FREE FROG POSTER

$8.95 EX GST
$9.50 INC GST

NatureAustralia

WINTER 2000

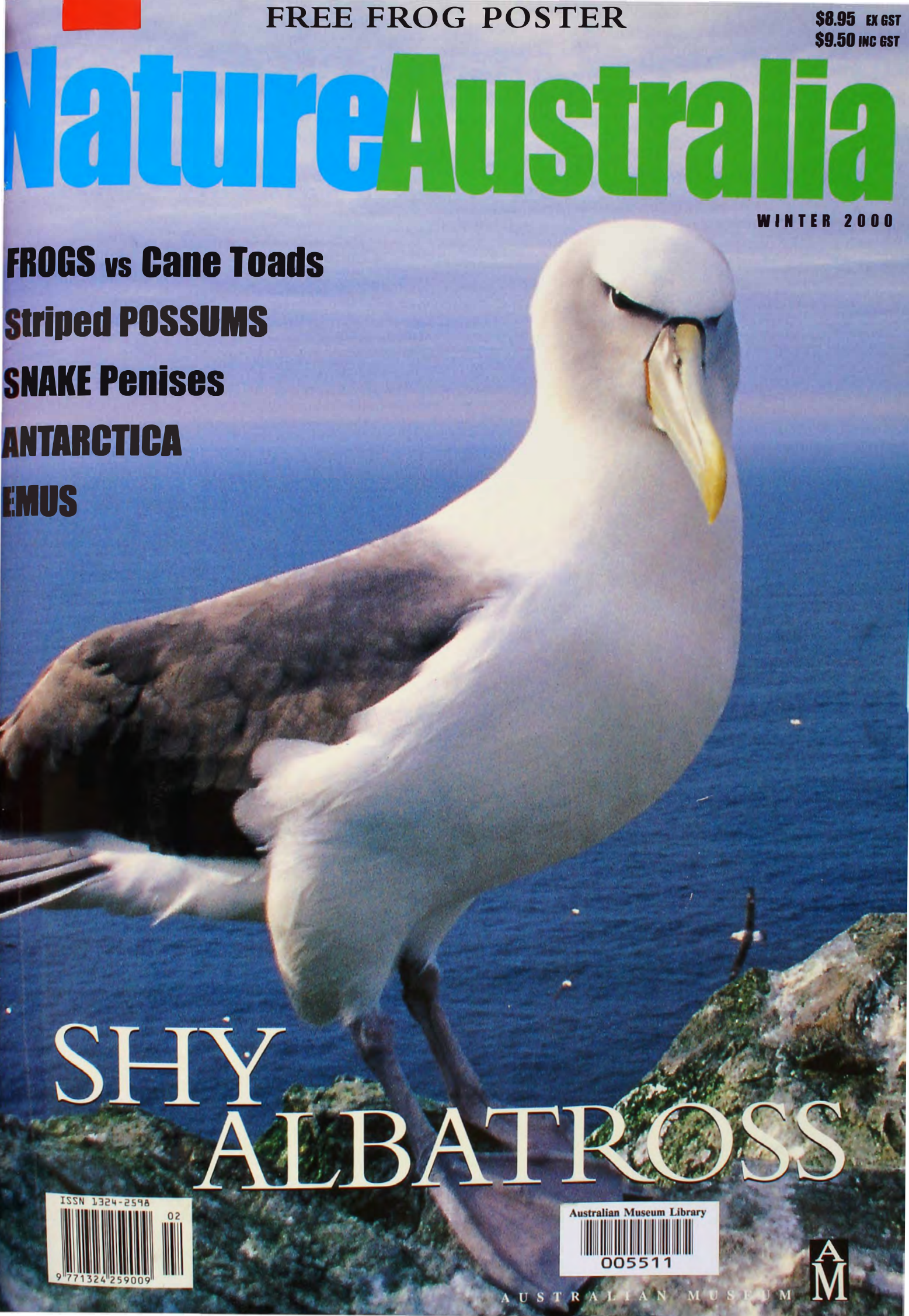
FROGS vs Cane Toads

Striped POSSUMS

SNAKE Penises

ANTARCTICA

EMUS



SHY ALBATROSS

ISSN 1324-2598 02

AUSTRALIAN MUSEUM

SILVA

UNSURPASSED QUALITY AND ACCURACY

WORLD'S BEST SELLING COMPASSES

from camping stores everywhere

SHOCKPROOF•WATERPROOF•6 YEAR WARRANTY

Trade enquiries: Macson Trading Company Pty Ltd Tel (03) 9489 9766 Fax (03) 9481 5368

E-mail: info@macson.com.au Web: http://www.macson.com.au/silva

contents

ARTICLES

REGULAR FEATURES

COLUMNS

PHOTOS: NICHOLAS BIRKS/WILDFLIGHT AUSTRALIA

NatureAustralia

WINTER 2000 VOLUME 26 NUMBER 9

Published by the Australian Museum Trust
6 College Street,
Sydney, NSW 2010.
Phone: (02) 9320 6000
Fax: (02) 9320 6073
Web: http://www.austmus.gov.au
Trust President: Malcolm Long
Museum Director: Michael Archer

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

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

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

Design & Production
WATCH THIS! DESIGN

Printing
EXCEL PRINTING

Advertising
ROBBIE MULLER
Phone: (02) 9320 6119
email: robbiem@austmus.gov.au

Subscriptions
KAREN HILLIGER
Phone: (02) 9320 6119
Toll-free (1800) 028 558
Fax: (02) 9320 6073
email: karenh@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.

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

Published 2000 ISSN–1324–2598

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

FRONT COVER
The Shy Albatross (*Thalassarche cauta*) is the only albatross to breed entirely within Australia.
Photo by Graham Robertson/Auscape.

up front

We invited them in but now we want them to go. As far as most people are concerned, Cane Toads are the guests from hell. They are offensive to look at, kill our pets, poison our children, and are reputed to have an adverse effect on many of our native animals. To top it all off, they haven't even helped us control the beetles they were brought out for! But the real problem is, these guests have decided to stay. And who could blame them? The weather's great, there's food galore and, best of all, lots of prime habitat to occupy. And the habitat they want next is Kakadu. So how do we get rid of these toady pests? It seems that in order to get funding for an eradication program, scientists must first prove that these toads do actually harm our native wildlife. By eavesdropping on the local frog populations as the toads march their way across the Northern Territory, Gordon Grigg hopes to provide an insight into the impact Cane Toads will have on our World Heritage Area.

If kissing a frog is thought to bring forth a handsome prince, what do you think sucking a sea slug could do? Believe it or not, this may be the next way to relax an overactive nervous system. But before we get too excited, a careful study of their ecology is needed to help manage this valuable resource. For a glimpse into other potential pharmaceuticals from the sea, turn to page 50.

In the tropical rainforests of northern Queensland lives Australia's smartest and most elusive marsupial—the Striped Possum. Despite being hard to find and even harder to catch, Kath Handasyde became fascinated with these beautiful animals and set out to learn what she could about their biology and ecology. Read "Striped Possums: the Bold and the Beautiful" and see why Kath is so enraptured.


GORDON GRIGG

A Northern Dwarf Tree Frog (*Litoria bicolor*).

Is one better than none? This was the question Jonathan Majer and Harry Recher wondered when considering the ecological benefits of a single tree in an otherwise totally cleared field. Although it's common practice for farmers to leave one tree in a field to give shade for stock, does that tree also provide habitat for native wildlife? The team compared the faunas from isolated trees with those growing in different situations, and the results were surprising.

In the last issue we brought you the tactical mating game of butterflies. In this issue Scott Keogh investigates the bizarre, and often brutal, sexual world of snakes. And not just any snakes, for Scott takes a particular interest in the penises of elapids, which includes our most deadly reptiles. Scott asks why snakes have two penises and how they evolved such an amazing array of appendages.

Other authors pursue pumice across the Pacific, get slippery with Emu oils, and ask how safe the recently released Rabbit calicivirus really is. We also see how important butterfly food trees are and why the Shy Albatross is under threat again. And last, but certainly not least, we hope you enjoy reading the new look *Nature Australia* magazine.

—JENNIFER SAUNDERS

letters

Spidery Herbs

Having recently photographed four species of carnivorous native herbs in the Popran and Brisbane Waters National Parks (NSW), I found Brian Chudleigh's Letter (*Nature Aust.* Winter 1999), on the rapidity of closure of the Venus Fly Trap, interesting. The traps used by our own native bladderworts (*Utricularia*) act very quickly. These plants grow in seepage areas. The traps attached to their roots consist of small hollows with an entrance closed by a trapdoor, activated by a trigger of hairs or glands. The hollow is under negative pressure so that the door opens very quickly when triggered, sucking the triggering insect in with a rush of water. The door then closes and the insect is digested. One common species in the Sydney District is Fairies Aprons (*U. dichotoma*).

I also found sundews (*Drosera*) interesting. The Pale Sundew (*D. peltata*) and the Tall Sundew (*D. auriculata*) are similar and common in the Sydney District. The traps used by these sundews are very different from those used by the bladderworts. Appendages on the ends of their stalks act as both insect traps and digestive cavities. The appendages have fine hairs that produce sticky droplets. These droplets glisten in the sunlight to attract insects. Once the insect is trapped in the sticky fluid, the hairs close over the insect, pressing it into the central digestive cavity. The plant then secretes a fluid containing an enzyme, which converts the protein in the insect into a soluble form that is absorbed by the plant.

It is interesting to compare the actions of these herbs with those of spiders. Some spiders feed on the same insects as the sundews. Spiders also trap insects by using a sticky fluid on their webs. The sticky droplets on the webs of orb-weaving spiders and the sticky globules of the bolas spiders seem to consist of a fluid very like that used by the sundews to form their sticky droplets. It appears that both the spiders and the sundews use proteolytic enzymes to digest the protein in their insect prey.

—Ted Hind
Avoca Beach, NSW

Native Wildlife off the Menu

I have been a regular subscriber to *Nature Australia* and, until the Spring 1999 edition,

M. COUPAR NATURE FOCUS

Spiders and carnivorous herbs such as the Tall Sundew have more in common than we think.

I have been delighted to read your magazine. However, I can't believe you published Steve Van Dyck's article "Greys Hot in the Long-jump Steaks", which seems absolutely out of place in a magazine that normally inspires a love of nature and informs the readers on the amazing biodiversity of Australian native flora and fauna. I am deeply offended that Van Dyck perpetuates the myth that killing and eating kangaroos will partly solve Australia's habitat-destruction problem. His article is nothing but a promotional story for the Australian kangaroo industry. Kangaroos are part of the Australian landscape, they are closely connected with their environment and do not breed out of control if left on their own device. They belong to this land and should be treated with respect and dignity. Australia's land-degradation problems are caused by poor agricultural management policies, 120 million Sheep and 60 million Cattle, land-clearing and so on, and anyone with any common sense would know that kangaroos don't play an important role in the destruction of Australia's landscape and that they do not need to be killed. Harvesting kangaroos, just like the harvesting of any species of animal on this planet, never is ecologically sustainable. The species harvested is always a victim of suffering and abuse, and becomes endangered if not extinct thanks to human greed. Van Dyck seems to have chosen to ignore the cruel way kangaroos are being harvested by the kangaroo industry. Those methods are just as horrific as the ones referred to in his article at the time of European settlement, if not more horrific, considering our society's supposed understanding of animal rights issues.

I have cancelled my subscription and urge you to reconsider the direction your magazine is taking. *Nature Australia* should not promote the harvesting of any wildlife and should definitely not encourage Australians to eat their native wildlife.

—Brigitte Charron
Melbourne, Vic.

The appearance of both your Letter and my offending paragraphs in the same publication should inspire you to renew your recently cancelled subscription. Opinion diversity in the public forum is as much a national treasure as biological diversity.

Because they are different-things-to-different-people, our fauna will always be much more than just the objects of admiration and respect that you (and I) would like them to be. And as long as most of us live in the city and are not truly hungry, there are always going to be differing opinions as to what to do with our fauna. When we disagree, we vote. The Goss (Labour) Government in Queensland essentially lost office over what it failed to do for Koalas. But you can't ultimately conserve fauna just by celebrating it. Those who are acquainted with the range of public opinion are better equipped to contribute meaningfully to debate prior to the vote.

Like you, I find the processes of animal abuse, exploitation and cruelty repugnant. But I also find the natural processes of life and death just as unsettling. There is no "elephants' burial ground". In the wild, most young animals, along with most of the old and displaced, either get torn apart by predators or eventually die of stress-related disease or injury. If the issue of your protest isn't vegetarianism, and if animals are dealt with humanely, how does a cow differ from a chicken from an earthworm from a kangaroo?

But I don't share your concern that the comments of a few individuals are sending Nature Australia *careering off on the slippery path of economic animal rationalism. Your relinquished subscription is my regret, but* Nature Australia *would find a more offended audience if it closed its doors to the breadth of sensible opinion that reflects our varying attitudes to wildlife.*

—Steve Van Dyck
Queensland Museum

Both my partner and I are keen laypersons interested in wildlife and turn to publications such as *Nature Australia* to enhance our knowledge. We look forward to each issue and the new wealth of photographs, information and understanding that your magazine brings to us each quarter. I was distressed to read, however, the article by Steve Van Dyck (Spring 1999), in which he promotes the eating of kangaroos. I was always under the impression that your magazine's purpose was to expose the general public to the wonder and beauty of biodiversity, to develop an appreciation through understanding and, through that understanding, to realise active conservation of as many of the remaining species as we can. Van Dyck's article seems disturbingly out of place in this framework. The cavalier style in which the piece is written, not to mention the very nature of it, has caused me to reconsider the values of your publication and for me to question whether I can continue to support it.

Michael Archer is a well-known advocate of the ideas reiterated by Van Dyck and it has left me feeling as though the magazine is now running 'advertorials' (campaigns dressed up to look like legitimate scientific study, designed to sway the reader in favour of whatever the author is pushing, when in fact they are thinly disguised propagandist pulp).

I can't tell you how sorry I am to see such inclusions in *Nature Australia*. Our macropods, like nearly all of our

COURTESY ALFRED H. GUHL

The Arizona Coral Snake—a match for Australian bandy-bandies?

marsupials, are under extreme pressure. The last thing they need is to have publications like *Nature Australia* (which I mistakenly believed to have ideals higher than the hip pocket) providing feeble justification to the continuing practice of wildlife exploitation/extermination. Our wildlife needs a voice to speak in its defence. The queue of exploiters squabbling over ways to make a killing is quite loud enough! I hope *Nature Australia* has the decency to run a counterargument to this view.

—Craig Barrass
Mulgrave, Vic.

Purring Cheetahs

I am writing in response to the Letter in the Spring 1999 issue on whether or not big cats can purr. In June 1994 my wife and I were visiting a residential park at Okijima in Namibia. Living there and mixing freely with the guests were two adult Cheetahs, a Warthog and a baboon called Elvis. I have a video of my wife patting the male Cheetah called Caesar. He is distinctly heard purring and mewing. Elvis the baboon sat on a chair at the breakfast table with us and ate his Corn Flakes and milk with a spoon.

—H. Neville Greenberg
Balmain, NSW

Bandy-Bandies and Coral Snakes

I greatly enjoy reading *Nature Australia*—originally a gift subscription from some mates in South Australia—but the Spring 1999 issue was exceptional! Good on ya, mates!

Sarah Smith's article ("Banded Burrowers") was incredible, as her description of the bandy-bandies almost exactly describes our Arizona Coral Snake (*Micruroides euryxanthus*)! Well . . . except for colouration (see photo). This individual was about the diameter of my little finger (about 13 millimetres) and 50 centimetres in length. With research showing bandy-bandies only eat blind snakes (Typhlopidae), I wondered if the Coral Snake's diet was similarly narrow. After a phone chat with the Reptile Department of the Arizona-Sonora Desert Museum, I was told they eat mainly small snakes, namely (Slender) Blind Snakes (Leptotyphlopidae) and Ground Snakes (*Sonora semiannulata*) and perhaps others. In captivity, the Museum's Coral Snake is also fed Black-headed Snakes (genus *Tantilla*) and baby gopher snakes (*Pituophis* spp.). It also accepts thawed frozen snakes.

And how about the other articles? "Thorny Devils and Horned Toads", "Fire, Seeds & Parrots" and "A First for Norfolk" are all appreciated. Wow! What a great issue! I shouldn't forget the great portrait of the longicorn beetle in Nature Strips. You can even see the fourth tarsal segment tucked in between the two lobes of the third. It was a truly awesome issue. Many, many thanks.

—Al Guhl
Tucson, Arizona, USA

Riversleigh Insects

I would like to correct an error in my article (*Nature Aust.* Spring 1999) regarding the discoverer of the first fossil insects from Riversleigh. It was a sharp-eyed Bill Brown (then a technician in the University of New South Wales) who first picked out these treasures among the bits in the sorting tray. Steph Williams, incorrectly credited with the first discovery, made many later discoveries of equally interesting invertebrates—and the discoveries continue.

—Michael Archer
Australian Museum

Sleepy Lizard

Shambling up the garden trail,
Contented is the Stumpy Tail.
Finding sunlight in her track,
She stops to warm her shingled back.

The spring night air begins to chill,
She ambles once more down the hill
To the refuge of her sleepy hollow,
Resting, for the trek tomorrow.

—Paul Schafer
Strathalbyn, SA

Easter Bilby for All

Robert G.B. Morrison's claim (*Nature Aust.* Summer 1999–2000) that the Foundation for Rabbit-Free Australia is a national conservation organisation would be more convincing if he did not also claim a restrictive ownership of the Easter Bilby. If the Easter Rabbit is ever to be replaced in Australia by the Easter Bilby, ownership of the latter must be extended to each and every Australian.

A narrow restriction of it to the trademark of one organisation will raise money for that organisation but will also prevent its adoption by the community as a whole. What a pity similar narrow commercial interests were not

around when the Easter Rabbit became common property!

—Eleanor Stodart
Curtin, ACT

Easter Bilby's Mine!

The Foundation for Rabbit-Free Australia (RFA) may control the trademark Easter Bilby, but it did not originate the concept. Robert G.B. Morrison (RFA), in *Nature Aust.* (Summer 1999–2000) states that I only created the concept in 1997 (in my book *Billy the Aussie Easter Bilby*). Morrison is correct in saying that the book was not registered with the National Library until 1997, but he fails to state that I first wrote the story in Adelaide in 1979 and have been telling it ever since to schools in South Australia, Victoria and Queensland. I have support from all around Australia, from the Prime Minister to TV stars, children's parents, and teachers. I used to promote RFA's work, by giving the organisation a 'donation' (not 'royalty', as Morrison said, which is very different) from each of the copies sold, but I no longer do this. I support the survival of the Bilby through the Queensland Parks and Wildlife Service. Morrison also says RFA supports and promotes my book, but why, when I state quite clearly on the front cover that I first created the concept of "Aussie the Easter Bilby" in Adelaide in 1979?

—Rose-Marie Dusting
Mackay, Qld

Potoroo Rediscovery

I was led to believe that the Broad-faced Potoroo (*Potorous platyops*) had been rediscovered in 1994. I have scoured my back issues of *Nature Australia* for some confirmation of this happy event, alas with no success. Could you please in your next issue set the record straight, yea or nay?

—Peter Williams
Branxton, NSW

*It was not the Broad-faced Potoroo that was rediscovered in Western Australia in 1994, but Gilbert's Potoroo. The Broad-faced Potoroo is considered extinct, as the last-living specimen was taken from the wild in 1875. In December 1994, Elizabeth Sinclair of the University of Western Australia trapped two unusual animals at Two Peoples Bay Nature Reserve, east of Albany on the south coast of Western Australia (*Aust. Mammal. *19: 69–72; 1995). These turned out to be the first live specimens of Gilbert's Potoroo* (Potorous gilbertii) *captured for more than a century. Gilbert's Potoroo had been synonymised with the more common Long-nosed Potoroo* (P. tridactylus) *from the east, and so the two trapped animals were originally assigned to this species. However, recent genetic and molecular work by Sinclair and Mike Westerman from La Trobe University* (J. Mamm. Evol. *4(3): 147–161; 1997) has shown that they are a distinct species—*P. gilbertii. *A captive-breeding program has since been initiated by the Department of Conservation and Land Management.*

—Norah Cooper
Western Australian
Museum

Nature Australia **requests letters be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in this issue will receive a copy of *Visions & pathways for the 21st century* by Robert Theobald. The winner this issue is Ted Hind.**

nature strips

COMPILED BY GEORGINA HICKEY

RICHARD FULLAGAR, KARINA HOLDEN, KAREN MCGHEE, STEPHEN RICHARDS, LORELLE SCHLUTER, RACHEL SULLIVAN AND ABBIE THOMAS ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Fungus-farming Pharmacists

Attine ants, like the tropical leaf-cutters, are renowned as Nature's 'horticulturalists'. In a mutually dependent relationship, these ants maintain gardens of fungus that they cultivate and harvest as their primary food source. New research shows they are surprisingly sophisticated 'pharmacists' as well, having exploited antibiotics for over 50 million years.

A team of scientists led by Cameron Currie (University of Toronto) revealed a crucial third organism in this highly evolved symbiotic relationship while investigating a powdery grey crust that forms on the hard outer cuticle of the ants. Referred to as a 'waxy bloom', the substance was formerly thought to be secreted by the cuticle. Instead, the coating turned out to be a bacterium in the genus *Streptomyces*. Many species of *Streptomyces* produce metabolic by-products that kill specific fungi or bacteria. In fact, most antibiotics used by humans come from this group of micro-organisms.

Currie and his team investigated 22 different species of attine ants, all of which were found to carry this same bacterium. They showed in laboratory experiments that the antibiotic by-products specifically suppressed the growth of a virulent parasitic fungus (*Escovopsis*) which, if left unchecked, destroys the ants' gardens. Field studies revealed that young queens leaving colonies to start new ones carried the bacterium with them (as well as some of the fungal garden stock).

Human use of antibiotics over just five decades has led to a worrying array of antibiotic-resistant microbes. How ants have managed to successfully maintain antibiotic use over millions of years could prove to be critical to human health.

—K.McG.

Cherry Cures

Next time you bite into a piece of Black Forest cake, don't feel guilty. The cherries within could help stave off pain, or even prevent cancer.

Muralee Nair and colleagues from Michigan State Universi-

CHRISTIAN ZIEGLER

The white bacterium growing on this fungus-farming *Acromyrmex* ant protects the all-important fungus gardens from disease.

ty (MSU) have discovered that tart cherries contain pharmaceutically active levels of anti-oxidants and anti-inflammatory substances. There has been anecdotal evidence that cherries help relieve the pain of gout and arthritis, but no-one knew why. The MSU researchers can now point the finger at anthocyanins and cyanidin, compounds that naturally occur in cherries to deter predators.

Using a fluorescent compound that detects the presence of anti-oxidants, the researchers found that anthocyanins extracted from just 100 grams of pitted cherries (about 20 cherries) produced anti-oxidant activity that compared favourably with two commercial anti-oxidants. The cherry anti-oxidants also turned out to be even more effective than vitamin E.

Anti-oxidants play an important role in breaking down free radicals, produced in the cell. Free radicals are single oxygen atoms whose high energy state can severely damage DNA, cell membranes and proteins. The body does produce its own anti-oxidants but sometimes not enough to keep up with the number of free radicals around. There is growing evidence that free radicals are associated with cardiovascular disease, arthritis, various cancers and Alzheimer's disease.

The researchers also tested cyanidin extracted from cherries for its anti-inflammatory properties. Anti-inflammatory drugs work by inhibiting certain enzymes to convert an acid (arachidonic acid) to prostaglandins, which is what produces the inflammation. In this study, cyanidin showed better anti-inflammatory action than aspirin, although not as good as two other commercial drugs, naproxen and ibuprofen. They also found that the cherry-derived chemicals had less adverse effects than some anti-inflammatory drugs.

So next time your joints are aching, don't go to the chemist; try the greengrocers instead.

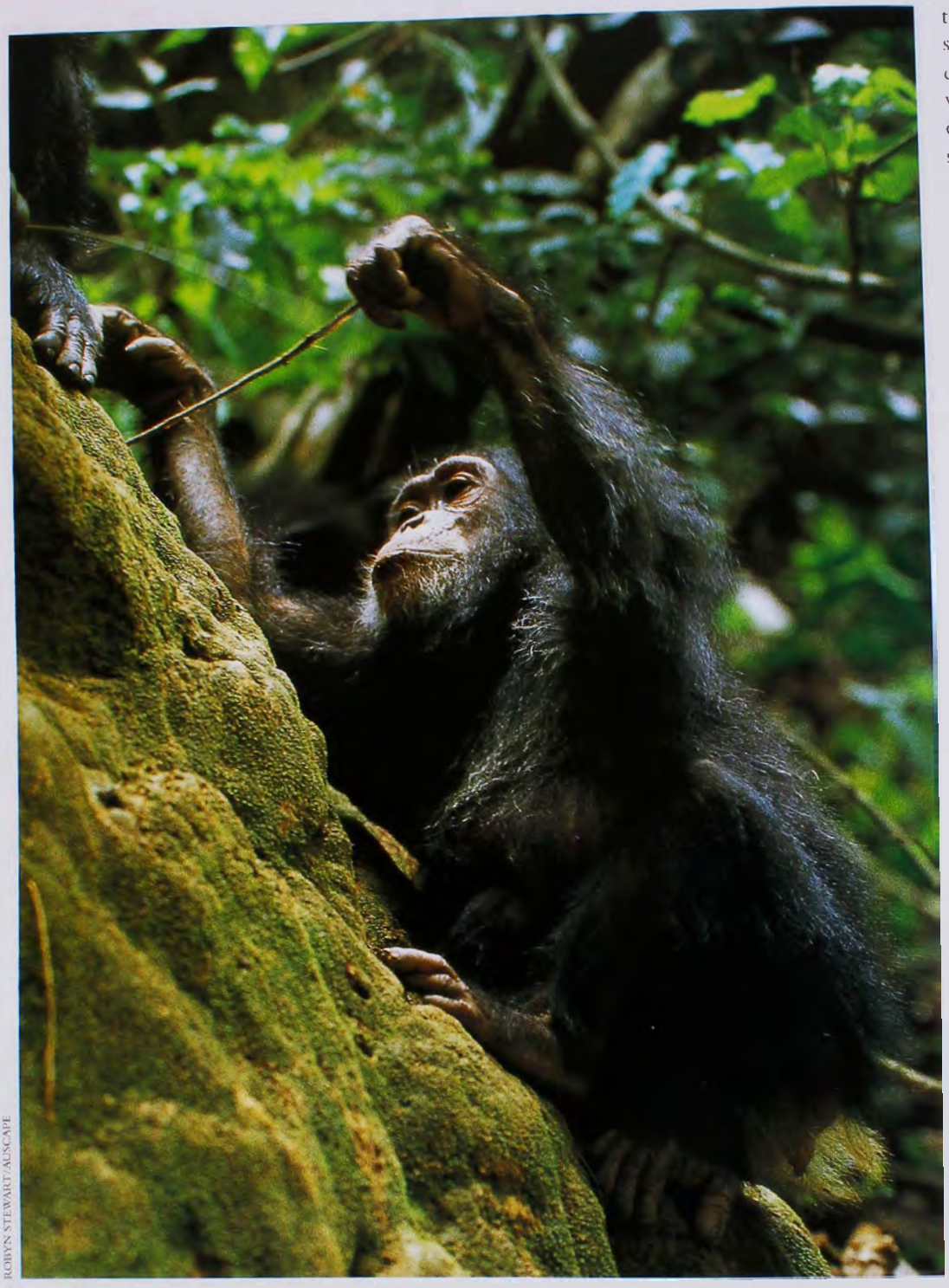
—A.T.

