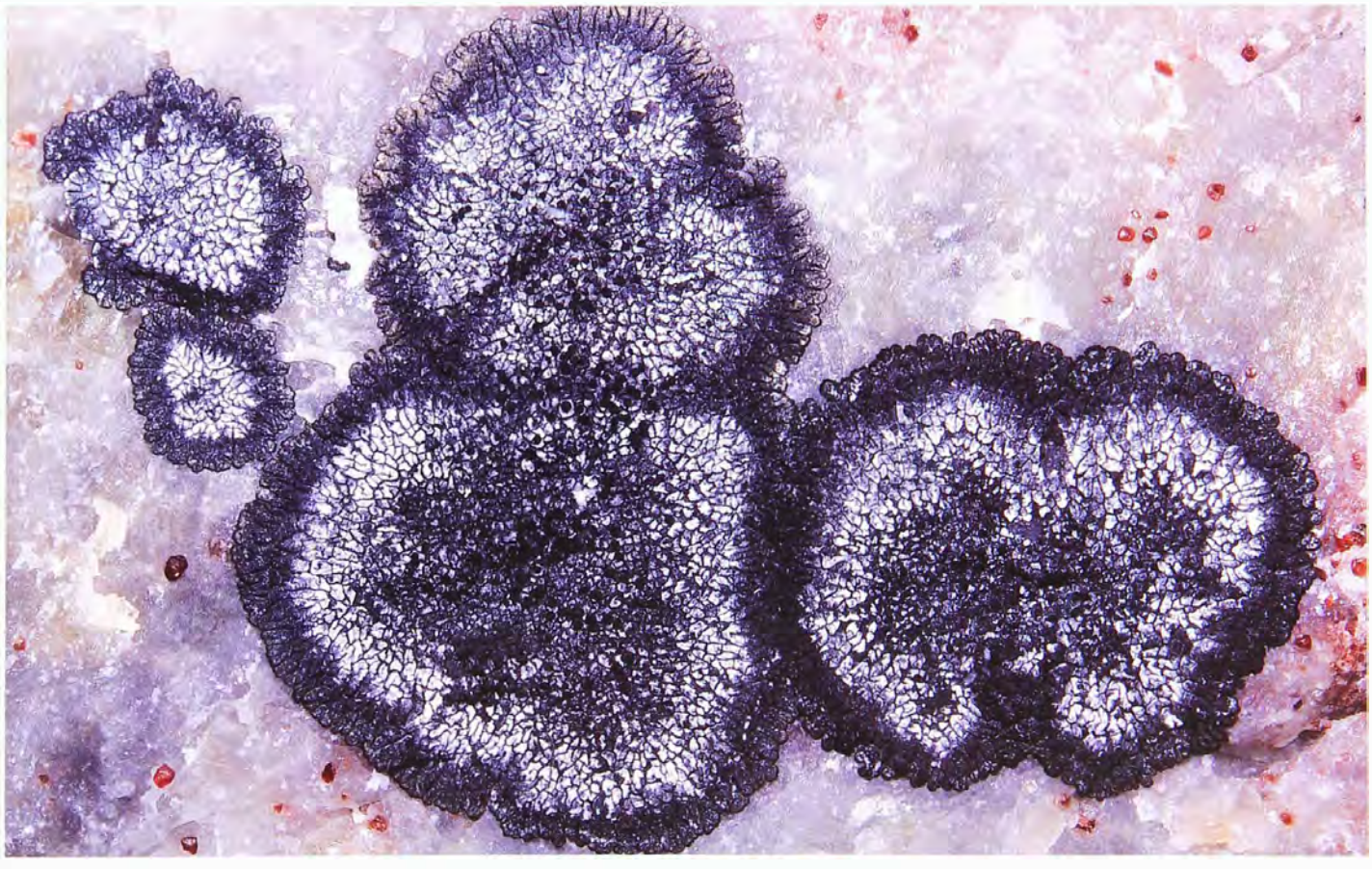
FURTHER READING

Lewis Smith, R.I., 1988. Classification and ordination of cryptogamic communities in Wilkes Land, Continental Antarctica. Vegetatio *76: 155–166.*

Ovstedal, D.O. & Lewis Smith, R.I., 2001. Lichens of Antarctica and South Georgia: a guide to their identification and ecology. *Cambridge University Press: New York.*

Wynn-Williams, D.D., 2000. Cyanobacteria in deserts: life at the limit? In The ecology of cyanobacteria: their diversity in time and space, *ed. by B.A. Whitton and M. Potts. Kluwer Academic: Boston.*

TIM LOW IS A BIOLOGIST AND AUTHOR OF SIX BOOKS, INCLUDING *FERAL FUTURE* AND *THE NEW NATURE*. HE WAS AWARDED AN AUSTRALIAN ANTARCTIC ARTS FELLOWSHIP BY THE AUSTRALIAN ANTARCTIC DIVISION TO VISIT ANTARCTICA (CASEY STATION) IN 2004.

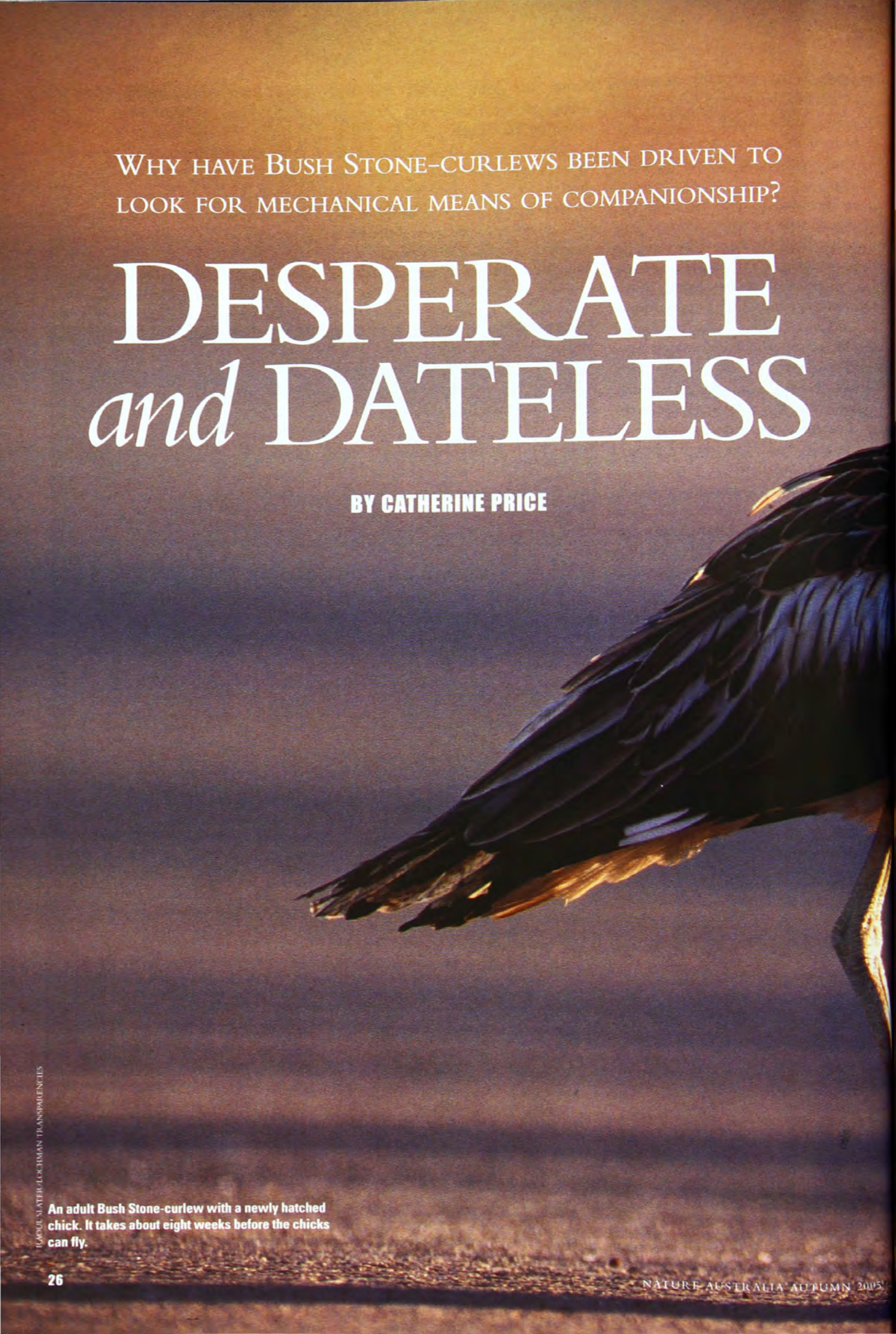


Buellia frigida **is one of the hardiest of all Antarctic lichens, growing farther inland than most species, and even at altitudes of up to 2,000 metres.**

WHY HAVE BUSH STONE-CURLEWS BEEN DRIVEN TO LOOK FOR MECHANICAL MEANS OF COMPANIONSHIP?

DESPERATE *and* DATELESS

BY CATHERINE PRICE



RAQUEL SLATER-LUCHMAN TRANSPARENCIES

An adult Bush Stone-curlew with a newly hatched chick. It takes about eight weeks before the chicks can fly.

HOW COULD THE MOTORBIKE just leave like that without even the hint of a goodbye? The heartbroken bird turned, called its haunting, forlorn cry, and then, when there was no response, went back to pecking the ground for grubs while keeping a watchful eye out for Foxes.

A bizarre tale of bird meets motorbike, bird falls for motorbike, and motorbike leaves bird? Yes, and apparently it's true. In the often-lonely life of an endangered ground-dwelling bird, it seems that even a motorbike can look like a reasonable choice for a partner. But why have Bush Stone-curlews been driven to look for mechanical means of companionship? Is the singles' scene for these birds really so dire?

FOR THOSE WHO HAVE NEVER SEEN a Bush Stone-curlew (*Burhinus grallarius*), it is a unique member of Australia's bird fauna that's recognised more from its call than appearance. Many old-timers recall the haunting nightly call, once a characteristic sound of the Australian bush. The birds look somewhat out of place in the woodlands west of the Great Dividing Range, resembling waders with their lanky legs, awkward gait and long neck. I am always amazed at their size, standing at around 50–60 centimetres tall. Their eyes are large and yellow, and well suited to their nocturnal lifestyle.

Across south-eastern Australia, where large flocks of Bush Stone-curlews were once regularly seen and heard, isolated pairs or increasingly only single birds in scattered locations are now reported. Single birds have often been alone for years and as there is little prospect of finding a mate, they are destined to live out their years companionless (unless they can hook up with an agreeable motorbike). While we can all sympathise with the individual lonely bird, which can be quite a character in its local area, the single life has grave implications for the species as a whole. You don't need a degree in biology to know that, for a wild animal, no mate means no young. And several years with few offspring leads to an aging population headed for extinction.

During preparation of the Recovery Plan for this charismatic bird, it soon became clear why the Bush Stone-curlew had declined. The bird lives and nests on the ground and raises chicks that take two months before being able to fly. While its mottled grey, brown and white plumage provides incredible camouflage amongst fallen timber and ground cover, and protects the stone-curlew against birds of prey and other visual predators, it's less of a match against introduced predators with an impressive sense of smell, such as the Fox. In short, a bird of this size makes a tasty meal for a Fox, and its eggs and chicks tempting appetisers. No surprises that the area of the Bush Stone-curlew's decline correlates strongly to areas where Foxes are common.

But is it really that simple? While introduced predators definitely deserve their portion of the blame for the demise of many of Australia's native mammals and birds, it is generally accepted that their impact on native species is greater in areas where native

DAVE WATTS/LOCHMAN TRANSPARENCIES

Two chicks lay flat on the ground in a response to danger approaching.

A family of Bush Stone-curlews. The chicks sometimes stay with their parents until next year's breeding season.

ecosystems have been disrupted and habitat fragmented. The area of the Bush Stone-curlew's decline also correlates strongly to areas of the country that have a long history of European settlement.

In the densely populated coastal region of south-eastern Australia and the wheat–sheep belt of Queensland, New South Wales and Victoria, it is becoming harder and harder for breeding birds to find a quiet spot to settle down. The increasing density of urban and semi-rural settlements and the intensification of agriculture have left much habitat unsuitable for the Bush Stone-curlew.

We whinge about rising interest rates and crazy housing prices. Imagine the

The Bush Stone-curlew usually lays two well-camouflaged eggs on the ground.

problems of finding suitable real estate if you need somewhere that fits all of the following criteria: private (little likelihood of being disturbed by humans, Foxes, Dogs, Cats, birds of prey, goannas); open outlook (for a good field of vision to see predators approaching from all directions); well-kept (short, sparse groundcover so birds sitting on eggs have a clear view); natural setting (preferably native ground cover, fallen timber and leaf litter for camouflage while nesting); close to water (especially in lowland areas); close to shops (reliable source of insects, spiders, worms, berries, crabs, frogs, lizards etc.).

The need for short, sparse grass and an open outlook seems to explain why Bush Stone-curlews often nest in areas that otherwise appear devoid of much obvious conservation value. Nesting birds are frequently reported in grazed paddocks amongst Horses, Cattle or Sheep, in recently ploughed paddocks, on vacant lots, golf courses, building sites, in suburban backyards and school grounds, and even at airports.

Once a suitable and successful area is found, a pair of stone-curlews tend to use it year after year. While this predictability should make protecting known nesting sites easier, the need for short grass often requires ongoing grazing or mowing, particularly if the pasture is not native. The birds' apparent nervousness and sensitivity to human activities and disturbance while nesting also poses logistical problems for managing breeding sites in settled areas.

Fortunately, across northern Australia the Bush Stone-curlew is still in reasonable numbers. Locations like Magnetic Island in the Whitsundays, and Kakadu National Park in the Northern Territory, are great places for birdwatchers to view them.

When weighing up the evidence, it seems likely that at least equal blame for the demise of the Bush Stone-curlew in the south-east must be laid on the clearing and modification of natural ecosystems. As woodlands are fragmented, the resulting habitat supports fewer individuals. And with fewer individuals in an area, the impacts of introduced predators, such as Foxes and Cats, are much greater. When fallen timber is picked up in paddocks, vital camouflage for the birds and their chicks is removed, in addition to habitat for their prey. As

Bush Stone-curlew

Burhinus grallarius

Classification
Family Burhinidae.

Identification
Large, long-legged, ground-dwelling bird with grey, brown and white plumage. Well-camouflaged. Large pale eyes set in big rounded head. Short dark bill. Body length 54–59 cm; wingspan 82–105 cm; weight 670g (males), 625g (females).

Habitat and Distribution
Widespread in Aust., southern NG and on many offshore islands. Open woodland with few shrubs, short grass and fallen timber. In coastal areas, saltmarsh and mangroves. Low elevations.

Biology
Pairs for life. Breeds in spring. Two clutches of eggs. Both parents raise chicks, which take 8 weeks to fledge and can remain with parents until next breeding attempt. Forages for invertebrates, small reptiles, amphibians, mammals, seeds. Eerie, wailing nocturnal call.

PHOTO BY RAOUL SLATER/LOCHMAN TRANSPARENCIES

(Above) A Bush Stone-curlew stretches and balances on one of its long legs. (Right) The Bush Stone-curlew is quite a large bird, standing up to 60 centimetres in height.

wetlands are drained, foraging grounds disappear, limiting the number of individuals an area can support and forcing birds to fly farther to find food. As new areas are settled, people and their animals move into once-remote locations. Settled areas are often great habitat for Foxes, which exploit the abundance of food and shelter provided by humans, and then these predators move into surrounding lands.

WITH THE ODDS SEEMINGLY STACKED against it, what is being done to conserve this unique species? Luckily for the Bush Stone-curlew it has a number of supporters willing to spread the message of its plight, and act on the processes causing it to disappear from the landscape. Thanks to the dedication of several farmers and community groups, the call to save the Bush Stone-curlew is being heard by government agencies, councils and other authorities that often hold the purse strings for conservation activities. And being largely found on private land, the reality is that the Bush Stone-curlew's future lies in the hands of landholders keen to see it remain on their properties.

In New South Wales, the stronghold for the Bush Stone-curlew is the Riverina area. Here the locals have really taken the species under their wing and are leading the way with activities aimed literally at getting more chicks on the ground. Paddocks with suitable habitat for the birds, particularly breeding areas, have been Fox-proofed by either adding 'hotwires' to the existing fences, or by building an additional fence to provide a protected area. Several types of fencing, to suit the needs of different landholders, are being trialled. The idea is that the protected paddocks can still be used for stock when the birds aren't breeding. One farmer was thrilled to have a Fox-proof paddock that could be used for autumn lambing as well as conserving stone-curlews.

The fencing program is integrated with a concerted effort to reduce Fox and feral Cat numbers across the Murray catchment. Fox-baiting is run by the Hume and Murray Rural Lands Protection Boards and local Fox shooters regularly patrol known stone-curlew sites. Dedicated landholders are also visiting local schools and teaching kids how 'tidying up' fallen timber in paddocks can reduce habitat for Bush Stone-curlews. "Don't flog our logs" is the catchy slogan used to raise awareness of the need to retain wood on the ground. For many kids and adults who have grown up west of the divide, they know the eerie call but have never seen the cryptic bird that makes it.

Around Caragabal in the central-west of New South Wales, a similar project to increase Bush Stone-curlew numbers and reduce lambing losses is being undertaken by farmers with the assistance of the Forbes Rural Lands Protection Board. Farmers bait for Foxes across a set grid and then monitor numbers of stone-curlews. Hopefully the dual outcome of more curlews and more lambs will encourage additional farmers to get involved in the program. A better understanding of the habitat used by the Bush Stone-curlews will also be gained from monitoring the birds within the area.

HI, I WAS WONDERING IF I COULD see your curlew", I gingerly asked the Manager of the Berrigan Golf Club. It's not generally my conversation opener, but a few people had told me of a lone curlew that had become the mas-

GEOFF TAYLOR/LOCHMAN TRANSPARENCIES

Bush Stone-curlews often turn up in areas that are generally not recognised for their conservation value.

KATHIE ATKINSON

Bush Stone-curlews are often seen in pairs, particularly during the breeding season.

cot of the golf club in this small Riverina town. Apparently it was quite a star. One lady had rung to let me know that she had seen it while on holiday a number of years before, and had never forgotten it opening the screen door into the bar and prancing in.

"Righteo. Where's Curl today?", the manager asked the attendant without batting an eyelid.

"I saw him earlier; I think he's outside." She checks outside and, sure enough, Curl is sitting in the sun seemingly unaware of his celebrity status. Curl is a local identify in the town and I duly bought a T-shirt and golf ball both sporting images of the famous Berrigan Bush Stone-curlew.

Curl's story is unfortunately familiar. It (male and female Bush Stone-curlews can't be distinguished visually) had apparently lost its mate several years earlier to a Fox while sitting on eggs. Another mate has never turned up despite Curl's lone evening chorus.

Whether Curl will see out its days alone is anyone's guess but hopefully the future is starting to look brighter for single stone-curlews. Through the combined efforts of landholders, community groups and government agencies, the decline of the Bush Stone-curlew may be able to be reversed so that the singles' scene is once again thriving for this quirky Australian bird. □

FURTHER READING

Johnson, C. & Baker-Gabb, D.J., 1994. The Bush Thick-knee in northern Victoria (Part 1): conservation and management. Arthur Rylah Institute Tech. Rep. *No. 129.*

National Parks and Wildlife Service, 2003. Draft NSW Bush Stone-curlew Recovery Plan. *New South Wales National Parks & Wildlife Service: Hurstville.*

Robinson, D. & Johnson, G., 1997. Bush Stone-curlew *Burhinus grallarius.* Flora and Fauna Guarantee Action Statement No. 78. *Victorian Department of Natural Resources and Environment: Melbourne.*

Webster, R. & Baker-Gabb, D.J., 1994. The Bush Thick-knee in northern Victoria (Part 2): population monitoring between 1985 and 1991. Arthur Rylah Institute Technical Report *No. 129.*

CATHERINE PRICE WORKS IN THE BIODIVERSITY MANAGEMENT UNIT OF THE DEPARTMENT OF ENVIRONMENT AND CONSERVATION (NEW SOUTH WALES) PREPARING RECOVERY AND THREAT-ABATEMENT PLANS FOR THREATENED SPECIES. SHE IS THE NEW SOUTH WALES RECOVERY PLAN COORDINATOR FOR THE BUSH STONE-CURLEW AND HAS RECENTLY COMPLETED A STUDY OF THE SPECIES FOR A MASTERS OF APPLIED SCIENCE (WILDLIFE AND POPULATION MANAGEMENT) AT THE UNIVERSITY OF SYDNEY.