J.F. LANZARONE - HOA QUI/AUSCAPE

For relief of pain, take a handful of cherries.

Bird's Orgasmic Organ

Only three per cent of bird species have a penis or intromittent organ, which is kept inside the bird when not in use. The others make do with 'cloacal kissing' (see *Nature Aust.* Summer 1998–99). But one group of birds, the African buffalo weavers (*Bubalornis* spp.), has a stiff phallus-like rod that sits just outside the bird's vent. In an effort to understand the function of this organ, Tim Birkhead and colleagues from the University of Sheffield, UK, studied Red-billed Buffalo Weavers (*B. niger*) in captivity. Males of this species have a 1.5-centimetre-long phalloid organ, and females also have



ROBYN STEWART/AUSCAPE

Culture vultures: Chimpanzees have a remarkable ability to invent new customs and to pass these on socially.

one, although it is much smaller (half a centimetre). They placed 13 males, six females and one stuffed model of a female, complete with artificial cloaca, into an aviary, and sat back to watch the show. They were rewarded with 57 copulations between males and females, and 34 instances of males mounting the model.

As far as normal bird mounting goes, mounting in these buffalo weavers was a long, drawn-out affair, lasting nearly 30 minutes. At no time was the phalloid organ used intromittently, as was once assumed. Rather, it was rubbed against the female's cloacal region. Towards the end of each mounting session, the male experienced what can only be described as 'orgasm', during which his wing-beats slowed to a quiver, his whole body shook, his leg muscles spasmed and his feet clenched, drawing the female towards him. This 'orgasmic' state, which has not been described for any other bird, was immediately followed by ejaculation. In fact, as the stuffed model confirmed, ejaculation only occurred after orgasm, which also only occurred after prolonged stimulation.

Birkhead and colleagues speculate that the bird's stimulatory organ may have evolved in response to their promiscuous lifestyle. Red-billed Buffalo Weavers are communal nesters, and DNA work by the researchers confirmed that in the wild most broods were fathered by more than one male, indicating intense sperm competition. Just how a stimulatory organ would increase a male's reproductive success, however, is not clear. Perhaps, as in some rodents and primates, prolonged mounting and stimulation before ejaculation may increase the chances that a female will use that male's sperm. But this would only apply if the female was also stimulated . . . which makes me wonder, do female buffalo weavers, with their smaller phalloid organs, also experience orgasm?

—G.H.

Highbrow Chimps

Some Chimpanzees use a leafy twig to fan away annoying flies. Some announce their presence by knocking on the nearest hard surface. Some fish for termites with short sticks, eating their prey singly, while others accumulate many on a long wand, sweeping them into the mouth with a single hand movement.

After decades of patient observation, a team of nine researchers led by Andrew Whiten (University of St Andrews, UK) and Jane Goodall (Gombe Stream Research Centre, Tanzania) now agree that the range of behaviours exhibited by Chimpanzees (*Pan troglodytes*)

can be summed up in one word: culture.

They compiled an exhaustive list of the various habits of wild Chimps from the seven most long-term field studies. Removing ecologically explainable differences, like where high Leopard or Lion predation forces the animals to sleep in the trees rather than on the ground, left the researchers with a list of 39 behaviour patterns, relating to tool use, grooming and courtship, that vary across African Chimpanzee communities.

While genes determine general abilities like tool usage, there was no evidence that habits vary more between, than within, the three existing subspecies, so genetics cannot account for the variability. The evidence is conclusive: Chimps have a remarkable ability to invent new customs and technologies, and these are passed on socially, not genetically.

Many animal species learn fundamental survival skills from their parents, with their habits differing depending on where they live. Songbirds, for example, learn local dialects of their species' song. But, as the researchers point out, these cultural variations are for single behaviours only. The variety of culturally transmitted behaviours among Chimps is unparalleled. And this raises another concern: deforestation means not just the loss of different Chimpanzee populations, but their cultural diversity as well.

—R.S.

Malaria-infected mosquitoes drink more blood and bite more people than uninfected mosquitoes.

PAUL ZBOROWSKI

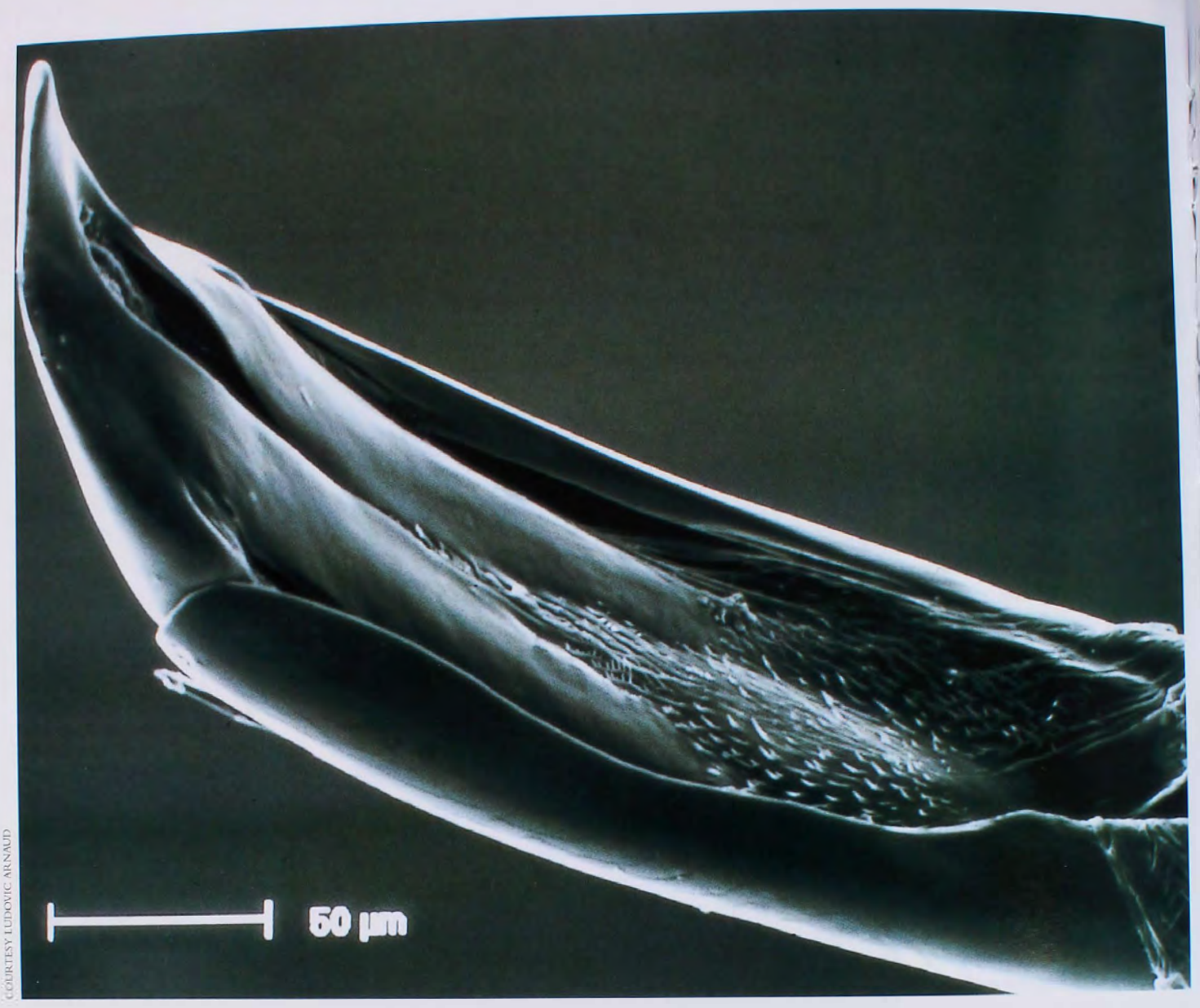
Malarial Manipulators

Anyone bitten by a malaria-carrying mosquito could consider themselves unlucky, given the chills, fever and weakness associated with the disease, and even death if left untreated. But luck has nothing to do with it. Infected mosquitoes are more likely to bite people than uninfected mosquitoes, because the parasite makes them do it.

The ability of parasites to manipulate the behaviour of their vectors is well known, and is presumably a mechanism to increase their own transmission. Laboratory studies have shown that mosquitoes infected with malaria (*Plasmodium falciparum*) increase the rate and duration of probing, but to date these studies have failed to demonstrate whether this behaviour leads to an increase in disease transmission by increasing the number of people bitten.

To investigate this, Jacob Koella and colleagues from the University of Aarhus in Denmark examined the feeding behaviour of the malaria-transmitting mosquitoes *Anopheles gambiae* under natural conditions in Tanzania. They analysed the blood meals of mosquitoes collected in houses with genetically screened occupants, and found that the mosquitoes infected with the parasite not only consumed larger blood meals, but tended to bite more people each night than uninfected mosquitoes.

Koella and his team believe the malaria parasite interferes with the physiological mechanism involved in host-seeking behaviour, by increasing the blood-volume threshold at



COURTESY LUDOVIC ARNAUD

The spiny, scoop-like genitalia of male flour beetles enable males to fertilise the eggs of females they've never met before.

which mosquitoes stop feeding. If disturbed, rather than being satisfied with a half-empty stomach, an infected mosquito will continue its search for food, leading to an increased number of host contacts and more efficient disease transmission. Such information on the biting behaviour of infected mosquitoes under natural conditions is vital for future planning of effective malaria-control programs.

—S.R.

Mating by Proxy

In many grain silos around the world, a fierce sexual battle is being waged. The flour beetles *Tribolium castaneum* are a common pest in stored grain. They gather on the surface during frenzied mating sessions, copulating as often as once a minute. Competition among sperm is as fierce as among individual insects.

Eric Haubruge and colleagues from the University of Agricultural Sciences (Belgium) and Matthew Gage from the University of Liverpool (UK) discovered that male flour beetles have some ingenious ways to get their sperm to the eggs first—without even having sex with the female that eventually bears their young.

The researchers tracked the mating outcomes of genetically marked flour beetles. They found that the second male to mate with a female had a two-thirds better chance of fertilising the eggs than her first partner. Male flour beetles use their spiny genitalia to scrape out the sperm deposited by previous males, before depositing their own. But in a brilliant counter-manoeuvre, the ousted sperm, by continuing to stick to the spines, may be carried to the next female. Such sperm can survive for at least five minutes on another male's genitalia, long enough for the highly promiscuous beetle to find his next mate. The researchers found that about ten per cent of females are fertilised this way, with sperm from a male they've never met.

Such 'mating by proxy' has

never been reported in other organisms, but genetic studies could reveal it to be a common strategy for other animals that take part in equally frenzied mating scrambles.

—A.T.

Age-old Problem

Did our early and even quite recent human ancestors really die young? Conventional wisdom has it that not only the good died young, but few humans lived beyond the age of about 40 until the last few centuries. However, new research has highlighted flaws in the traditional methods used to estimate age of death from skeletons. It now seems that the dead have grown older!

One of the first hints that something was wrong came from an important study of 18th- and 19th-century burials in Spitalfields Church, London. This study, published in 1993, showed that the age-of-death estimates based on skeletons was way out of whack with the documentary evidence obtained from the gravestones, underestimating older ages by up to 30 years. The skeletal evidence had been carefully compiled and was based on known changes in many variables including tooth wear, cranial sutures, pelvis, ribs, joint degeneration and microscopic bone surfaces. So what went wrong? By comparing similar sets of unrelated data, a team of researchers has recently shown that, yes, some of the age indicators are less than perfect but, more importantly, we have all been using the wrong statistics.

University of Leeds mathematician Robert Aykroyd, and archaeologists from the University of Bradford, identified an inherent problem in the statistical technique called regression analysis. In this method, as it applies to the age-at-death problem, the skeletal and/or dental variables for a given reference sample are plotted individually or as a total score against the actual known age at death. A line of best fit is drawn through these reference points, which allows estimates of age at death to be made when only skeletal or dental data are known. However, the researchers have shown the method to be inherently biased, underestimating old adults and, to a lesser degree, overestimating the young. The bias was found to be particularly strong when the age indicators used are not highly correlated with actual age at death. David Lucy, one of the Bradford archaeologists, devised a new method to reduce this bias, based on a theory of probability known as Bayes' theorem. Together the researchers have demonstrated that application of this method provides more precise estimates of age, compared to classic regression analysis of the same data.

Conventional wisdom has it that not only the good died young, but few humans lived beyond the age of about 40.

The authors point out that widely accepted estimates of age, and also Earth's climatic and environmental history, may similarly be flawed, because they too have depended on the same technique of regression analysis. Application of their 'Bayesian' methodology could well remove much of the grey from these areas as well.

—R.F.

Just Passing Through

On island archipelagos it is quite common for lizards to tuck into the fruits of paradise. As a consequence, fruit-eating reptiles play an important role in dispersing seeds on a local scale. However, researchers working on the Canary Islands have found that plants rely not only on reptilian consumers to spread their seeds, but also on the consumers of reptiles.

The red berries of the thorny *Lycium intricatum* shrub are the only fleshy fruits available on the arid island of Alegranza, and so they are voraciously consumed by the local lizards, *Gallotia atlantica*, as a vital source of moisture. And so too are the lizards voraciously consumed by the resident birds, most significantly the Great Grey Shrike (*Lanius excubitor*). By preying on skinks the shrike unintentionally takes on board the fruit load devoured by the lizard, forming a secondary stage of dispersal for the plant. As these birds travel large distances, this may allow plants a far greater chance of colonising new islands.

Manuel Nogales and colleagues from the University of Laguna in Spain collected lizard droppings and shrike pellets from the island, and tested the viability of seeds in germination experiments. Interestingly, the seeds from the shrike pellets were more successful (64 per cent) in germinating than those from lizard droppings (50 per cent). Although it is not fully understood why, it appears that, for the seeds of the *Lycium* shrub, two guts are better than one. Such findings highlight the

BRIAN RUDDICK

importance of secondary seed dispersal and the role predators may unwittingly play in island biogeography.

—K.H.

Badges of Fatherly Pride

It has long been thought that sexual ornaments (physical characteristics that do little to aid survival, but are used to attract mates) act as indicators of genetic well-being to prospective partners. Now Simon Griffith (currently at Uppsala University, Sweden) and colleagues have shown that in House Sparrows (*Passer domesticus*) the quality of the sexual ornament, in this case a bib of black feathers on males, has less to do with genetics, and more to do with fatherly love.

The researchers studied a population of House Sparrows on Lundy, an island in the Bristol Channel. The island's 100 breeding adults were marked and introduced to artificial nest boxes where they could be easily observed.

To test how environmental variation might affect the expression of sexual ornaments, the researchers performed cross-fostering experiments, so each chick had an identifiable biological and foster father. Surprisingly—and contrary to the 'good genes' model of sexual selection—they found that badge size of sons resembled that of their foster father, not their biological father. The researchers suspect that it is the quality of the parental care that determines the size of the badge. Perhaps, for example, those fathers that are able to keep their nests free of parasites will raise the most sexually attractive sons. (Parasites could either chew off the badges, or suck the birds' blood making them weak and reducing badge condition.) Early-hatching sons also tended to have larger badges. Clearly environmental factors affect the size of these sexual ornaments.

Although genetic factors probably also play some part in determining badge size, the researchers strongly suggest any future models for sexual selection should take both genetic and environmental factors into account.

—R.S.

What determines the size of the male House Sparrow's 'sexy' black bib? Nature or nurture?

Move Over Smokey the Bear

Smokey the Bear achieved legendary status among North American forest folk for his ability to smell smoke, locate fires and rescue woodland critters that had gotten themselves a little hot under the collar. Now other far less impressive animals, in terms of size rather than apparatus, have been recognised as having the potential to save human lives through their ability to detect smoke.

Jewel beetles of the genus *Melanophila* are equipped with two special sensory systems that they use to home in on

forest fires more than a kilometre away. Not only do they have a pair of infra-red receptors on their thorax that helps them detect heat from distant fires, but recent work by Stefan Schütz (Universität Giessen, Germany) has shown that these receptors work in combination with the beetles' antennae, which can 'smell' a compound found in wood smoke called guaiacol. The exact chemical make-up of the guaiacol varies depending on the type of tree being burnt, and the researchers suspect the beetles, which show a significant preference for fire-damaged pine trees (*Pinus sylvestris*), may even be able to identify the species of tree on fire.

Other beetles tested for their smoke-detecting status failed to exhibit the levels of sensitivity to guaiacol exhibited by *Melanophila*. So, why should *Melanophila* have evolved this remarkable smoke-detecting talent? It is probably related to the fact that the larvae of this genus can only develop in the wood of freshly burnt trees. (Newly fire-damaged trees are unable to produce the defensive resin that would normally drown the feeding larvae.)

Understanding how these 'Smokey the Bear' beetles detect fires could help in the development of more effective smoke-detection systems for use in buildings and homes, and early-warning systems for forest fires.

—L.S.

The Attraction of Symmetry

Few people would knowingly select a partner because he or she is symmetrical . . . and yet we probably all do to some extent, albeit subconsciously. This characteristic plays an important role in sexual selection across the natural world. Studies in animals as diverse as Barn Swallows and apes have revealed symmetry to be an attractive, even crucial, quality in a mate.

It's been a difficult trait to study in humans, however. The problem has been that there are other physical characteristics that also contribute to our perceptions about attractiveness, such as skin tone and eye colour, and these obviously vary between people. But in genetically identical individuals these kinds of traits are constant, making twins the best subjects for comparisons regarding symmetry.

And so a team of researchers, led by Linda Mealey from the University of Queensland, photographed 34 sets of identical twins and asked volunteers to identify the most attractive of each pair. On average, the twin with the most symmetrical face was regarded as more attractive than his or her counterpart.

How did the researchers measure facial symmetry? Before starting the tests, they created computer-manipulated images of the twins. For each individual, two images were produced—one by combining the right side of the face and its mirror image, the other using the same procedure for the left side. Then, for each set of siblings, volunteers were asked to identify the pair of images that appeared to be most alike, indicating the twin with the most symmetrical face.

The reason symmetry matters, speculate the researchers, is because it conveys information about the individual's

DENSEY CLYNE

The mud-dauber wasp *Sceliphron laetum* is fussy about the spiders she chooses to stock her pot.

genetic quality. Uneven facial features can result from an interruption of the normal developmental processes, such as may occur if an individual is exposed to toxins or infection, and may be indicative of an inferior immune system.

—K.McG.

Clever Caterers

Imagine waking up inside a spidery tomb, and having to eat your way out through a maze of legs and hairs. This is the lot of young mud-dauber wasps.

The female wasp builds her offspring's nursery chamber out of clay. She then captures and paralyses a spider, the first of many, and places it at the base of the pot. She lays a single egg on this hapless spider (the larva's first meal), fills the pot with similarly stunned spiders, and seals it before nightfall. Once the larva has eaten all the food, it pupates and, as a young adult, eventually drills through the chamber wall.

Apart from the odd spider leg, no food is wasted. The mother wasp seems to have the catering worked out to a T. What's her secret?

To investigate, Mark Elgar and Matthew Jebb (University of Melbourne) opened the pots of the Australasian wasp *Sceliphron laetum*, while working in Madang, Papua New Guinea. They found at least a dozen different species of orb-web spiders, particularly those of *Argiope*, *Neoscona* and *Gasteracantha*. The latter spiders are a curious inclusion in the mother's mixed dozen as they possess a hard exoskeleton; tough chewing for tiny larvae. However, Elgar and Jebb showed that the wasp overcomes this problem by selective placement of spiders within the pot. Typically, the first spiders in the chamber are the soft-bodied *Argiope* or *Neoscona*. *Gasteracantha* are more frequently located toward the entrance to the pot, being suitable meals for older and larger larvae. Just how this mud-dauber wasp has acquired its skill in spider taxonomy is a mystery.

Intriguingly, *Sceliphron laetum* also manipulates the number and size of spiders captured. The pots contain between three and nine spiders; the smallest weighing as little as one milligram and the largest 30 milligrams. Each pot contains roughly 440 milligrams of spiders, comprising either a few large or several small spiders, or somewhere in between. How does the wasp provision her pot with the same total weight of spiders? Does she simply stuff spiders into the pot until no more can fit, or is she more discerning?

Using tweezers, Elgar and Jebb removed spiders from the pots while the wasps were away hunting. The wasps did not compensate by capturing more spiders. Instead, they stopped hunting after collecting the specified weight of spiders. But how do the wasps know they have reached their quota? Without a built-in set of scales to keep a tally on the cumulative weight, the wasps may respond to their energy expenditure, and simply give up after they have done enough work. Flying back and forth with a few large spiders may be equivalent to making more frequent flights with smaller spiders.

By providing their young with a carefully controlled diet of selected spiders, these clever caterers ensure they have a good chance of survival.

—CATHRYN CUTLER

Empty Seeds

Seeds don't come cheap—physiologically speaking, that is. However, the high cost of producing them usually has obvious returns for a plant. After all, seeds, as embryos 'in wait', represent a new generation.

And yet a large number of plant species put time and energy into creating inviable or 'empty' seeds with absolutely no reproductive potential. Marcelino Fuentes (Universidade da Coruña, Spain) and Eugene Schupp (University of Utah) looked for a reason why in the Utah Juniper tree (*Juniperus osteosperma*).

This tree produces fruit containing non-reproductive seeds intermingled with identical fruit containing viable seeds. In ideal circumstances the fruit drops to the ground where

rabbits and hares devour it and, as a by-product of their foraging, disperse fertile seeds away from parent trees. But one little bird with a taste for Juniper seeds throws a proverbial 'spanner in the works'.

The Plain Titmouse (*Parus inornatus*) rips away the fruit pulp to expose the seeds, which it then breaks open and destroys with its sharp beak. Fertile seeds contain a nutritious feed but inviable seeds are discarded—a frustrating waste of time and energy.

Fuentes and Schupp assessed the impact of the Plain Titmouse on a population of Utah Junipers. They found that the trees with the highest levels of empty seeds suffered the lowest predation and *vice versa*. It was as if the birds had learned that trees with high levels of inviable seeds weren't worth the effort and were better left alone, opting instead for trees that gave them a higher strike rate. The odd fruits that did contain viable seeds were thus left to be eaten by less-destructive animals.

A large number of plant species put time and energy into creating 'empty' seeds.

And so, it seems, the Utah Juniper has evolved a seed trick where less means more.

—K.McG.

Ancient Mariners ?

Stone artefacts on the Indonesian island of Flores indicate the presence of humans over 840,000 years ago and therefore the likelihood of remarkably early sea crossings. These discoveries help fill a gap in the fossil record of South-East Asia. Although skeletons thought to be *Homo erectus* have been found in Java and dated to over a million years old, there were no other secure indicators of human presence in the region until after 40,000 years ago. The virtual absence of confirmed stone tools prior to this time presented a bit of a problem. Were the early hominids in this part of the world a spanner short of a tool box, or did they simply use archaeologically invisible technologies (like bamboo)? The findings on Flores offer new insights.

This work appears to confirm an older idea, first floated in the 1960s, that stone artefacts from Mata Menge (central Flores) were found in association with an extinct fauna (fossil elephants and others) thought to be about 750,000 years old. The idea was rejected at the time because few archaeologists accepted that the stones were definitely of human origin, or were the same age as the fauna. However, Mike Morwood (University of New England) and colleagues revisited the area and have now published details of at least 20 stone artefacts found *in situ* (14 from Mata

COURTESY MIKE MORWOOD

Archaeological work on the Indonesian island of Flores indicates humans arrived there between 800,000 and 900,000 years ago. And to get there they would have had to have made substantial sea crossings.

Menge, six from nearby Boa Lesa). The researchers are convinced that these are in fact stone tools. And age estimates (based on fission track dating of sediments below and above the artefacts) demonstrate they must be between about 880,000 and 800,000 years at Mata Menge and older than 840,000 at Boa Lesa.

Even with the lowest sea levels imaginable, Bali appears never to have been connected to Lombok, nor was Sumbawa connected to Flores. Therefore the new findings from Flores, although still not accepted unequivocally, suggest that whoever made the artefacts (probably *Homo erectus*) would have had to have made two sea crossings: 25 kilometres from Bali to Lombok (which was probably joined with Sumbawa at low sea levels), and 19 kilometres from Sumbawa to Flores.

While the technology and production of the stone artefacts do not attest to any extraordinary skills for *Homo erectus*, affirmed sea crossings 840,000 years ago would have several interesting implications. First, some archaeologists have argued that substantial sea crossings demand language and intellectual abilities not normally associated with *Homo erectus*. Second, if early hominids really made it to Flores 840,000 years ago, how far could they have gone? Previous arguments for early humans in Australia, even prior to 100,000 years ago, seem less outrageous. Third, if *Homo erectus* were a lot smarter than we thought (or more like us), could they have been so easily replaced by *Homo sapiens* on their way out from Africa, as argued by one theory of modern human origins? It makes one of the alternative, less violent theories more appealing. The Flores data, together with new evidence of interbreeding between European Neanderthals and *Homo sapiens* (see next issue), make it more likely that modern humans had their roots in a mixed ancestry.

—R.F.

Sea crossings demand intellectual abilities not normally associated with Homo erectus.

Self-eating Octopus

One of the most bizarre causes of death known to science has to be self-cannibalism in octopuses. Entire study populations of laboratory-kept *Octopus vulgaris* have been known to mysteriously kill themselves by eating their own arms. Having witnessed 161 such cases of 'autophagy', neurobiologist Bernd Budelmann (University of Texas) was desperate to know what was turning his laboratory charges suicidal.

While some octopus species may voluntarily amputate their arms to escape (autotomy), this is seen as a survival strategy, with the arms healing or regenerating without any adverse effects. However, the self-mutilation occurring in Budelmann's study population resulted in death of the individuals within one to two days. Scientists in the past have put this behaviour down to hunger or stress, but Budelmann suspected something more sinister was forcing the octupuses to gnaw off and consume their own arms.

Budelmann noticed that the onset of self-cannibalism was usually preceded with trembling arm movements, which led him to believe the octopuses' nervous system was involved. Yet this still didn't explain why the whole population succumbed to the bizarre behaviour.

Although individuals were kept separately, the same sea water was being circulated between tanks. Budelmann identified a time lag of one to two weeks between suicidal cases, which made him think that the animals were being infected by some kind of agent, possibly a virus or bacterium that attacked the nervous system during this incubation period. While the agent responsible for self-cannibalism is yet to be found, we can only hope this infectious, deadly disease is rare in nature and unable to jump species!

—K.H.

Moths & STDs

Sexual encounters for the Rattlebox Moth (*Utetheisa ornatrix*) are a bitter–sweet experience. The sperm package presented to the female is laced with a poisonous con-

coction, yet this is not an act of malice. The chemical gift from the male actually bestows the female with a lifelong 'STD'—sexually transmitted defence—against predatory spiders.