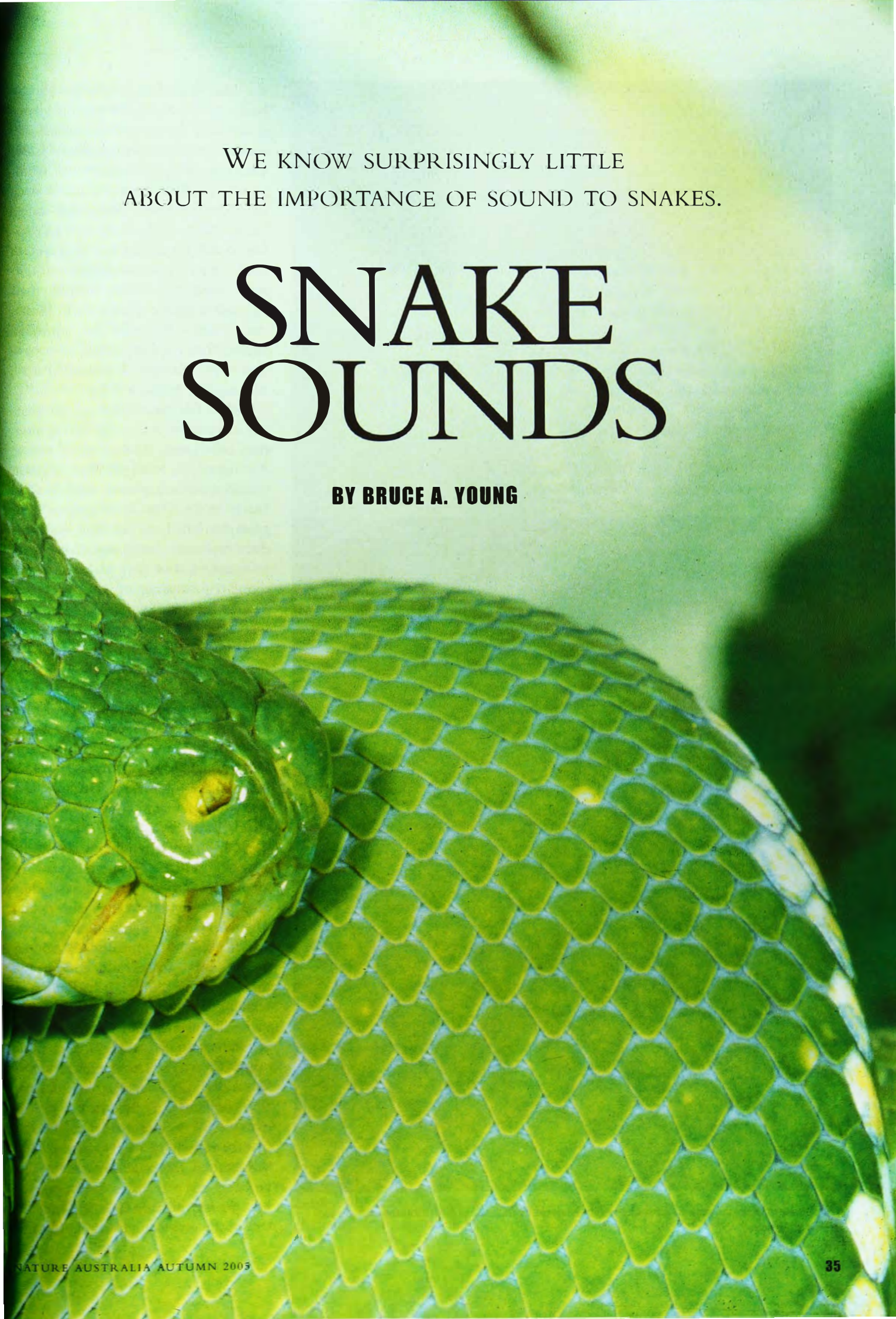
© MICHAEL CERMAK

The arboreal habitat of the Green Python means that it would be exposed almost exclusively to vibrations from the air or tree limbs.

We know surprisingly little about the importance of sound to snakes.

SNAKE SOUNDS

BY BRUCE A. YOUNG



SNAKES, AS DEPICTED IN MOVIES and television, are rather noisy animals. Most people have seen footage of a North American rattlesnake rattling; and that popular sound is often played for effect even when non-rattling snakes are shown! If not rattling, the snakes always seem to be hissing. However, this popular depiction of snakes is both inaccurate and ironic, as the majority of the roughly 2,800 species of snakes produce no noise at all.

We know surprisingly little about the importance of sound to snakes—whether it be sound production or perception. But a few generalities are beginning to emerge.

IN SNAKES

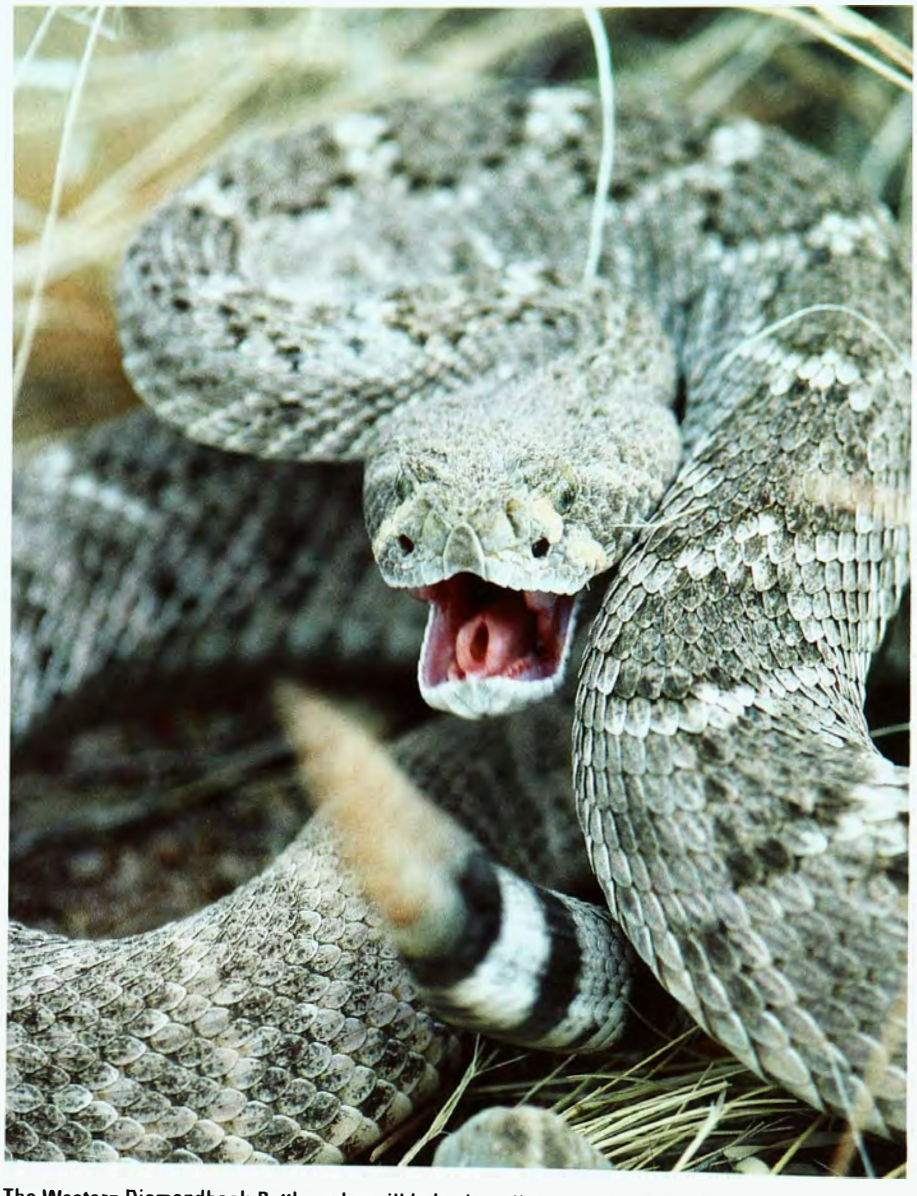
there are no documented cases of mating calls, territorial calls, or any context for sound production except defensive encounters.

THE MOST COMMON FORM OF SOUND production in snakes is certainly the hiss, which is simply an audible burst of exhalation. However, some snakes (like the King Cobra, *Ophiophagus hannah*, found throughout Indo-China) have unusual tracheas (or windpipes) that allow them to produce deep reverberating hisses commonly called growls. Some of the vipers make a rasping sound by sliding one segment of body scales against another; other snakes produce sound by vibrating their tail (either against a substrate or with a rattle); and a few even use controlled audible flatulence as a defensive behaviour (see "Snakes' Defensive Farts", *Nature Aust.* Autumn 2001).

Despite this variation, sound-producing snakes have one thing in common: they only produce one type of sound. An agitated Black-headed Python (*Aspidites melanocephalus*) and Spotted Black Snake (*Pseudechis guttatus*), for example, will hiss; but they will produce the same sound regardless of the provocation, and they make no other sound. By contrast, an irate Black-bellied Swamp Snake (*Hemiaspis signata*) will rapidly vibrate its tail from side-to-side over the ground, but will never hiss, no matter how much it is disturbed.

In snakes there are no documented cases of mating calls, territorial calls, or any context for sound production except defensive encounters. This makes snakes quite unusual among terrestrial vertebrates, the majority of which produce a variety of vocalisations. Even other reptiles, such as Saltwater Crocodiles (*Crocodylus porosus*) or the House Gecko (*Hemidactylus frenatus*), produce different types of calls depending on the behavioural context.

It is possible to quantify the sounds produced by snakes and to measure their possible information content, which is proportional to the acoustic variability over time. I examined snake sounds using a statistical technique called 'cross-correlation matrix analysis', and it turns out that the information content of the snake hiss is extremely low, due mainly to the fact that the sounds are nearly constant. It is this limited information content that probably prevents snakes from using the hiss during non-threatening encounters. If the only sound you could make



JOHN CANCALOSI/AUSCAPE

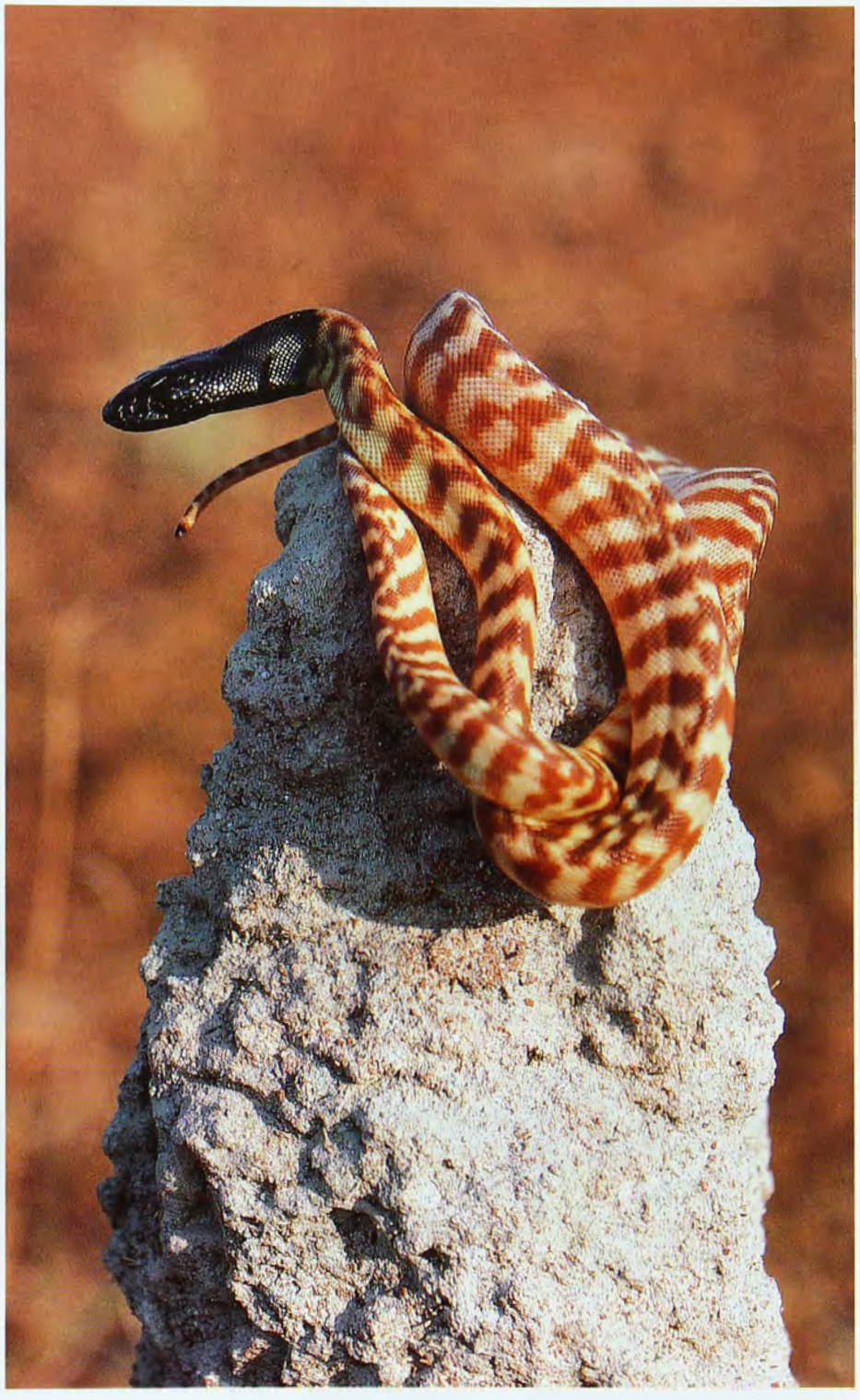
The Western Diamondback Rattlesnake will behaviourally respond to both airborne and ground-borne vibrations.

was equivalent to "aaa", for example, it would by very difficult to communicate two disparate ideas such as "Get away!" and "Would you care for tea?". Having a low information content, however, does not make the snake hiss an 'inferior' sound; quite the contrary. The snake hiss is purely a warning sound and it is very effective in that regard. The broad frequency spectrum of the hiss (3,000–13,000 hertz) assures that almost every terrestrial animal can perceive it. You only have to watch the seemingly innate aversion most people have to a snake hiss to appreciate how effective it is as a defensive mechanism.

But why doesn't the Black-bellied Swamp Snake, or other non-hissing snakes, hiss? It turns out there is no obvious answer to this question. Although the anatomy and physiology of all snakes should enable them to produce an audible hiss, there are many snakes, venomous and non-venomous, that are not known to hiss. Size does not appear to be particularly relevant here: snakes as diminutive as the Flowerpot Snake (*Rhamphotyphlops braminus*), which is typically just 12 centimetres long, have been reported to hiss, and most of the largest pythons in the world will hiss when disturbed. Phylogeny (or relatedness) also does not appear to have anything to do with sound production. While the Spotted Black Snake hisses, the closely related King Brown Snake (*Pseudechis australis*) never hisses. Similarly the tail vibration that characterises the defensive displays of the Black-bellied Swamp Snake has not been described from the closely related Grey Snake (*Hemiaspis damelii*).

As a generality, arboreal snakes are less inclined to produce sounds, by hissing or other means, than other snakes. Instead, snakes such as the Common Tree Snake (*Dendrelaphis punctulata*) tend to use visual, not acoustic, threat displays. Snakes that rely on camouflage or crypsis, either for predation or defence, such as the Common Death Adder (*Acanthophis antarcticus*), also rarely produce sounds. But these generalities alone are not enough to explain the distribution of sound production among snakes.

There are likely to be interesting relationships between sound production and habitat, but these have received almost no attention from researchers. The Taipan (*Oxyuranus scutellatus*), which is found in a variety of habitats along the northern and eastern coasts of Australia, vibrates its tail as a warning display. But identical tail vibrations could result in very different sounds depending on the local habitat of the snake. Consider, for example, Taipans that vibrate their tails whilst lying on three different substrates: the downed green fronds of a soft tree fern, a pile of dried shed bark, or a patch of loose dry sand. The interaction between the vibrating Taipan's tail and each of these substrates would result in the production of very different sounds. Those different sounds could, at least in theory, have a significant impact on how effective this defensive mechanism was during particular encounters.



MICHAEL CERMAK

The Black-headed Python hisses loudly when threatened.

THERE IS ANOTHER SIDE TO THE acoustic biology of snakes—one that has been generally overlooked—and this is hearing. It may seem odd to think of snakes as hearing, for there is a pervasive myth that snakes are deaf and only 'feel' vibrations. These preconceptions about the auditory abilities of snakes may stem, at least in part, from their external appearance. Snakes are unusual among terrestrial vertebrates in lacking all external evidence of an auditory system. There is neither an ear flap (or pinna), nor an exposed eardrum (the tympanic membrane visible in frogs and most lizards), nor even just an auditory tube or ear opening. But like the Australian lizards of the genera *Ophidiocephalus* and *Tympanocryptis*, both of which also have no external evidence of an auditory system, snakes do have a well-developed hearing apparatus.

The vertebrate ear is often divided into three functional parts: the inner ear, where mechanical vibrations are converted into neural impulses; the middle ear, which transmits and amplifies the mechanical vibrations; and the external ear, which converts pressure waves in the environment into mechanical vibrations. Snakes have distinctive inner and middle ears, but lack any trace of an external ear. In most vertebrates, the tympanic membrane is the key feature of the external ear, and where the pressure waves are actually converted into mechanical vibrations. However, in snakes the lower jaw, as well as the adjacent portions of the skull, associated musculature and overlying scales, functions like the tympanic membrane of other vertebrates.

LARGE SEMI-AQUATIC *constrictors like the Water Python will react to underwater pressure waves, essentially hearing underwater.*

Researchers studying the auditory physiology of snakes have shown that snakes are indeed sensitive to environmental vibrations, but this sensitivity is restricted to a very narrow frequency range (about 100–400 hertz). To put this in perspective, goannas (*Varanus* spp.) have an auditory sensitivity range of 400–2,000 hertz, Budgerigars (*Melopsittacus undulatus*) 1,500–5,500 hertz, while humans (depending on our age and the types of sounds our ears have been exposed to) hear within the range of 40–20,000 hertz. The frequency range of snakes would include such things as human footsteps and deep (bass) human voices, but would certainly be too low to detect most sounds produced by other snakes.

Within its narrow frequency range, the snake auditory system can perceive both ground-borne and airborne vibrations. This is one of the most commonly misunderstood aspects of snake biology: as long as the sound is in the correct frequency range, a snake can perceive purely airborne vibrations, the same signals that we think of as sounds. Snakes have added an unusual twist to their auditory system. As Peter Hartline (University of California, San Diego) and other scientists have shown, in addition to using their middle ear and inner ear to perceive vibrations, snakes can detect vibrations (both airborne and ground-borne) by way of their body surface. In other words, the elongate body of the snake may well function as a kind of vibrational antenna helping the snake monitor its surrounding environment.

Recent behavioural studies in my laboratory have shown that snakes can

PAVEL GERMAN

Loose dry substrate, like that under this Taipan, can amplify the sounds produced by vibrations of the tail.

PAVEL GERMAN

react to purely airborne sounds, provided they are within the frequency range of the snake's perception. My students and I have also shown that snakes like the Coral Snake (*Simoselaps australis*) that burrow through sand foraging for lizards can use the sound of a lizard's footfalls to locate their prey. Another recent study I completed showed that large semi-aquatic constrictors like the Water Python (*Liasis fuscus*) will react to underwater pressure waves, essentially hearing underwater.

A recent study of hearing in the Western Diamondback Rattlesnake (*Crotalus atrox*) from North America suggests that hearing in snakes may be more complicated, and more ecologically important, than previously realised. Undergraduate student Erica Neri and I presented snakes with a variety of synthesised sounds, including different sounds that fell within the auditory sensitivity range of the snakes. By

MARK O'SHEA

(Top) Common Tree Snakes will flee or use visual displays when threatened, but do not produce sound. (Bottom) The author tests for behavioural responses by presenting assorted snake sounds to a wild Monocled Cobra (*Naja kaouthia*) in India.

KEN GRIFFITHS

Copperheads may be able to locate frogs by listening for their calls.

using special acoustic chambers, we were able to present the sounds as either purely ground-borne vibrations (with no airborne component) or as purely airborne vibrations. The snakes took significantly longer to respond to the airborne vibrations, and were much better at localising the source of ground-borne vibrations. The strength of the behavioural response to each synthesised sound also differed depending on the source: the tone that engendered the strongest reaction when presented as an airborne vibration produced the weakest response when presented as a ground-borne vibration (and *vice versa*). These findings suggest that snakes have (at least) two different ways of hearing; that is, within the nervous system of the snake, airborne and ground-borne vibrations are processed, and perhaps interpreted, differently.

In a related study, we showed that sounds that produce strong behavioural reactions when presented to an agitated rattlesnake had little behavioural impact when presented to a foraging rattlesnake. In other words, if the snake is nervous, it will react to the sound, but if it is 'concentrating' on finding food, the identical sound produces no response. This differential response can only happen if the snake has what are normally called 'higher-association centres' in its brain. These allow the snake to respond differently to the same stimulus depending on 'mood' or behavioural context.

If the results from this study of rattlesnake hearing are typical of snakes in general, then hearing in snakes may be far more varied and ecologically important than previously realised. For example, the Green Python (*Chondropython viridis*) is an almost exclusively arboreal snake that might only receive vibrations from the tree in which it is resting. In contrast, the Yellow-bellied Sea Snake (*Pelamis platurus*) spends its entire life underwater where it would be exposed to few airborne vibrations. Have the nervous systems of these two species evolved to maximise their sensitivity to the types of vibrations present in their preferred habitats? If the higher-association centres of snakes work like those of other vertebrates, then the snake may have stored acoustic 'images'. Thus the Copperhead (*Austrelaps superbus*) may recognise the calls of the frogs that form the bulk of its diet, whereas the Fierce Snake (*Oxyuranus microlepidotus*) could use the ground-borne vibrations produced by scurrying mammals as cues while foraging.

It would be nice to move beyond the all-too-common depiction of snakes as noisy, but deaf, animals. Both sound production and hearing in snakes are more diverse than generally recognised. Exploring that diversity may offer some significant insights into the behavioural ecology and evolution of snakes. □

FURTHER READING

Wever, E., 1978. The reptile ear: its structure and function. *Princeton University Press: Princeton, New Jersey.*

By not producing sounds, these two Common Death Adders do not give away their cryptic concealment.

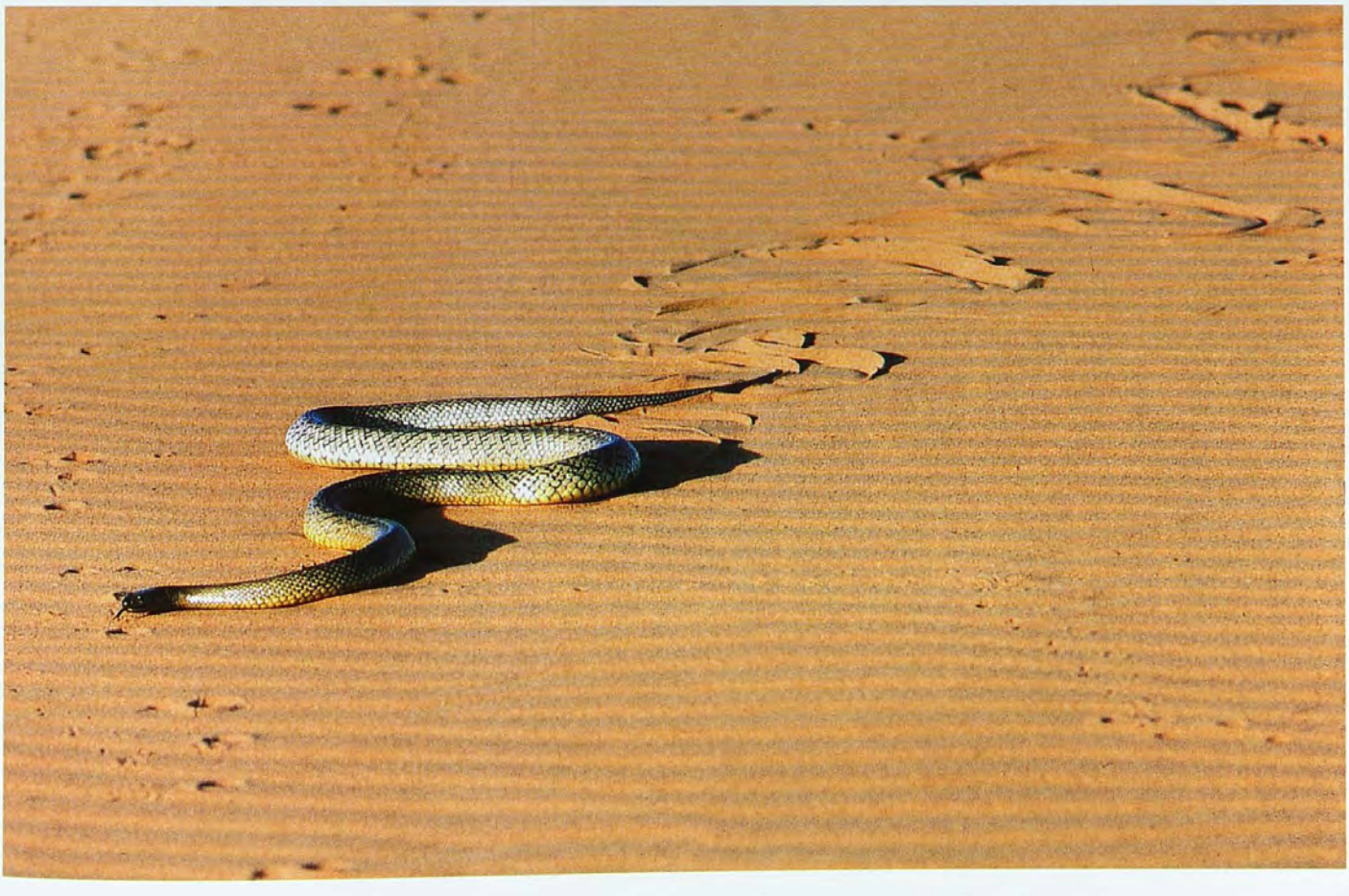
WADE HUGHES/LOCHMAN TRANSPARENCIES

Young, B.A., 2003. Snake bioacoustics: towards a richer understanding of the behavioral ecology of snakes. Quart. Rev. Biol. *78(3): 303–325.*

Young, B.A., Nejman, N., Meltzer, N. & Marvin, J., 1999. The mechanics of sound production in the puff adder, Bitis arietans *(Serpentes: Viperidae) and the information content of the snake hiss.* J. Exp. Biol. *202: 2281–2289.*

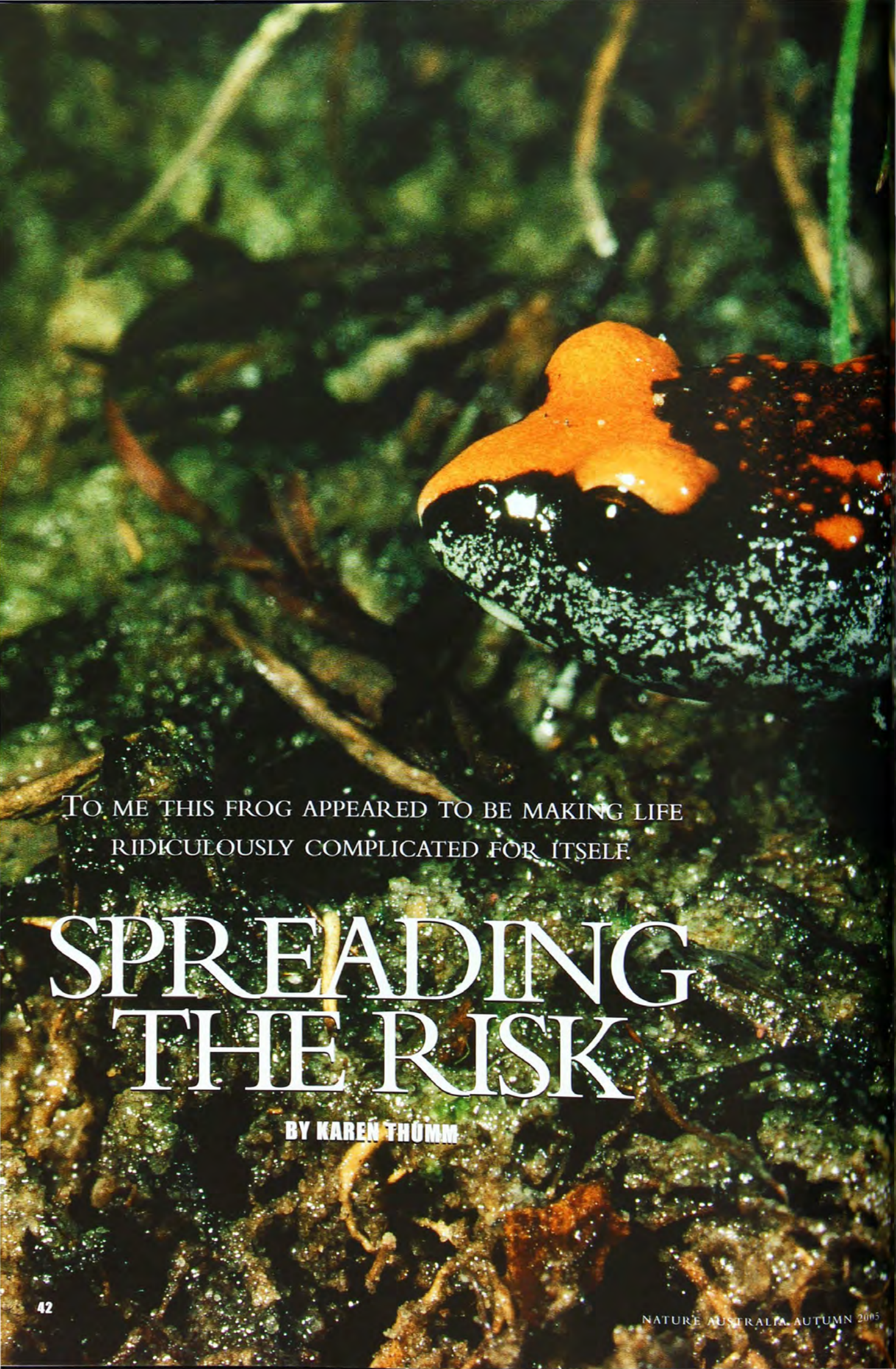
*Young, B.A. & Aguiar, A., 2002. Response of western diamondback rattlesnakes (*Crotalus atrox*) to airborne sounds.* J. Exp. Biol. *205: 3087–3092.*

BRUCE A. YOUNG IS AN ADJUNCT ASSOCIATE PROFESSOR IN THE SCHOOL OF BIOLOGICAL SCIENCES AT WASHINGTON STATE UNIVERSITY, USA. HIS RESEARCH CENTRES ON THE BIOACCOUSTICS OF SNAKES AND OTHER REPTILES, AND THE MECHANICS OF VENOM INJECTION IN SNAKES.



D. PARER & E. PARER-COOK/AUSCAPE

Many snakes, like the Fierce Snake, may locate mammals on the move by the ground-borne vibrations they produce.



To me this frog appeared to be making life ridiculously complicated for itself.

SPREADING THE RISK

BY KAREN THUMM

Red-crowned Toadlets are only about 2.5 centimetres long and are rarely seen in the open. Generally they call from under the leaf litter or from under logs or rocks, and you have to search for them at their calling site if you want to see them.

H. EHRMANN

I'M SURE WE ALL KNOW SOMEONE who continually makes the wrong choices; someone with a knack for making life difficult. I am convinced that, if the frog at the centre of my research were a human, then this is the sort of person I would be dealing with.

I have been studying the reproductive biology of the Red-crowned Toadlet (*Pseudophryne australis*), a small, brightly coloured frog found in the sandstone regions of the Sydney Basin. According to my initial calculations, this frog was heading straight for extinction. Week after week I'd go to my study site to check the fate of eggs in the terrestrial 'nests' constructed by the males. Each time I'd find the eggs had dried up a little bit more, until, once again, there were no survivors. It just didn't add up.

Red-crowned Toadlets spend much of their time out of sight under leaf litter, becoming most active when it is wet. Their call is a short, sharp 'erk', which the males use to attract females and to warn off competitors. Strangely (from the point of view of onlookers), the best way to pinpoint one is to yell out. Any words would probably do, but a very loud "Hello frog!" works for me. The male frog answers with a distinctive call that presumably warns intruders to stay out of his territory. By provoking him to call a few times, I then know where to dig. The eggs are usually not far away, tucked away in a small depression in the leaf litter.

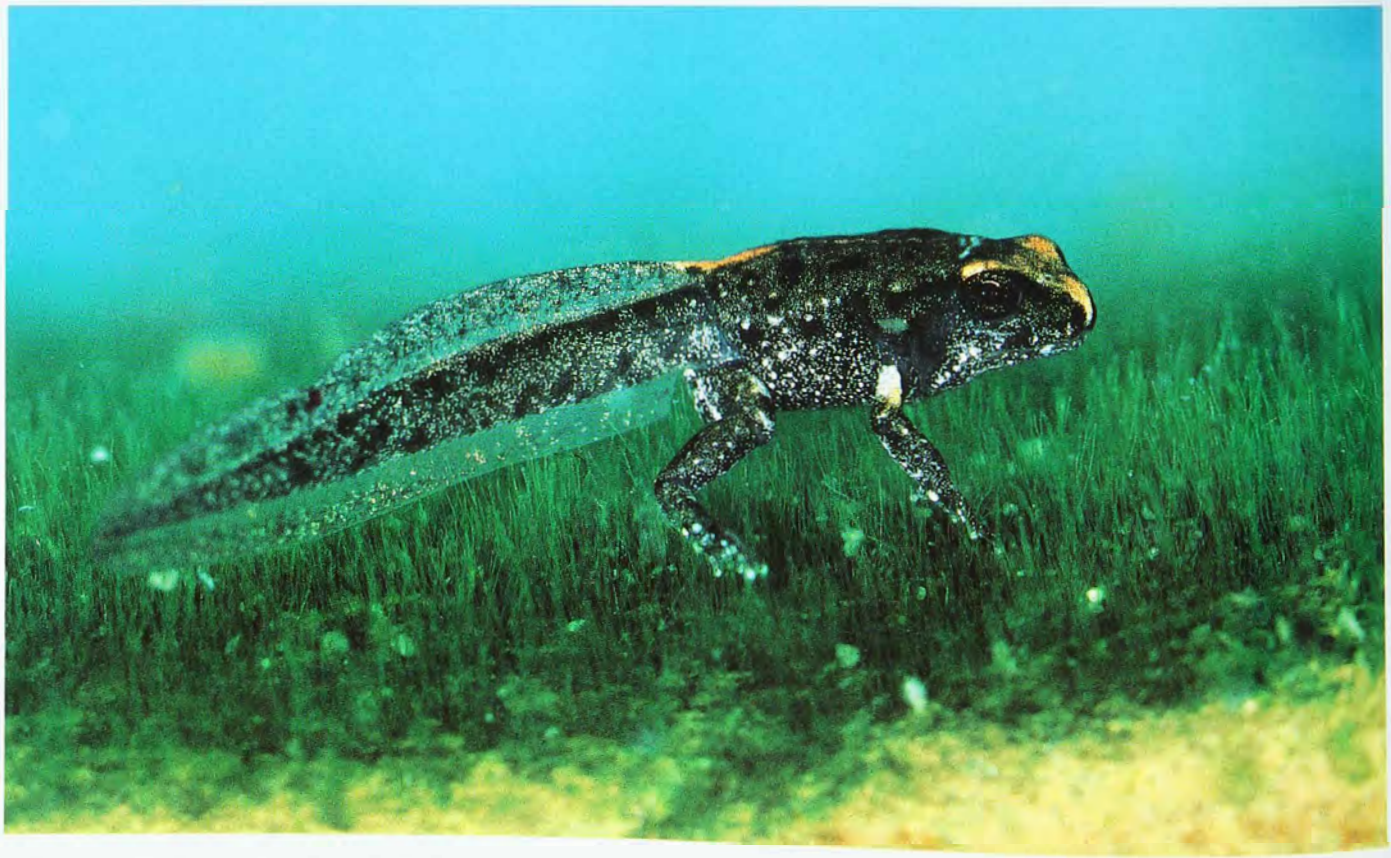
STRANGELY THE BEST WAY

to pinpoint one is to yell out. Any words would probably do, but a very loud "Hello frog!" works for me.

The female Red-crowned Toadlet lays about 25 eggs, slightly smaller than peas, into the nest. This is located in a moist place along the edge of a 'feeder creek', a drainage line that carries the water off the ridges down to the creeks below. When Sydney experiences heavy rain, water pours down these feeder creeks, releasing the tadpoles from their egg capsules and sweeping them into tiny pools where they develop into frogs.

Well, at least that was the theory. After returning regularly to the breeding site for three years, I found that if any embryos did survive to get washed by rain into a pool, then most of the tadpoles also dried up before they had a chance to turn into frogs. Over those years I saw only 11 baby frogs survive out of 57 clutches. Less than one per cent of offspring were surviving to metamorphosis.

To me this frog appeared to be making life ridiculously complicated for itself. Why didn't it just go to the nearest permanent pond, farther down the slope, and lay its eggs into water, just like the rest of the frogs in the area? Come to think of it, it is the only frog in this region, apart from its close relative the Brown Toadlet (*Pseudophryne bibronii*), to spend a large part of its development in a terrestrial egg capsule,



KEN GRIFFITHS

Red-crowned Toadlet tadpoles only get their characteristic orange colouring on their crown and lower back when they have nearly completed metamorphosis.

ROSS KNOWLES

Male Red-crowned Toadlets defend their nest sites, but there is no evidence of parental care in this species.

living off a yolk reserve, rather than hatching straight into a feeding tadpole after a few days. It was time to look more closely at how long the embryo could survive inside the capsule, before it was able to hatch.

IT HAD BEEN UNUSUALLY WET IN SYDNEY with rain periods over several months. I managed to excavate nine nests. Some nests had only one clutch of eggs, but others had several. And one male seemed to have nine lots of eggs in his nest!

It is possible to work out how old the eggs are by looking at the developing embryo through the jelly capsule. Red-crowned Toadlet eggs are large enough to be able to see the first cell division with the naked eye. After about two days you can see the beginning of a backbone and about three days later a small 'comma'-like embryo starts to rise

H. EHMANN

Red-crowned Toadlet tadpoles at different stages of development.

above the energy-giving yolk. Eyes develop between the first and second week, and after about two weeks the yolk starts to develop a 'swirl', which turns into a gut coil, and then the mouthparts develop. In most other frog species the embryos hatch at this stage into free-swimming tadpoles.

Nests contained egg masses of different ages. There were newly laid clutches, clutches that contained one-week-old eggs, and others with eggs all about two weeks old. However, some clutches contained eggs that appeared to be at different stages of development, even though they had presumably been laid at the same time and were the same age. I was also surprised to find embryos that were so well developed that they seemed to look straight back at me. They even had back legs, some of which had fully developed knees, thighs and feet with five toes. Direct development, where the embryo develops all the way to a baby frog stage inside the egg without having a free-swimming tadpole stage, is known for some Australian frogs, but was not known in this genus. Although I didn't actually find any embryos with arms as well as legs, I did find some embryos that had developed inside the egg way beyond the expected hatching stage for the genus. In other *Pseudophryne* species embryos pause development when the buds for the legs have just appeared, and then only continue to develop once they have started life as a free-swimming tadpole. More confusing for me, however, was the fact that individuals within a clutch appeared to be developing at different rates.

So I decided to set up a series of experiments in the laboratory, where I could keep all eggs at the same temperature and stop them from drying out. I found out that brothers and sisters from the one clutch did indeed hatch at dif-

Red-crowned Toadlet

Pseudophryne australis

Classification
Family Myobatrachidae.

Identification
Grey or dark brown with orange triangle on head, orange midline stripe on lower back, and varying numbers of orange dots on back; belly black with large white blotches. Males approx. 25 mm snout–vent length and females slightly larger (28 mm).

Habitat and Distribution
Small natural drainage lines mainly within Hawkesbury Sandstone formations in the Sydney Basin.