This 'STD' comes in the form of pyrrolizidine alkaloids (PAs) and is sequestered from plants the larvae feed on, including the Rattlebox Plant (*Crotalaria mucronata*) from which they get their name. These chemicals remain in the moths' bodies until adulthood, and become concentrated in the sperm package along with other nutrients.

Andrés González and colleagues from Cornell University have teased out the journey that these sexually transmitted chemicals take throughout the moth's life cycle, and have revealed an intriguing story. Immediately after coupling, the female disperses the poison throughout her body so that she becomes unappetising to spiders that try to eat her. Although a female moth may have some store of PAs accumulated from her days as a caterpillar, the boost provided from sex keeps her thoroughly inedible. An alkaloid-rich diet is hard to come by for an adult moth, and so the sperm package is an important supplement. The female is able to pass on this benefit to her eggs, also safeguarding them against predation until they hatch.

So desirable are PA-laden males that the seduction of female moths is determined by the amount of alkaloid in the puffs of pheromone released by the male during the courtship dance. And, since a female may mate with up to ten different partners, the researchers wonder whether PA levels may even be high enough to deter larger animals, such as vertebrates.

—K.H.

FURTHER READING

Aykroyd, R.G., Lucy, D., Pollard, A.M. & Roberts, C.A., 1999. Nasty, brutish, but not necessarily short: a reconsideration of the statistical methods used to calculate age at death from adult human skeletal and dental age indicators. Amer. Antiquity *64(1): 55–70.*

Budelmann, B.U., 1998. Autophagy in Octopus. S. Afr. J. Mar. Sci. *20: 101–108.*

Currie, C.R., Scott, J.A., Summerbell, R.C. & Malloch, D., 1999. Fungus-growing ants use antibiotic-producing bacteria to control garden parasites. Nature *398: 701–704.*

Elgar, M.A. & Jebb, M., 1999. Nest provisioning in the mud-dauber wasp Sceliphron laetum *(F. Smith): body mass and taxa specific prey selection.* Behaviour *136: 147–159.*

Fuentes, M. & Schupp, E.W., 1998. Empty seeds reduce seed predation by birds in Juniperus osteosperma. Evol. Ecol. *12: 823–827.*

*González, A., Rossini, C., Eisner, M. & Eisner, T., 1999. Sexually transmitted chemical defense in a moth (*Utetheisa ornatrix*).* Proc. Natl Acad. Sci. USA *96: 5570–5574.*

Griffith, S.C., Owens, I.P.F. & Burke, T., 1999. Environmental determination of a sexually selected trait. Nature *400: 358–360*

Haubruge, E., Arnaud, L., Mignon, J. & Gage, M.J.G., 1999. Fertilization by proxy: rival sperm removal and translocation in a beetle. Proc. R. Soc. Lond. B *266: 1183–1187.*

Koella, J.C., Sørensen, F.L. & Anderson, R.A., 1998. The malaria parasite, Plasmodium falciparum, *increases the frequency of multiple feeding of its mosquito vector,* Anopheles gambiae. Proc. R. Soc. Lond. B *265: 763–768.*

Mealy, L. & Bridgstock, R., 1999. Symmetry and perceived facial attractiveness: a monozygotic co-twin comparison. J. Personality Social Psychol. *76(1): 151–158.*

Morwood, M.J., Aziz, F., O'Sullivan, P., Nasruddin, Hobbs, D.R. & Raza, A., 1999. Archaeological and palaeontological research in central Flores, east Indonesia: results of fieldwork 1997–98. Antiquity *73: 273–286.*

Morwood, M.J., O'Sullivan, P.B., Aziz, F. & Raza, A., 1998. Fission-track ages of stone tools and fossils on the east Indonesian island of Flores. Nature *392: 173–176.*

Nogales, M., Delgado, J.D. & Medina, F.M., 1998. Shrikes, lizards and Lycium intricatum *(Solanaceae) fruits: a case of indirect seed dispersal on an oceanic island (Alegranza, Canary Islands).* J. Ecol. *86: 866–871.*

Schütz, S., Weissbecker, B., Hummel, H.E., Apel, K.-H., Schmitz, H. & Bleckmann, H., 1999. Insect antenna as a smoke detector. Nature *398: 298–299.*

Wang, H., Nair, M.G., Strasburg, G.M., Booren, A.M. & Gray, J.I., 1999. Antioxidant polyphenols from tart cherries. J. Agric. Food Chem. *47: 840–844.*

Wang, H., Nair, M.G., Strasburg, G.M., Chang, Y.-C., Booren, A.M., Gray, J.I. & DeWitt, D.L., 1999. Antioxidant and anti-inflammatory activities of anthocyanins and their aglycone, cyanidin, from tart cherries. J. Nat. Prod. *62: 294–296.*

Whiten, A., Goodall, J., McGrew, W.C., Nishida, T., Reynolds, V., Sugiyama, Y., Tutin, C.E.G., Wrangham, R.W. & Boesch, C., 1999. Cultures in chimpanzees. Nature *399: 682–685.*

Winterbottom, M., Burke, T. & Birkhead, T.R., 1999. A stimulatory phalloid organ in a weaver bird. Nature *399: 28.*

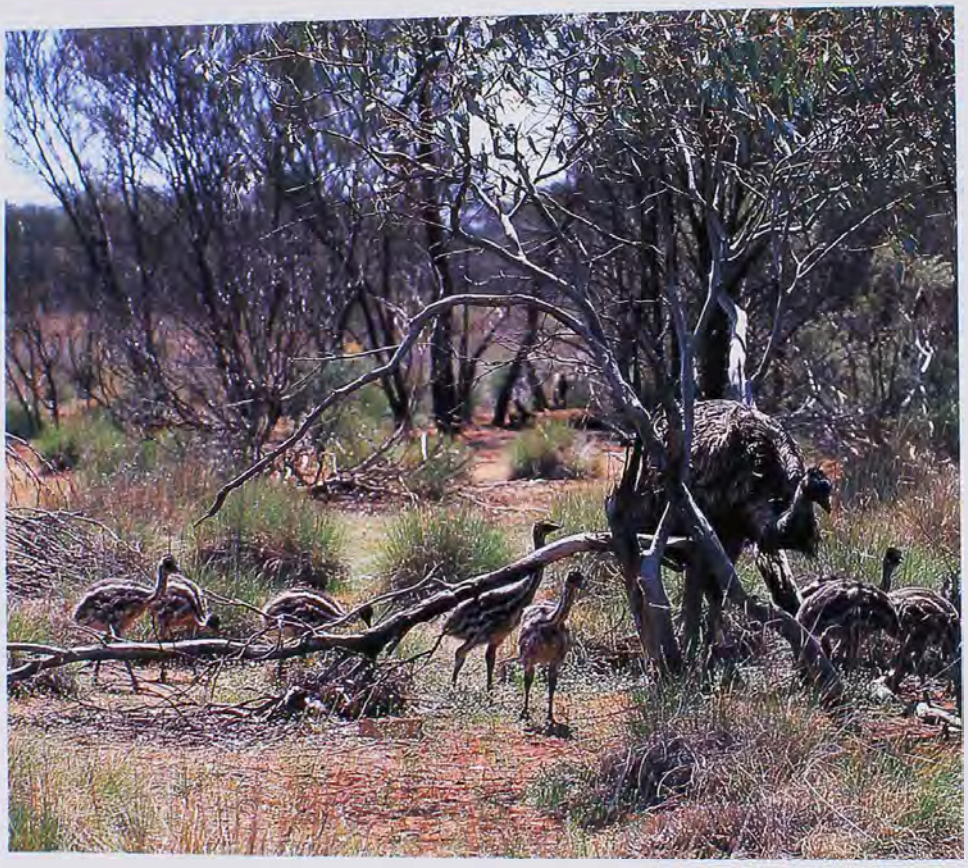
QUICK QUIZ

1. *What do Leatherback Turtles eat?*
2. *Name the largest island off Darwin.*
3. *What do you call an artificially produced creature that is made up of parts from different types of animals?*
4. *Which animal is best associated with Jane Goodall?*
5. *What name have archaeologists given to the best-known example of the hominid fossil* Australopithecus afarensis*?*
6. *What do twitchers do?*
7. *To the nearest million, how many people live in Australia?*
8. *What does 'scuba' stand for?*
9. *Which famous comet-spotter's ashes were carried on the Lunar Prospector and crash-buried on the Moon in July last year?*
10. *What nickname was given to the Southern Right Whale that visited Sydney Harbour in August 1999?*

(Answers on page 83)

KFC with a kick

The Emu's capacity to eat practically anything, to form large aggregations around drinking holes, and to communicate mainly by grunting, has more than compensated in its qualification as Australia's national bird emblem.



JAN ALDENHOVEN/AUSCAPE

A male Emu supervises his offspring. Emu chicks are raised by their father and usually stay with him for seven to eight months.

IN THE DAYS BEFORE ORAL SABIN, children had to be dragged screaming to those grim little vaccination caravans that materialised outside Coles for shopping mothers to trip over. Today, notwithstanding the thinning of my hair and other landmarks of chronological maturity, getting me into a wildlife park where Emus roam free is no less a screaming match. If I could wear a full-face helmet, an overcoat, Harley gauntlets, and carry a rake, I'd feel comfortable enough to enjoy a walk or maybe a picnic. However, the threat of heat stroke and police arrest leave me content to wait outside and mind the bags.

As it is, if I am ever coaxed past the ticket office, the moment the Emus inside hear the clicking of the turnstile, and smell the fear pumping out of my panic-glands, they, like Pavlov's Dogs, run salivating to my side. The great shaggy snoopers, half-crazed by the gleam of sweat on my brow, start gawking over my shoulder, and probing through my pockets, bags and picnic baskets like conscientious customs agents onto a junkie.

I've never really been sure what sort of serious damage they could do with their great snapping beaks. And those monumental drumsticks fit for a Wagnerian opera! It's always been too hard to assess the situation objectively from under a picnic bench with an upturned esky on my head.

It's a different story when they're little. I remember chasing down a young chick long ago near Boulia, western Queensland. Chicks run hard for a while then plonk themselves in the grass and sit perfectly still, hoping their stripes will melt them into the background. Worried for its welfare during the cold night, I slept with the chick pushed halfway down inside my sleeping bag. After a restless night trying not to squash it, it was to my great relief (and its) to find it alive and well in the morning. And as if to thank me for my concern, it had managed to empty the entire overnight contents of its very loose and palpably voluminous bowels throughout my bag.

Not-so-reluctantly I turned it over to our maternal shaggy black Dog into which the chick would nuzzle and burrow. It took to having its head and neck licked with the same total confusion it exhibited when lurching after the Dog to 'help' retrieve a ball. As it grew, it consistently failed to twig why, at four times the size of the Dog, it could no longer shuffle under its 'mother', legs bent and moving forward like a pair of pronged fork-lift tines, without practically disembowelling and eggflipping the poor Dog.

For me it has always been hard to raise Emus, and not be tempted to conclude that their heads contain one of the more modest achievements in the evolution of avian grey matter. Fortunately though, the Emu's capacity to eat practically anything, to form large aggregations around drinking holes, and to communicate mainly by grunting (particularly in matters related to sex), has more than compensated in its qualification as Australia's national bird emblem.

But away from fences and in their own domain, wild Emus are nothing short of spectacular. Whether they are striding among coastal banksias, or far out on the crackling edges of the Simpson Desert, the imagination can be fired by no more prehistoric sight than a mob of Emus lop-ing along with their shivery-grass skirts pulled up around their nuggetty thighs.

Such a demonstrable link with Australia's past, with its great diversity of large flightless birds, has done little though to endear Emus to the white Australians who have traditionally regard-

BY STEVE VAN DYCK

ed them poorly and treated them accordingly. As payment for the inability of the Emu's two-million-year-old brain to immediately appreciate the deep significance of wire fences that suddenly criss-crossed its grasslands, Emu eggs were habitually smashed by boundary riders or taken back home for souvenir making. And because the Emu couldn't appreciate that Sheep and Cattle had exclusive rights to every green blade of grass on the continent, it faced the Lewis guns of the infamous 1932 'Emu War' staged in Western Australia.

Emus might be exceptional for their primeval appearance, but under that hoary haystack of teased-up quills lie two substances of even more bizarre significance—mind-altering hormones and oil. Courtship begins around December when Emus pair up, male and female wandering together, putting on fat (until they might weigh around 60 kilograms). While the (smaller) male stays calm and passive, the female Emu bristles with hormones that catapult her on a course of strutting, drumming, propositioning and seduction. However, around April or May when she presents him with nine or ten large dark green eggs, he does a psycho-flip and becomes so aggressively possessive that he may not even let her finish laying the clutch, and she is forced to lay the tough-shelled remainder elsewhere to the ingenuity of hungry Dingoes and goannas. She either wanders around until hatching and helps defend the area and the clutch, or kicks up her heels with other runaway wives to form large wandering flocks. She may even go off and breed with a different male. The male sits closely on the eggs for nearly eight weeks, getting up only occasionally to slink off for a drink. In the incubation process he might lose up to ten kilograms. The young stay with him for up to 18 months.

So taken with the house-husband role is the sitting male that, if his precious clutch is smashed or stolen, he might pretend to carry on as usual by incubating any other suitable eggy objects at hand, whether they be jam melons, pumpkins, oil filters or stubbies. And if chicks don't eventually cheep from under his shag pile, or if his Pademelons or lager bottles don't hatch, then it is impending starvation that finally drives him from the happy home-cum-garbage tip.

Concerning the matter of Emu oil (see *Nature Aust.* Autumn 1994), great use was made during early colonial times of the bird's slippery bits, which, like Dugong, goanna and turtle oil, were godsends in a hot dry continent full of lean-meated creatures. The Emu's skin was plucked, cut into strips and then boiled to produce around seven litres of yellow oil that was used for burning in lamps, on the locks of firearms, as an antirheumatic and for rubbing into sprains and bruises of livestock.

Ludwig Leichhardt once let slip the following little home truth: "Several times, when suffering from excessive fatigue, I rubbed [Emu oil] into the skin all over the body, and its slightly exciting properties proved very beneficial" (!).

While the great explorer's recommendation is compelling, I'd be careful about rushing out and repeating the exercise. Without knowing it, Leichhardt may have been lucky enough to have rubbed himself down with March oil, drawn from the soft bits of a female Emu and sizzling with the hormones of long-legged lust. Knowing my luck I'd get July male oil, fog-bound with the secretions of the committed incubator. Stagnating indolence and resolutions to give up drink are no real strangers to me, but to go to the green-grocers and be less interested in what you can eat . . . than what you can sit on and hatch . . . is a bit of a worry. Thank goodness for Dencorub!

Emu

Dromaius novaehollandiae

Classification
Family Dromaiidae.

Identification
Big, unmistakable, flightless; adults up to 2 m high and weigh 30–45 kg. Shaggy, grey-brown-black, three-toed, sparsely feathered neck, female bigger and wider across the rump, but sexes generally difficult to tell apart. Can run up to 60 km/h. Naturally inquisitive.

Distribution
Almost anywhere in mainland Aust. (outside dense, wet forest) where there is access to suitable food and water. Exterminated in Tas. Nomadic, following seasonal food abundances over enormous distances (e.g. 500 km).

Food
Green vegetation, fruit, seeds, insects and flowers. Fleay (1972) documented the following from the stomach of a shot bird: grass, general herbage, fruit, grain and coarse grit, 1 carpenter's steel-pointed plumb-bob, 2 three-pin plastic electric wall plugs, 1 wash-tub plug, 1 spring and 3 solid rubber door stops. In other birds (captives) he noted tastes for paper, ice-cream cups, bottle-tops, keys, coins, broaches, cement powder and broken glass (which eventually emerges smooth-edged!).

Reproduction
Nests in the winter so chicks hatch to graze on spring-rain-induced grass; 7–12 eggs laid in rough nest of twigs, grass, leaves and bark built on ground, and incubated for nearly 8 weeks by male. Chicks stay with male up to 18 months but usually 7–8 months.

FURTHER READING

Fleay, D., 1972. Emus stomach it from A to Z . . . Courier Mail, *Brisbane 27 November 1972.*

Olsen, P., Crome, F. & Olsen, J., 1993. Emus. Pp. 177–181 in Birds of prey and ground birds. *Angus and Robertson: Sydney.*

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

Shy Albatross

It will take long and careful management before the Shy Albatross colonies around Tasmania can return to their former splendour.

Ah! well a-day! what evil looks
Had I from old and young!
Instead of the cross, the Albatross
About my neck was hung.
—Samuel Taylor Coleridge 1798

On 9 December 1798, the same year Coleridge wrote his magnificent poem "Rime of the Ancient Mariner", George Bass and Matthew Flinders found a precipitous and forbidding islet 30 kilometres north of Tasmania that "appeared to be almost white with birds". While Flinders stayed aboard their boat fighting the raging current, Bass landed on the island and had to literally fight his way through the seabirds.

The 33-hectare islet accommodated 20,000 pairs of nesting Shy Albatrosses (*Thalassarche cauta*). It is little wonder that Bass christened it Albatross Island. Flinders recalled that the albatrosses, "being unacquainted with the power or disposition of man, did not fear him: we taught them their first lesson of experience".

Their 'education' certainly continued: sealers and guano traders promptly began taking eggs and chicks for food, and killing adults for their feathers. After visiting the island in 1832, George Robinson recounted that the gruesome stench of thousands of rotting albatross carcasses was intolerable. The population had already been halved. In 1909, Albatross Island contained only 250–300 albatrosses.

By this time, the treacherous journey to the essentially barren rock was no longer worth the risk, and steadily, slowly, the colony began to recover. In 1927, D.F. Thomson remarked that the birds had increased in numbers. There were 670 nests in 1960; 1,505 in 1973; 2,000 in 1983; 3,000 in 1991; and by 1995 there were over 5,000 annual breeding pairs on the island.

Shy Albatrosses—the only albatross to breed entirely within Australia—nest on only two other islands, Mewstone and Pedra Branca, both 20 kilometres south of Tasmania. The number of pairs breeding at both these sites has increased dramatically in recent decades, indicating that they too had previously suffered at the hands of humanity. Today, 7,000 pairs breed on Mewstone, and 250 on tiny Pedra Branca.

While the increase in Shy Albatross numbers is encouraging, their continued recovery is jeopardised by numerous modern threats. This is of particular concern as Shy Albatrosses, which probably live for decades, take at least five years to attain sexual maturity. In addition, although they breed annually, reproductive output is low—on average, one fledgling is produced every two to four years. Consequently, populations are imperilled even by small increases in mortality rates.

In recent times the greatest threat to albatrosses has been long-line fishing. The birds' extraordinary ability to undertake epic voyages (one juvenile Shy Albatross was recovered over 10,000 kilometres from Tasmania), combined with the global expansion of long-line fisheries, means that every albatross is likely to interact with long-line-fishing vessels at some stage of its life. Sadly, many of these interactions are fatal. Behind long-line-fishing vessels a melee of seabirds piratically compete for the sinking baits. Here Shy Albatrosses are not shy at all; indeed they are one of the most aggressive species, sometimes plunging seven metres below the surface and remaining under water for 20 seconds in pursuit of prey. These skills make them particularly vulnerable to long-line-fishing operations around Tasmania and throughout the Southern Hemisphere. While the rate of albatross capture may seem low (0.4 birds per 1,000 hooks in some areas), over one billion hooks are set worldwide per annum. As a result, thousands of albatrosses are killed every year.

In 1998 a Threat Abatement Plan, designed to minimise the by-catch of seabirds during long-line-fishing operations, came into effect. If everyone followed the recommendations (such as deploying hooks under water or at night), by-catch within the Australian Fishing Zone should be reduced to below 0.05 seabirds per 1,000 hooks by 2003, and may ultimately be eliminated. However, several other factors also affect Shy Albatrosses, including accidental mortality in trawl fisheries, intentional shooting by fishers, over-fishing of albatross prey-species, marine pollution and chemical contamination. For these reasons a Recovery Plan has been drafted that aims at minimising all anthropogenic threats not only to Shy Albatrosses but to the other 21 albatross and two giant-petrel species that visit Australian waters. Significantly, the plan stipulates that to be effective requires cooperation of all Southern Hemisphere nations.

It will take long and careful management before the Shy Albatross colonies around Tasmania can return to their former splendour. When we consider how close we came to exterminating these remarkable creatures, I hope it is we humans who have learnt a most valuable lesson of experience.

KATHIE ATKINSON

BY CHRIS BOLAND

FURTHER READING

Robertson, G. & Gales, R., 1998. The albatross: biology and conservation. *Surrey Beatty and Sons: Chipping Norton, NSW.*

Chris Boland is a PhD student in the Division of Botany and Zoology, Australian National University, and the consultant to Environment Australia on the Recovery Plan for Albatrosses and Giant-Petrels.

Flutter by, butterfly

In 1889, Australian Painted Ladies bred up in such awesome numbers that a remarkable butterfly plague struck Victoria.

PHOTOS: TIM LOW

AS A WAY OF ATTRACTING WILDLIFE into the suburbs, the planting of larval food plants for butterflies is becoming popular. Sometimes it works wonders. Last year I planted a Red Passionflower (*Passiflora cinnabarina*) and a Native Mulberry (*Pipturus argenteus*) in my garden, and within a fortnight Glasswing caterpillars (*Acraea andromacha*) were demolishing the Passionflower (almost killing it) and a couple of months later, to my great surprise, the Native Mulberry was attacked by caterpillars of the White Nymph (*Mynes geoffroyi*), a butterfly I've never seen in my suburb before.

Butterflies have been benefiting for a long time from the sowing of plants for other reasons. Orange and lemon trees provide excellent fare for Orchard Swallowtail larvae (*Papilio aegeus*), which mimic bird droppings; and the Australian Crow Butterfly (*Euploea core*) is so fond of oleander hedges that many people know it as the 'Oleander Butterfly'. Blue Triangles (*Graphium sarpedon*) dote on Camphor Laurel (*Cinnamomum camphora*) leaves, Palegreen Triangles (*G. eurypylus*) love Custard Apple (*Annona muricata*) foliage, and Pea Blues (*Lampides boeticus*) go for bean and pea leaves.

There are other species that prefer weeds. In 1889, Australian Painted Ladies (*Vanessa kershawi*) bred up in such awesome numbers on Capeweed (*Arctotheca calendula*), an African pest that was proliferating alarmingly, that a remarkable butterfly plague struck Victoria. Painted Ladies darkened the skies, landing on ships miles out to sea. According to biologist Frederick McCoy, "The newspapers mentioned the stoppage of trains in the tunnel on the Castlemaine Railway, from the masses of bodies of these insects crushed, lubricating the wheels to such an extent that they could not bite the rails as they turned, and came to a standstill until sufficient supplies of sand could be sent."

Most of the butterflies we see fluttering about in our cities and towns have probably developed on exotic plants. Indeed, exotic plants are so abundant and reliable they are probably now the main foods for the larvae of some species, the Glasswing for example. Such butterflies may benefit when forests are felled for housing, since suburban gardens and parks carry more food plants (mainly exotic) than eucalypt forests, and certainly more nectar, produced by garden shrubs such as pentas and buddleias. It is probably true to say that suburbia is now the optimal habitat for many of the common butterflies; and that many are truly urban insects, no longer dependent upon natural habitats.

Exotic plants have allowed some butterflies to expand their frontiers. The Orchard Swallowtail and Dingy Swallowtail (*Papilio anactus*) have spread west by following citrus trees growing around outback homesteads, and today they flutter about gardens in Alice Springs. More spectacular have been the range expansions of two tiny butterflies called palmdarts. Palms have come to symbolise the good life in Australia, and gardeners now grow them in regions where they don't naturally occur, to the great advantage of these insects. According to the classic text *What butterfly is that?* (1932), the Orange Palmdart (*Cephrenes augiades*) occurs in eastern Australia as far south as Sydney, and the Yellow Palmdart (*C. trichopepla*) south to Rockhampton. But although that held true when the book first came out, Orange Palmdarts now dart about in suburban Melbourne, and Yellow Palmdarts have reached Byron Bay. What's more, both insects have colonised Perth, hitchhiking across from northern or eastern Australia with truckloads of potted palms. Their arrival in the west has proved no blessing, for their larvae disfigure the foliage of ornamental palms (both native and exotic). They are too small and

BY TIM LOW

bland to add much colour and charm to gardens.

In recent years, books have come out that list native plants to grow to attract butterflies. Some of the advice seems questionable. I don't see much point in trying to help butterflies that are already thriving. Australian Crow Butterflies have more than enough oleanders and mandevillas to munch on. As for Glasswings, not only are they faring very well, but their caterpillars perform good service by browsing down Corky Passionflower (*Passiflora suberosa*), a smothering weed, and this taste for exotic fare should be encouraged. There are other butterflies that can't be helped because they won't enter cities and towns. Many of the browns, for example Bank's Brown Butterfly (*Heteronympha banksii*), require humid shady meadows, and planting their food plants won't lure them into cities, no matter what the books may suggest.

The butterflies to target are those that are declining from loss of native food plants, and which have no exotic substitutes to turn to, and no scruples about visiting suburbs. There aren't huge numbers of these, but showy examples include the White Nymphs I mentioned before, the Eastern Brown Crow (*Euploea tulliolus*), and the celebrated Richmond Birdwing (*Ornithoptera richmondia*). Richmond Birdwings, native to northern New South Wales and southern Queensland and now very rare, seldom visit inner-city gardens, but they will occasionally breed in gardens some distance from bushland, and they have been helped along by a concerted campaign to plant their food plants (see *Nature Aust.* Summer 1996–97). But even here, a word of caution. The Richmond Birdwing Vine (*Pararistolochia praevenosa*) is patchily distributed, and the integrity of rainforest remnants should not be compromised by planting it in valuable remnants where it never grew before.

FURTHER READING

Common, I.F.B. & Waterhouse, D.F., 1981. Butterflies of Australia. *2nd ed. Angus & Robertson: Sydney.*

Eichler, J., 1999. The orange palm dart skipper Cephrenes augiades sperthias *(Felder) in Melbourne.* Vic. Nat. *116(1): 16–18.*

McCoy, F., 1878–90. Natural history of Victoria: prodromus of the zoology of Victoria. *Government Printer: Melbourne.*

TIM LOW IS AN ENVIRONMENTAL CONSULTANT AND A NATURE WRITER WHO ONCE WORKED AS AN ENTOMOLOGIST. HE IS THE AUTHOR OF *FERAL FUTURE* (PENGUIN, 1999) AND A FORTHCOMING BOOK, *THE NEW NATURE*, WHICH LOOKS AT RELATIONSHIPS BETWEEN NATIVE ANIMALS AND EXOTIC PLANTS.

(Above) The Glasswing is one of several well-known butterflies that often complete their life cycle within suburban gardens.

(Left) The Australian Crow Butterfly is one of the most common butterflies in Australian gardens and one that needs no assistance from gardeners.

With its beautiful black-and-white coat and long, expressive tail, it didn't take long for me to become totally hooked on Stripeys.

STRIPED POSSUMS:

the bold and the beautiful

BY KATH HANDASYDE

As a biologist from the heavily populated south-east corner of the continent, my first encounters with Australia's northern rainforests were a total buzz. Shipton's Flat, about 40 kilometres south of Cooktown, Queensland, was so different from anything I had previously experienced. Wonderful birds that I had never seen or heard before, huge buttressed trees, antipersonnel

DOMI NIC CHAPLIN/NATURE FOCUS

In general body shape and posture, Striped Possums are similar to other petaurid possums, such as the Sugar Glider. However Striped Possums do not possess a gliding membrane.

plants that burnt and tore at your skin, invertebrates fantastic in size, colour and shape, and some of the strangest and most fascinating mammals I had ever encountered.