Biology
About 25 eggs (range 10–51) laid in terrestrial nest in any month of year. Embryonic and larval duration variable (15–110 days). Life span at least 8–12 years in captivity. Call generally a short, sharp 'erk'. Nocturnal.

Status
Listed as 'Vulnerable' in the *NSW Threatened Species Conservation Act* 1995.

ferent ages and at different stages of development from each other. Embryos could hatch after 15 days or just hang about in the capsule for over four months (119 days). This is rather like one woman being pregnant for two months or for seven or for nine. What could be the point in this?

Perhaps it had something to do with Sydney's rainfall pattern? Yet I soon discovered that 'pattern' is the wrong word to link with Sydney's rainfall. It is true that if you even out the bumps in 70 years of rainfall data, you can detect a pattern of fairly uniform rainfall throughout the year, with a slightly smaller amount in the second half. However, if you look at 10-year data sets, you find that there is no rainy or dry season. It rains heavily in Sydney several times a year, but it's anyone's guess as to when. I postulated that the varied hatching times of Red-crowned Toadlets is an adaptation to these rainfall conditions. Rainfall is unpredictable, so the frog spreads the risk by having eggs that hatch at different ages. Those that hatch early need repeated rains to keep

Dorsal (back) patterns are variable amongst individuals, but the differences between back patterns cannot be used as reliably for identification as their belly patterns.

the pool full while they develop into small frogs. Those that stay in the egg capsules longer still need enough rain to keep the ground moist and the eggs from drying out, but when they do hatch, they will be more physically advanced and therefore require less time in the pool. This system of spreading risk by producing offspring that respond in different ways to the environment has been called 'diversified bet-hedging'.

BUT THAT'S NOT WHERE THE BET-hedging stops. Female Red-crowned Toadlets don't put all their eggs in the one basket, literally. In contrast to the majority of frogs in the Sydney region that lay a single or perhaps two clutches a year and in a defined breeding season, Red-crowned Toadlets lay eggs throughout the year, even in mid-winter. That way, if a nest dries up, they get another chance. Females keep returning to the breeding site over and over again at intervals from between 15 days and several months. One female that I have kept in captivity for over 12 years has produced 35 clutches of eggs! Red-crowned Toadlets live a long time in captivity, but there is no reason to believe they aren't also long-lived in the wild, once they have survived to metamorphosis.

Then there's a third manifestation of bet-hedging. I know that female Red-crowned Toadlets can lay up to 51 eggs, but the usual clutch size is about 25. Why doesn't a female lay the most she can, every time she lays her eggs? Maybe Red-crowned Toadlets simply lay whatever eggs they have ready, as soon as it rains. Then again, if they lay fewer eggs, they would waste less (in terms of reproductive effort) if they all dried up. Share investors use a similar bet-hedging strategy when they buy small parcels of shares in many companies, rather than a large amount in just one.

This principle has also been used in captive-breeding programs. For example, wildlife managers removed one of the two eggs usually laid in each nest of the endangered Whooping Crane (*Grus americana*). The total number of survivors was higher than when parents were left to care for two eggs. (Better to raise one to fledging than two only half way there.) Other experiments manipulating the number of eggs in bird nests have shown that birds often lay smaller clutches than the number they could produce. This means that if they have trouble feeding the chicks due to unfavourable weather conditions, losses are smaller. The expression usually used in this context is 'facultative brood reduction'. This term is also used when chicks commit siblicide. Laughing Kookaburras chicks (*Dacelo novaeguineae*), for example, will peck the weakest chick in the nest to death (see "To Kill a Kookaburra", *Nature Aust.* Winter

Red-crowned Toadlets have characteristic bands of white on their upper arms. The frogs in the southern part of their distribution have a light orange wash over this white patch.

The belly patterns of Red-crowned Toadlets are unique and can be used to identify individuals. This female is now twelve and a half years old and has laid 35 clutches of eggs.

ROSS KNOWLES

2002). For a frog that neither shows any form of parental care, nor commits siblicide, the term 'facultative brood reduction' seems rather out of place. I need to coin another expression that covers just the idea of reducing losses.

There's one more aspect of this frog's life-history strategy that seems odd, considering the number of eggs that just dry up in nests. Because only a few tadpoles make it into the ponds in amongst Sydney's sandstone rocks, you'd think they would metamorphose into frogs as quickly as possible, so that they don't dry up with the ponds. Many desert frogs speed up metamorphosis if they sense that their pond is becoming shallow. Do tadpoles of the Red-crowned Toadlet possess a similar ability to speed up the rate of development? True to form, this species seems to have a complex response to this part of its life as well.

A few tadpoles *do* metamorphose fairly quickly. The shortest time from hatching to metamorphosis is about a month, which is still much longer than some Australian desert frogs. Some turn into small frogs in a couple of months. Others stay as tadpoles for up to six months, getting bigger and fatter until they either die of desiccation, or eventually turn into a frog if rain has been unusually regular and plentiful. So just as hatching is staggered over time, even among eggs of the same clutch, metamorphosis is also spread out. Unlike other frogs that breed in short-lived water bodies, Red-crowned Toadlets appear incapable of speeding up development when they are running out of water. Tadpoles that stayed in the water longer did turn into bigger frogs. This is supposed to be an advantage when getting a mate in adulthood, and may therefore be worth the risk of desiccation.

So does the life-history of this frog really add up? These are the facts: Red-crowned Toadlets hedge their bets by breeding throughout the year, taking their chances that there will be repeated rains, sometime or other. They spread their energy into small numbers of eggs each time. They don't all hatch at the same time, so that the risk is spread even further. And they even seem to divide up the costs and benefits of metamorphosing earlier or later.

Perhaps we should ask the question another way: what does it need to add up to? To keep a population stable, you need to produce one offspring to replace yourself and one to replace your mate. That's all. Two in, two out. The life-history strategy of bet-hedging at every level may have seemed ludicrously complex to me over my years of study, but I think I may be prepared to put my money on this frog now. That's if I were the gambling type. □

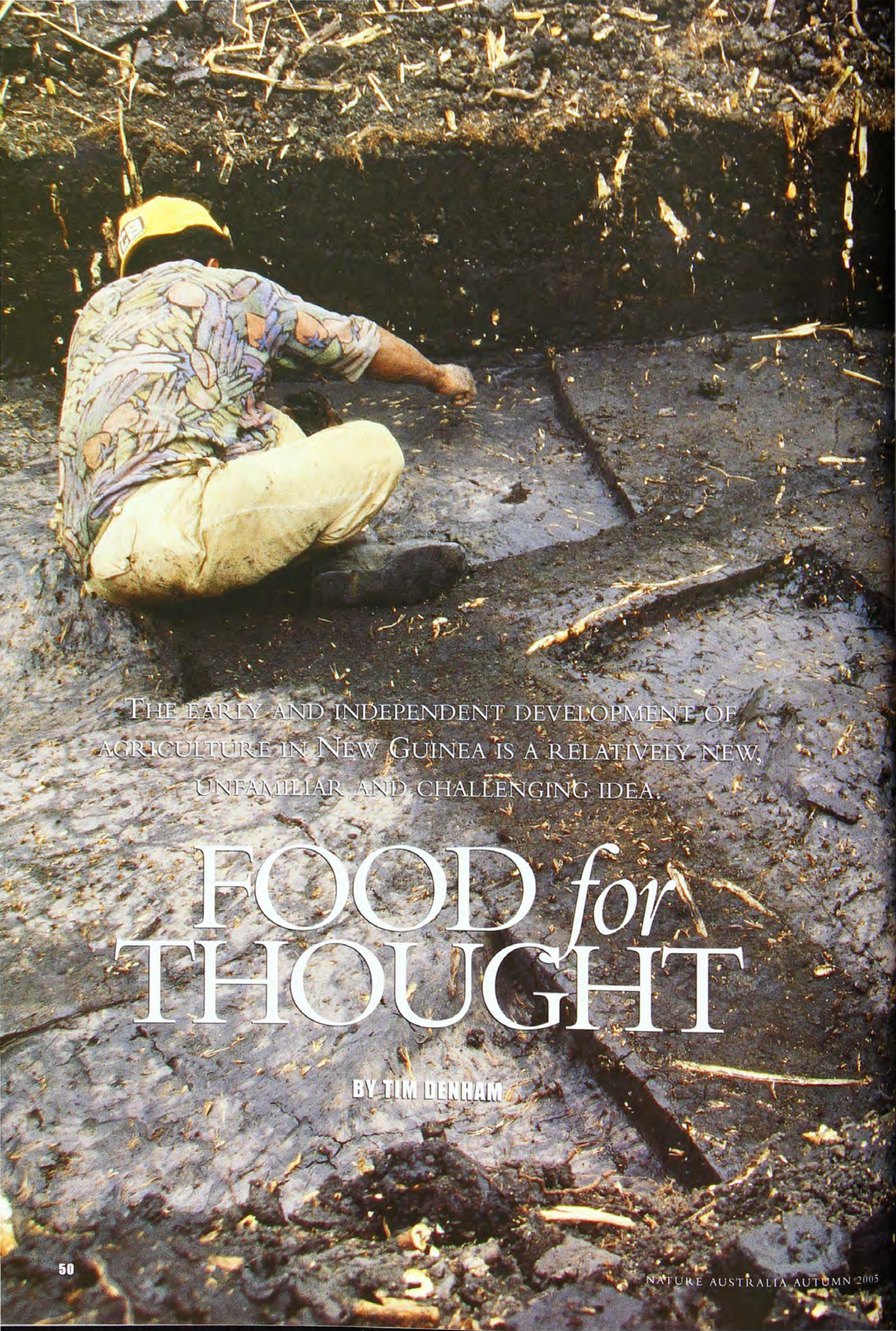
FURTHER READING

Thumm, K. & Mahony, M., 1999. Loss and degradation of red-crowned toadlet habitat in the Sydney region. Pp. 99–108 in Declines and disappearances in Australian frogs, *ed. by A. Campbell. Environment Australia: Canberra.*

Thumm, K. & Mahony, M., 2002. Evidence for continuous iteroparity in a temperate-zone frog, the red-crowned toadlet, Pseudophryne australis *(Anura: Myobatrachidae).* Aust. J. Zool. *50: 151–167.*

Thumm, K. & Mahony, M., 2002. Hatching dynamics and bet-hedging in a temperate frog, Pseudophryne australis *(Anura: Myobatrachidae).* Amphibia-Reptilia *23: 433–444.*

KAREN THUMM WAS A POSTGRADUATE STUDENT IN THE SCHOOL OF ENVIRONMENTAL AND LIFE SCIENCES, UNIVERSITY OF NEWCASTLE. HER PH.D. RESEARCH INVESTIGATED THE WAY IN WHICH THE PERIODICITY OF ENVIRONMENTAL CHANGE AFFECTED LIFE-HISTORIES, AND HOW WILDLIFE MANAGEMENT NEEDS TO TAKE DIFFERENCES IN LIFE-HISTORY STRATEGIES INTO CONSIDERATION.



THE EARLY AND INDEPENDENT DEVELOPMENT OF AGRICULTURE IN NEW GUINEA IS A RELATIVELY NEW, UNFAMILIAR AND CHALLENGING IDEA.

FOOD *for* THOUGHT

BY TIM DENHAM

Excavations at Kuk in 1998 exposing archaeological remains of cultivation dating to 7,000–6,400 years ago. Excavators include members of the local Kawelka community, a staff member of the Papua New Guinea National Museum and Art Gallery, and Professor Jack Golson (in a white shirt, back to camera).

JIM ALLEN/FLINDERS UNIVERSITY

"I KNOW WHAT YOU WANT. YOU want a story that won't surprise you. That will confirm what you already know. That won't make you see higher or further or differently." (Yan Martel, *Life of Pi*, 2002).

According to conventional wisdom, the independent origins of agriculture are often associated with the development of 'civilisation'. Such interpretations originated in the 19th century and continue to dominate thinking about European history. The origins of European agriculture and civilisation can be traced back 11,000 years to South-west Asia, or the 'Middle East'. Agricultural peoples, their Indo-European languages and their 'civilisation' subsequently expanded from this 'cradle' to colonise much of Europe and parts of Asia. This version of Eurasian history is familiar and unsurprising.

Research over the last few decades has broadened this picture and shown that agriculture may have arisen independently in several places across the globe, including centres in the Americas, Africa and South-east China. More recent research has conclusively added the island of New Guinea to this list.

Agriculture was practised in the Highlands of New Guinea by at least 7,000–6,400 years ago and perhaps as early as 10,000 years ago. The emergence of agriculture in New Guinea occurred independently of any known influence from South-east Asia, or beyond. The early and independent development of agriculture in New Guinea is a relatively new, unfamiliar and challenging idea.

Recent research demonstrating the origins of agriculture in New Guinea raises questions concerning the assumptions and biases that pervade accounts of long-term history, not only in New Guinea but also in other regions of the world. For example, why do we study early agriculture? Why this concern with finding its origins? Is it a coincidence that claims for the earliest agriculture in the world centre on South-west Asia and are linked to the development of European culture? Do we use agriculture, and the term 'Neolithic' (referring to agricultural peoples of the late 'Stone Age'), as signs of something else—something that justifies the pre-eminent position of our own Western society in the modern world?

Before addressing the issues raised by these questions, let us consider the evidence for early agriculture in New Guinea.

TIM LOW

Leaves of Taro, a starch-rich plant with a long history of use and cultivation in New Guinea.

EVIDENCE FOR EARLY AGRICULTURE IN New Guinea is restricted to wetland archaeological sites in the Highlands (that is, above 1,200 metres altitude). There are no comparable sites known from the lowlands. Most evidence comes from investigations at Kuk Swamp in the Upper Wahgi Valley, at an altitude of 1,560 metres.

Jack Golson, from the Australian National University, was the first to direct archaeological excavations at Kuk, in the 1970s, and was joined in 1974 by his colleague Philip Hughes. In 1998 and 1999, as a research student under Golson's supervision, I re-excavated the site. Using archaeological, archaeobotanical, radio-carbon and palaeoecological data, my aim was to clarify the nature and timing of the earliest agricultural practices identified during previous investigations.

The earliest archaeological remains at Kuk, dating to 10,000 years ago, are few and difficult to interpret. Golson and

Hughes believe that a buried channel is evidence that the wetland was deliberately drained for agriculture at this time, whereas I am more circumspect, recommending further excavations be undertaken before we can be sure that the channel was made by humans. However, we do know, from buried features indicative of digging, staking and localised drainage, that people were at least manipulating the wetland margin at this time. And from plant and charcoal remains, we know that people were using woody and starch-rich plants, including Taro (*Colocasia esculenta*), and fire to help clear rainforest in the vicinity.

Multidisciplinary investigations show that agriculture was definitely practised by at least 7,000–6,400 years ago at Kuk. There is archaeological evidence of mounded cultivation (for better-aerated soils), the use and presence of a range of edible plants such as Taro and *Musa* bananas (including species from which most of the world's domesticated bananas derive), and dramatic human-induced burning and degradation of the local environment from rainforest to grassland. By this time, people had largely cleared the natural vegetation and had become increasingly focused on wetlands for crop production. People prepared soil and deliberately cultivated plants within cleared plots, activities that are consistent with most definitions of agriculture.

Subsequent agricultural phases at Kuk (from about 4,000 to 100 years ago) consist of episodes of swamp drainage. Plots were delineated using ditches, and connected to the major drainage channels. Earlier ditch networks were less formal than later gridded field systems. The findings at Kuk, combined with those from other sites in the Highlands, give us a picture of how agricultural practices in New Guinea developed over the last 7,000 or possibly 10,000 years.

IF THE DEVELOPMENT OF AGRICULTURE IN New Guinea was early on a world

IMAGES COURTESY R. FULLAGAR, J. FIELD & D. PAGE

A retouched chert flake, about six centimetres long, dating to 10,000 years ago from Kuk. (Inset) High-magnification image of Taro starch granules (under cross-polarised light) taken from the artefact.

T. DENHAM

Kawelka men at Kuk take a lunch break from archaeological excavations. Bananas (*Musa* sp.), Sweet Potato, assorted greens, and chicken have been steamed and spread out for a midday feast.

scale, why do we not see many of the associated cultural, social and political characteristics that are so typical of the South-west Asian record? Early agriculture in New Guinea was not associated with domesticated animals, seed-based cultivation or pottery, but was largely based on the vegetative propagation of cuttings, tubers and other plant parts. New Guinean societies are not politically stratified, highly urbanised, large-scale civilisations, but are relatively egalitarian, village-based, and organised around 'big men', whose followers and influence are limited. The absence of characteristics so often associated with the independent origins of agriculture in other parts of the world, particularly in South-west Asia, was a major reason why agricultural practices in New Guinea were originally thought to have spread from South-east Asia.

In his book *Guns, germs and steel* (1997), Jared Diamond (University of California, Los Angeles) presents an argument to explain why the long-term history of New Guinea was so different to other regions of the world in which early agriculture developed independently, such as South-west Asia and the Americas. He suggests three major limitations to the development of food production in New Guinea: the absence of cereals and pulses (peas, lentils etc.), the absence of domesticated animals, and the resultant protein deficiency in the Highlands. New Guinea has several other 'strikes against it' that prevented the development of 'advanced' societies, including geographical isolation, limited cultivable land and a restricted altitudinal zone for cultivation. Additionally, Diamond argues that rugged terrain and endemic warfare fostered cultural, linguistic and social fragmentation.

Diamond offers several reasons to account for the 'primitive' nature of New Guinean societies in comparison to those in other agricultural heartlands, particularly South-west Asia. His reasons all focus on biological and environmental constraints, absences, or limitations. In evaluating these reasons individually, however, it is apparent that none is a necessary impediment to social development in New Guinea. For example, 'civilisation' based on the cultivation of root crops developed in parts of Africa, so why not in New Guinea?

Diamond concludes that "the limits on indigenous food production in New Guinea had nothing to do with New Guinea peoples, and everything [to do] with the New Guinea biota and environment". In attempting to overcome race-based interpretations, Diamond leans too heavily on biological and environmental constraints as causal factors of history. In so doing, he simultaneously perpetuates Eurocentric views of the world and downplays the way people create their own history in given geographical and social contexts.

Diamond's perspective is Eurocentric because food production and social developments in New Guinea are evaluated against an historical norm, that is, equivalents in European and South-west Asian history. There is a presumption that history in other places should somehow follow along similar paths unless it is held in check or limited by constraints or absences. Such a view of history evaluates all pasts from the perspective of a European or Western experience; it fails to confront profound differences in the way people live(d) in different parts of the world. For example, should we assume that people in New Guinea needed or wanted to generate food surpluses in the first place?

In an essay entitled *The ladder of social evolution: archaeology and the bottom rungs* (1977), Jack Golson suggests that the level of agricultural production in New Guinea was limited by demand, and not by a lack of labour or the absence of a desire to maximise output. New Guineans invested their time and resources in cultural and social, rather than economic, activities. From this perspective, social developments in New Guinea were of a different, less material kind to those in some other parts of the world, such as South-west Asia.

The major assumption underlying Diamond's view of history is that biological and environmental conditions restrained an inherent 'human nature' to improve personal wealth and status, and to seek control and dominion over others and their resources. As well as including accidents of geography (such as climate, topography and the available resource base), constraints have also been portrayed as accidents of history (in terms of technological innovations such as agriculture or the wheel). In portraying such views of the past, are we eliciting something fundamental about being human, something that is observable in the past or the present, or are we really embedding our own assumptions into a concept of 'human

T. DENHAM

A Highland big man persuading members of his local community to contribute to a compensation payment. Compensation payments are commonplace in the Highlands as communities seek to redress the negative effects of an accident or criminal act on another person or group.

JEAN-PAUL FERRERO/AUSCAPE

A house in the Highlands surrounded by Sweet Potato gardens. Sweet Potato (*Ipomoea batatas*) was introduced to New Guinea after European exploration of the region, and is now the dominant staple crop across much of the Highlands.

nature'? Is not any concept of 'human nature' merely a projection onto different cultures and peoples in history, of values from one particular cultural and historical standpoint, in this case our own European-derived society? Are we not reading our present into everyone's past?