The reason I was visiting this extraordinary place was that my fellow biologist and partner, Roger Martin, had just launched into the first ecological study of Bennett's Tree-kangaroo (*Dendrolagus bennettianus*), a little-known rainforest species that spends much of its time in the canopy. This habit makes it very difficult to see, let alone study. Nights would pass without even a glimpse of one of these handsome, dark animals. However our Bennett's-free time was certainly not wasted, for there were other nocturnal rainforest animals to be seen. For me the most extraordinary one was the Striped Possum (*Dactylopsila trivirgata*), with its beautiful black-and-white coat and long, expressive tail. It didn't take long for me to become totally hooked on Stripeys.

There are four known species of *Dactylopsila*. All occur in Papua New Guinea and only one extends its range into Australia. They belong to the family Petauridae, which also includes the endangered Leadbeater's Possum (*Gymnobelideus leadbeateri*) and most of the gliders, such as the Sugar Glider (*Petaurus breviceps*) and Yellow-bellied Glider (*P. australis*). The petaurid possums are generally regarded as rather social animals, often living in small family groups. Most species feed on plant exudates (like nectar and sap), but supplement their diet with small invertebrates. Leadbeater's Possum, thought to be the Striped Possum's closest relative, is regarded as more insectivorous than the gliding petaurids, feeding mainly on crickets and other arthropods that live under bark.

Most information on the diet of Striped Possums is anecdotal, but suggests they are generalist insectivores (although they have been reported to occasionally eat fruit, leaves and honey). Wood-boring insect larvae are thought to be a particularly important food for Striped Possums, and the animals have several distinctive morphological characteristics that appear to be adaptations for excavating these energy-rich morsels from the trunks and branches of trees. Their lower incisors are very large, and they use these to gouge and dig into wood. Their skull is also very rounded, making it structurally more robust to cope with the stresses imposed when the animals lever up chunks of hard wood with their teeth. The other notable thing about Striped Possums is their elongated fourth finger, which they use to winkle out fat beetle larvae from their cosy tunnels in the tree trunk. They also use their long finger for tapping on wood to locate cavities containing insect larvae. All these characteristics make the Striped Possum remarkably convergent with Madagascar's Aye-aye (*Daubentonia madagascariensis*), which is known to specialise on wood-boring insect larvae.

One other feature of Striped Possums that caught my attention while I was searching for information on their biology was the size of their brains. They have the largest brain (relative to body size) of any marsupial, suggesting that they are fairly intelligent. Perhaps their large brain has evolved in response to living in a highly complex and patchy environment full of predators (see *Nature Aust.* Winter 1999). A very interesting animal but, apart from a few general articles written by Steve Van Dyck from the Queensland Museum (one of the few people to attempt to collect any ecological information on the animals), I could find only a

Striped Possum

Dactylopsila trivirgata

Classification

Order Diprotodontia, family Petauridae.

Identification

Slender, medium-sized possum, with longitudinal black and white stripes. Stripes of subadults sharply delineated into areas of black and white; adults black and greyish-white fur with less abrupt transitions between contrasting patches, particularly on rump. Tail tip black or white. Elongated 4th finger and very long tail. Does not possess a gliding membrane. Adult weight range: males 440–545 g, females 430–455 g; head–body length about 270 mm; tail length about 340 mm.

Distribution and Habitat

Rainforest and adjacent open woodlands in north-eastern Aust. from Townsville to tip of Cape York, however in coastal areas Stripeys may occur in woodlands in the absence of rainforest. Also throughout PNG–Irian Jaya, and on Aru Islands, Japen and Waigeo.

Behaviour

Bold, agile and very active possum, which may rove rapidly around in a tree when feeding. When excavating branches and trunks to obtain invertebrates, its presence is often betrayed by the sound of chewing into wood and the accompanying rain of debris to the forest floor. Frequently moves through the canopy along vines, or by running to the end of a branch and taking a large leap into the foliage of an adjacent tree.

Food

Mainly invertebrates, including wood-boring beetle larvae and social insects (including ants and termites), but also some honey and nectar, and occasionally fruit and leaves.

Reproduction

Little information available, litter size 1–2 (most commonly 2).

Status

Distribution in Aust. limited and appears to occur at relatively low density; widespread in PNG.

JEAN-PAUL FERRERO/AUSCAPE

(Above) The black and white stripes of the Striped Possum may look obvious under a spotlight, but probably serve as camouflage in the dark.

(Right) Striped Possums have a typical petaurid hind foot (top), but their front foot has an elongated fourth finger, which they use as a probe to extract wood-boring beetle larvae from tree trunks. No other petaurid possum possesses this unusual feature.

ILLUSTRATION BY PETER SCHOUTEN FROM POSSUMS OF THE WORLD

couple of papers on the biology of Striped Possums. There had been no detailed field studies of their habitat use or social life. So we decided to conduct a study on Striped Possums at Roger's established field site, where there appeared to be a reasonable population of animals. Bold idea!

THE FIRST STRIPEY we caught was a subadult male that happened to be sitting about two metres above the ground in a small sapling. A vigorous shaking by Charlie Roberts, a local naturalist who worked with us, brought the surprised and somewhat angry little possum to the ground. These animals are renowned for having a fearsome bite, and it took a number of very wary attempts on our part before it was safely in the bag. (I have rarely seen Charlie accord such a small animal so much respect!) We took our prized possum back to camp and fitted him with a radio-collar so we could monitor his movements.

We followed this animal for 38 days, locating him each night when he was out feeding, then checking him during the day to find out where he was denned. He used an area of around 20 hectares and proved to be quite mobile. He changed dens frequently and when we located him at night he was often several hundred metres from the den he had slept in that day. While he confined most of his activities to the patch of rainforest where we caught him, he occasionally ventured out into the surrounding open eucalypt forest. His longitudinal black and white stripes made him extremely difficult to see in the vertically oriented foliage of the *Eucalyptus tereticornis*, which dominated this open forest. We mused that stripes seemed to be the perfect night camouflage against visual predators such as owls, which were common in the area, and very fond of possum. On the 39th day Roger was unable to locate our possum (I had had to return to Melbourne for

teaching), and then for the next two days his signal was coming from a particular rainforest tree, slightly odd for such a mobile animal. On the following day Roger and Charlie captured an Amethystine Python (*Morelia amethistina*) in this tree, complete with radio-collar and possum inside!

In this early phase of the study we discovered the reason why there was so little information available on Striped Possums: while not rare, they were fairly difficult to pinpoint and extremely difficult to catch. I set traps on trees where the animals had been excavating wood-boring insect larvae, but all I caught were the ever-present and numerous rainforest rats (they filled my traps every night). Back to spotlighting! While Stripeys were not easy to find, we became more skilled at locating them. We would walk some distance, then periodically turn off our headlamps and listen carefully for the faint sounds of distant possums dropping debris to the forest floor as they chiselled into the trunks in search of food. Occasionally we would locate them by their smell. Striped Possums are reputed to smell like Skunks, but I could not disagree more! They have a sweet musky smell with a hint of pollen, and while this smell may persist on your hands for a day or so after handling them, there is nothing foul about it. Perhaps the persistence of the smell and the Skunk-like black and white stripes have caused this confusion.

Locating a possum (about once a week if we spotlighted every night) turned out to be the easy part. How on Earth do you capture a possum sitting 10 to 30 metres up a tree? Our main problem was their mobility. The dense foliage and network of vines in the rainforest provided plenty of avenues for escape, and any attempt to climb a tree to capture an animal resulted in the possum disappearing rapidly into the canopy. (Once or twice when animals were located in small trees we even tried cutting the whole tree down, but vines usually prevented the tree from falling all the way to the ground, and the possums always seemed to vanish into thin air.) We needed to reduce their mobility, but how?

Roger had been catching his tree-kangaroos using a tranquilliser gun and darts, but no-one had ever attempted to dart an animal as small as a Stripey before (adults weigh around 450 grams; about the size of a guinea pig). However, miniature darts seemed to be our only option, and they worked! Once we started darting, our capture rate increased, although we were only able to dart a small proportion of the animals we sighted as many captures were simply too difficult to attempt. While darting we ran into another frustrating problem: possums are simply not designed to fall out of trees, drugged or undrugged! (They always seem to be able to hang on, prevented from falling by a single claw, or that long tail looped around a branch.) Often the only way to get them down was for Roger or Charlie to climb and cut the branch, which the ground crew would catch on a large piece of netting. Every capture was a triumph.

NEWLY CAUGHT WILD
animals soon forgot their normal shyness and rapidly devoured the honey we provided for them.

IT WAS SLOW WORK but gradually, over a number of field trips between 1990 and 1998, we began to piece together a picture of the lives of these extraordinary animals. After many hours of observation one came away with the impression that they were bold, alert and very active (they were certainly not dull and sluggish as described by one early observer). Our field data supported the idea that Striped Possums were indeed insectivores: most of the animals we observed at Shipton's Flat were feeding on arthropods living in dead wood, under bark, or in vine stems. We frequently saw them roving about in the canopy, clearly catching invertebrates. Wood-boring beetle larvae were particular favourites, and our captive animals were certainly very fond of these. Free-ranging animals repeatedly visited trees infested with beetle larvae, and these trees rapidly began to resemble a mining site, with large holes excavated all over their trunks.

Stripeys also appeared to have a taste for sweet things. On a few occasions we observed them feeding on nectar, and Indigenous Australians say that they eat the honey of native bees. Locals in northern Queensland told us stories of Striped Possums raiding honey from domestic bee hives left in the forest (after tearing a hole in the wooden hive), and newly caught wild animals we held in cages soon forgot their normal shyness and rapidly devoured the honey we provided for them. Stripeys are also known to raid sugarcane, bananas and rambutans, which does not always endear them to farmers!

We fitted the possums we caught with radio-collars and, as with our first animal, we would locate them at night and also track them to their dens (usually tree hollows) during the day. By doing this we were able to map the home range of each individual, and plot their den sites within this range. Dens were generally scattered through the possum's home range, with adult females using fewer dens than males. The difference in the number of dens used by males and females may be related to the fact that males ranged over considerably larger areas of forest than females and subadults. Male Striped Possums certainly proved capable of covering large distances very rapidly, as we sometimes found out while tracking our animals. Occasionally, one of our males, Dave, would depart for a site over a kilometre from the edge of the study area, racing and crashing noisily through the canopy with huge leaps. At these times we were often left behind, thrashing our way through the thick lantana on the ground.

Dave also provided us with some other unexpected insights into the ecology of Striped Possums. He was often extremely difficult to locate. Many nights we would climb the highest ridges trying in vain to pick up a signal from his radio-collar. It was extremely frustrating, as we initially had no idea of where he was. Gradually, as we became more familiar with his roving ways, we discovered he was using the ridges and steep gullies away from the main gallery forest along the Annan River. Our supposedly rainforest possum seemed to have no qualms about spending a considerable amount of his time foraging in the stunted open ironbark forest on the top of a dry ridge!

Finding Dave each night became a somewhat arduous task, particularly in the late dry season when the weather was hot and humid. This is the time when the country in the north burns. For someone

JEAN-PAUL FERRERO/AUSCAPE

Despite being fairly elusive animals, Striped Possums are not always shy. They will often sit quietly and peer back at you from a safe spot in the canopy.

from the south-east, where bush fires are often catastrophic infernos, fires in the forest around Shipton's Flat initially made me extremely nervous. However these northern fires are fairly cool, moving slowly through the country, mainly along the ground. We went out to track Dave one night when a fire had finally reached one of the ridges high above the river. His signal was coming from the direction of that ridge, and when we located him he was out foraging happily as the fire burnt through beneath him!

Since other petaurid possums are renowned as somewhat social animals, we were interested to see whether Stripeys spent much time in groups. We found little evidence of this. During spotlighting we rarely saw Stripeys together, and the home ranges of the different individuals did not overlap as much as one would expect if the animals were highly social. Despite this we made occasional observations that indicated there was at least some level of social interaction. For example, one night Roger and Charlie caught a male Stripey, which vocalised loudly in alarm (a deafening and unsettling sound if you are close by). Within a short time, two other Striped Possums appeared, obviously in response to the distress call of the captured male. Alarm calls such as this appeared to be a common response when the animals felt threatened. One evening, as we were sitting around in our camp, we heard a Stripey calling repeatedly. When we investigated, we found the animal baled up in the entrance to a tree hollow with an Amethystine Python poised above it in striking position. Roger climbed the tree and managed to shoo the python away, but we were beginning to suspect that pythons were a major predator of our possums.

The fate of Mickey, one of our subadult males, added to our suspicions. I had noticed that most of the adult possums changed their den trees regularly, and wondered why. In contrast, Mickey used very few dens and had one favourite tree that he slept in day after day. Being a subadult with a relatively small home range, I thought that perhaps he had few dens available to him. We had monitored Mickey closely through to the end of a field trip. On our return to the study site some months later we found him (or rather his remains) and his radio-collar in a python scat close to his favourite den tree. Maybe sleeping in the same spot is a dangerous thing to do when there are wily predators such as pythons around: a costly mistake for a naive young possum.

Our field work has come to an end for the present, and as always, we have generated far more questions than answers. How long do Striped Possums live? Are they territorial? What is their mating system? How often do they breed? Hopefully we, or others, will be able to continue the study of these spectacular animals in the future. With their large brains and bold, fascinating behaviour, they are certainly a worthy subject for more research.

FURTHER READING

Cartel, M., 1974. Daubentonia, Dactylopsila, *woodpeckers and klinorhynchy. Pp. 655–670 in* Prosimian biology, *ed. by R.D. Martin, C.A. Doyle and A.C. Walker. University of Pittsburg Press: Pittsburg.*

Flannery, T., 1994. Possums of the world. *Geo Productions and The Australian Museum: Sydney.*

*Handasyde, K.A. & Martin, R.W., 1996. Field observations on the common striped possum (*Dactylopsila trivirgata *Gray) in north Queensland.* Wildl. Res. *23: 755–766.*

Van Dyck, S., 1995. Striped Possum. P. 222 in The mammals of Australia, *ed. by R. Strahan. The Australian Museum/Reed Books: Sydney.*

DR KATH HANDASYDE IS A LECTURER IN THE DEPARTMENT OF ZOOLOGY AT THE UNIVERSITY OF MELBOURNE. HER MAIN RESEARCH INTERESTS ARE THE HABITAT REQUIREMENTS, GENERAL ECOLOGY AND CONSERVATION OF MARSUPIALS AND MONOTREMES.

CANE TOADS ARE ON THEIR WAY, HAVING MARCHED OVER THE BORDER FROM QUEENSLAND, AND ARE NOW QUICKLY SPREADING IN THE NORTHERN TERRITORY.

CANE TOADS *v.*

The Cane Toad: love it or hate it, you have to admire the biological skills of this invader, to expand its range at such a rate and across such a diversity of habitats. The dry country around the southern Gulf was taken in its stride.

MICHAEL CERMAK

NATIVE FROGS

BY GORDON GRIGG

EACH EVENING DURING THE WET season, at 14 lonely outposts in the Northern Territory, computers mounted in tall poles topped by solar panels listen out for frog calls that they've been trained to recognise. Every pole has its own sweaty and frustrating story to tell—but all worth it if we find what we're looking for. You see, Cane Toads are on their way, having marched over the border from Queensland, and are now quickly spreading in the Northern Territory. We hope to find out whether they have any impact on the native frog fauna by monitoring the frogs before and after the arrival of the toads.

The introduction of Cane Toads (*Bufo marinus*) to northern Queensland is a familiar story to most Australians. So is their failure to control the beetles they were brought out for, and their subsequent spread north, south and west at rates of around 25 kilometres a year. As such Cane Toads are bad news. Apart from their perceived ugliness, their unpopularity is amplified by the danger posed to children and Dogs by the venom secreted from large glands behind their ears, and by beliefs that they have done a lot of damage to native fauna. Snakes, goannas and quolls are thought to have suffered, presumably from naively eating Cane Toads and dying from the poison. There are many compelling accounts of population declines following the arrival of the toads. The deeply entrenched abhorrence of toads extends even to an apparent community acceptance of driving over them, and using them for impromptu soccer matches or to practise your golf swing.

Toads are painted as villains, even to the extent that Bob Hawke made it a 1990 election promise to provide funds to prevent Cane Toads ever reaching Kakadu. Part of these funds were used by CSIRO to set up the now-defunct Cane Toad Research Advisory Committee, of which I was a member.

But are Cane Toads really such villains? Despite substantial anecdotal information, good scientific data are lacking. It is technically very difficult to monitor the number of goannas, or death adders, or black snakes, or quolls, before and after the toads move in. Also, the data that have been collected are equivocal. Unpublished data collected by Bill Freeland, now with the Parks and Wildlife Commission of the Northern Territory, suggest that goanna populations suffer initially, but that enough individuals survive the onslaught and, in due course, the populations recover. Bill also tackled the question of impact on the native frogs, in the Gulf country, but was unable to find an effect. Absence of evidence, however, is not evidence of absence and, even if some scientists think that Cane Toads are not really a problem, others accept that toads will more likely turn out to be another biologically as well as aesthetically unfortunate and damaging import. Non-scientists, of course, have already made up their minds—they want toads out!

Perhaps if there were really good data to show that Cane Toads are significant pests, governments would be more likely to provide money for their control.

But how to get the data? This question was pondered by the Cane Toad Advisory Committee in December 1994 and newspaper advertisements called for research proposals with the promise of funding. As a member of that committee, I was prompted to revisit an idea I had a couple of years earlier. I reckoned that the overall variability of things in the wet–dry tropics meant we would be looking for what might be a very small 'signal', caused by the arrival of the toads, in a very large 'noise'. I already knew about this variability, from personal experience in Cape York. I recalled driving along a road on sequential humid evenings and seeing on one night hundreds of the large, spectacular burrowing frogs, *Cyclorana novaehollandiae*, while on the next night none. Clearly comparative surveys before and after toads could easily be confounded.*

The trick would be to have a very high sampling rate, preferably daily. Field work can be good fun at first, but it soon becomes tedious and daily sampling in a

A 'toad pole' showing its solar panel and a microphone pointed to a gravel pit (obscured by the trees) that floods in the wet. Poles along the Roper Valley Highway have been given nicknames, based on famous computer scientists or biologists; this one is called Church (after the great logician Alonzo Church). The monitoring equipment, powered by batteries, fits into a canister that hangs inside the pole. The top of the pole is painted black to promote a convective, cooling flow of air.

remote area, for months at a time, is a tall order. We needed something automatic. What could we monitor daily and automatically? Frogs were the obvious candidates. It is easy to imagine that frogs might suffer when toads arrive; both eat insects and have aquatic tadpoles, so competition between toads and frogs is likely to occur in both the juvenile and adult stages. Also, and of great attraction for automatic monitoring, the males sing to attract females, with each species having a different, recognisable song.

All we would have to do would be to set up automatic recording stations at frog ponds in front of the approaching hordes

(Right) Maurizio Bigazzi and Les Fletcher finalise the wiring on the solar panel before the pole is lifted and bolted into position.

(Left) Frank Seebacher (kneeling), Tim Jessop and Andrew Taylor install a programmed monitoring system into a pole, where it is connected to batteries, temperature sensors, the rain gauge and the microphone, and pulled into position by a rope over a pulley, high enough to avoid being flooded when the rains come.

PHOTOS: GORDON GRIGG

* This problem is exemplifed by a CSIRO study by Peter Catling and colleagues, funded at the same time as ours, in which abundances of various fauna in the Roper River area were measured, pre- and post-toads, over four five-day periods between October 1995 and May 1997. The researchers found "little evidence that cane toads have a significant adverse effect in the short term", although they did identify some negative short-term effects on Dingoes and beetles, and suggest an indirect long-term effect on the small reptile fauna (through depletion of their food supply). They caution, however, that "the effect of the toads might be masked by . . . climatic variations". This is exactly the sort of ambiguity that our study seeks to avoid. Whether or not we will be successful remains to be seen.

PHOTOS: GORDON GRIGG

(Above) This is the first Cane Toad the researchers saw at Roper Bar, Northern Territory, in January 1996, a couple of weeks after the first toads were recorded there. Graeme Watson blocks its westward journey.

(Right) Les Fletcher checks a site we call Darwin (after Charles), before putting a recording system in for the 1999–2000 wet season. The bushfire didn't damage the solar panels, batteries, microphone nor cabling, which remain in the poles year round. Lightning is another potential hazard to their survival.

of hungry toads, and monitor calling activity before and after the toads arrive, and then for a few more years. Simple! I had put the idea hesitantly to the committee in November 1992, but soon dropped it because of the obvious practical difficulties: we would be forever having to change the recording tapes and, besides, the toad front was in country quite inaccessible in the wet season.

But by 1994 the need for research on the impact of toads had again been recognised. Also, the toads were heading into more accessible country. It looked as though accessible recording sites could be placed in the western Gulf country between Mataranka and Roper Bar, along the (nearly) all-weather Roper Valley Highway. Furthermore, I realised that computer software and digital-storage technology had probably improved—hopefully to a point where the recording could be done digitally, for long periods throughout the wet season without having to continually change tapes. Maybe the idea was worth resurrecting. However, the implementation of this sort of computer application was way beyond me and, with only a week to submit a proposal before the closing date, I needed to find an expert, quickly.

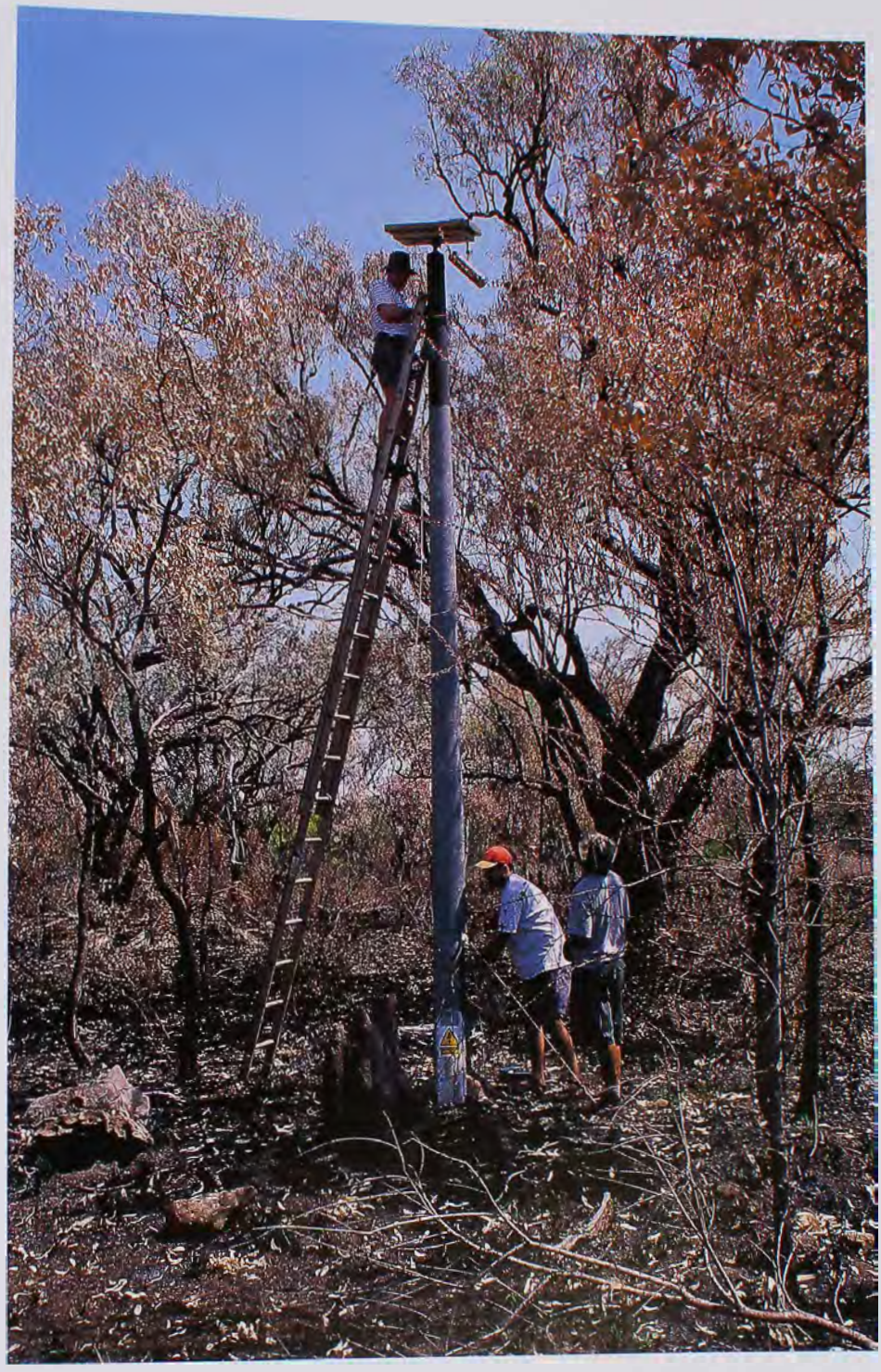
I found one in Andrew Taylor, from the University of New South Wales' School of Computer Science and Engineering, whose sister happened to be a friend of a friend of a friend . . . But Andrew's whereabouts were unknown. He was on holidays. The proposal was due in by Wednesday, one week away. Eventually, on Friday, after much pestering, I prised out of his departmental secretary that Andrew and his wife Monica were at Pajinka Lodge, an ecotourism resort at the very tip of Cape York. I left messages. On Sunday evening I was told he was out on a spotlighting walk and I could catch him about 10 pm. I phoned back. Could I interest him? I described the idea. There were long silences at his end. But then, yes, he'd done something technically sim-

ilar on night-flying birds. Yes, it was possible, but it wouldn't be easy. Did I have recordings of all the frogs? (No, but I was sure we could get them.) Would we be able to find sites with mains power? (No, but I imagined we could use solar power. Lots of sunshine in the Territory, and didn't computers run on low-voltage DC anyway?) Yes, but what about in the wet season? Wouldn't there be lots of cloud? (Mmmm. Yes. But it's often clear in the mornings before the cloud builds up, except if there's a cyclone or something.)

Andrew then spelt out what could be done. The idea would not be to record all the sounds, but to 'train' software to recognise the calls made by each of the species of frogs ('voice recognition' training), and to record only the species name, coded. This would be a huge saving in storage requirements. Instead of having to tape and store large amounts of digitally recorded sound samples, the system would identify the species calling and record just that, in brief text form. The system could listen for several hours every night, running on battery power, and store the data at regular intervals, and for months at a time. Nightly sampling times could be altered in response to hours of sunlight during each day, and batteries would recharge the next day. Andrew would determine sources and costings for suitable batteries, computer boards and ancillary hardware as soon as he got back from his holidays. When was the application due in? Bloody hell! "And by the way", Andrew said, "Cane Toads have reached Cape York. We saw the first one here tonight, on our spotlighting walk."*

I still hadn't met him, but Andrew seemed to be the expert we needed. And what a rare find he has turned out to be. How many computer experts do you know who are specialists in computer identification of biological sounds, who can write computer software, and who can also diagnose and replace faulty electronic components and solder up circuitry by torchlight, surrounded by mozzies and squatting under a flapping tent-fly erected hastily in the face of increasing drizzle? And all this while still following the cricket?