We often find it difficult to embrace difference in many realms of contemporary society, and interpretations of the past are no exception. Just as we need to confront prejudice in our own society, we need to confront interpretations of the past that are based on, and ultimately seek to legitimate, ethnocentric accounts of the present. Opening our minds to the diversity of experience after the inception of agriculture is but one small way to challenge linear and narrow versions of human history. That is why determining the early development of agriculture in New Guinea is so important and has global implications for our understanding of human social development. □

FURTHER READING

Denham, T.P., 2003. Archaeological evidence for mid-Holocene agriculture in the interior of Papua New Guinea: a critical review. In Perspectives on prehistoric agriculture in New Guinea, *ed. by T.P. Denham and C. Ballard.* Archaeol. Oceania *Spec. Issue 38(3): 159–176.*

Denham, T.P., Haberle, S.G., Lentfer, C., Fullagar, R., Field, J., Therin, M., Porch, N. & Winsborough, B., 2003. Origins of agriculture at Kuk Swamp in the Highlands of New Guinea. Science *301: 189–193.*

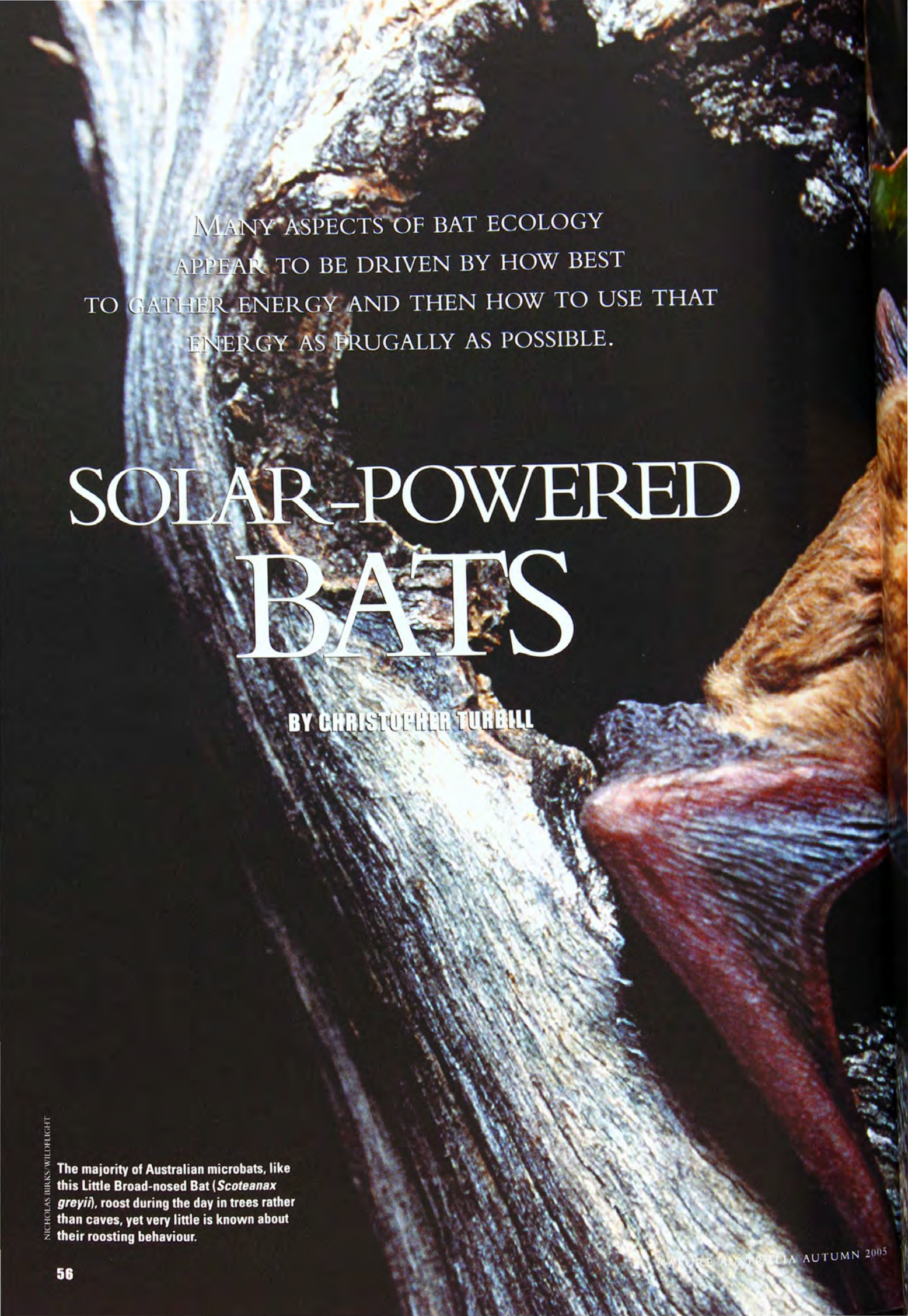
Golson, J., 1977. No room at the top: agricultural intensification in the New Guinea Highlands. Pp. 601–638 in Sunda and Sahul: prehistoric studies in southeast Asia, *ed. by J. Allen, J. Golson and R. Jones. Academic Press: London.*

DR TIM DENHAM IS A LECTURER IN THE DEPARTMENT OF ARCHAEOLOGY, FLINDERS UNIVERSITY, ADELAIDE. HIS RESEARCH FOCUSES ON UNDERSTANDING EARLY AGRICULTURAL AND ARBORICULTURAL PRACTICES IN NEW GUINEA, AND HE HAS RECENTLY INITIATED AN ENVIRONMENTAL HISTORY OF THE ADELAIDE HILLS.

MANY ASPECTS OF BAT ECOLOGY APPEAR TO BE DRIVEN BY HOW BEST TO GATHER ENERGY AND THEN HOW TO USE THAT ENERGY AS FRUGALLY AS POSSIBLE.

SOLAR-POWERED BATS

BY CHRISTOPHER TURBILL



NICHOLAS BIRKS/WILDFLIGHT

The majority of Australian microbats, like this Little Broad-nosed Bat (*Scoteanax greyii*), roost during the day in trees rather than caves, yet very little is known about their roosting behaviour.

RADIO-TRACKING A BAT IS AN exciting but sometimes frustrating game of hide-and-seek. The bat could, literally, be anywhere. From every vantage point you scan with the directional antenna, straining to discern a pulse against the loud hiss of static. It is a great relief once a signal is detected, and the chase begins with a renewed sense of urgency.

It had taken considerable trapping effort (and some painfully cold hands) to catch a Lesser Long-eared Bat (*Nyctophilus geoffroyi*) in winter. And now, after fitting it with a tiny radio-transmitter and releasing it last night, I had finally pinpointed the bat's signal to a large, partly dead eucalypt. In summer, these bats often roost in quite exposed locations, such as under loose bark. But their winter roosts had remained a mystery. I had assumed they would roost deep within well-insulated tree hollows, which would provide a more stable, cave-like microclimate, perfect for hibernation. Yet the signal appeared to come from the tree trunk, where there were no obvious hollows. Then I saw the thin wire aerial from the bat's transmitter, glinting in the sun. It was poking out from under a piece of partly shed bark, just two metres above the ground on the trunk's northern face. This seemed to contradict all expectations. Winter minimum temperatures were frequently below zero at my field site near Armidale, on the Northern Tablelands of New South Wales. How, I wondered, did these bats successfully hibernate in such exposed roosts?

CHRISTOPHER TURBILL

A Lesser Long-eared Bat is equipped with a miniature temperature-sensitive radio-transmitter before release.

In addition to helping me find the bat's roost, the transmitter included a thermal sensor, which allowed me to measure the bat's body temperature. As keeping warm (or not) depended upon their metabolic rate, I could use body temperature to work out how much energy the bats consumed while roosting. Energy is the currency of life, and is of critical importance to small 'warm-blooded' animals. Indeed, many aspects of bat ecology appear to be driven by how best to gather energy (in the form of insect food) and then how to use that energy as frugally as possible.

A BAT'S ENERGY BUDGET IS DANGEROUSLY stretched in winter. Most nocturnal flying insects are inactive at temperatures below around 10° C. Hence, on many winter nights, foraging is a waste of a bat's precious energy. Sometimes bats can go for weeks or months with-

What is Torpor and Hibernation?

Internal regulation of body temperature (endothermy) is expensive, especially in small species. With many bats weighing less than ten grams, they 'feel the cold' as soon as the air temperature falls below 30° C. Below this, keeping warm requires a steep increase in metabolic activity (and therefore energy consumption). Added up over the daylight hours, thermoregulation, even in a warmish roost, can consume a large proportion of a bat's daily energy budget.

But bats have another option—torpor. Upon entering torpor, a bat essentially turns down its internal thermostat. The body temperature of many hibernators is allowed to cool by about 35° C. A bat's temperature fluctuates passively with the environment whilst in torpor. However, at a lower critical limit (typically around 2° C), heat production kicks in to keep body temperatures from freezing. Torpor results in a dramatic reduction in energy expenditure. At 10° C, bat metabolism is reduced to a trickle, just 0.5 per cent of the energy normally consumed; even at an air temperature of 25° C, torpor reduces energy use to ten per cent.

A bout of torpor can last from hours up to weeks at a time. Hibernation (a period of seasonal dormancy) is entered during winter by bats inhabiting cool temperate climates. During the hibernation season, bats typically enter a series of prolonged torpor bouts (lasting days to weeks), interrupted by short periods of arousal. However, bats also use torpor in the warmer months, most often for several hours in the early morning during roosting, but also in the afternoons. Understanding the thermal biology of bats provides a crucial insight into their ecology and habitat requirements.

CHRISTOPHER TURBILL

Radio-tracking showed that male Lesser Long-eared Bats have a preference for roosting under bark on the northern, sunny side of the tree trunk.

out an opportunity to feed. So how do they manage to survive? They can't rely on extensive fat stores, for they are too small and must be able to fly. Instead, they save energy by entering a state of torpor and hibernating (see box).

Roost temperatures strongly affect the cost of keeping warm and the savings gained by entering torpor. In the 1960s, Australian bat researcher Peter Dwyer, working at the University of New England, showed that Eastern Bent-wing Bats (*Miniopterus schreibersii*) select cave roosts according to their changing thermoregulatory needs. During winter hibernation, bent-wing bats roost in caves that provide a stable, cold microclimate. By allowing their body temperature to drop to that of their surroundings, their metabolism and energy use is reduced to just a trickle. In summer, however, bent-wing bats form maternity colonies in caves that have a dome-shaped roof. By trapping the colony's body heat, these summer roosts are heated by up to 9° C and remain warm despite cooler night-time temperatures. This makes keeping warm as cheap as possible for mother bats and their young.

However, the majority of bat species roost in trees rather than caves. While bats in caves are relatively easy to find and observe, searching for occupied tree roosts is practically impossible. As a result, much less is known about the ecology of tree-roosting bats. Only in the last five years, by using tiny radio-transmitters as small as 0.4 gram, have bat researchers been able to find and describe the roosts of tree bats.

In general, tree-roosting bats prefer large, old or dead trees, presumably because these trees contain the most hollows. Large tree hollows are needed by female bats in spring/summer, when the roost must accommodate small maternity colonies of 10 to 100 bats and their young. Males of most species roost solitarily in summer, and can use smaller roosts in cracks, under bark or in dense foliage. In contrast to cave bats, tree bats also switch between roost trees almost every day. A change in a bat's preference for thermal microclimate may explain some inter-roost movements. But frequent switching could also help trick predators or prevent a build-up of parasites. A single bat or a maternity colony (including their flightless young) may move between ten or more different tree-roosts in the space of four weeks. However, they remain faithful to a restricted roosting area. For conservation purposes, some bat biologists argue that we should consider this local collection of roost trees as a 'single' roost, equivalent to a cave.

Of course, tree-roosting bats face the same energetic constraints of small size and a temperature-dependent food supply as cave-roosting bats. So, in theory, temperature of their roosting sites should be equally important. Potential tree-roosts vary in their level of insulation from external temperatures, ranging from thick-walled hollows in the trunk or large branches, to smaller hollows, cracks in dead wood, or under partly shed bark. And, unlike caves,

AFTER FOLLOWING SEVERAL BATS AROUND,

not only was I shocked to learn that male and female long-eared bats roosted under bark and in shallow crevices even in the middle of winter, but that, in these exposed roosts, they spent up to two weeks in continuous torpor.

some tree-roosts can be heated to above external temperatures by exposure to direct solar radiation.

Lesser Long-eared Bats are bark-roosting specialists. Bark obviously provides very little protection against external conditions, so these bats experience much more variable thermal conditions than do cave bats. How do these differences affect their use of torpor and energy budgeting? Fritz Geiser (University of New England) and Mark Brigham (University of Regina, Canada) had studied the thermal physiology of long-eared bats in the laboratory. They found that captive bats readily entered torpor at air temperatures below 25° C and even at these high temperatures were able to reduce their metabolic rate by 90 per cent. In the laboratory, under artificial conditions and constant temperatures, cave bats and tree bats are physiologically similar. But, because of their opposing roost environments, their natural thermoregulatory behaviours are likely to differ greatly. So, with Fritz as my principal supervisor, I began my Ph.D. in March 2002 to investigate the relationship between roost selection and the thermoregulatory behaviour of free-ranging long-eared bats.

I STOOD THE BEST CHANCE OF CATCHING bats in winter if I trapped only on the warmest nights, when the odd insect might be out and about. I soon realised that the best nights could be predicted by the approach of a winter cold front. This connection struck me as I was contemplating why the weather always turned nasty just when I had to start radio-tracking. On the night before a cold front, north-westerly winds and high cloud cover often keep temperatures warmer than usual. By the time I'd caught and released my bat, the cold southerly air behind the front would arrive, bringing wind and rain.

NICHOLAS BIRKS/WILDFLIGHT

Reproductive female Lesser Long-eared Bats prefer to keep warm during roosting and can reduce their heat loss and therefore save energy by huddling in groups.

PAVEL GERMAN

The Lesser Long-eared Bat is one of Australia's most common and widespread native mammals.

After following several bats around, not only was I shocked to learn that male and female long-eared bats roosted under bark and in shallow crevices even in the middle of winter, but that, in these exposed roosts, they spent up to two weeks in continuous torpor. As is typical for other hibernators, several days of torpor were broken by short arousals lasting only hours. These almost always coincided with dusk. Also, bats came out of torpor more often, and spent longer periods active (occasionally for the whole night), on especially warm nights. This strongly suggested that they took advantage of increased insect activity to forage on some winter nights, and confirmed why I had better trapping success on the warmest nights.

Most hibernators, including cave bats, have almost constant, low body temperatures whilst in torpor, reflecting their choice of well-insulated winter shelters. Large variations in temperature would cause them to rouse unnecessarily—a dangerous waste of energy. However, hibernating long-eared bats, in their somewhat flimsy winter roosts, had body temperatures that fluctuated passively by about 10° C per day, from as low as 2° C, but they remained in torpor for many days nevertheless. A preference for roosting on the north-western side of the tree also meant that on sunny days they could be warmed passively to 25° C, despite a daily maximum of only 10° C outside.

Overall, I found that Lesser Long-eared Bats are somewhat opportunistic hibernators. Whilst capable of spending up to two weeks in continuous torpor, during occasional mild weather bats will rouse almost every night. Winter arousals are usually a costly process, but Lesser Long-eared Bats gain a partially free ride owing to their exposed, sun-heated roosts. And, because they are in touch with outside temperatures, they can more readily tell if a night is warm enough to make foraging worthwhile. This may allow them to take advantage of winter feeding opportunities otherwise missed by cave bats, and at a much reduced energetic cost.

Despite these advantages, during torpor wouldn't these bats use more energy than similar cave-dwelling bats? Not necessarily. Bats hibernating in caves have an almost constant body temperature, matching that within the cave, which is close to the monthly average

Lesser Long-eared Bat

Nyctophilus geoffroyi

Classification
Suborder Microchiroptera (microbats), family Vespertilionidae.

Identification
Small bat with long ears and a low, Y-shaped muzzle ridge; fur grey above, whitish below, and rust-brown around face and ears; males 5–7 g, females 7–9 g.

Habitat and Distribution
Occurs commonly throughout Aust., apart from Cape York and east coast of Qld, and in most habitats, including farmland.

Biology
Slow, manoeuvrable flight; insects taken in flight, or gleaned off vegetation or ground. Roosts in trees, usually under bark or in cracks; in summer, females form small maternity colonies and roost in tree hollows. A single young or often twins born late Oct./Nov.

Even in a subtropical climate, the five-gram tree-roosting Eastern Forest Bat regularly enters torpor during the day in summer.

of outside temperatures. This means that, overall, the body temperature and energy expended by long-eared bats in torpor are roughly equal to that of cave bats. However, a drop in roost temperature below 2° C would require a very costly increase in energy expenditure. While cave bats are protected against very cold overnight temperatures, long-eared bats can be caught out. On a few occasions I recorded long-eared bats rousing early in the morning to move to a better-insulated roost, apparently in response to plummeting temperatures in their current roost.

While it makes sense to enter torpor in winter, surely there is no need for torpor in summer when it is warm and insects are abundant? Indeed, I found

Solitary male bats, like this Gould's Wattled Bat (*Chalinolobus gouldii*), often exploit the space under partly shed bark for day-roosting.

SURELY THERE IS NO NEED

for torpor in summer when it is warm and insects are abundant?

that lactating female Lesser Long-eared Bats largely avoided entering deep torpor. During summer, small maternity groups of females and their young selected roosts within tree hollows. Like for cave bats, it appears that by trapping their body heat, these better-insulated roosts provided a warm and stable climate. Avoiding low body temperatures allows continuous lactation by females and faster growth rates of their young. In contrast, male long-eared bats, roosting solitarily under bark or in shallow cracks, entered torpor every day in summer, with patterns of torpor use closely matching the daily temperature cycle.

During summer, male bats always entered torpor before sunrise. Their body temperatures were lowest at dawn, being close to the minimum air temperatures outside. Roost temperatures (and body temperatures of torpid bats) rose rapidly during the morning. Bats typically roused from torpor about mid-morning, after first being warmed passively to around 20–25° C. Thermally unstable roosts, heated to near or above external maxima for several hours, provided a period during the rest phase when keeping warm was as cheap as possible. Poor insulation, however, meant that roosts cooled in the late afternoon, during which bats would often enter another short bout of torpor, finally rousing again just after dark. In comparison, the energy expended in a thermally stable roost (such as a deep tree hollow or cave) by a bat using a similar pattern of torpor and arousal would be twice as much.

The use of torpor during summer was not restricted to bats on the Northern Tablelands. While working with Brad Law (State Forests of New South Wales) at his field site in the subtropical eucalypt forests of the mid-north coast, I found that male Eastern Forest Bats (*Vespadelus pumilus*) employed a similar pattern of two torpor bouts per day. This was the first record of torpor use by free-ranging bats from a subtropical climate, and in summer! It demonstrates clearly that torpor use by small bats is not an 'emergency' response to a shortage of food or to cold temperatures, but rather forms a regular part of their roosting behaviour. □

FURTHER READING

*Geiser, F. & Brigham, R.M., 2000. Torpor, thermal biology, and energetics in Australian long-eared bats (*Nyctophilus*).* J. Comp. Physiol. B *170: 153–162.*

Turbill, C., Körtner, G. & Geiser, F., 2003. Natural use of heterothermy by a small, tree-roosting bat during summer. Physiol. Biochem. Zool. *76: 868–876.*

Turbill, C., Law, B.S. & Geiser, F., 2003. Summer torpor in a free-ranging bat from subtropical Australia. J. Therm. Biol. *28: 23–26.*

CHRISTOPHER TURBILL IS A PH.D. STUDENT IN THE CENTRE FOR BEHAVIOURAL AND PHYSIOLOGICAL ECOLOGY, UNIVERSITY OF NEW ENGLAND, ARMIDALE.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

(Above left) Trumpetfish (*Aulostomus chinensis*) in red coral, Papua New Guinea. By Ann Worthy. Runner-up, Underwater Subject.