Graeme Watson, a zoologist from the University of Melbourne, joined the crew as our much-needed expert on Northern Territory frogs and their calls, and Hamish McCallum, down the corridor from me in Zoology at the University of Queensland, agreed happily to ensure we had a suitable experimental design and to undertake the analyses when (and if!) we got data.

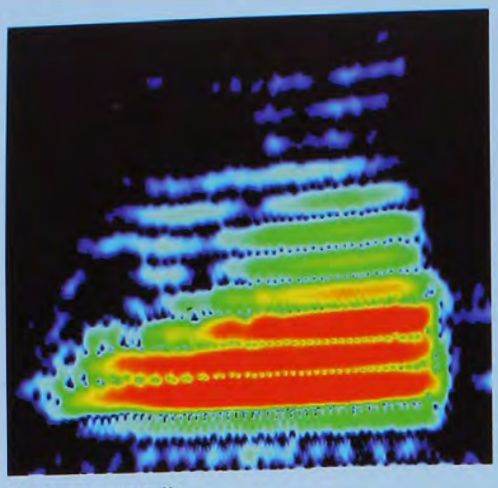


So we had a team. The application was submitted in time and the committee, without me there, gave its approval. All we had to do now was do it.

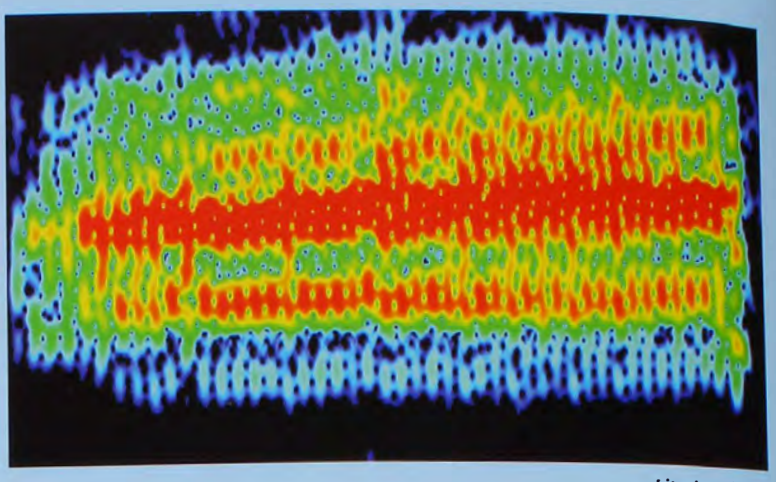
A TRIP TO THE STUDY AREA in January 1996 helped build the collection of recordings of relevant mating calls, and we found froggy-looking sites for monitoring stations along the road between Mataranka and Roper Bar. Our arrival at Roper Bar coincided with that of the first toads. We'd have to get cracking, or the proposed study area would be inundated before we even got the monitoring systems in place.

Now Andrew had to write the software and we had to decide how best to put fragile computer equipment into a protective housing of some sort, safe from the weather and potential vandalism, with solar panels mounted suitably, and then

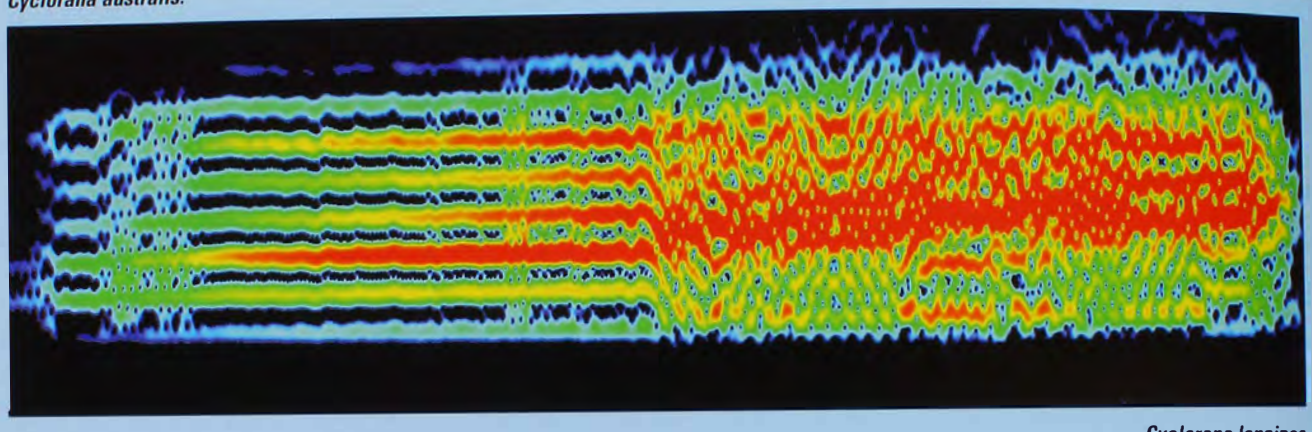
* My wife Jan and I visited Pajinka in January 1998 and were told that the quolls that used to be a real attraction, mingling with the guests nightly and taking kitchen scraps, had disappeared after the Cane Toads arrived.



Cyclorana australis.



Litoria rubella.



COURTESY ANDREW TAYLOR.

Cyclorana longipes.

Automatic recognition of frog calls

The familiar frog sounds we hear on wet summer nights are the calls of male frogs, advertising for female partners. Typically, all the males of a frog species use the same advertisement call and this call is different from that of other frog species living in the same area. The calls have distinctive patterns in both frequency and time, which allow females to recognise the calls of their species. It also allows our computer software to identify the species of advertising male frogs.

Shown here are spectrograms of the calls of three different frog species, each recorded from a single frog calling only centimetres from the microphone. These spectrograms clearly show the distinctive patterns recognised by the female frogs, and by our software too.

However, frogs don't usually take it in turns to call, nor do they always 'speak clearly into the microphone', and there is often other background noise, like rain, wind or insects, to contend with. Thus the sound coming into our systems is a lot more cluttered.

Identifying frog species under such conditions was the major challenge in developing our software. It is accomplished by breaking sound into brief fragments less than a tenth of a second long. Some fragments will contain parts of frog calls without interferences from other frogs or background noise. Although these fragments are too brief to allow identification of the frog species with certainty, when we combine many such fragments we can reliably identify the call as belonging to a particular species.

Every ten minutes, between 8 pm and midnight, the software logs the identity of any species heard with a rough estimate of their abundance. Temperature and rainfall data are also logged on an hourly basis. Once we analyse all the data over consecutive wet seasons, we should be able to determine whether there are any changes in abundance of native frogs after the arrival of Cane Toads in the area.

—Andrew Taylor
University of New South Wales

GORDON GRIGG

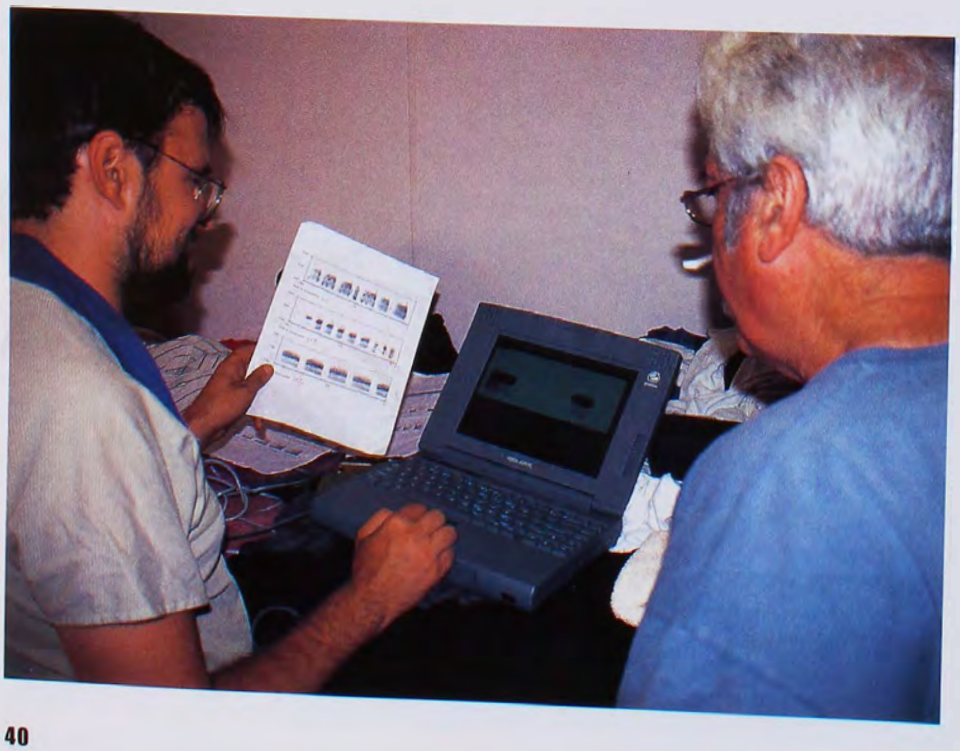
The Long-footed Frog (*Cyclorana longipes*), a burrowing species of the tropical woodlands of the Top End, breeds in temporary ponds. The prolonged nasal moan of advertising males is heard only early in the wet season on nights after heavy rainfall.

build and deploy them.

Thanks to Les Fletcher and Bill Stablum, stalwarts in the University of Queensland's Zoology workshop, a suitable system was devised. For each of the stations, the monitoring equipment, comprising two computer boards, power supply, pre-amplifier for the microphone etc., is mounted within a section of PVC water pipe. This metre-long canister hangs from a shackle attached to four 12-volt batteries in a frame, and the whole assembly hangs from a pulley in the top of a hollow steel six-metre lighting pole. The canisters and batteries can be inserted into the poles through a panel at the bottom and pulled up, on a rope over the pulley, higher than the water level likely during the wet season. Solar panels are mounted at the top of the pole, along with temperature sensors, the microphone and a tipping-bucket rain gauge, and cables run within the poles to connect everything appropriately. The poles are bolted onto concrete footings and, when complete, look little different from any number of installations along roadsides everywhere, so they attract little attention.

Ten of the pole stations were installed in January 1997 with a great deal of help from Les and from volunteers, particularly Frank Seebacher, Tim Jessop, Peter Kind, Tim Schultz, Ida and Maurizio Bigazzi and Jan Grigg. The toads were already well west of Roper Bar, so we had to abandon the two most easterly planned sites and replace them with two new sites farther west, closer to Mataranka. We spent more than a week digging holes, mixing concrete, and lifting and bolting the poles and their solar panels into position. Hot work.

We hoped to catch the end of the 1996–97 wet season, and managed to get four prototype systems into the most easterly poles. When Tim Schultz downloaded them in May, everything had worked beautifully except for a minor glitch in which the frog-call identification



PHOTOS: ORDON GRIGG

software was not turned on. We had lovely data on temperatures, rainfall, sampling times and battery voltages, but no frogs! Andrew assured us it was a simple error, easily fixed, and so it proved, because we got a full run of data for the 1997–98 wet season, from November to May (see box).

Meanwhile, I approached Piers Barrow, Project Officer at Kakadu National Park, to see if he was interested in getting some baseline data there before the Cane Toads arrived, in maybe five years time. He was, so we again headed north with more poles, and more concreting, and installed four more recording systems, bringing the total to 14.

After downloads in April 1999 we now have good data sets in two areas over two wet seasons. The toads have engulfed six out of the ten sites along the Roper Valley Highway, from the east. By the time

this article is published, after the 1999–2000 wet season, we will have enough data for serious analysis to begin. We hope to collect data for several more years, if we can find the money.

WILL CANE TOADS reach Kakadu? You can bet on it. What biological damage will they do? No-one knows. We may measure what they do to the native frogs, but it will require collection of other baseline data to determine possible impacts on other biota. However, many people believe that just having toads in Kakadu would be damage enough, because they are unsightly and foreign.

Could Cane Toads be eradicated? Probably not, except I think it would be worth spending money to try. Hand collection or direct killing is obviously impractical. Viruses specific to the family Bufonidae, which might be able to be spread through the population by an insect vector, offer a possibility. However, especially after the PR disaster with the Rabbit Calicivirus, community pressure may prevent the release of any virus, even for the much-maligned toads. The Australian Animal Health Laboratories at Geelong, in Victoria, pursued some promising lines of investigation as part of the CSIRO's Bufo Project, but that stopped when the funds dried up.

The best hope is for the discovery of some sort of hi-tech magic bullet or, perhaps, some sort of control by pheromones. Rapid advances in biotechnology offer at least a tiny ray of hope, for this and for all our non-native pests. Otherwise, along with several hundred other species of deliberate but deleterious biotic imports, from grasses to vines and from Rabbits to Camels, we will have to be resigned to Cane Toads in Kakadu and, probably, just about everybloodywhere else.

(Left above) Giant Frogs (*Cyclorana australis*) in amplexus. These frogs breed at the start of the wet season in shallow, static water.

(Left below) Andrew Taylor and Graeme Watson compare reference material with sonograms on screen from the previous night's recording session near Roper Bar, Northern Territory. The library of advertisement calls collected were then used to 'train' the monitoring equipment.

FURTHER READING

Barker, J., Grigg, G.C. & Tyler, M.J., 1995. A field guide to Australian frogs. *Surrey Beatty and Sons: Sydney.*

*Catling, P.C., Hertog, A., Burt, R.J., Wombey, J.C. & Forrester, R.I., 1999. The short-term effect of cane toads (*Bufo marinus*) on native fauna in the Gulf Country of the Northern Territory.* Wildl. Res. *26: 161–185.*

Taylor, A., Watson, G., Grigg, G.C. & McCallum, H.I., 1996. Monitoring frog communities: an application of machine learning. In Proceedings of the 8th Innovative Applications of Artificial Intelligence Conference, Portland, Oregon August 5–7, 1996. *The AAAI Press: Los Alamitos, California.*

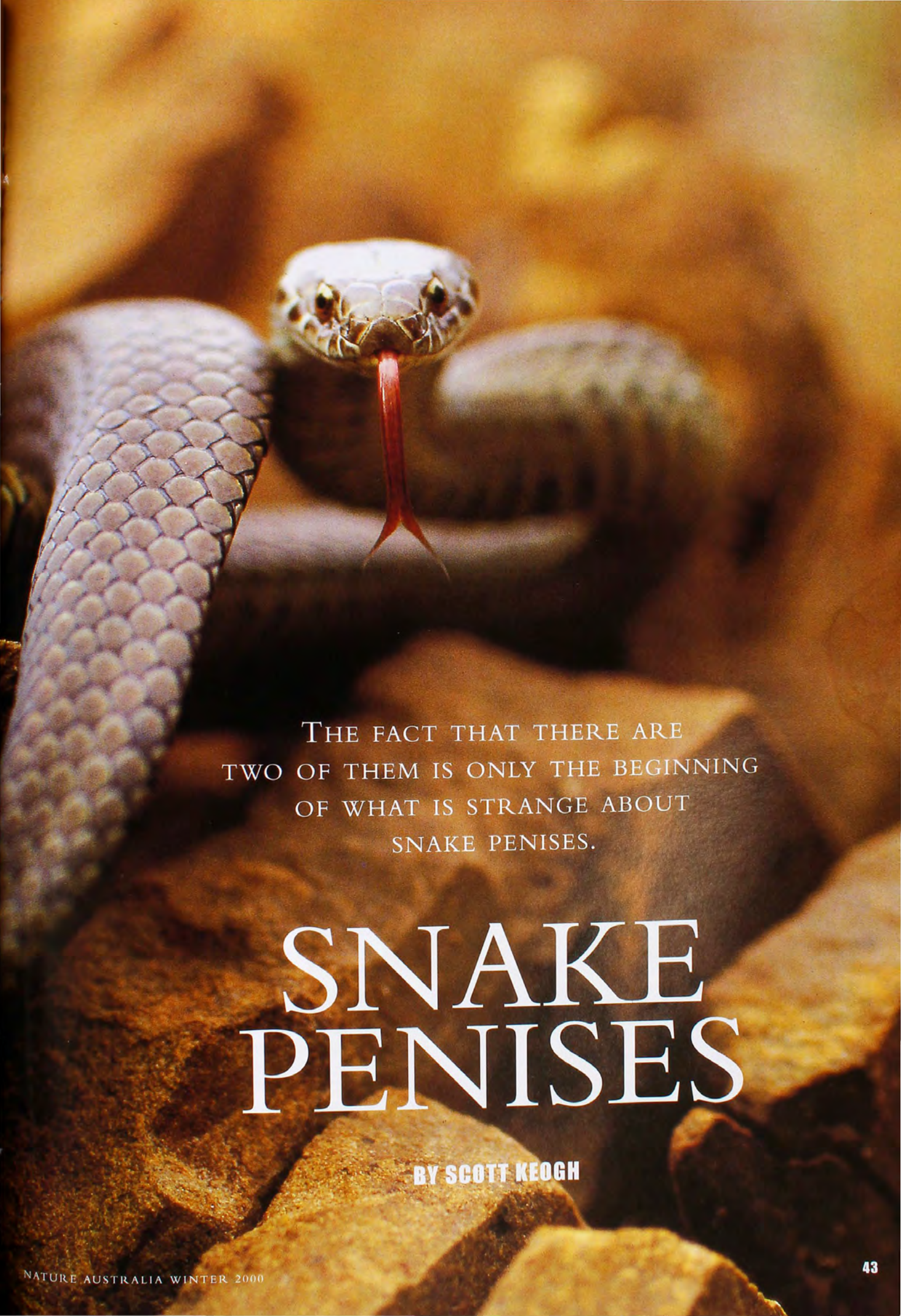
Tyler, M.J., 1989. Australian frogs. *Viking O'Neill: Melbourne.*

PROFESSOR GORDON GRIGG IS A ZOOLOGIST IN THE DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY AT THE UNIVERSITY OF QUEENSLAND. HE HAS A PARTICULAR FONDNESS FOR CROCODILES, ECHIDNAS, KANGAROOS, FROGS AND FLYING, AND HOPES THAT NEXT TIME HE GETS A MADCAP IDEA LIKE THIS ONE, ESPECIALLY IF IT INVOLVES CONCRETING, SOMEONE WILL QUIETLY STRANGLE HIM.

The Desert Tree Frog (*Litoria rubella*) is widespread and occurs in many arid areas. Males advertise with a harsh and rather boring squark, repeated endlessly.

NICHOLAS BIRKS/WILDFLIGHT AUSTRALIA

The Dwarf Copperhead (*Austrelaps labialis*) has hemipenes that are virtually indistinguishable from the Bardick (*Echiopsis curta*) and tiger snakes.



THE FACT THAT THERE ARE TWO OF THEM IS ONLY THE BEGINNING OF WHAT IS STRANGE ABOUT SNAKE PENISES.

SNAKE PENISES

BY SCOTT KEOGH

MALE SNAKES, AND MALE lizards too, have extraordinary penises. To start with, they have two! Males tend to be either 'right-handed' or 'left-handed' with respect to which penis they use, although it also depends on which side of the female they end up on when the critical decision comes up. But to put your mind at ease, a male can use only one of his penises at a time.

The fact that there are two of them is only the beginning of what is strange about snake penises. In snakes the sperm is not transmitted through the penis in a tube (as in mammals) but rather down a groove in the side of the penis. When not in use, the penises are carried inside-out within the base of the tail. When mating takes place, the appropriate penis is everted and expanded. Once mating is completed—and it can take several hours in some snakes—the male pulls the penis back into its inside-out state by small muscles attached to the inside of the penis. Of course this means the muscles are attached to the outside of the penis when in the inside-out state—it's complicated!

These attributes are interesting and strange, but by far the most intriguing thing about snake penises for me is their tremendous anatomical diversity. The evolution of anatomically complex copulatory organs is one of the most widespread themes across all sexually reproducing animals. However, it has proven very difficult to understand why such complexity has come about. In this article I will outline some of the reasons why biologists think this fantastic diversity has evolved.

I AM A BIOLOGIST and much of my research involves trying to figure out the evolutionary relationships of venomous snakes. I generate family trees that illustrate the relationships between species based on data drawn from both anatomy and DNA sequences. With these trees, not only do we get a better understanding of the snakes' evolutionary history but we also can generate classifications and taxonomies that reflect these relationships. Much of my recent work has been on the venomous elapid snakes of Australia and New Guinea and their relatives. The family Elapidae includes virtually all of Australia's 90 or so species of venomous snakes (brown snakes, black snakes, death adders, Taipan, Tiger Snake etc.), but also includes around 200 species from other parts of the world, such as the African and Asian cobras, African mambas, American and Asian coral snakes and also sea snakes.

Part of my recent research involved a comprehensive descriptive survey of penis morphology for nearly all species of Australian elapid snakes. It took many months, but I searched through hundreds of jars in all the museum collections in Australia to find them. In the end I examined over 700 penises from 63 species that were each scored for 14 aspects of their morphology. Why did I concentrate on the snakes' penises? Well, part of what makes snake penises so bizarre to look at also makes them very good for inferring evolutionary relationships and taxonomy. For example, I discovered that there are eight different types of penis, which are each unique to individual groups within the Australian elapid snakes. Thus those snakes that share a hemipenis type are also thought to be closely related, and these results are corroborated by DNA sequence data.

In scientific circles the male copulatory organs of snakes and lizards are referred to as 'hemipenes'; right and left hemipenes, that is. There is a tremendous diversity in size, shape and what only can be called ornamentation. Herpetologists describe this ornamentation using such terms as spines, barbs, fleshy protuberances, ridges, terminal awns, apical caps, nude disks and hooks. There are almost 3,000 species of snakes in the world and these species display hundreds of strange and unique hemipenes. Perhaps the best place to start is to simply outline the tremendous diversity that exists in snake hemipenes.

Many pythons have bulbous hemipenes with many complex convolutions and valleys on the surface. But pythons tend to have very smooth hemipenes. This is in contrast to most other snakes that have the entire outer surface covered in numerous sharp, calcified spines. It gives the hemipenis a rough texture similar to that of a Cat's tongue. These spines can vary in density and size between species, but more interestingly, they also vary in their arrangement. Some snakes have the small spines arranged in complex whorls around small indentations, or in neat rows that run around the hemipenis. Hemipenis shape also shows fantastic diversity with some being corkscrewed,

Double trouble

How did snakes and lizards end up with two penises? We don't know for sure, but the best explanation is probably that the ancestors of snakes and lizards gave up having a penis for a while and reverted to 'cloacal kissing', that is simply touching the two cloacas together to exchange sperm. Most birds (with a few exceptions; see *Nature Aust.* Summer 1998–99) mate without the use of any sort of penis and it works just fine. There is some support for this idea if we look at the New Zealand Tuatara (*Sphenodon punctatus*), a primitive lizard-like animal thought to be a member of the ancestral group that gave rise to lizards and snakes. Tuataras have neither a single penis nor hemipenes; they are cloacal kissers. At some later stage, the ancestors of lizards and snakes must have then re-evolved intromittent organs, but this time they were free to re-invent the structure. Clearly the double structure they ended up with is quite unusual.

W.G. JENKINS/NATURE FOCUS

others long thin rods, and still others that look like short thick lumps with fleshy protuberances.

The Golden Crowned Snake (*Cacophis squamulosus*) (above) has two unusual projections from the tip of each hemipene lobe (right).

STUART HUMPHREYS/NATURE FOCUS

SO WHY DID THIS diversity in penis morphology evolve? One of the oldest and most favoured hypotheses for the evolution of complex genitalia is what is called the 'lock-and-key' hypothesis. It's pretty simple. The male copulatory organ represents the 'key' and its anatomy is such that it will only fit into the right 'lock', the reproductive system of the females of his species. Thus evolution is thought to have favoured a system where it is difficult or impossible for matings to take place between members of different species. Females are able to make sure they are mating with the correct male by his possession of the appropriate 'key'. This theory necessitates that a new 'lock' and 'key' evolve each time one species evolves into two.

With regard to snakes, it is easy to see why this hypothesis might seem plausible. In most species, each individual hemipenis is bilobed. This means the top of each hemipenis is divided into two parts. In some species this is so pronounced that, if both hemipenes are protruded, it looks like the male has four penises! The sperm-transmitting groove (the sulcus spermaticus) on the outside of the hemipenis is also split in two and continues to the tip of each lobe. The female reproductive system of most snakes also is made up of two tubes, the left and right oviducts. The division of the hemipenis into lobes is thought to facilitate the transfer of sperm to both of the female's oviducts.

This sort of arrangement seems to lend some evidence to the 'lock-and-key' hypothesis for snakes, but there is other compelling evidence against it. Female snakes don't really seem to have 'locks' that fit the 'keys'. The diversity in female reproductive tracts in no way compares to the diversity observed in male hemipenis morphology. We can compare ten species of snake, each with completely different types of hemipenes, but the reproductive tracts of the females from each of these species are likely to look very much the

ROBERT VALENTIC NATURE FOCUS

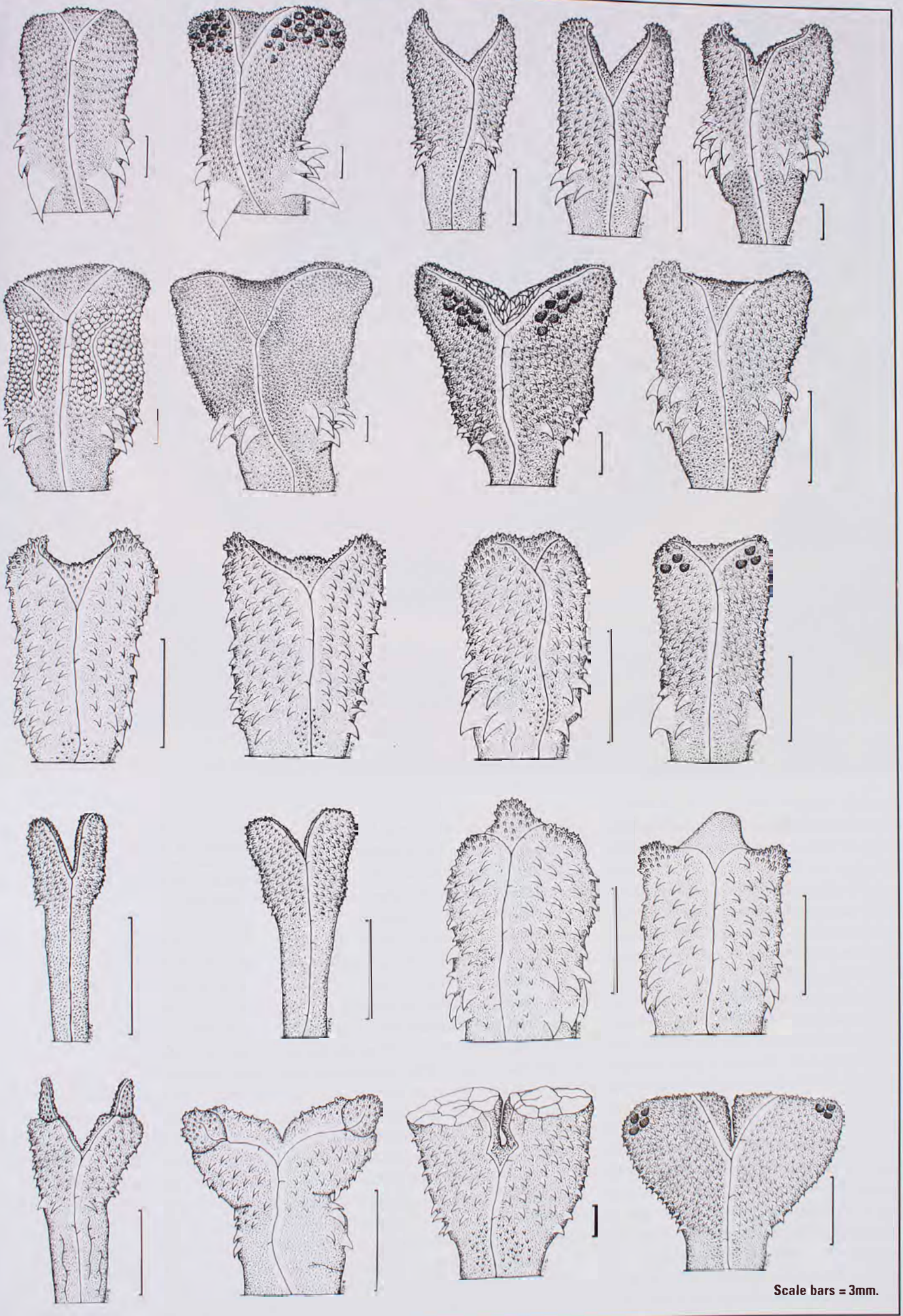
JOHN WEIGEL

(Above) Western Brown Snakes (*Pseudonaja nuchalis*) have prominent basal hooks and spines on their hemipenes (left). These are used to 'lock' the male into the female once mating has started.