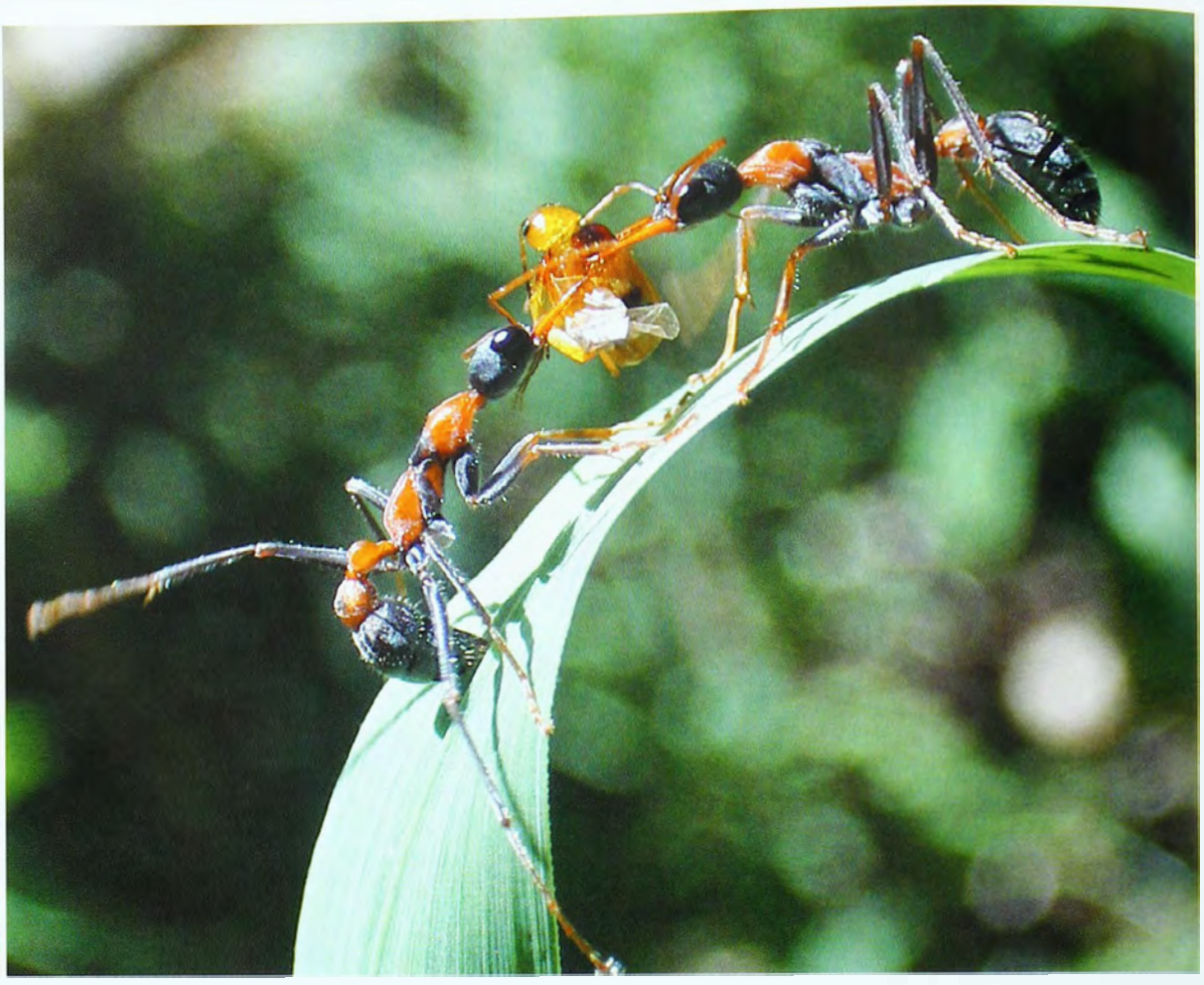
(Above right) Northland Green Gecko (*Naultinus grayi*), North Island, New Zealand. By John O'Sullivan. Winner, Animal Behaviour.

(Left) Blowfly on a grevillea flower, Sydney, New South Wales. By Cameron Mills. Runner-up, Digital Camera Photography.

ANZANG Nature and Landscape

Photographer of the Year 2004

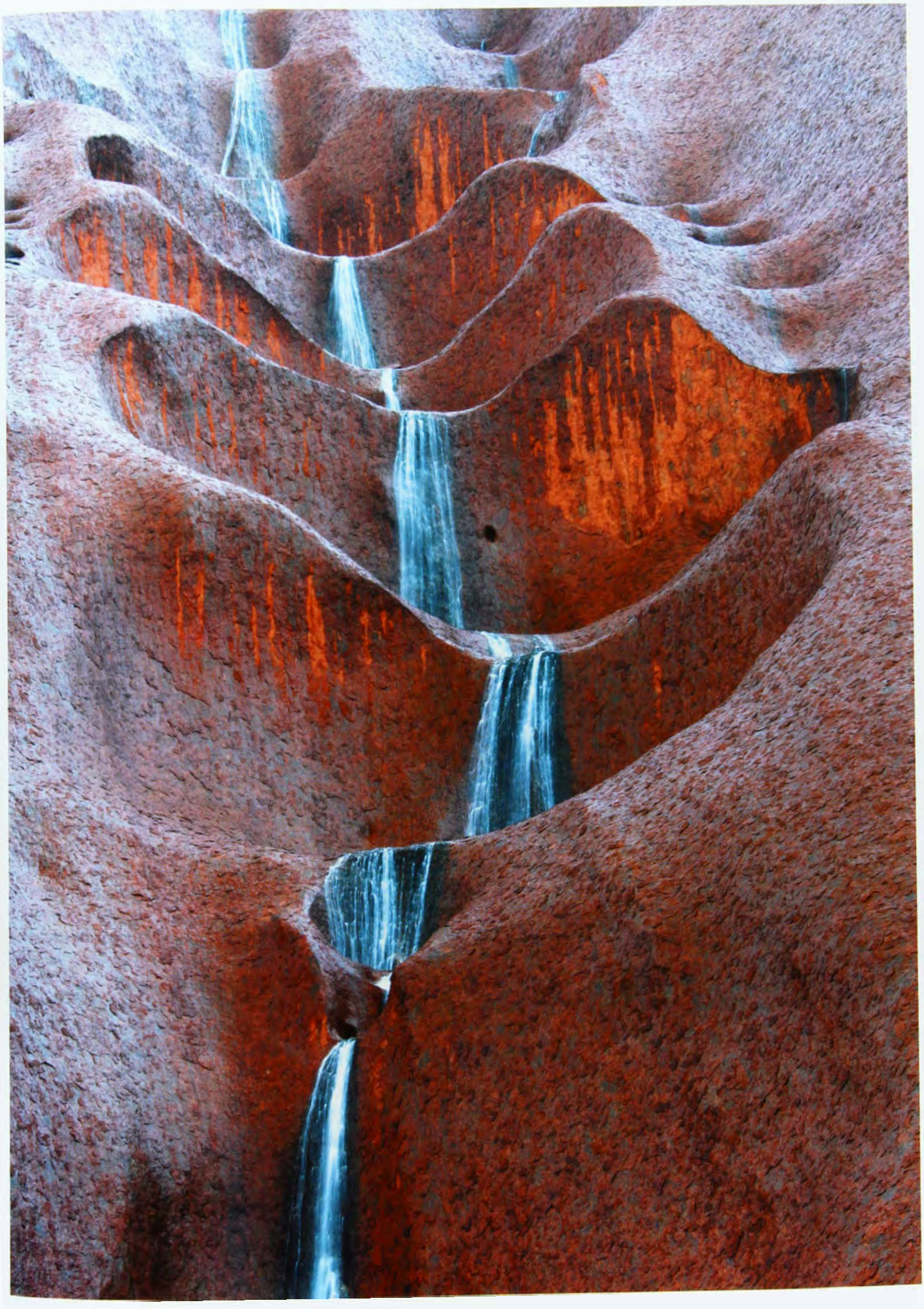
Information regarding the annual ANZANG Competition can be found at www.anzangnature.com



(Above) Jumper Ants (*Myrmecia nigrocincta*), Mullumbimby, New South Wales. By Mohana Grierson. Winner, Junior Photography Section.

(Right) Juvenile Black-naped Tern (*Sterna sumatrana*), Barrier Reef Cay, Queensland. By Graeme Guy. Winner, Digital Camera Photography and Photographer of the Year 2004.

(Far Right) Cascades, central Australia. By Ted Mead. Winner, Wilderness Landscape.



Bugs in jugs

Victims sucking nectar from the lip often lose their footing and end up in the drink.

PHOTOS SIMON D POLLARD

The fluid-filled jugs of pitcher plants (*Nepenthes*) act like insect traps, drowning insects lured to the plant's nectar.

DESPERATE FOR A DRINK, THE famous naturalist Alfred Wallace drank the liquid from a group of pitcher plants while exploring Malaysia. Although the fluid was full of dead insects and looked "uninviting", he wrote in 1890 that he and his friends "found it very palatable, though rather warm, and we all quenched our thirst from these natural jugs". They must have been almost delirious with dehydration to have quaffed a few pitchers, as one local name for these plants translates to 'the place where rats pee', probably because of the urine-like smell from decomposing insects. While I have drunk the fluid from unopened pitchers (slightly sweet and slimy), when it smells like a rat urinal, and comes from a vessel often called a 'hanging stomach', it does not sound like a drink that will improve with age.

Pitcher plants have jug-shaped leaves that have evolved into insect traps. The plants lure insects, mostly ants, with nectar that is produced on the lid of the pitcher and around the slippery lip. Victims sucking nectar from the lip often lose their footing and end up in the drink. These plants are usually found in areas with infertile soils and the nutrients necessary for the plant's growth are instead extracted from the drowned insects.

In many ways the pitchers are like the stomachs of animals. Although not bubbling cauldrons of flesh-dissolving digestive fluid, they do contain bacteria and antioxidants that break the insects down. One animal that often ends up with pitcher-plant food in its own stomach is the crab spider *Misumenops nepenthicola*, which captures insects lured to the plant's nectar. *Misumenops* is a rather malevolent lifeguard as it saves insects from drowning—either before they have a chance to fall, or just after, by hauling them out of the fluid. However, the kiss of death, rather than the kiss of life, follows the rescue. Many other species of crab spiders also exploit the attractiveness of nectar by living on flowers and ambushing pollinating insects.

Misumenops lives with a number of the almost 40 species of pitcher plants in the genus *Nepenthes*, where it steals their food, and even uses the plant's insect trap to defend itself. When I first started peering into the pitchers of *N. gracilis* in Borneo, I was sure I sometimes caught a flash of red. This turned out to be the spider leaping from the walls or lip of the jug into the fluid. And predators a lot smaller than me have the same effect. The footsteps of large nectar-loving ants, three to four times the size of the spider, are enough to make the spider take the plunge. Fortunately for the spider, no underwater wrestling ensues, as these ants are somehow able to avoid the pitfalls of a slippery lip.

If the pitcher had only recently opened for business and was not full of drowned victims being broken down into plant nutrients, I could see the spi-

BY SIMON D. POLLARD

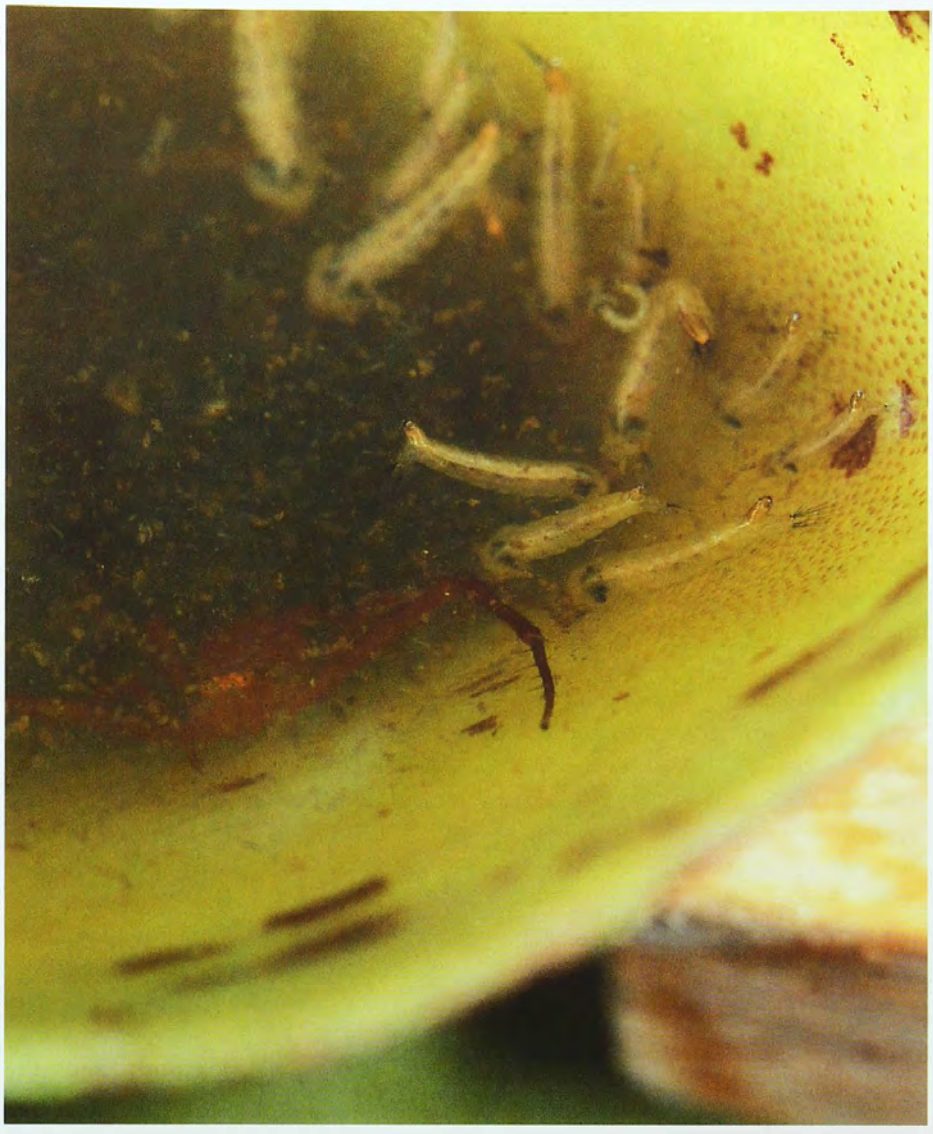
der clearly beneath the fluid. When the pitcher was a murky mass of bodies (or 'necromass' as I like to call it), the spider would scuttle crab-like beneath the corpses in their watery grave and later emerge, zombie-like, with its body cloaked in the partially digested bodies of ants and other insects.

How does this spider manage to breath underwater? Unlike some aquatic spiders, which trap a bubble of air over their entire body, adult and large juvenile *Misumenops* trap only a small air bubble over a pit on the anterior ventral abdomen next to the book lungs, which are used for breathing. The pit seems to allow the spider to hold onto the bubble in spite of the pitcher-plant fluid having a property that encourages drowning rather than breathing. Pitcher plants produce a surfactant or wetting agent (hence the liquid's slimy feel when I drank it) that reduces the surface tension on the fluid's surface. This facilitates the smooth transition from air to liquid for plummeting insects. Obviously, pitcher plants want their food inside their stomachs, not skating around on the surface breathing tiny sighs of relief! However, for a plummeting spider, low surface tension also makes it more difficult to trap an air bubble. *Misumenops* appears to overcome this by having hairs inside the pit that help push the bubble against the opposite sides, keeping it in place.

With an air bubble attached, the spider can stay underwater for about 40 minutes. If it needs to come up for a breather, but still feels threatened, it can just raise its hairy pit above the surface and take down another bubble of air. *Misumenops* does not have a water-repellent cuticle, like some aquatic spiders, and so it emerges from the fluid looking like the proverbial drowned rat. Although the fluid only digests the dead, the spider carefully grooms itself dry, before waiting to steal another sweet-toothed insect from the jug.

Female *Misumenops* build an egg sac just above the pitcher's fluid line, and when the baby spiders emerge they disperse around the dry walls inside the pitcher. Just like their parents, the babies also leap into the fluid when disturbed. The sight of 50-odd spiderlings making tiny splashes as they submerge reminds me of an arachnid version of "Titanic"! Because the spiderlings are so small, they can trap an air bubble over their entire abdomen, and will stay submerged for as long as the adults. Ironically, while the lower surface tension makes it more difficult for the adults to trap a bubble of air, the babies actually benefit from the surfactant, as it allows their small bodies to slip underwater more easily. When I made the babies jump into regular water, a number got stuck on the surface.

What does the carnivorous plant get out of having a free-loading carnivore living in its insect trap? Well, probably nothing, except the spider at least uses the pitcher as a gigantic toilet and returns some of what it stole from the plant. This makes me feel even less like following Wallace's 'line'; but if I ever had to, it would be one cocktail I would neither shake nor stir. □



The crab spider *Misumenops nepenthicola* not only pinches the pitcher plant's food but also takes refuge from predators in the fluid.

FURTHER READING

Clarke, C., 1997. Nepenthes of Borneo. *Natural History Publications: Kota Kinabalu, Borneo.*

Phillipps, A. & Lamb, A., 1996. Pitcher plants of Borneo. *Natural History Publications: Kota Kinabalu, Borneo.*

Wallace, A.R., 1890. The Malay Archipelago. Macmillian: London.

DR SIMON D. POLLARD IS CURATOR OF INVERTEBRATE ZOOLOGY AT CANTERBURY MUSEUM, AND A SENIOR FELLOW IN THE SCHOOL OF BIOLOGICAL SCIENCES AT THE UNIVERSITY OF CANTERBURY, IN CHRISTCHURCH, NEW ZEALAND.

Making the cut

The oldest clear-cut evidence for circumcision comes from 4,000-year-old Egyptian mummies and ancient inscriptions.

IT IS NO SURPRISE THAT MALE circumcision—cutting away of the foreskin—is a sensitive topic in health science. Especially now that there's talk about the possibility of it reducing HIV infection. But before you start queuing up at the clinic, consider the alternatives. And, if you are already cut, have you ever wondered why?

Karl Kruszelnicki (University of Sydney) wrote an article in the *Sydney Morning Herald's Good Weekend* magazine, challenging the common misconception that male circumcision was originally performed for hygienic reasons. He cited evidence from medicos who refute the claim that foreskins of uncircumcised soldiers encourage infection, and suggested instead that the link between circumcision and hygiene arose sometime during the Victorian era when "it was promoted as a way to desensitise the penis to thwart masturbation, which was thought to cause headaches, paralysis, bed-wetting, insanity, epilepsy, tuberculosis, short-sightedness, criminality and heart disease. The hygiene that circumcision was meant to encourage was, it seems, not physical but moral."

The article prompted Brian Morris (also from the University of Sydney) to complain of editorial bias, arguing that Dr Karl, as he is known on Triple J radio, had ignored the demonstrated health benefits of the practice. While the Australian Press Council dismissed the complaint, Morris may have a point.

Steven Reynolds (Johns Hopkins University, Baltimore) and colleagues from India's National AIDS Research Institute investigated whether circumcised men really did have a lower risk of contracting HIV. In a study of 2,300 men (191 circumcised), those uncircumcised were more than six times more likely to acquire HIV than circumcised men. But could this just be a consequence of uncircumcised men being more careful? No, because both groups had the same rates of infection for other sexually transmitted diseases (gonorrhoea, syphilis and herpes). It seems the foreskin is a magnet to HIV, being rich in receptor cells that the virus apparently binds to. But even if true, is circumcision the best solution? Why not a condom?

Body decoration is among the earliest indicators of modern human behaviour.

There is an obvious religious aspect and therefore a social side to circumcision that complicates cut-and-dried medical solutions on a global scale. It would be impossible to enforce all males to make the cut. Similar legislation to ban female circumcision or excision (cutting away all or part of the external genitalia—less common now but formerly practised in several parts of the world) would likely be seen as interference in fundamental religious rights, even though many would now regard this practice as abhorrent.

Anthropologists have documented many forms of body mutilation, decorative modifications and surgical cuts. The head, neck, ears and lips have taken a lot of damage, from shaving and dangling foreign objects, to tooth pulling, scarification, and inserting rings and large plates where they were not meant to go. But who hasn't got some of their body cut or pierced?

Body decoration can be traced archaeologically and is among the earliest indicators of modern human behaviour. The earliest beads, for example, are perhaps 77,000 years old in Africa, although not widespread until about 40,000 years ago (see "Oldest Modern Beads" page 11, this issue). Body modification, including circumcision, is more difficult to track, but it is likely that its origins related at least in part to initiation rites and social identity. Determining an original link between body modification and hygiene or health benefits may be impossible to prove archaeologically, although the Iceman's tattoos, preserved for 5,300 years, may mark acupuncture points (see "X Marks the Spot", *Nature Aust.* Autumn 2000). On the other hand, stone and glass tools associated with various surgical practices survive well archaeologically and are held in museum collections.

The oldest clear-cut evidence for circumcision comes from 4,000-year-old Egyptian mummies (yes, the males) and ancient inscriptions, which reveal that Egyptian boys were cut between ages 6 and 12. As far as I know, the Iceman was not. Some perform the operation soon after birth (Jews and Mohammedans) and others at puberty, and the documented reasons are diverse: a sacrifice for immortality; atonement for incestuous desires; promotion of fertility; and, of course, hygiene. Christians don't have to do it according to Acts XV, but many do.

Circumcision and subincision (cutting the urethra, lengthwise, on the underside of the penis) have been important parts of male initiation among Aus-

BY RICHARD FULLAGAR

tralia's desert Aborigines for many generations. Details of the ceremonies associated with first and subsequent cuts are restricted to those men already initiated in Aboriginal Law, and cannot be revealed to the general public. The extent of this male cult marks the expansion of the Western Desert culture into the south-west of Western Australia, as was documented by Daisy Bates (1859–1951), the famous, even if controversial, Irish woman who lived and worked with remote Aboriginal people for many years.

Martin Gibbs (University of Sydney) and Peter Veth (Australian Institute of Aboriginal and Torres Strait Islander Studies) have explored how such rituals were probably used to build alliance networks and social bonds—essential elements for survival in harsh environments. When times are tough and serious drought kicks in, you can always call in on the neighbours for help and access to scarce food resources, especially if they know you would do the same for them. Circumcision would have been visible and would clearly demonstrate commitment to the ritual package. Gibbs and Veth argue that the historic spread of the circumcision rite into south-western Australia is an example of how the intensive ceremonial and social interactions allowed Aboriginal groups to inhabit the risky marginal landscapes of arid central Australia. To maintain and extend the help lines, new initiates from neighbouring groups were recruited into the desert cult through ceremonial exchange, and sometimes by persuasion, sorcery and fear of retribution. Historically, as far as I know, the question of hygiene never came into it.

Circumcision is losing its popularity in modern Australia where less than 20 per cent of newborn males are circumcised each year, well behind the USA, where 60 per cent of males make the cut. It is still rare in Scandinavia—the Finno-Ugrian speakers are among the few groups that never traditionally practised circumcision. Interestingly, Australian anthropologist Kim Akerman, who has grown up with traditional Aboriginal Law, tells me that circumcision continues to increase in popularity among some Aboriginal language groups today.

COURTESY ANTHROPOLOGY DEPT, WA MUSEUM, DA 1987.12.001

Daisy Bates, with Joobaitch, Perth district, circa 1905. She lived and worked with remote Western Desert Aborigines and documented the spread of the circumcision rite into coastal areas.

For many of us the decision to be cut, or not to be cut, was made at birth by our parents (in contrast with Aboriginal initiation at puberty). Reasons can be for religion, status, or just decoration; but for hygiene? The bulk of current medical advice now seems dead against circumcising babies, at least as a preventative measure—if it ain't broke, don't fix it. □

FURTHER READING

Akerman, K., 1980. The renascence of Aboriginal Law in the Kimberleys. Pp. 234–242 in Aborigines of the West, *ed. by R.M. Berndt and C.H. Berndt. University of Western Australia Press: Perth.*

Gibbs, M. & Veth, P., 2002. Ritual engines and the archaeology of territorial ascendancy. Tempus *7: 11–19.*

Kruszelnicki, K.S., 2004. May the foreskin be with you. Good Weekend *10 January 2004: 13.*

Reynolds, S.J., Shepherd, M.E., Risbud, A.R., Gangakhedkar, R.R., Brookmeyer, R.S., Divekar, A.D., Mehendale, S.M. & Bollinger, R.C., 2004. Male circumcision and risk of HIV-1 and other sexually transmitted infections in India. The Lancet *363: 1039–1040.*

Related web sites:
http://www.cirp.org/
http://familydoctor.org/042.xml
http://www.fathermag.com/health/circ/

DR RICHARD FULLAGAR IS AN HONORARY SENIOR RESEARCH FELLOW IN ARCHAEOLOGY AT THE UNIVERSITY OF SYDNEY. HE IS PARTICULARLY INTERESTED IN ARCHAEOLOGICAL INDICATORS OF HUMAN BEHAVIOUR.

All in the family

Our native heaths and beard-heaths are now nestled in with the rhododendrons of China.

SIMEE LOCHMAN/LOCHMAN TRANSPARENCIES

The beard-heath *Leucopogon cryptanthemis*—long but incorrectly thought to be 'false cousins' of the 'true' heath family.

IN A BRIEF TRIP AROUND YUNNAN Province of China last year, I was surprised by the prominence of the Australian flora. Tasmanian Blue Gums (*Eucalyptus globulus*) marching across the fields like telephone poles with mops on top (the side branches are harvested each year for fire wood), Silky Oaks (*Grevillea robusta*) lining the main streets of local capital city Kunming, and the occasional flicker of Silver Wattle (*Acacia dealbata*) blossom in town squares. Of course these are all imports into China, and the plants of that country have few links with our Gondwanan flora.

Or do they? The most noticeable flowers in the Yunnan Province, at least to this Australian traveller, are the rhododendrons. When I visited in their late summer, the rhododendrons and azaleas (all *Rhododendron* spp.) were in fruit, rather than flower, so the mountainsides were dry and dull green. In spring, the vibrant colours we know from azaleas and rhododendrons in our own gardens transform the landscape—although 'double-flowered' cultivars are restricted to parks and monasteries, where some of the trees are many hundreds of years old. But in any season, these well-known members of the heath family, Ericaceae, are a key feature of the Chinese 'bush'.

In Australia, we have only a few members of the Ericaceae. Most of the 3,000 species in 100 genera are found in China and nearby Himalayan countries, and in New Guinea and southern Africa. There are only nine species native to Australia, including two rhododendrons from far north Queensland: *Rhododendron viriosum* from high-altitude rocky outcrops around Cape Tribulation, and *R. lochiae* from similar habitats on the Bellenden-Ker Range. There are also a few African and European heaths now weedy in natural areas, and our gardens of course are full of exotic *Rhododendron* cultivars.

However we do have a family of what have for a long time been considered 'false cousins', a group of plants that look similar but have been treated as quite separate families (like the euphorbias of Africa and the cacti of the Americas). Many members of the 'southern heath' family, the Epacridaceae, are heath-like and their common names reflect this likeness: the Pink or Common Heath (*Epacris impressa*) is the State emblem of Victoria, and Fuchsia Heath (*Epacris longiflora*) is a highlight of native and garden settings around Sydney. These vernacular names are akin to the much maligned names sometimes given to marsupials (for example, 'native cats' for quolls).

The Epacridaceae is pretty much an Australian family. There are a few species in New Zealand and farther north into Asia, and one in South America, but 360 of the 450 or so species are native here. The family includes many well known heath and woodland genera, such as the native heaths (*Epacris*) and beard-heaths (*Leucopogon*). Their sprays of white or reddish tubular flowers, typically poking out from prickly leaves, are a common sight on nutrient-poor acidic soils around the country.

The green thumbs amongst you will have raised an eyebrow at the mention of acidic soils. Anyone who grows azaleas or rhododendrons will know that they too have a fondness for low pH. This, and the fact that many of the species look similar, turns out to be a better indicator of evolutionary relationship that we had thought. Plant sci-

BY TIM ENTWISLE

entists are now busy deconstructing our epacrid family and it looks like the false cousins are destined to become siblings.

Recent research places the Epacridaceae smack bang in the middle of the Ericaceae. In the new family tree, our native heaths and beard-heaths are now nestled in with the rhododendrons of China (and those two from Australia), the heaths (*Erica*) of southern Africa and the heathers (*Calluna*) of Scotland. Their closest relatives turn out to be the blueberries, a cluster of plants including true blueberries (*Vaccinium*) from all over the world, and the waxberries (*Gaultheria*) from Australia, New Zealand and South America. However all is not lost and we can still retain some national pride. Because the southern heath genera have a common and unique ancestor, they will form a distinct subfamily, called the Styphelioideae (within the family Ericaceae).

If you ever need to separate the 'epacrids' (now styphelioids) from the rest of the family Ericaceae, the leaves usually have parallel veins and the flowers produce as many stamens (the male bits that shed pollen) as petals. There are also some more obscure characters that support the grouping, such as thickenings on leaf epidermal cells and the mechanics of pollen release. And of course there are the genetic similarities. The comparison of gene sequences continues to provide new insights into plant relationships, or sometimes confirm long-held intuitions.

Sorting out the familial relationships is just the start. Many of the features used to identify plant genera, such as leaf shape and flower structure, are remarkably consistent among the 'epacrids'. Darren Crayn and Chris Quinn (Botanic Gardens Trust), and their colleagues from Sydney and farther afield, are exploring the genetic diversity within the Styphelioideae, searching for natural relationships and reliable features for the identification of genera and species.

Early indications are that the beard-heaths have been a dumping ground for unrelated species and may include members of as many as eight genera. The highly localised *Budawangia* (from the south-east of New South Wales) and *Rupicola* (from sandstone escarpments around Sydney) appear to be just unusual members of the Common Heath genus *Epacris*. So although there won't be any more surprise liaisons between China and Australia, there may be a few painful separations and amalgamations in your local bush. □

JIRI LOCHMAN/OCHMAN TRANSPARENCIES

Fuchsia Heath, one of Australia's 'native heaths' (*Epacris*), is another long-lost relative to join the family.

FURTHER READING

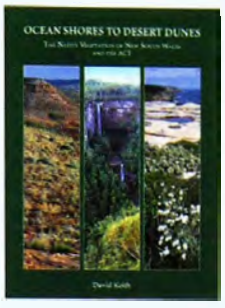
Crayn, D.M., Kron, K.A., Gadek, P.A. & Quinn, C.J., 1998. Phylogenetics and evolution of epacrids—a molecular analysis using the plastid gene rbcL with a reappraisal of the position of Lebetanthus. Aust. J. Bot. *46: 187–200.*

Kron, K.A., Judd, W.S., Stevens, P.F., Crayn, D.M., Anderberg, A.A., Gadek, P.A., Quinn, C.J. & Luteyn, J.L., 2002. Phylogenetic classification of Ericaceae: molecular and morphological evidence. Bot. Rev. *68: 335–423.*

Quinn, C.J., Crayn, D.M., Heslewood, M.M., Brown, E.A. & Gadek, P.A., 2003. A molecular estimate of the phylogeny of Styphelieae (Eriacaceae). Aust. Syst. Bot. *16: 581–594.*

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

reviews



Ocean Shores to Desert Dunes: The Native Vegetation of New South Wales and the ACT

By David Keith. Department of Environment and Conservation (NSW), Hurstville, NSW, 2004, 353 pp. $79.95 rrp.

THE TITLE IS MISLEADING. THIS IS NOT A MERE PLANT BOOK—MORE AN EXPLORATION OF THE New South Wales environment, with sumptuous illustrations of the landscape. The text is a carefully justified and explained classification of the 15 major vegetation types, fully referenced for those who want more information. But this is not a dry book: besides the beautiful photographs, there are amusing quotes from explorers, and snippets about individual animal and plant species.

The vegetation categories are further split up, so that 99 are recognised together, each of which is described and mapped. Most of the western vegetation types are widespread or are fragments of types found extensively over the border, but many eastern types are rare and vulnerable (particularly heaths and wetlands).

The maps of existing native vegetation are sobering and confirm impressions from the road: the drive from Goulburn to Narrandera is boring because there really is nothing there. The western half of the State may be overgrazed but is largely native, and the eastern sixth is generally well protected. But the big swathe of the western slopes and tablelands from Glenn Innes–Walgett to Tumut–Deniliquin is a sea of extinction.

What to say about a book that makes you want to leave the keyboard and get back out into the bush? Those desert woodlands look good.

—CHRIS REID
AUSTRALIAN MUSEUM

Tree Ferns

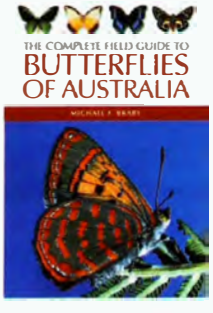
By Mark F. Large & John E. Braggins. CSIRO Publishing, Collingwood, Vic., 2004, 360 pp. $59.95 rrp.

TREE FERNS ARE POPULAR PLANTS, BOTH IN GARDEN CULTURE AND AS NATURAL-HISTORY SUBJECTS. THEY INCLUDE some of the largest-leaved of all plants, with fronds sometimes reaching four metres in length, and trunks two metres in diameter. Because they occur in many parts of the world, the idea of one book featuring every species is appealing.

Unfortunately, tree-fern classification is very unsettled. No-one can say how many species there really are, nor how many genera should be recognised. Many species were named in the past without adequately comparing them to similar species found elsewhere. This book is thus compromised by the high level of uncertainty, the authors admitting that some of the species they feature might not really exist.

Tree ferns is nonetheless a very useful book. As well as providing a brief account of every recognised species, plus 60 pages of colour plates, it contains informative introductory sections on anatomy, life style, cultivation, evolution, and an interesting section on human uses. Tree ferns have been used as food, medicine, stuffing for pillows, walls for huts, and even as paving for roads.

—TIM LOW



The Complete Field Guide to Butterflies of Australia

By Michael F. Braby. CSIRO Publishing: Collingwood, Vic., 2004, 340 pp. $39.95 rrp.

MOST AUSTRALIAN HOUSEHOLDS HAVE A COMPACT FIELD GUIDE TO AUSTRALIAN BIRDS, YET FEW have one for Australian butterflies. Is this because Australians are not interested in butterflies? No. I think it is simply because there has not been the right package of information available.

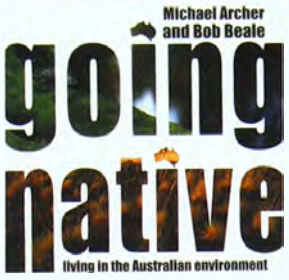
The complete field guide to butterflies of Australia fills this vacancy. The attractively packaged paperback contains all 416 of the described Australian species, including those from offshore territories. It fits easily into a backpack and is simple to use, with detailed introductory information to assist the non-entomologist. There are excellent colour photographs of set specimens for all species, as well as some photographs of habitats, live adults and immature stages. Common names and distribution maps are given for all species, as well as text descriptions of the species, their habitat, life-history, and conservation status. Similar species are mentioned in each description, with information provided so you can tell which species you have in front of you.

Butterflies are flagships for invertebrate appreciation. Even entomophobes can appreciate butterflies. It is critical that the general public can access information on these insects, and identify the species that occur in their own backyards, parks and reserves. This book will fulfill that role and introduce Australians to a whole new facet of our natural history.

—DAVE BRITTON
AUSTRALIAN MUSEUM

NatureAustralia library boxes

ENSURE YOUR COPIES OF NATURE AUSTRALIA REMAIN IN MINT CONDITION. PURCHASE AUTHENTIC NATURE AUSTRALIA LIBRARY BOXES. EACH BOX HOLDS TWELVE ISSUES OF THE MAGAZINE. FINISHED IN DURABLE, DARK GREEN PVC. EACH BOX IS $14.24 INCLUDING SHIPPING. SEE THE ORDER FORM LAST PAGE.



Going Native: Living in the Australian Environment

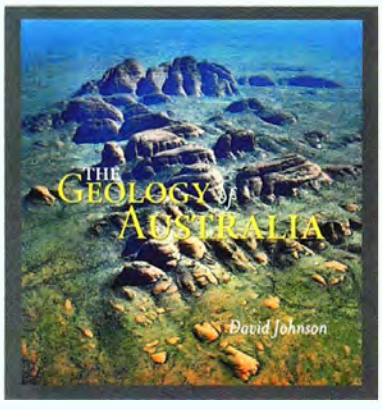
By Michael Archer and Bob Beale. Hodder Headline Australia, Sydney, NSW, 2004, 358 pp. $35 rrp.

The introduction to *Going native* calls for a revolution in the way Australia thinks about current and future management of its natural resources. With such a challenging premise, the ideas put forward are necessarily big, bold and often controversial.

Divided into 13 chapters, with an extensive bibliography, it begins with a four-chapter overview of the geological, biological and human-influenced changes that have shaped Australia's present-day ecosystems. The conclusions drawn from this overview are that, if we continue with our present 'traditional' (that is, non-sustainable) land-management practices, our environment will be irreversibly degraded and our present-day levels of economic productivity will just not be possible. The authors then suggest a series of solutions to the worst of our future problems. These range from the fairly mild—production and marketing of bush-food products, better water and soil management—through native-tree forestry and alternative agricultural practices, to more confronting ideas about wild-animal farming and harvesting, mining as a sustainable practice, and gene technology.

Going native is definitely thought-provoking and should generate constructive debate among key stakeholders in Australia's environmental future, especially governments, land managers and investors, which seem to be the book's target audience.

—Ondine Evans
Australian Museum



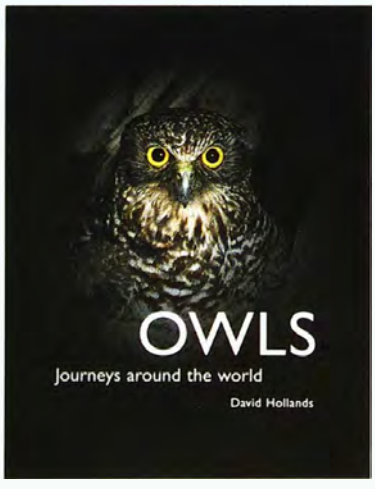
The Geology of Australia

By David Johnson. Cambridge University Press, Cambridge, 2004, 276 pp. $150 hardback, $69.95 paperback rrp.

The astonishing diversity of Australia's geology is capably brought out within this book. The author starts by putting the continent's geology into introductory perspective (Chapter 1), then explains geological terms and processes (Chapter 2), before sweeping through the vast tracts of geological evolution that created the complex continent that now resides between the Indian and Pacific Oceans (Chapters 3–10). The last of these chapters focuses on the growth of Australia's crowning glory, the Great Barrier Reef. To top off the journey, Johnson places Australia into its planetary context (Chapter 11), during Earth's evolution within the solar system, and shows that Australia's cradle is not immune to impacts from this outer sphere. The final chapter emphasises the complex interplay between evolution and extinctions and the lessons geology has for our human dimensions.

The book is illustrated with a wide variety of geological reconstructions, diagrams, pictures of landforms, rocks, minerals and fossils, many of them in colour. It explains the processes that have led to our present continent, often so different in the past. A few facts go astray within this telling, but overall the book presents a masterly synthesis for the reader.

—Lin Sutherland
Australian Museum



Owls: Journeys Around the World

By David Hollands. Bloomings Books, Melbourne, 2004, 239 pp. $59.95 rrp.

This book represents a personal odyssey by the author David Hollands. He is respected in the ornithological world and his knowledge of owl-kind is apparent as you journey along with him to 12 locations spanning six continents, including of course Australia. Hollands states from the outset that this book is not a scientific endeavour; rather it is a work of passion. The author does not attempt the impossible task of photographing every one of the 205 owl species in existence, but focuses on the 21 species that he has encountered in his travels.

The photography is outstanding and the book is a pleasure to read. Each encounter is interesting and the joy the author experiences is tempered with the inevitable tragedy that occurs when humans encroach on owl territory. Many of these owls face an uncertain future and the book serves as a record of the lives of these iconic birds. This book is a must for owl lovers everywhere.