(Right) This plate illustrates representatives of all the major types of hemipene shapes and ornamentations found in Australian elapid snakes. Note the diversity in spine distribution and size, the pronounced 'basal hooks', and the exaggerated ornamentation.

same. Further, it implies that a female must actually go as far as mating with a male just to find out if he is of the same species, and that can be dangerous since she may be wasting reproductive effort. Thus the 'lock-and-key' phenomenon is probably not what is fuelling the evolution of complex genitalia in snakes.

Another argument is that males and females may have a reproductive conflict of interest, in evolutionary terms, and this may translate into an 'arms race' with respect to the evolution of genitalia. From a male's point of view, he wants to fertilise as many eggs as possible with his abundant sperm and that means mating with as



Scale bars = 3mm.

COURTESY SCOTT MOOR

MICHAEL CERMAK

A pair of Taipans (*Oxyuranus scutellatus*) engaged in mating. The male only ever uses one of his hemipenes during mating. Which one he uses depends on which side of the female he ends up on after courtship.

many females as possible. From a female's point of view, she needs to make sure her few eggs are fertilised by the best male possible. Because males and females have different interests at heart, it has been proposed that this could lead to different evolutionary forces acting on male and female copulatory organs.

With regard to reproductive organs, we could predict that males should evolve structures that make sure the females will use their sperm. There is a good example of this in snakes. Some snakes have two or more exceptionally large spines at the base of the hemipenes. These are called 'basal hooks'. During mating, these giant hooks are lodged directly into the wall of the female reproductive tract and, while mating is taking place, it is virtually impossible for the female, or the male for that matter, to quickly break up the engagement. All seven species of Australian brown snakes (*Pseudonaja* spp.) have very large basal hooks. This may be useful for males for a couple of reasons. First, the basal hooks would make it very difficult for another male to dislodge the mating male. Male combat is fairly common in snakes and it is often the case that a male will try and compete for a female even after mating has started. Second, these hooks can cause some superficial damage to the female's reproductive tract and it may be that males have evolved the hooks for just that reason. The female may not be willing to mate again soon, ensuring that the male that inflicted the damage also will be the one that fathers the offspring. We can speculate that the female evolutionary counter-attack to this male reproductive strategy could be to evolve tougher reproductive tracts that are not as easily damaged by the basal hooks, thus preserving her ability to mate again with another male soon after copulation. Of course males could respond to this by evolving even larger basal hooks. Thus in this arms race, each evolutionary move in one sex must be dealt with in the other sex on a continual basis.

Hemipenis morphology also points to other evolutionary solutions to the problem of male combat. A rather spectacular example of evolution gone wild is represented in the hemipenes of the African Mole Snake (*Pseudaspis cana*). This species has what may be the largest hemipenes relative to body size of any snake: when extended, each corkscrew-shaped hemipenis is up to ten per cent of the snake's body length. What would be the purpose of such ridiculously long hemipenes? If females tend to mate with more than one male, then we might pre-

dict that male Mole Snakes should have long hemipenes to make sure it is their sperm that are used for fertilisation if they are lucky enough to get a mating (assuming that it is the sperm placed farthest up the reproductive tract that fertilise the eggs). But there are lots of other snake species whose females mate with more than one male that have smaller hemipenes. Perhaps male Mole Snakes also have to physically fight for matings. Sure enough, when we look at Mole Snake mating behaviour it becomes clear that they are ferocious competitors. They engage in brutal battles for females that often involve lacerating each other with their teeth and inflicting debilitating wounds. These battles go far beyond what male snakes of other species engage in. Why do they do this? Female Mole Snakes have very large litters of up to 95 babies and that's a lot of reproductive potential to lose if your hemipenis is not up to the task. It may be that hemipenis length is an alternative to basal hooks in male Mole Snakes. Whatever the case, evolution has probably been acting very strongly on both fighting ability and hemipenis length in this species because, if you can win the brutal fight, then you had better make sure your hemipenis is going to secure a large number of fertilisations.

THESE PARTICULAR CASES may provide partial explanations for why basal hooks and long hemipenes have evolved in some snakes, but they cannot explain the evolution of the multitude of other more subtle structures in snake hemipenes, or indeed the tremendous diversity in copulatory organs found in all sexually reproducing animals. How can we explain fleshy protuberances, ridges, spines, apical caps or nude disks?

Another hypothesis is arguably the best supported and offers us the most wide-reaching explanation—female choice. The argument goes something like this. Females are generally the choosy sex with respect to picking a mate because their reproductive investment comprises only a few precious eggs compared to the male's many sperm, thus females need to have some way of evaluating a male's potential to make sure she gets the best one possible to father her offspring. The female-choice hypothesis for the evolution of elaborate male genitalia suggests that females discriminate among potential mates based on preferences for particular aspects of the male's genitalia—and she does this probably after she has used other cues (such as large body size or fighting ability) to decide to mate with him in the first place.

But why would females use copulatory organs as a way of choosing a good male? Wouldn't they be risking their reproductive effort if they mate with a male that turns out not to be so good? Well, there are two important points to keep in mind. First, copulation and fertilisation generally do not occur at the same time, so a female can mate with a male but not necessarily receive any sperm if she ends the mating early; and if she does receive sperm, she may not necessarily use it to fertilise her eggs if she mates with other males afterwards. Thus, copulation can serve as a sort of 'internal courtship'.

DURING MATING,
these giant hooks are lodged directly into the wall of the female reproductive tract and it is virtually impossible to quickly break up the engagement.

Second, for as yet unexplained reasons, females do tend to prefer some aspects of hemipenes over others and, importantly, these preferences are generally quite arbitrary. Moreover, a preferred hemipenis does not necessarily have to translate into the male being good at other things such as catching food or growing big; the female preference for a particular type of hemipenis may be there just by chance alone and indeed may even contradict other male quality cues. This is easier to explain by using an analogy. We all know that some people prefer chocolate icecream while others prefer vanilla. In our case, the choices in icecream we make have no bearing on our survival or reproductive potential, yet there may still be a genetic basis for our preference. With snake hemipenes, arbitrary female preferences can translate into evolutionary change in males because the preferred attributes of their hemipenes have a genetic basis. Thus a male that possesses some new and preferred hemipenis feature will father more offspring and, eventually, this feature may become established as the norm for the species. What makes all this work is that female preferences evolve and change too, often quite quickly, and as they do the male anatomy will be altered over successive generations as those males with the preferred variations will have greater success in fathering young.

This same theme, sexual selection by female choice, is common to all sorts of biological attributes that females might use to assess a male's quality. We see its by-products in the exaggerated horns of male ungulates, the gaudy colours of male birds, and large male body size in many primates. It is an amazing and pervasive biological theme, yet it is also a highly complex one—the study of sexual selection always leads to more questions. We can ask the ubiquitous question "Does size matter?". Sometimes it does, sometimes it doesn't; the answer will always depend on which female you ask and to what species she belongs.

FURTHER READING

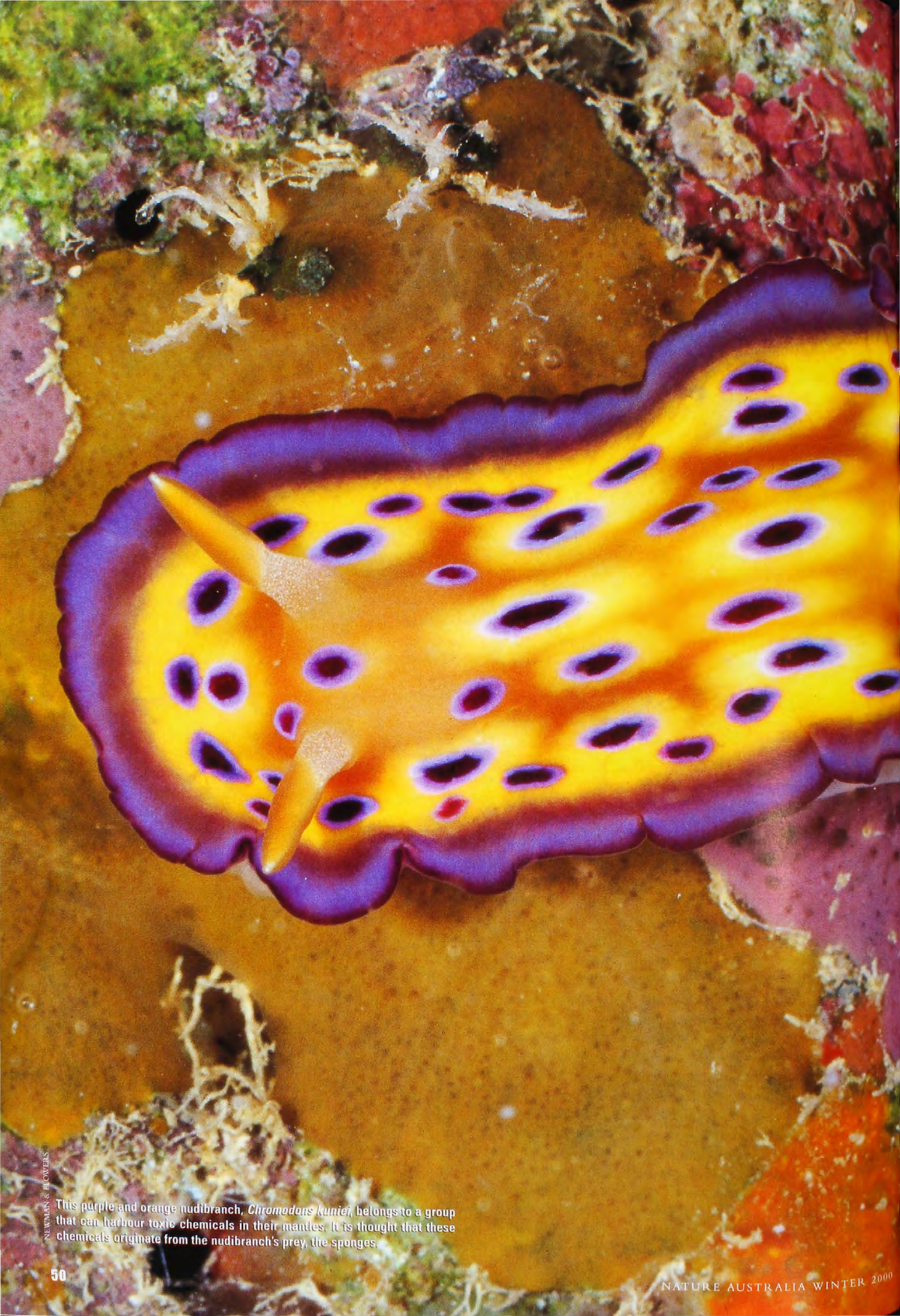
Arnqvist, G., 1998. Comparative evidence for the evolution of genitalia by sexual selection. Nature *393: 784–786.*

Eberhard, W.G., 1985. Sexual selection and animal genitalia. *Harvard University Press: Cambridge.*

Eberhard, W.G., 1993. Evaluating models of sexual selection: genitalia as a test case. Amer. Natur. *142: 564–571.*

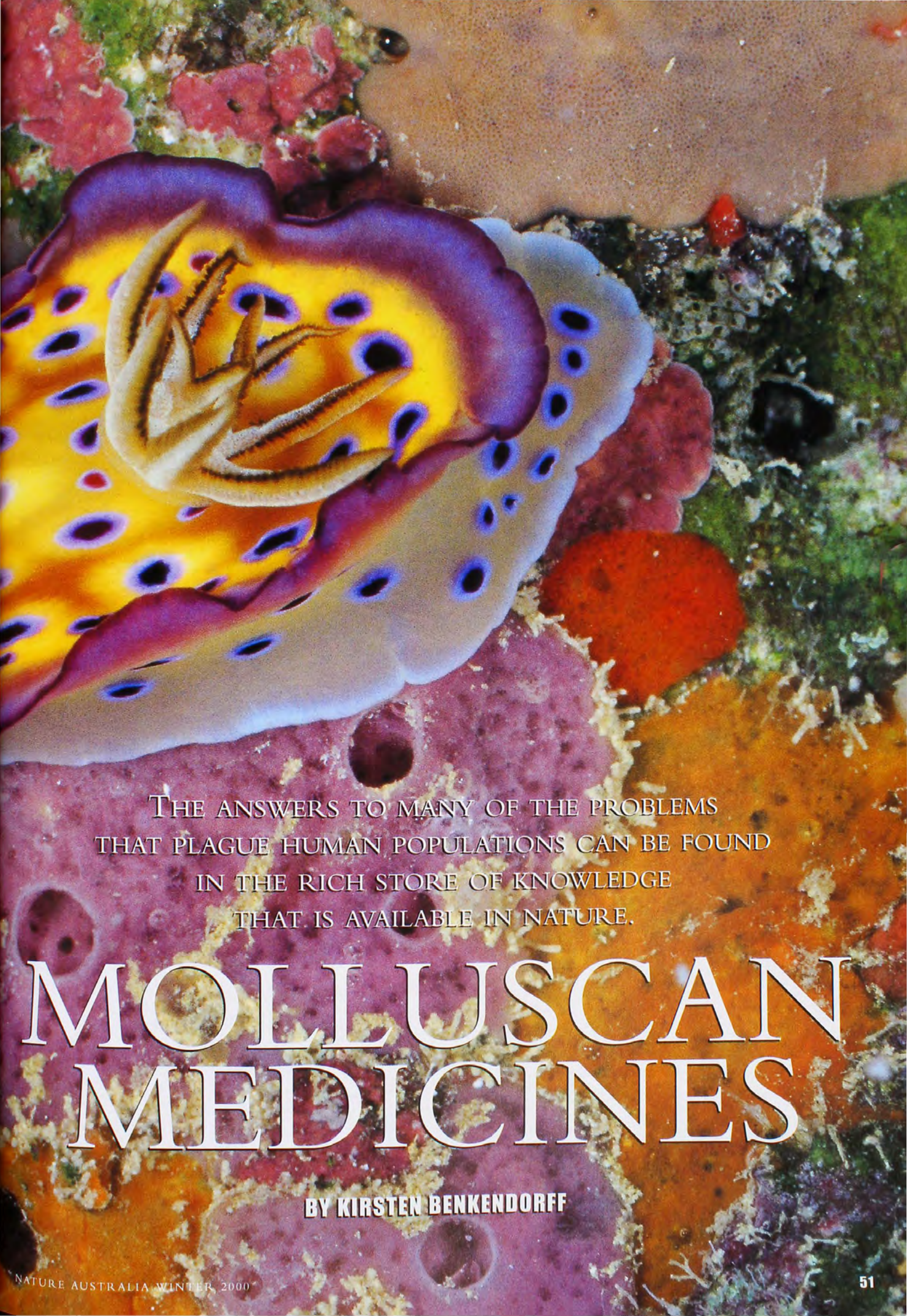
Keogh, J.S., 1999. Evolutionary implications of hemipenial morphology in the terrestrial Australian elapid snakes. Zool. J. Linn. Soc. *125: 239–278.*

DR J. SCOTT KEOGH IS A LECTURER IN EVOLUTIONARY BIOLOGY IN THE DIVISION OF BOTANY AND ZOOLOGY AT THE AUSTRALIAN NATIONAL UNIVERSITY. HIS MAIN AREA OF RESEARCH CONCERNS THE EVOLUTIONARY RELATIONSHIPS OF AUSTRALIAN AND AFRICAN VENOMOUS SNAKES AND HE USES BOTH MOLECULAR AND MORPHOLOGICAL DATA TO ADDRESS THESE PROBLEMS.



This purple and orange nudibranch, *Chromodoris kunieri*, belongs to a group that can harbour toxic chemicals in their mantles. It is thought that these chemicals originate from the nudibranch's prey, the sponges.

NEWMAN & FLOWERS



THE ANSWERS TO MANY OF THE PROBLEMS THAT PLAGUE HUMAN POPULATIONS CAN BE FOUND IN THE RICH STORE OF KNOWLEDGE THAT IS AVAILABLE IN NATURE.

MOLLUSCAN MEDICINES

BY KIRSTEN BENKENDORFF

A FEW YEARS AGO I moved to Wollongong on the New South Wales south coast, to study for my doctorate on the medicinal properties of marine organisms. Hemmed in by a majestic escarpment and a rugged coastline, what better environment for a young, enthusiastic student to test some ideas about life. One of my university lecturers had taught me that the answers to many of the problems that plague human populations could be found in the rich store of knowledge that is available in nature. The creatures and plants with which we share the Earth provide a library of successful evolutionary strategies and the greatest bank of resources available to humankind. But what I didn't know was how little we understand and appreciate our natural resources, nor did I realise the true magnitude of the pleasure and satisfaction that can be gained from studying them.

CONTAGIOUS DISEASE is an unavoidable consequence of living in high-density populations. It is a problem that humans, and other colony-forming organisms, have been fighting throughout evolution. The discovery of antibiotics was a remarkable achievement in human history. But over the last couple of decades micro-organisms have fought back, through the evolution of multi-drug resistance. Coupled with the desire to discover safe and effective drugs against a wide range of diseases (including HIV and cancer) we are now forced to search for new sources of potential pharmaceutical agents. And it is not surprising that many researchers have turned towards the sea.

The world's oceans represent the largest untapped reservoir of biologically active natural products. The ocean is said to harbour more biological diversity and a greater diversity of chemical structures than terrestrial ecosystems. Yet research on marine natural products lags a long way behind the equivalent research on land. This is primarily due to the difficulties associated with working in the marine environment and confounded by the lack of traditional medical knowledge on marine organisms. Nevertheless, the majority of natural compounds that are now showing promise as anticancer drugs

NEWMAN & FLOWERS

KIRSTEN BENKENDORFF

come from below the surface of the ocean.

In the search for new drugs from the sea, researchers have made the most of clues from the natural history of marine organisms. Medicinal research has concentrated on soft-bodied, brightly coloured, slow-moving or sessile organisms that appear to require toxic compounds to protect themselves. Marine species use toxic compounds to compete for space, keep their surfaces free from fouling organisms, and ward off potential predators and pathogens. Through their long history of evolutionary warfare many so-called 'primitive' invertebrates have had to fight off ever more sophisticated predators and competitors. The chemicals that have evolved to protect these marine invertebrates are often highly biologically active and are therefore the compounds we seek for medicinal purposes.

Molluscs (slugs, snails, cephalopods etc.) comprise the second largest phylum of invertebrate organisms, with over 80,000 living species described. Nevertheless, the chemistry of by far the majority of molluscs has not been explored to any degree. This is partly because it is assumed that the physical protection provided by the shells of snails prevents the need for toxic chemicals. Notable exceptions are the predatory cone shells, members of the genus *Conus*. Many of these mainly Indo-Pacific snails feed on worms or other molluscs but about 70 species are specialised to feed on fish. These fish-eating cone shells have evolved a sophisticated hunting mechanism that involves harpooning their prey with a poisonous barb. The poison is a deadly mixture of nerve toxins, powerful enough to kill a human. The toxins lock onto receptors in

(Above) The serene rock pools at Bass Point, Shellharbour, provide the perfect breeding habitat for a large diversity of intertidal molluscs.

(Left) One of the predatory cone shells, the Textile Cone (*Conus textile*).

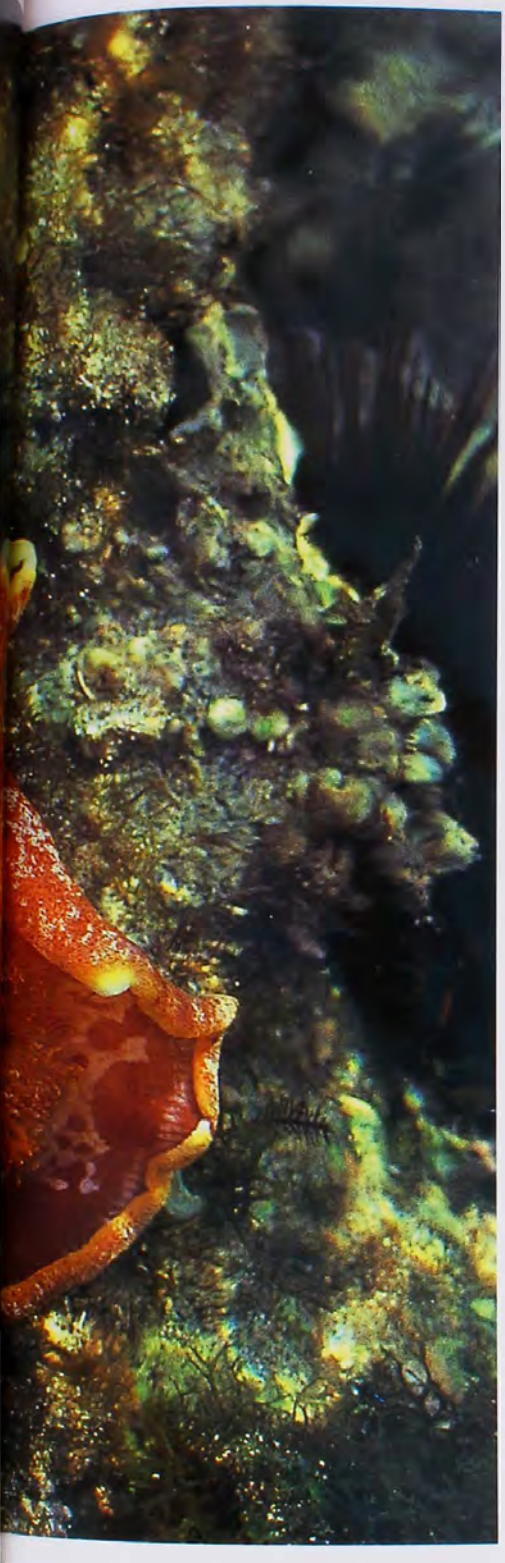
IAN HUTTON

Many nudibranchs like this Spanish Dancer (*Hexabranchus sanguineus*), shown here with its egg mass, embed their eggs in fragile ribbons that are firmly attached to boulders.

nerve and muscle cells with remarkable precision, and for this reason the 'conotoxins' are regarded as valuable research tools by neuroscientists around the world. Conotoxins are also being researched for use as strong pain killers, as well as potential drugs against epilepsy, depression and schizophrenia.

Limited chemical work has also focused on shelled molluscs in the family Siphonariidae. Known as false limpets, these snails usually inhabit the upper intertidal zone. Several compounds isolated from Australian species of *Siphonaria* have antibiotic properties, as well as being toxic to fish. Thus some marine snails still require chemical protection despite the presence of a shell.

Most research into molluscan natural products has concentrated on the shell-less marine snails or 'sea slugs'. One such species is the large intertidal slug *Onchidella binneyi* from California. This amphibious animal produces a milky white secretion to deter potential predators. The defensive secretion is primarily sugary



mucus but it also contains a compound called onchidial. Onchidial not only deters intertidal predators, but it irreversibly inhibits an enzyme involved in mammal neurotransmission. The specific biological activity of onchidial means that it could have potential medical applications in the relaxation of overactive nervous systems. Several species of *Onchidella* and its relatives occur in the mangroves and estuaries around Australia, and these would certainly be worth investigating.

Some of the most appealing marine molluscs are the brightly coloured nudibranchs, literally meaning 'naked gills'. These sea slugs are adorned with a beautiful cluster of feathery gill plumes, which in some species can be rapidly withdrawn into a cavity on their backs. They boldly display colour combinations such as pink, red and orange and the result is a living artwork. It has been suggested that nudibranchs use these bright colours to warn potential predators of their toxic nature. Indeed a great variety of toxic chemicals has been isolated from the nudibranchs. Many nudibranchs appear to sequester these toxins from their chemically endowed prey, such as the sponges, ascidians (sea squirts) and anemones (see *Nature Aust.* Winter 1986). These compounds are often too toxic to be used directly as pharmaceutical agents but they do provide important leads for the chemical synthesis of drugs.

ONE INTERESTING *shell-less mollusc, the sea hare, harbours the most potent anticancer compound known to humans.*

Another interesting shell-less mollusc is the sea hare *Dolabrifera dolabrifera*. Sea hares graze on algae and their name reflects their ecological role as hares of the ocean. With a plain olive-green colouration and wart-like projections, these creatures have been unfairly described as the ugly sisters of the nudibranchs. Being well camouflaged among intertidal algae, most people would walk straight past one of these sea hares, or perhaps slip on its slimy surface as it ejects a mucous defence. But these creatures are of great potential value. *Dolabrifera dolabrifera* is the unstudied 'sister' of another sea hare, *Dolabella auricularia*, which harbours the most potent anticancer compound known to humans. The toxic nature of this cosmopolitan sea hare has actually been known for over two millennia. In fact, extracts from the species were used as early as 200 BC by the ancient Greeks to treat a variety of diseases. After ten years of research an anticancer agent isolated from this sea hare is now in final-stage clinical trials in the United States.

Another group of molluscs, well known in ancient times, are snails from the family Muricidae. Also known as the purples or murexes, these marine whelks were the only source of a natural dye called Tyrian Purple. The rarity of this colour from other natural sources meant that the murexes were a highly valuable resource for nearly 3,000 years (from at least 1400 BC to 1453 AD). In Roman times some species of murex were even offered as gifts to the gods and many Mediterranean centres grew rich from the harvesting and production of the dye. During this period it is likely that many species of murex were overexploited. The murexes produce the purple compound in a small gland and it takes 1,200 large individuals to obtain only one gram of the dye. However, by around 380 AD Tyrian Purple became protected by laws that restricted its use to the emperors and members of the clergy. It is likely that this was the first law that was ever passed to protect a natural marine resource.