—Leoné Lemmer
Australian Museum

SOCIETY PAGE

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

ANIMAL WELFARE

North Queensland Wildlife Care Inc.
PO Box 1446
AITKENVALE QLD 4814
Ph: 0414 717 374
Contact: Lana Allcroft
Membership: $10.00 Child $25.00 Adult $35.00 Family or Organisation

WIRES
NSW Wildlife Information & Rescue Service
PO Box 260
FORESTVILLE NSW 2087
Ph: 02 8977 3333
& 1800 641 188
Web: *www.wires.org.au*
Contact: Carol MacDougall
Membership: $40.00

ASTRONOMY

Western Sydney Amateur Astronomy Group
PO Box 400
KINGSWOOD NSW 2747
Ph: 02 4739 1528
Web: *www.tpqi.com.au/users/usaag/*
Contact: Tony Ellis

BIRDS

Birds SA
11 Shaftsbury Street
EDEN HILLS SA 5050
Ph: 08 8278 7866
Web: *www.birdssa.asn.au*
Contact: Dr David Robertson

CONSERVATION

Australian Ecosystems Foundation
PO Box 606
LITHGOW NSW 2790
Ph: 02 635 21133
Web: *www.ausecosystems.org.au*
Contact: Trevor Evans
Membership: $10.00 Single $25.00 Family $100 Corporation

Friends of Lane Cove National Park Inc.
c/- Lane Cove National Park
Lady Game Drive
CHATSWOOD NSW 2067
Web: *http://users.bigpond.net.au/folenp*
Contact: Noela Jones

EDUCATION

CSIRO's Double Helix Science Club
PO Box 225
DICKSON ACT 2602
Ph: 02 6276 6643
Web: *www.csiro.au/helix*
Contact: Jo-Anne McRae
Membership: $27.00 or $24.00

Gould League of NSW
PO Box 846
MARRICKVILLE NSW 2204
Ph: 02 9560 7844
Web: *www.gould.edu.au*
Contact: Michael Brennan

EARTH SCIENCES

Australian Field Geology Club
16 Arbutus Street
MOSMAN NSW 2088
Ph: 02 9969 2135
Contact: Douglas Raupach

ENVIRONMENTAL

Royal Geographical Society of SA Inc.
c/- R.G.S.S.A.
GPO Box 419
ADELAIDE SA 5001
Ph: 08 8207 7265
Contact: Nick Harvey
Membership: $55.00

INSECTS

Entomological Society of Victoria
56 Looker Road
MONTMORENCY
VIC. 3094
Ph: 03 9435 4781
Web: *www.vicnet.net.au/~vicento*

Society for Insect Studies
12 Park Avenue
ROSEVILLE NSW 2069
Ph: 02 9417 6171
Contact: Hon. Treasurer

MICROSCOPY

Postal Microscopical Club of Australia (PMCA)
36 Western Avenue
BLAXLAND NSW 2774
Ph: 02 4739 1528
Contact: Tony Ellis

MUSEUMS

TAMS—The Australian Museum Society
6 College Street
SYDNEY NSW 2010
Ph: 02 9320 6225
Web: *www.amonline.net.au/tams/*
Contact: Alison Byrne
Membership: $88.00 Family $70.00 Single $52.00 Concession

The Waterhouse Club
SA Museum
NorthTerrace
ADELAIDE SA 5000
Ph: 08 8203 9802
Web: *www.waterhouseclub.org.au/whc*
Contact: Mary Lou Simpson
Membership: $90.00 Family $70.00 Single

NATURAL HISTORY

Dinosaur Club
Australian Museum Education
6 College Street
SYDNEY NSW 2010
Ph: 02 9320 6223
Contact: Kate Cox
Membership: $15.00

Field Naturalists Club of Victoria
Locked Bag 3
BLACKBURN VIC. 3130
Ph: 03 9877 9860
Web: *www.vicnet.net.au/~fncv*
Contact: Mimi Pohl

Royal Society of SA
SA Museum
North Terrace
ADELAIDE SA 5000
Ph: 08 8223 5360
Web: *www.agwine.adelaide.edu.au/industry/RSSA/*
Contact: John Love

REPTILES & AMPHIBIANS

Hawkesbury Herpetological Society Inc.
PO Box 30
EMERTON NSW 2770
Ph: 02 9832 9013
Contact: J.A. Banks

QLD Frog Society
PO Box 7017
EAST BRISBANE
QLD 4169
Ph: 07 3366 1868
Web: *www.qldfrogs.asn.au*
Contact: Jenny Holdway

Newsletter/Journal; Monthly meeting; Bi-monthly meeting; Annual meeting/Conference; Weekly meeting; Quarterly meeting; Field outings/Tours; Conservation/Working programs; Discounted Goods; Magazine; Social/Education activities; *Nature Australia* magazine; Seminars

q&a

COURTESY RUTH WALTER

Cockroaches on the Move

Q: *In May we were travelling west on the Balonne Highway to Cunnamulla, Queensland. We stopped for lunch at Nebine Creek and were intrigued by these insects (cockroaches?), which were about 50 millimetres long and were floating/swimming downstream in large numbers. Many were also walking across the highway for up to two kilometres from the creek. Can you tell us more about them?*

—Ruth & John Walter
Pittsworth, Qld

A: The Walters have reported an uncommon event. What they saw were indeed cockroaches of the soil-burrowing variety. Locally known as rain beetles, this species (*Geoscapheus dilatatus*) burrows up to 60 centimetres below the ground surface in sandy areas west of the Great Divide, from southern Queensland to western Victoria. They feed mainly on dead tree leaves and thus are useful as nutrient recyclers. They come to the surface only after autumn/winter rains, typically for about four or five days. Not much is known of their biology but they can sometimes be seen in their hundreds and thousands. What they are doing is dispersing and they will construct a new burrow at the end of the day.

'Rain beetles' surface only after rain.

In a burrow, there is usually a single adult, or a male with a female. After mating, the male leaves the burrow. The young are born alive and are provisioned by the mother, which gathers and drags leaves from the ground surface to the burrow. After about a year, the juveniles leave to construct their own burrow. It takes about three years from birth to adulthood, and the adults can live five to seven years. In droughts, there is no migration; the cockroaches simply stay underground until the next rain.

—Harley Rose
University of Sydney

Underwater Bubbles

Q: *I was diving under Portsea Pier in Melbourne last January and came across this thing (see photograph). It is about the size of a softball or a bit bigger. What is it?*

—Samantha Bell
Rowville, Vic.

A: What you saw was a Bubble or Swimming Anemone (*Phyctenactis tuberculosa*), a native of temperate Australian waters. It's the largest anemone in southern waters and reaches a height of about 15 centimetres. The bubble-like vesicles covering the column of the anemone are the source of one of its common names. It's more usually known, however, as the Swimming Anemone because of its habit of detaching itself from the substrate and drifting in the current. *Phyctenactis tuberculosa* lives subtidally and attaches to rocks, rubble, or seagrass, but because of its drifting habit, it is often washed ashore. In daylight, the tentacles are usually retracted, making it look like a large mass of bright bubbles. At night, the tentacles are expanded for feeding. The Swimming Anemone should not be confused with the similarly named *Phyctenanthus australis*, which is also covered in bubble-like vesicles. However *Phyctenanthus australis* lives firmly attached to the substrate, and has smaller, less bulbous vesicles that are dull-brown or gray in colour.

—Shane Ahyong
Australian Museum

CARL BENTO/AUSTRALIAN MUSEUM

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *A David Suzuki collection: a lifetime of ideas.* Summer's Pic Teaser was fish otoliths.

Wiley Wagtails

Q: *Last spring a pair of Willie Wagtails nested in a coil of wire in my shed. These birds are great breeders, are clearly very adaptable, and appear not to have many predators. So why aren't they even more common? What keeps their populations in check?*

—Robyn Hewitt
Sarsfield, Vic.

A: Willie Wagtails (*Rhipidura leucophrys*) are indeed prolific breeders, producing 3–4 clutches of 2–4 eggs each year. However, many breeding attempts are unsuccessful. Predation rates can be very high. The main nest predators are other birds—butcherbirds, currawongs, kookaburras etc.—which take chicks and eggs from the Wagtails' poorly concealed nests. Another major factor that keeps populations in check is this species' territorialism. Both sexes vigorously defend a territory of 1–3 hectares throughout the year, thus limiting how many individuals can be packed into an area.

—G.H.

COURTESY SAMANTHA BELL

Bubble Anemone.

Answers to Quiz in Nature Strips (page 14)

1. *Dogs*
2. *Ultrasound*
3. *Tasmania*
4. *A lizard*
5. *Five*
6. *Epping Forest*
7. *It gets darker.*
8. *No*
9. *Chlorophyll*
10. *Mars and Saturn*

Taxonomy: biology's infrastructure

Infrastructure is so familiar that it is boring; that is until it fails and suddenly everyone wonders what went wrong.

BRIDGES, ROADS, PORTS, LAW courts, sewers and weather forecasts. They are all basic infrastructure: the physical and conceptual structures that society needs to function smoothly. Governments build and maintain the infrastructure, and the public uses it in whatever way it sees fit. And as we all know, infrastructure is so familiar that it is boring; that is until it fails and suddenly everyone wonders what went wrong.

There is also a basic infrastructure in biology. It is called taxonomy. And like more familiar aspects of infrastructure, everyone takes taxonomy for granted; that is until that taxonomy isn't up to scratch when it is needed.

Taxonomy is two things. First, it is the scientific discovery, description and naming of species. This tells how the species can be distinguished from all other species and gives the species a legal name. The description also includes basic biological information about the species. Second, taxonomy tries to determine where species fit into the tree of life. There is only one tree of life and knowing which twig any species occupies in the tree is a fundamental part of what that species is. For all practical purposes, a species doesn't 'exist' until it has been described by a taxonomist.

Just as everyone uses roads, bridges, sewers and weather reports, so too does everyone use taxonomy. If you're interested in biodiversity and conservation, then you are interested in concepts that are simply currently fashionable derivatives of taxonomy. If you're a greenie carrying a placard down Macquarie Street saying "Save the Koala", you're using the taxonomy of a pointy-headed scientist with a funny accent who worked 188 years ago. If you're an ecologist trying to determine what controls the distribution and abundance of two species of limpets on a rock platform, you accept a taxonomist's word that the species you're studying are really two and not three, otherwise your work is cactus.

If you're a greenie carrying a placard down Macquarie Street saying "Save the Koala", you're using the taxonomy of a pointy-headed scientist with a funny accent who worked 188 years ago.

Ideally, taxonomy should be at hand when the need arises. You should be able to just take it off the rack and use it. Unfortunately, this is rarely the case, and taxonomists, just like road engineers, are constantly monitoring need and trying to anticipate it. But the effort is only as good as the resources allocated to it.

The consequence of not having an up-to-date taxonomy at hand is most easily seen with each outbreak of a new viral disease. Most of the initial work is a mad scramble to determine what new 'strain' the virus may be. The virus' basic taxonomy is so critical that all other work is on hold until researchers know the 'taxonomy' of the organism they are dealing with.

Is taxonomy ever finished? Is work on the roads, bridges and ports ever finished? No. New concepts, new technologies and new needs mean that the taxonomy of any group of organisms requires regular review and upgrading. Some railway bridges go back to the 19th century, but they need constant maintenance and one day may have to be replaced. The Green Turtle (*Chelonia mydas*) has been known as a species since 1758, but it is only recently that we have learned, using genetics, that the turtles that breed in different parts of the world, or even on different sides of Australia, show little interbreeding; that is, they are arguably separate twiglets on the tree of life. This realisation means that conserving the breeding turtles in eastern Australia will do nothing for the turtles in western Australia.

Taxonomy can only be done in or through institutions that maintain large collections of specimens, which allow simultaneous detailed comparisons among specimens. These institutions are primarily natural history museums and herbaria. In all countries, except the United States, these institutions are largely owned and run by governments, which is fitting, given that taxonomy is the infrastructure for all other biological endeavour. And just as governments are judged by their ability to maintain the basic infrastructure of rails, roads, ports, courts and sewers, so too can they be judged by their maintenance of their natural history museums and herbaria.□

DR ALLEN E. GREER IS A PRINCIPAL RESEARCH SCIENTIST IN THE HERPETOLOGY SECTION OF THE AUSTRALIAN MUSEUM.

BY ALLEN GREER

SUBSCRIBE TO NatureAustralia

Save time and money by having Nature Australia delivered to your door!

In the next issue...

- *Northern Common Cuscus*
- *Pheasant Coucals*
- *Spider Web Design*
- *Termites*
- *Wallum Froglets*
- *Mistletoe Birds*
- *Extreme Plants*
- *Origins of Sport*

Winter issue available June 2005

Toll-free Subscription Hotline: (1800) 028 558

See reverse for details of back issues

NEW SUBSCRIBER YES!

PLEASE SEND A SUBSCRIPTION FOR

❑ 3 years for **$97.90** *(overseas $A116-surface, $A176-airmail)*
❑ 2 years for **$69.30** *(overseas $A83-surface, $A123-airmail)*
❑ 1 year for **$36.30** *(overseas $A45-surface, $A65-airmail)*
Prices are GST inclusive where applicable.
❑ Start this subscription with _____ issue

Name _____
Address _____
Suburb/Town _____ **Postcode** _____

Payment by ❑ Cheque ❑ Money Order ❑ Bankcard ❑ Visa ❑ Mastercard ❑American Express

My card number is ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ Expiry Date /

SIGNED _____ CARDHOLDER'S NAME (Print) _____

❑ *Tick if you require a GST tax invoice.*

NatureAustralia

Cheque or card authority has to accompany order. Make cheques payable to 'Australian Museum'. *Nature Australia* is a quarterly magazine, with issues released in March, June, September and December. Please allow up to 12 weeks for delivery of first issue (unless backdated). Prices valid to December 2005. **PHONE THROUGH CREDIT CARD ORDERS ON ☎1800 028 558. SUBSCRIBE BY FAX 02 9320 6073.**

AUTUMN 2005

GIFT SUBSCRIPTION YES!

I WOULD LIKE TO SHARE MY FACINATION WITH NATURE WITH SOMEONE ELSE

❑ 3 years for **$97.90** *(overseas $A116-surface, $A176-airmail)*
❑ 2 years for **$69.30** *(overseas $A83-surface, $A123-airmail)*
❑ 1 year for **$36.30** *(overseas $A45-surface, $A65-airmail)*
Prices are GST inclusive where applicable.
❑ Start this subscription with _____ issue

To _____
Address _____
Suburb/Town _____ **Postcode** _____
From _____
Address _____
Suburb/Town _____ **Postcode** _____

Payment by ❑ Cheque ❑ Money Order ❑ Bankcard ❑ Visa ❑ Mastercard ❑American Express

My card number is ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ Expiry Date /

SIGNED _____ CARDHOLDER'S NAME (Print) _____

❑ *Tick if you require a GST tax invoice.*

NatureAustralia

Cheque or card authority has to accompany order. Make cheques payable to 'Australian Museum'. *Nature Australia* is a quarterly magazine, with issues released in March, June, September and December. Please allow up to 12 weeks for delivery of first issue (unless backdated). Prices valid to December 2005. **PHONE THROUGH CREDIT CARD ORDERS ON ☎1800 028 558. SUBSCRIBE BY FAX 02 9320 6073.**

AUTUMN 2005

SEND THIS CARD AND PAYMENT POSTAGE FREE TO:

BACK ISSUES

Australian Museum
Reply Paid 66752
Darlinghurst NSW 2010
Australia

SEND THIS CARD AND PAYMENT POSTAGE FREE TO:

Australian Museum
Reply Paid 66752
Darlinghurst NSW 2010
Australia

SEND THIS CARD AND PAYMENT POSTAGE FREE TO:

Australian Museum
Reply Paid 66752
Darlinghurst NSW 2010
Australia

BACK ISSUES AND SUPPLEMENTS

Available at $5.50 each (including postage & handling and GST)

ISSUE #	CONTENTS
25/1	• Wandering Albatross • Right Whales • New Tree-kangaroo • Itchy Spiders
25/4	• Wallabies • Stick-insects • Parrotfish • Frog Decline
26/7	• Glossy Black-Cockatoos • Mosquitoes • Brush-tailed Rock-wallabies
26/8	• Rock Ringtail Possum • Magpie Geese • Butterfly Mating • Origin of Life on Earth
26/9	• Striped Possums • Cane Toads • Snake Penises • Shy Albatross
26/10	• Port Jackson Sharks • Wedge-tailed Eagles • Humans in Australia • Marsupial Carnivores • Brown Tree Snakes
26/11	• Crimson Rosellas • Marsupial Moles • Mud-dauber Wasps • Butcherbirds • Crocodiles as Dinosaurs
26/12	• Grey Nurse Shark • Cassowary • Box Jellyfish • Centipedes • Giant Bear Cuscus
27/1	• Eclectus Parrots • Healing Honey • Velvet Worms • Desert Skinks
27/2	• Malleefowl • Dugongs • Great Burrowing Frogs • Hagfishes
27/4	• Leadbeater's Possums • Dogs and Humans • Humpback Whales • Barn Owls • Jabirus
27/5	• Kookaburras • Lungfish • Jumping Spiders • Sea Snakes • Lost Giants
27/6	• Brushtail Possums • Beaked Whales • Fire Ants • Fairy-wrens • Mimic Octopuses
27/7	• Cicadas • Purple-necked Rock-wallabies • Coorong Wetlands • Sauropod Dinosaurs • Origins of Art
27/9	• Elephant Seals • Jacky Dragons • Curtawongs • Australian Tsunami • Tree Hollows
27/10	• Feathered Dinosaurs • Magpie Mimics • Victorian Possums • Making Faces • Bogongs • Cane Toads
27/11	• Blue Whales • Crazy Ants • How Smart are Birds • Simpson Desert • Myth of Reptile Domination
27/12	• Ringtail Possums • Northern Snake-necked Turtles • Black Swans • Quokkas • Origin of Language • Leapfrog Birds
28/1	• Ice Man • Musky Rat-kangaroos • Pacific Blue-eyes • Urban Foxes • Cuckoos and Wrens • Cunningham's Skinks • Tawny Frogmouths
28/2	• Naked Mole-rats • Quolls & Cane Toads • Seabirds & Plastic • Rough-scaled Pythons • Norther Hairy-nosed Wombats
28/3	• Tasmanian Devil Disease • Fire Experiment • Sex, Lies & Wasps • Pugh's Mountain Frog • Ice-age Hunters

* Denotes limited stock

SUPPLEMENTS

$2 Tracks Through Time – The Story of Human Evolution – a look at our origins @ $10.94 each (including postage & handling and GST)

ORDER FORM

Qty	Issue/Suppl. No	Price $
	THE EVOLUTION OF AUSTRALIA @ $24.95	
	TRACKS THROUGH TIME @ $ 10.94	
	2002 FLAT POSTER COLLECTION @ $ 12.00 per set	
	LIBRARY BOXES @ $14.24 each	
	TOTAL $	

Post to:
NATURE AUSTRALIA, AUSTRALIAN MUSEUM,
REPLY PAID 66752, DARLINGHURST NSW 2010
(or phone 1800 028 558 toll-free or fax 02 9320 6073)

Name _____

Address _____

Suburb/Town _____ **Postcode** _____

Debit my ❑ Bankcard ❑ Visa ❑ Mastercard ❑ American Express EXPIRY DATE /

Card Number ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

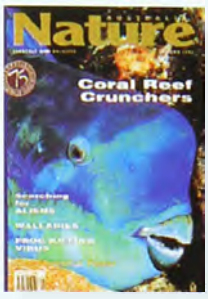
Signature _____

Cardholder's Name (print) _____

Cheque or card authorisation must accompany order. Please make cheques payable to 'Australian Museum'.

BACK ISSUES AND SUPPLEMENTS

25/1



25/4

26/7

26/8

26/9

26/10

26/11

26/12

27/1

27/2

27/4

27/5

27/6

27/7

27/9

27/10

27/11

27/12

28/1

28/2

28/3

PURCHASE A BACK ISSUE OF
NATURE AUSTRALIA
FOR ONLY $5.50

NatureAustralia
library boxes

HOLD TWELVE ISSUES OF THE MAGAZINE. FINISHED IN DURABLE, DARK GREEN PVC, IT WILL ENSURE YOUR COPIES REMAIN IN MINT CONDITION.

TO ORDER USE THE FORM OPPOSITE

LIFE BEYOND THE TOMB

death in ancient Egypt

WIN A HOLIDAY FOR TWO TO EGYPT!
Visit the exhibition and enter the competition
Prize courtesy of Explore Holidays and Malaysia Airlines

Mummy secrets and rituals exposed!

Discover a wealth of stunning artefacts including tools used for mummifying bodies and the spiritual and death ceremonies of an ancient civilisation.

HURRY! MUST END 22 MAY

Australian Museum
6 College Street, Sydney (opposite Hyde Park)
Open daily 9.30am – 5pm
Telephone 02 9320 6000 www.amonline.net.au

Image: © National Museum of Antiquities, the Netherlands

nsw arts

The Australian Museum is a statutory authority of, and principally funded by, the NSW State Government.

Principal Sponsor

NATIONAL GEOGRAPHIC CHANNEL

THIS EXHIBITION IS CO-PRODUCED BY THE NATIONAL MUSEUM OF ANTIQUITIES LEIDEN, THE NETHERLANDS

AM AUSTRALIAN MUSEUM