Until recently, there has been no explanation for the natural function of Tyrian Purple. In fact it has been stated that the purple dye is of no advantage to the snails. However, my research on the Australian murex *Dicathais orbita* indicates that the purple compound is actually the breakdown product of a novel antibiotic that is used to sterilise the egg mass of this species. Two compounds related to Tyrian Purple are found in the egg mass and these effectively inhibit the growth of both marine and human pathogens. One of these compounds is at least as potent as

THE ADHESIVES USED BY OYSTERS TO ATTACH THEMSELVES TO THE ROCK SURFACE *have been investigated and it is thought that medicine may find a use for them, such as sealing wounds in internal organs.*

penicillin and is considered to be a useful drug lead.

Many marine molluscs, both shelled and shell-less, deposit egg masses that are devoid of any apparent physical or parental protection and yet they don't appear to have any major natural predators or pathogens. This suggests that shelled molluscs may provide a much greater opportunity for the discovery of useful chemicals than was previously thought. In fact, my studies on a wide variety of molluscan egg masses has shown that most molluscs protect their eggs with antimicrobial chemicals.

The egg masses of marine molluscs come in a great variety of forms. Some hang like droplets from the bottom of a boulder, such as the delicate capsules that enclose the next generation of the tall, slender, black mitre shell *Mitra carbonaria*. These eggs, like those of the murex *Dicathais orbita*, undergo rapid colour changes in sunlight, from white through orange to a deep magenta. Others, such as the nudibranchs, embed their eggs in colourful, gelatinous ribbons. These are attached to boulders in an anticlockwise spiral, then left to defend themselves with nothing but the help of toxic chemicals. The compounds responsible for protecting these egg masses have not yet been identified. Thus Australian marine molluscs offer a novel source of natural products and enormous pharmacological potential.

Other possibly useful products from molluscan egg masses include the adhesives used to attach the eggs to the substratum. Glues from marine sources have the ability to stick under water and are resistant to corrosion. The adhesives used by oysters to attach themselves to the rock surface have been investigated and it is thought that medicine may find a use for them, such as sealing wounds in internal organs.

THERE HAS BEEN SOME concern over the exploitation of marine biological resources for medicinal purposes (see *Nature Aust*. Autumn 1997). While these concerns are definitely justified, collection of large quantities of marine organisms for pharmaceutical research is fairly uncommon and mostly unnecessary. Over the last decade we have seen the miniaturisation of biological assay systems and the development of sophisticated analytical techniques that permit the identification of many natural products from fairly small amounts of material (less than 500 grams). Once identified, active compounds can often be chemically synthesised or produced by a variety of other artificial means. This prevents the need for large-scale collections for clinical trials or pharmaceutical sales.

Nevertheless, some marine organisms are likely to be vulnerable to even small collections and care must always be taken to prevent overcollection. My research on the egg masses of marine molluscs is a case in point. Because the distribution and abundance of many of the species I chose to study was unknown, I conducted surveys to ensure that only a small proportion of the populations was collected. Thus natural-products research has stimulated studies on the natural history of marine molluscs and this should ultimately contribute towards their conservation. In general, however, bioprospecting for pharmaceuticals can be environmentally sustainable, as long as natural-products chemists pay attention to the importance of biological data.

Of greater concern is the disappearance of organisms, and the destruction of habitats, before anyone has had the chance to explore them. Bioprospecting has no long-term potential unless there is an intensified effort to conserve biological diversity. The continued discovery of useful medicinal compounds from the sea depends on the maintenance of large viable populations and appropriate habitat. My research on temperate Australian marine molluscs indicates that, for many species, suitable breeding habitat is hard to come by. Only the toughest species can survive the harsh living conditions on the open coast, where crashing waves can toss enormous boulders as if they were pebbles. Many molluscs deposit their egg masses on the underside of boulders and for these species the chance that an unpredicted storm could destroy the next generation is too great a risk to take. Suitable breeding sites for many different molluscs on the south-eastern coast of Australia appear to be largely restricted to the northern side of

KIRSTEN BENKENDORFF

The sea hare *Dolabrifera dolabrifera* is well camouflaged amongst intertidal algae but may still produce toxic chemicals to protect it from predation.

KIRSTEN BENKENDORFF

The ancient dye Tyrian Purple is the breakdown product of antibiotics that are used by murex snails to sterilise their egg masses. Similar compounds are found in the egg capsules of the common Australian murex *Dicathais orbita*.

large headlands. These are the only spots that are suitably protected from the predominantly south-easterly swell.

Along the coast of Wollongong, New South Wales, sheltered reefs are rare. One of the most pristine and biologically diverse sites occurs on the northern side of Bass Point, Shellharbour. Here, protected water-filled hollows provide the perfect refuge from the onslaught of the sea and it is here that many molluscs come to lay their eggs. However, the marine area surrounding Shellharbour is currently threatened by the approved development of a 350-berth, open-water boat harbour. The extent of environmental degradation that could result from the construction of this boat harbour is unknown. I hope that it does not become another example where thoughtless planning and the undervaluing of natural ecosystems lead to the loss of a priceless biological resource.

We need make no excuses to preserve biological diversity; it is intrinsically valuable. But clearly, the need to conserve biodiversity is more likely to be appreciated if people realise the wide variety of resources that nature provides. The resource value of natural ecosystems extends far beyond the acquisition of commodities, such as food and potential pharmaceuticals. It encompasses ecosystem services, recreational and aesthetic value, as well as the knowledge that can be gained through the study of the evolution of life. To ask the value of important marine habitat, like Shellharbour, is like asking the worth of an irreplaceable library or art collection. How can we put a price on a living artwork? And what is the price of a cure for cancer? To effectively conserve our natural marine resources we must appreciate the inherent value and vulnerability of marine biological diversity.

FURTHER READING

Baker, J.T., 1974. Tyrian Purple: an ancient dye, a modern problem. Endeavour *33: 11–17.*

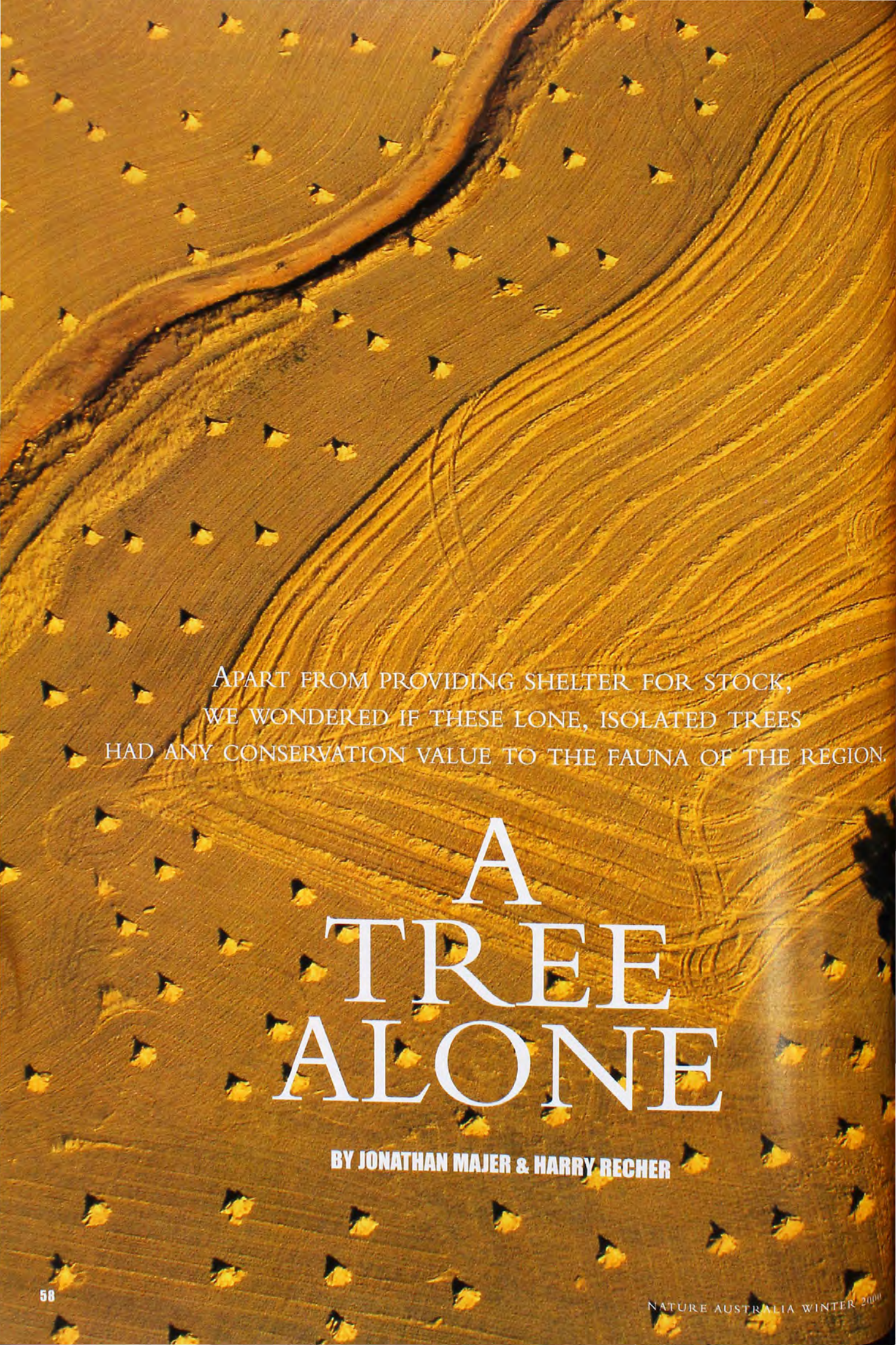
Beattie, A.J., 1994. Conservation, evolutionary biology and the discovery of future biological resources. In Conservation biology in Australia and Oceania, *ed. by C. Moritz and J. Kikkawa. Surrey Beatty & Sons: Sydney.*

Benkendorff, K., 1999. Molluscan resources: their past, present and future value. pp. *316–321 in* The other 99%: the conservation and biodiversity of invertebrates, *ed. by W. Ponder and D. Lunney. Royal Zoological Society of New South Wales: Sydney.*

Benkendorff, K. & Ayre, D., 1998. Submission from the Australian Flora and Fauna Research Centre regarding the proposed Shell Cove boatharbour/marina development. http://www.uow.edu.au/science/research/affrc/shellcove/shellhome.html

Faulkner, D.J., 1995. Chemical riches from the oceans. Chemistry in Britain *Sept. 1995: 680–684.*

DR KIRSTEN BENKENDORFF OBTAINED HER PHD FROM THE DEPARTMENTS OF BIOLOGICAL SCIENCES AND CHEMISTRY AT THE UNIVERSITY OF WOLLONGONG, WHERE SHE IS CURRENTLY A RESEARCH FELLOW. HER RESEARCH IS ON THE ANTIMICROBIAL PROPERTIES AND CONSERVATION STATUS OF AUSTRALIAN MARINE MOLLUSCS. SHE WON THE YOUNG AUSTRALIAN OF THE YEAR 2000 AWARD IN SCIENCE AND TECHNOLOGY FOR HER WORK ON MARINE ORGANISMS.



APART FROM PROVIDING SHELTER FOR STOCK, WE WONDERED IF THESE LONE, ISOLATED TREES HAD ANY CONSERVATION VALUE TO THE FAUNA OF THE REGION.

A TREE ALONE

BY JONATHAN MAJER & HARRY RECHER

Isolated trees, such as this Wandoo, support an abundant and diverse arthropod fauna. As well as contributing to the maintenance of arthropod biodiversity, these trees provide a food source for insectivorous birds that may be traversing the landscape.

JAY SARSON/TOOBIAN TRANSPARENCIES

PICTURE YOURSELF DRIVING through the countryside. The view is an endless expanse of paddocks, punctuated by the occasional nature reserve, a bush remnant on a farm, or a strip of vegetation along a watercourse or road. Our forefathers did a good job of clearing the bush—they cleared all but around seven per cent of it in the Western Australian wheat belt, and in Queensland and New South Wales we are still cutting it down.

Looking across the paddocks you see a lone tree that escaped the clearing. In some regions, as on the Northern Tablelands of New South Wales, the density of paddock trees is quite high, often blending into the trees of remnant bushland. This is called a 'variegated' landscape. Elsewhere, as in the wheat-growing areas of eastern and western Australia, there is an abrupt transition from the dense vegetation of the bush to the paddocks with their lone, scattered trees—a landscape referred to as 'fragmented'. The paddock trees in such landscapes can range in density from over 100 per hectare down to none.

Apart from providing shelter for stock, assisting to maintain water-table levels and reducing erosion, we wondered if these lone, isolated trees had any conservation value to the fauna of the region. With the aid of a grant from the Australian Research Council, we set out to answer this question using sites on the New England tablelands of New South Wales and in the Western Australian wheat belt.

THE STIMULUS FOR this investigation came from our previous work on insects and birds in uncleared forest in Western Australia and New South Wales. We sampled insects, spiders and other arthropods by hanging circular nets in the tops, or canopy, of tall trees and then spraying the trees with a fast-acting pyrethrin pesticide. From a total of only 40 trees of each of four species spread over the four seasons, we identified more than 1,600 species. This is almost as many as the species of birds, mammals, reptiles and frogs on the entire Australian continent.

Analysis of the nutrients in the leaves showed that trees with the highest nutrient levels supported the most arthropods and the greatest number of species. These in turn attracted more birds. Also, the New South Wales soils were richer in nutrients than those in Western Australia, leading to higher nutrient levels in the tree species from the east and richer, and more abundant arthropod and bird faunas.

JONATHAN MAJER

For our new study, we sampled Wandoo (*Eucalyptus capillosa*) trees in the wheat belt east of Perth, and Yellow Box (*E. melliodora*) trees near Armidale, New South Wales on the Northern Tablelands. At a range of sites, we compared trees in four situations: in the centre of intact woodland remnants, at the more

MARIE LOCHMAN/LOCHMAN TRANSPARENCIES

degraded edges, along road reserve corridors, and isolated in paddocks. Having designed our experiment, we set out to sample the trees for arthropods by the procedure we had used in our forest work. It was here that we experienced a major setback.

As a testimony to the effect of land clearing on the weather, even a moderate breeze at ground level became a gale in the tree tops and overturned the nets hung in trees. After attempting to weigh down the nets, we abandoned them in favour of a new technique we call 'branchlet shaking'. This involved accessing the canopy by cherry picker, grabbing tufts of foliage, and vigorously shaking them into an insect-collecting net. For each tree 60 branchlets were shaken into the net. After separating the arthropods from the inevitable debris of leaves, bark and dust, we identified and counted them. We also measured the nutrient contents of the foliage and the soil beneath the trees.

Initially, we sorted our catch to the

(Above) The canopy of a mature stand of Wandoo trees contains a rich and characteristic arthropod fauna. This diversity is further complemented by different types of animals associated with the bark, the leaf litter and the other plants in the woodland.

(Left) Even weighing down the nets with water-filled balloons was not enough to prevent the wind from overturning them in the open paddocks.

JONATHAN MAJER

level of order, that is to spiders, mites, beetles, thrips and so forth, and compared the numbers on trees growing in the four different situations. Arthropods were remarkably abundant on the isolated trees in paddocks and corridors, as abundant and often more so than in the remnants. This surprised us as we had assumed that these isolated and rather lonely-looking trees would have a relatively poor fauna by virtue of their isolation and increased exposure to the elements. However, just comparing total numbers was misleading. Some groups, such as sucking bugs, spiders and small wasps, were generally most abundant on trees at the remnant edge or in the paddock, while others seemed to prefer the remnant centres. So, although we found similar numbers of arthropods in the canopies of trees almost regardless of where they were growing, the kinds of arthropods and their relative abundances were different in each growing situation. As we had found in the forest, arthropods were much more abundant on the New South Wales trees than those in the Western Australian wheat belt. All of this required explanation and we again thought about a connection with nutrients.

ISOLATION AND *greater exposure affect how many and what kinds of animals can survive on paddock and corridor trees.*

The level of nutrients in the soils of the paddocks and corridors were generally higher than in the remnants, a trend that was also exhibited by the levels of leaf nutrients. No doubt this was a result of nutrient enrichment from fertilisers and animal excreta. As in our previous studies, high levels of nutrients in the soil and foliage encourage an abundance of grazing and sap-sucking insects, which in turn should attract predators.

However, nutrients cannot explain all the differences we observed. No doubt isolation and the greater exposure to the wind and sun affect how many and what kinds of animals can find, and survive on, paddock and corridor trees. The trees at the edges of remnants are also more exposed and should have different kinds of arthropods from those in the more sheltered remnant centres.

Having established that isolated trees were able to support high invertebrate

(Above) The authors resorted to sampling the fauna by shaking branchlets of foliage into a rectangular net. Here, the cherry picker is being positioned in preparation for taking the samples.

(Right) Live and dead pasture trees provide nest sites for Red-rumped Parrots (*Psephotus haematonotus*), which feed on the seeds of introduced weeds in the surrounding pastures. This bird species has become more abundant in the last decade in response to the increasing weediness of our environment.

populations, we went on to analyse some of the orders at the species level. It is important to do this because the entire count of animals within a given category could consist of one or a few 'weedy', cosmopolitan species, rather than a diverse array of native species. Taking just the beetles as an example, the total number of species in the four growing situations were 43 on Wandoo and 49 on Yellow Box. Paddock trees supported as diverse an array of beetle species as trees in other growing situations, with up to 12 and 31 species on Wandoo and Yellow Box paddock trees respectively, compared with 20 and 28 species on Wandoo and Yellow Box growing in blocks of remnant vegetation.

However, in Western Australia, the paddock and corridor trees supported a different beetle fauna to that in the remnants. By contrast, the corridor trees in New South Wales supported a similar beetle fauna to that of the remnants, although it differed from that in the paddocks. These differences cannot be explained by differences in nutrients. Instead, it seems likely that the differences between east and west are the result of land-clearing patterns. The corridors in New South Wales are wider and less isolated than in the Western Australian wheat belt, and are therefore more like the remnants themselves. This is also true for the paddock trees in the east, but the differences between them and the trees in the remnants and corridors suggest that even a small increase in isolation has a significant effect on the kinds of insects found on a tree.

Birds also used the trees we sampled. We counted 16 species visiting paddock trees in the west, compared with 36 in the remnants and 26 in the corridors. About the same number of bird species visited paddock trees in the east as in the west, but the eastern remnants and corridors had more than twice as many species. Paddock birds were generally the larger and more aggressive species, like Magpies, hawks, ravens, parrots and large honeyeaters. Many of these feed on the ground and use the trees for nesting and shelter. The smaller insect-eating thornbills and warblers never visited paddock trees or the narrow corridors of the west, but the tiny pardalotes and the large, insectivorous cuckoo-shrikes were regular visitors to paddock trees in both the east and west.

These differences in bird species help explain why paddock trees can be so rich in arthropods—basically there are fewer birds eating them. Nevertheless, paddock trees are still important for birds. Work done by others in northern New South Wales shows that the big, old paddock trees with their numerous hollows are used as nesting and resting places by parrots and owls, as well as possums and bats.

TREES IN PADDOCKS and along corridors have values far beyond those attributed to them by farmers as windbreaks and shelter for stock. For one thing, they provide food and shelter for birds that move across the landscape. Birds moving between bush remnants can rest and feed on such trees, in effect using them as a lunch stop. Where the abundance of invertebrates is elevated by raised leaf nutrients, food is plentiful. In providing this resource, paddock and corridor trees are a vital link in the highly diminished matrix of native vegetation.

Even lone trees in paddocks contribute to the maintenance of invertebrate biodiversity in the farm landscape. An isolated tree is a 'living zoo', supporting many of the elements of the invertebrate fauna that formerly occupied the landscape. Of course, these animals are not confined to a single tree. Like the birds, many of them fly, or are blown, across the land and interact with other trees and the fauna on those trees. Even the spiders are blown about on silken threads. By promoting a network of trees on our farms, we help to maintain the legacy of the original fauna. Paddock trees and those in corridors are not a substitute for larger remnants and conservation reserves, but they are invaluable. They complement conservation reserves and enhance the ability of reserves to protect Australia's unique plants and animals.

In many agricultural areas, the opportunity to retain trees has gone—most have been cut down or have died. The insects that are such an important part of these trees may even hasten their death by feeding too heavily on foliage and sap. It would help to encourage more birds, especially the smaller insect-eaters, by planting not only more trees, but shrubs and ground vegetation for shelter and nesting.

With the current move to 'green' our road verges and revegetate areas within our farmlands, there is the potential to provide for our invertebrate and verte-

HANS VERSLUIS

Harry Recher (left) and Jonathan Majer discuss the ever-increasing count of arthropod species that they are finding on trees in Western Australia and New South Wales.

JAN TAYLOR

A sawfly wasp (*Perga* sp.) with some recently hatched larvae—an example of the hundreds of species of arthropods that can be found in the canopy of Wandoo trees.

brate fauna, while beautifying the landscape and arresting erosion and salinisation. Unfortunately, many trees used in revegetation programs are not native to the region, often not even to Australia. Our observations show that non-Australian trees have a poor invertebrate fauna. Even Australian trees that are not local are sometimes unable to sustain the diversity of arthropods and birds found on plants native to the region. Planting exotics, even though they may be beautiful and easy to grow, is a wasted opportunity and really should not be done unless they are to be a commercial crop. A mix of native species, which will support a wide diversity of native animals, together with a rich plant understorey, is a much wiser option.

Next time you drive through one of our agricultural areas, look at the lone trees out there in the paddocks and remember that they are an important link in our conservation estate, one that should be maintained and, where needed, rehabilitated. If a tree is suffering from being ring-barked by stock, it should be protected; where trees are ageing, young ones should be planted. Fences should be used to restrict grazing and allow native plants to grow. If the number of trees is already so low as to be inadequate, a revegetation scheme should be drawn up and implemented. If land-holders do this, they will not only contribute to the conservation of our flora and fauna, but they will have more sustainable farmlands.

Many studies have shown that trees actually increase farm production by moderating the climate and the force of winds, and by lowering water tables. Planting trees is not only beneficial for wildlife, it is good economics. However, restoring Australia's farmlands is an enormous challenge—and not just for farmers, but for us all.

FURTHER READING

Recher, H.F., Majer, J.D. & Ganesh, S., 1996. Seasonality of canopy invertebrate communities in eucalypt forests of eastern and western Australia. Aust. J. Ecol. *21: 64–80.*

Recher, H.F. & Majer, J., 1996. One humble gum tree: home to 1,000 species. GEO *18(6): 20–29.*

Recher, H.F., Majer, J.D. & Ganesh, S., 1996. Eucalypts, arthropods and birds: on the relation between foliar nutrients and species richness. Forest Ecol. Manag. *85: 177–196.*

Stork, N., Adis, J. & Didhams, R., 1997. Canopy arthropods. *Chapman and Hall: London.*

PROFESSOR JONATHAN MAJER IS AN ENTOMOLOGIST IN THE SCHOOL OF ENVIRONMENTAL BIOLOGY AT CURTIN UNIVERSITY OF TECHNOLOGY, PERTH. AN EXPERT ON ANTS, HE HAS STUDIED THE RECOLONISATION OF MINE SITES, AGRICULTURAL LANDS AND FORESTS BY INSECTS AFTER DISTURBANCE, AS WELL AS CANOPY ARTHROPODS AND THE INTERACTIONS BETWEEN BIRDS AND INSECTS. PROFESSOR HARRY RECHER IS AN ENVIRONMENTAL SCIENTIST IN THE SCHOOL OF NATURAL SCIENCES AT EDITH COWAN UNIVERSITY, PERTH. BESIDES HIS WORK ON CANOPY FAUNA, MOST OF HIS RESEARCH IS CONCERNED WITH FOREST ANIMALS AND THE IMPACTS OF LOGGING AND FIRE ON FOREST ECOSYSTEMS.

Pumice Puzzles

BY LIN SUTHERLAND

When washed up on the Australian coast, pumice presents a natural puzzle.

PUMICE IS A well-known floating rock and often washes up onto shorelines. In some countries it is collected and used for all manner of things from a body cleanser for the bath to an industrial abrasive. Released by volcanic eruptions, the lightweight rock floats across oceans driven by winds and currents. When waterworn, this light-coloured rock can look just like hazelnut kisses, a popular sweet sold at confectionary and chemist counters. Unlike that treat, though, pumice is made of volcanic glass peppered with crystals and is quite inedible. The rock floats because it is buoyed up by myriad cavities and internal bubbles of trapped gas.

Several different volcanic rocks form pumice, which is simply a frothy variety of these rocks. Most pumices are rich in lightweight minerals such as quartz, feldspars and feldspathoids. Examples include rhyolite, dacite, trachyte and phonolite. Other volcanic rocks like basalt that contain large amounts of heavier minerals will not float even if they are well charged with gas.

When washed up on the Australian coast, pumice presents a natural puzzle. Where did it come from and when was it erupted? In late 1963 to early 1964, there was a profuse influx of pumice along southern Australian shores, and the source was pinned down to a huge volcanic eruption near the South Sandwich Islands off South America in 1962. This meant eastward travel by the pumice on the circumpolar West Wind Drift current, for over 8,000 kilometres. The pumice was prevented from spreading up the eastern Australian coast by the south-travelling East Australian Current. Pumice strandings are prevalent along the New South Wales and Queensland coasts, but these mostly come from eruptions in volcanic island chains between New Zealand and New Guinea. Pumice is also prominent on the Tasman Sea floor. Jim Lowry, a marine biologist at the Australian Museum, for example, reported pumice in many samples dredged from depths of 1,000 to 2,500 metres over an area between 158–163° E and 27–30° S. Clearly, pumice may eventually become waterlogged and sink during its drift across the sea and it is only the pumice with enough sealed gas bubbles that reaches Australian shores.

Pumice strandings are not just geological curiosities; they also deliver important biological elements. Goose barnacles, serpulid worms (a type of polychaete) and juvenile corals commonly encrust the underside of drift pumice. A study along the Great Barrier Reef showed that with each influx of pumice many thousands of coral colonies are transported from the Tonga–Fiji region, via the South Equatorial Current. This massive arrival of corals adds significantly to the coral budget of the Great Bar-

A. FLOWERS & L. NEWMAN

A close-up of pumice pieces stranded on a beach. Note the gas holes and dark mineral crystals.

rier Reef.

Pumice deposits were uncovered in excavations of an Aboriginal midden at Balmoral Beach in Sydney Harbour in 1992–1993. Archaeological investigations by Val Attenbrow from the Australian Museum, and studies of the beach profile by Riko Hashimoto from the University of Sydney, showed the main pumice layer was 3,300 years old and was deposited before the dunes had grown across the shore. The dating was based on radio-carbon measurements on charcoal found within the pumice bed. Pumice also appeared in underlying deposits dated between 3,300 and 3,500 years old, and in overlying deposits dated between 1,800 and 2,800 years old. Where did all this pumice come from? Could it have come from the one source? Donning our geological detective hats, my colleague Jane Barron (Australian Museum Geodiversity Research Centre) and I set out to solve the puzzle of the Balmoral pumice.

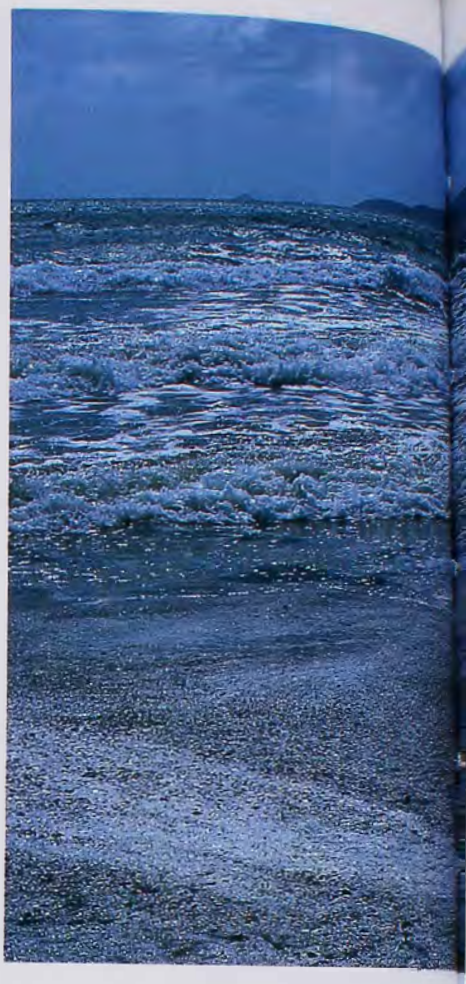
FIRST WE TOOK pumice pieces from the different layers and characterised them by analysing the embedded crystals and glassy matrix. Crystals of feldspar, pyroxene and iron oxide minerals were usually present in a silica-rich glass. This forms a combination often found in dacite lavas erupted in volcanic island arcs. Most pumices had two types of pyroxene minerals in them, some only one, so clearly variations existed among the pumices. One pumice also contained quartz crystals in a highly siliceous glass and was a rhyolite lava in composition. By a stroke of luck, the main pumice and some overly-

ing pumice contained rare crystals of olivine within the glass. This is very unusual as this magnesium-iron silicate mineral is mostly unstable in, and is generally absent from, silica-rich glass. It gave us an important clue, for this rare feature has been found in dacite from a Tongan Island submarine volcano called Metis Shoal.

The activity of Metis Shaol gives us a picture of the likely sort of eruptions that produced the Balmoral Beach pumice in the past. Metis Shoal has erupted nine times since 1851. It blew up in spectacular fashion in 1967 and again in 1979, liberating pumice and forming temporary volcanic-ash cones above the water. In other explosive eruptions in June 1995 a lava dome rose from the sea and formed a solid island up to 50 metres high and 300 metres across. The vent still showed slight activity when divers visited it in August 1998.

Pumice from Metis Shoal and other volcanoes along the Tongan-Kermadec arc is also noted for its distinctive low level of potassium. Similar low potassium levels were found in the Balmoral pumices, further confirming a Tongan-Kermadec source. To pinpoint the exact volcanoes that spawned the pumices was more of a challenge. For such fine tuning, we needed a precise inventory of the trace and rare-earth elements in each pumice to act as 'fingerprints'. We chose a special method that uses a laser beam to disintegrate the solid pumice matrix into a gaseous stream and then analyses the elements that are carried off in the gas.

The different element concentrations can be plotted on a graph. They produce spiky patterns called 'spidergrams', which are very useful for making detailed comparisons of the rocks. The Balmoral pumice 'spidergrams' suggested there were several separate sources for the pumice. The main 3,300-year-old layer differs in detail from Metis Shoal dacite and resembles pumice from more northern volcanoes in the Tongan chain. However, some of the younger (1,800–2,800-year-old) pumice pieces do closely match Metis Shoal dacite in their mineral and chemical characters. This implies that Metis Shoal has been erupting for over 2,000 years. The older (3,300–3,500-year-old) rhyolite pumice is quite different to Tongan–Kermadec lavas, resembling instead rhyolites that erupt from more southerly volcanoes, in the North Island of New Zealand.



(Above) Pumice washed up on an Australian beach after stormy weather.

(Left) The dome of emerged larva left after the 1995 eruption of Metis Shoal, Tongan islands. Note the bright yellow sulfur encrusting the dark dacite rock of the islet.

L.A. SUTHERLAND

The Balmoral pumice puzzle now appears to be resolved. When the Aborigines first saw these pumices being washed up onto the beach, they were witnessing the end of a 4,000-kilometre journey from Tonga. Such pumice journeys are not unusual, based on the few Australian studies, but many pumice puzzles remain. Where, for example, did pumice washing up on Kangaroo Island in April 1997 come from? Was it from an eruption off sub-Antarctic McDonald Island around the end of 1996? A neighbour of Heard Island, where Big Ben (the only other active volcano on Australian territory) occurs, McDonald Island lies 4,500 kilometres south-west of Perth, Western Australia. It is ideally placed to cast pumice on southern Australian shores several months later. McDonald Island pumice has been recovered and analysed, and is quite distinct from

MICHAEL CERMAK

pumice from the Pacific rim volcanoes. When the Kangaroo Island pumice is studied it should solve another pumice puzzle.

FURTHER READING

Jokiel, P.L., 1990. Transport of reef corals into the Great Barrier Reef. Nature *347: 665–667.*

Melson, W.G., Jarosewich, E. & Lundquist, C.A., 1970. Volcanic eruption at Metis Shoal, Tonga, 1967–1968: description and petrology. Smithson. Contrib. Earth Sci. *4: 1–18.*

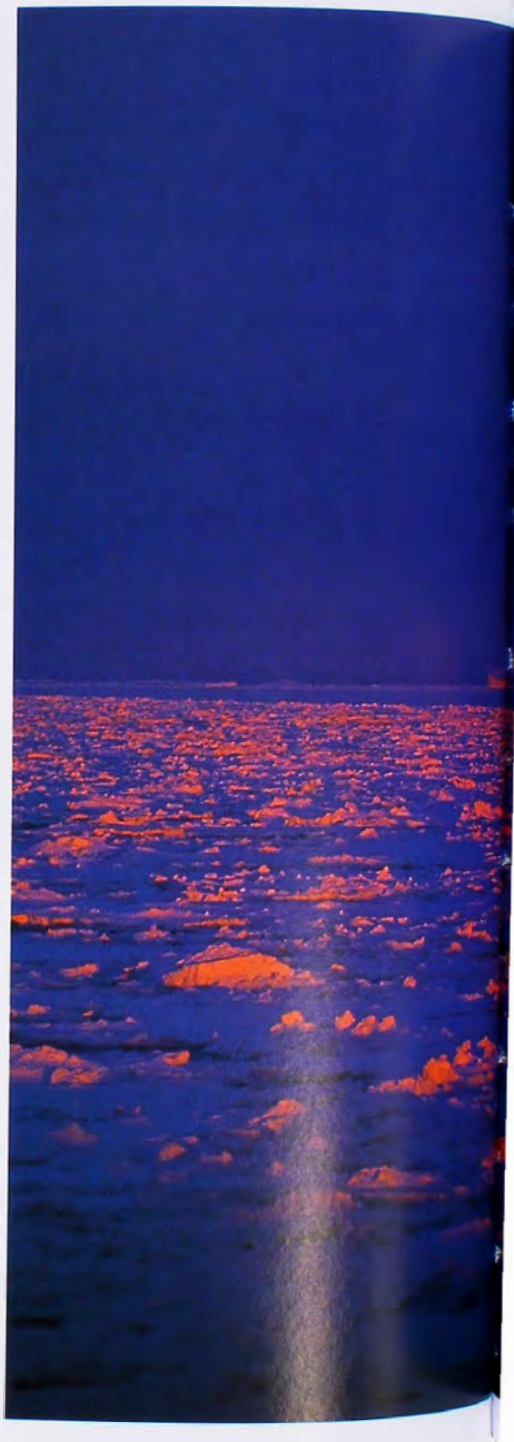
Sutherland, F.L., 1995. The volcanic Earth. *University of New South Wales Press: Sydney.*

Sutherland, F.L. & Barron, B.J., 1998. Balmoral Beach Aboriginal shell midden, Port Jackson, Australia: pumice petrology and sources. Rec. Aust. Mus. *50(3): 241–262.*

DR LIN SUTHERLAND IS A PRINCIPAL RESEARCH SCIENTIST AND LEADER OF THE GEODIVERSITY RESEARCH CENTRE AT THE AUSTRALIAN MUSEUM.

frostbite

BY TONY KARACSONYI



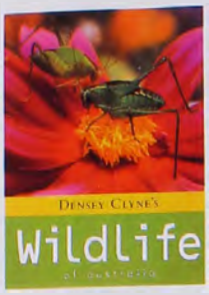
frostbite

frostbite

reviews

Wildlife of Australia

By Densey Clyne. New Holland, NSW, 1999, 144pp. $29.95rrp.



FOR THOSE WHO LIKE excellent wildlife photos with easy-to-read and well-explained text, this book is a must. The numerous photos are mostly by Densey but a few are by Jim Frazier and Glen Carruthers, both of whom have worked with her on various projects. All the photos are good, clear, and usually have artistic merit. They also often show interesting behaviour instead of just being portrait shots.

The book has 30 chapters on a variety of wildlife observations all over Australia, from slugs to kangaroos, and from outback Australia to the middle of Sydney. All this is written in Densey's unique style, which is both entertaining and informative. Much of the subject matter deals with familiar animals, or at least those that we are more likely to have heard of, although even these animals are often revealed in a different light. The behavioural observations are largely Densey's own. The result is a unique look at wildlife through the eyes of a keen observer. This book would be a welcome addition to any naturalist's library.

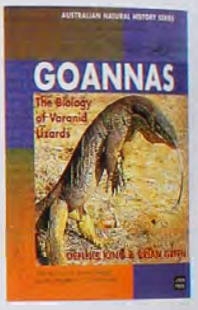
—MARTYN ROBINSON
AUSTRALIAN MUSEUM

Goannas: The Biology of Varanid Lizards

By Dennis King and Brian Green. Australian Natural History Series, UNSW Press, NSW, 1999, 116pp. $29.95rrp.

Sea Snakes

By Harold Heatwole. Australian Natural History Series, UNSW Press, NSW, 1999, 167pp. $29.95rrp.

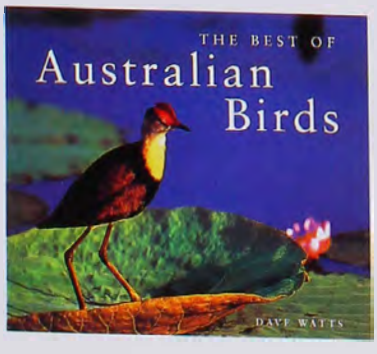


GOANNAS AND SEA SNAKES ARE THE REPTILIAN component of the Australian Natural History Series published by University of New South Wales Press. Both titles have appeared previously, *Sea snakes* in 1987 and *Goannas* in 1993 under similar series titles. The revised format for the two texts is parallel in presentation, with the addition of 12 pages of colour plates as a centre block. The 1999 version of *Sea snakes*, while adapted from the original 1987 text, is extensively rewritten and recent research has been incorporated into the text. Sea snakes are an unusual group of reptiles and much of the information is published in scientific journals or texts not readily available to most people. This book has succeeded in bringing together information on a number of aspects of the biology of these reptiles in a very readable style, while still containing sufficient detail to satisfy a more intense interest in the subject. *Goannas*, on the other hand, is similar in presentation and style but suffers from lack of depth. The 1999 edition is essentially a reprinting of the original, with an extra chapter on parasites. While the suggested reading list has been updated to include more recent references, this new information has not been incorporated within the body of the text. Although both texts are excellent introductions to their respective groups of reptiles, someone interested in goannas would be advised to refer to the goanna chapter in Greer's 1989 book *Biology and evolution of Australian lizards*. Even though this book was published four years prior to the first edition of *Goannas*, it provides a more comprehensive appreciation of this group of lizards.

—ROSS SADLIER
AUSTRALIAN MUSEUM

The Best of Australian Birds

By Dave Watts. New Holland, NSW, 1999, 128pp. $29.95rrp.



DAVE WATTS IS ONE OF AUSTRALIA'S premier wildlife photographers. As the photo editor for *Nature Australia* and Australian Museum publishing, I have watched David's work blossom over many years, eagerly looking through his photographs whenever I've needed pictures for one publication or another.

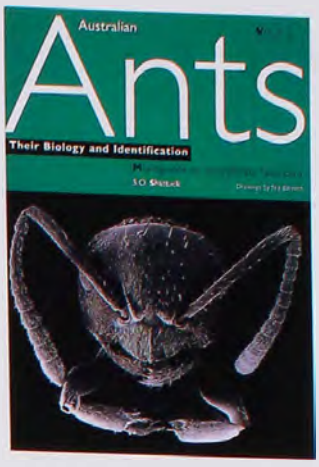
The pictures in *The best of Australian birds* are superb. Whether you're a twitcher, natural-history buff or just someone who thinks birds are attractive, you won't be disappointed. The book is well designed and beautifully simple. The text, which is mainly extended captions, has an introduction to each section (for example Wetlands, Coasts and Islands, Forests etc.) that helps to create an overall picture of the habitat in which the birds live. It is necessary to think of birds as part of an ecosystem and to understand that, while some birds are highly adaptable, others are so specialised that any change to their habitat is disastrous.

I was happy to be able to review this book, because it gave me the opportunity to thank Dave for his brilliant work in bringing the beauty of birds to everyone.

—K.L.

Australian Ants: Their Biology and Identification

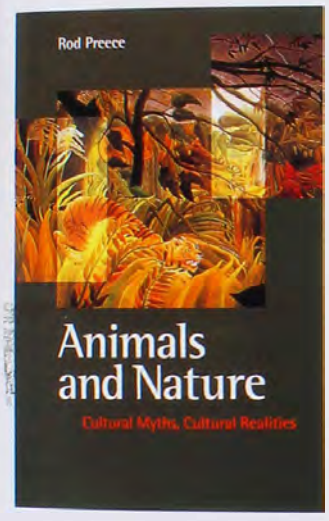
By Steven O. Shattuck. CSIRO Publishing, Vic., 1999, 226pp. $89.95rrp.



THIS ATTRACTIVE INTRODUCTION TO Australian ants is designed for both the specialist and the enthusiast using minimal technical language and extensive illustrations. The book contains an introductory section with information on the general biology of ants, distribution patterns, colony structure, life cycle, nests, feeding, pest status, ants as environmental indicators, their classification and identification, collecting and preparation of specimens. For those who wish to identify ants, there is an illustrated key to the subfamilies and the 103 genera of ants known to occur in Australia, with diagrams of the characters used in identification. The bulk of the book is detailed notes on all the genera of ants found in Australia, including more details to aid identification, biology, distribution and habitat, and a list of species and subspecies. Each genus has a distribution map showing known collection sites, and most have scanning electron micrographs of worker ants. There is a small glossary to define the few technical terms used and a useful reference list.

Australian ants is a great introduction to the diverse and fascinating ant fauna of Australia. It is an invaluable resource for anyone interested in the ants of Australia. It is the only book with a complete overview of the entire Australian ant fauna, the first to show the known distribution of all known Australian ant genera, and lists all the described species and subspecies of Australian ants. The use of line drawings to illustrate the keys to subfamilies and genera makes them amoung the easiest-to-understand keys I have ever used. The use of scanning electron micrographs for each of the genera not only improves the appearance of the book, but illustrates the rich diversity of these amazing organisms in a way that the line drawings of previous books could not. I highly recommend this book.

—DEREK SMITH
AUSTRALIAN MUSEUM



Animals and Nature: Cultural Myths, Cultural Realities

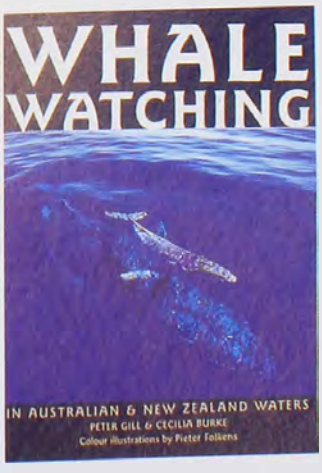
By Rod Preece. Distributed in Aust. by Unireps, University of New South Wales, 1999, 305pp. $45.00rrp.

IN *ANIMALS AND NATURE* Preece juxtaposes how humans really behave towards the rest of the natural world (cultural realities) with what humans regard as ideal behaviour (cultural myths). He is at great pains to show that reality falls far short of the ideal. To do this, he has drawn on the literature of various disciplines to provide the reader with many intriguing and sometimes disturbing accounts of cultural practices in both contemporary societies and those of the past. He mainly addresses himself to readers who have grown up in the Western world because, he argues, many Westerners have been convinced that mistreatment of the natural world is embedded in Western modes of thought. This self-denigration has been a part of Western thought for at least several centuries. Preece, although no apologist for the West, wants to dissuade Westerners from dismissing their own intellectual traditions. His argument is that there is a considerable gap between the ideal and the reality in most cultures, and that in searching for a way towards a future that minimises or eliminates cruelty to other species, it is best to start with a clear view of both the positive and negative aspects of one's own traditions. *Animals and nature* not only adds to the public debate on environmental and animal-rights issues, but offers some interesting insights into the very nature of intellectual debate in contemporary Western society: you may want to argue with the author!

—MIRIAM CHAPMAN
AUSTRALIAN MUSEUM

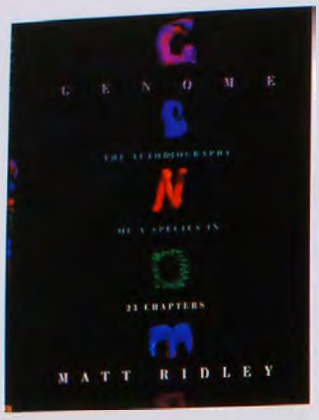
Whale Watching in Australian & New Zealand Waters

By Peter Gill and Cecilia Burke. New Holland, NSW, 1999, 148pp. $24.95rrp.



WHALE WATCHING IS a million-dollar industry in Australia and rightly warrants some good Australian books and literature on the subject. What sort of information is needed to enable people to gain more from the experience, or indeed make sure the whales and dolphins also 'gain' by a better-informed human audience? A combination of mini-field guide and natural-history book, including practical information on where to go and what to see, is the answer. This book does all that and more. It is a well-written, easily understood guide to what whales are and how they live. It provides information on how to identify the whale being watched, and some guide to understanding whale behaviour. It also documents all the known locations where whales can be seen, species that are likely to be observed there, and the available facilities, such as accommodation and tour boats. All this in a light field-guide size book designed to survive the odd splash of sea water, should the reader be lucky enough to experience the really close encounters with whales and dolphins that Australian and New Zealand waters are increasingly likely to provide.

—LINDA GIBSON
AUSTRALIAN MUSEUM



Genome: The Autobiography of a Species in 23 Chapters

By Matt Ridley. Allen & Unwin, NSW, 1999, 336pp. $45.00rrp.

OF THE MANY BOOKS that will undoubtedly be written on the advent of the revelation of the complete human DNA sequence, I expect that this will be one of the most thought-provoking. *Genome* (the author has appropriated the most important word of this era as his title) is well written and a pleasure to read.

Ridley uses a slightly contrived device to organise this material: each chapter is a 'chromosome'—number 1 to number 22, with 'X and Y' slotted in between chromosomes 7 and 8. There is generally some tenuous connection between a gene on the chromosome in focus, and the subject (and subtitle) of the chapter, but fortunately he does not let this chromosomal linkage restrain the flow of ideas. Chapter subtitles include "Life", "Fate", "Politics", "Death" and "Free Will".

It is obvious that Ridley has thoroughly researched, and is very familiar with, his subject matter. He presents us with a carefully chosen selection, ranging from the early history of genetics, to the very latest findings of research. Topics that a reader might already be familiar with are recounted entertainingly, and there will be something new for everyone. The book contains fascinating information, well compiled into a coherent narrative, and it leads to conclusions that may profoundly affect the reader's view of him/herself.

This book deserves a wide audience. I think that, as well as being for any reader who is interested in the field of science with the greatest human relevance, *Genome* has the potential to be useful as a text in courses and discussion groups about philosophical aspects of biology and science in general, or the implications of genetics for philosophy or for society. The book should be understood by a reader without much background in science and, for those who need it, Ridley gives an optional four-page 'executive summary' of key genetic terms and concepts in the preface.

Genome is not just a review of the state of genetics at the end of 1999, with the usual agonising about cloning, designer babies and genetically modified potato chips. Ridley has his own views, which are presented without didacticism, without condescension, with sense and reason, and with dry wit.

And if you are not a convinced genetic determinist by the time you have finished reading this book, then you are unlikely ever to become one—but the evidence will have been presented to you and, if you can't face its implications, it's probably because of something in your DNA.

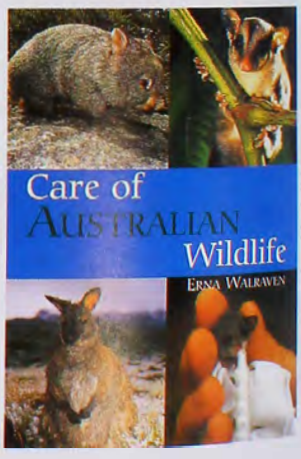
—ADAM MARCHANT
ROYAL BOTANIC GARDENS SYDNEY

Care of Australian Wildlife

By Erna Walraven. New Holland, NSW, 1999, 140pp. $19.95rrp.

Caring for Australian Native Birds

By Heather Parsons. Simon & Schuster, NSW, 1999, 120pp. $24.95rrp.



FOR MANY AUSTRALIANS, a daytime encounter with a native mammal, bird or reptile occurs only after that animal has sustained an injury or is sick. Correct handling and effective emergency care can mean the difference between full rehabilitation to life in the wild and prolonged suffering and death. Fortunately, these two authors have attempted to share with their readers the fascination of close association with Australian fauna and to pass on some of their expertise, backed by many years of experience.

Erna Walraven correctly emphasises the importance of establishment of good habitat for fauna and gives advice about how to set up a good environment or modify, with minimum expense, an existing garden. This will provide adequate food and shelter for free-living fauna in the urban or suburban setting—the primary level of care for all wildlife. However, for animals that do require care, the remainder of the book is a useful introductory guide to basic first-aid measures and handling procedures. A wide range of animals is covered, and this book is a valuable guide for anyone regularly involved in rescue of wildlife or who is likely in the course of travel or work to come upon an injured or orphaned animal.

The second book, as the title describes, is specifically about birds, particularly those of eastern Australia. The information about identification, rescue, care and rehabilitation is given in far more detail and will be of great use to the many people involved in care of injured birds, and also to those inexperienced in initial handling. Food requirements are described in detail for different bird groups; as are methods of starting up and maintaining colonies of live food. Important supplementary information is given in the appendices, such as normal weight ranges for adult birds, arrival and departure dates for migratory birds, and a comprehensive bibliography.

Both books contain an index that is easy to reference in an emergency situation; contact addresses are also given for professional assistance. Illustrations and photographs enrich the two texts and clarify descriptions. Both Walraven and Parsons are passionate about Australian wildlife, and enjoy a close relationship with it. By publishing these books they hope to share their passion with you.

—TISH ENNIS
AUSTRALIAN MUSEUM

SOCIETY PAGE

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

ANIMAL WELFARE

African Wildlife Rescue
PO Box 27
Mount Nebo Qld 4520
Ph: (07) 3396 5926
Contact: Mike King
Membership: $15 single, $25 family

WIRES - NSW
PO Box 260
Forestville NSW 2087
Ph: (02) 8977 3333
Web:www.wires.webcentral.com.au
Contact: Sheridan Thomas
Membership: $30

WRIN (Wildlife Rescue & Information Network Inc.)
30 Collins St
Kangaroo Flat Vic. 3555
Ph: (03) 5441 3211
Contact: Rob Schrieber
Membership: $15

ASTRONOMY

Western Sydney Amateur Astronomy Group
PO Box 400
Kingswood NSW 2747
Ph: (02) 4739 1528
Contact: Dave Gault

BIRDS

Cumberland Bird Observers Club Inc.
PO Box 550
Baulkham Hills NSW 1755
Ph: (02) 9769 0928
Contact: Rob Gibbons
Membership: $25 family; $22 metro; $15 pensioners/students/country

South Australian Ornithological Assoc.
c/- SA Museum
North Terrace
Adelaide SA 5000
Ph: (08) 8303 4498
Contact: John Hatch
Membership: $33

CONSERVATION

Australian Plants Society
PO Box 744
Blacktown NSW 2148
Ph: (02) 9621 3437
Contact: Mary Lou Simons
Membership: $35 single; $28 concession; $40 joint

Australian Trust for Conservation Volunteers
Box 423
Ballarat Vic. 3353
Ph: (03) 5333 1483 or freecall 1800 032 501
Web: www.atcv.com.au
Contact: Madeline Townsend
Membership: $30

National Parks Association of NSW
Level 4, 83—87 Castlereagh St
Imperial Arcade
Sydney NSW 2000
Ph: (02) 9233 4670
Contact: Kristi MacDonald
Membership: $43 adult; $48 household; $23 concession

Society for Growing Australian Plants (Qld Region) Inc.
PO Box 586
Fortitude Valley Qld 4006
Ph: (07) 5546 9494
Web: www.sgapqld.org.au
Contact: Mr Ian Waldron
Membership: $37 new members; $32 renewals

Tasmanian Conservation Trust
102 Bathurst St
Hobart Tas. 7000
Ph: (03) 6234 3552
Contact: Alistair Graham
Membership: $25

EDUCATION

CSIRO's Double Helix Science Club
PO Box 225
Dickson ACT 2602
Ph: (02) 6276 6643
Web: www.csiro.au/helix
Contact: Lynn Pulford
Membership: $27.50

Gould League of NSW Inc.
PO Box 16
Gladesville NSW 2111
Ph: (02) 9817 5621
Contact: Cath Hitchcock
Membership: $40

Science Teachers' Association of Victoria
PO Box 190
Richmond Vic. 3121
Ph: (03) 9428 2633
Website: www.stav.vic.edu.au
Contact: Dianne Hayes
Membership: $90 primary; $100 secondary

ENVIRONMENTAL

Friends of the Platypus
PO Box 84
Whittlesea Vic. 3757
Ph: (03) 9716 1626
Website: www.totalretail.com/platypus
Contact: Geoff Williams
Membership: $30 adult; $20 student; $45 family

MUSEUM

Queensland Museum Assoc. Inc.
Box 3300
South Brisbane Qld 4101
Ph: (07) 3840 7632
Contact: Carol Middleton

TAMS - The Australian Museum Society
6 College St
Sydney NSW 2000
Ph: (02) 9320 6225
Contact: Michelle Ball
Membership: $55 single; $75 household; $40 student

NATURAL HISTORY

Launceston Field Naturalists Club Inc.
PO Box 1072
Launceston Tas. 7250
Ph: (03) 6344 1076
Web: www.tased.au/tasonline/ltnfdnat/linkhtm
Contact: Dr A Pegler
Membership: $15 single; $20 family; $2.50 junior

NT Field Naturalists Club
PO Box 39565
Winnellie NT 0821
Ph: (08) 8981 0939
Contact: Annette Gaborlt
Membership: $30 family; $25 single; $15 student

REPTILES & AMPHIBIANS

Tablelands Frog Club Inc.
Mail Bag 71
Yungaburra Qld 4872
Ph: (07) 4096 6556
Contact: Beryl Davidson
Membership: $10 adult; $5 student; $15 family

Victorian Herpetological Society Inc.
16 Suspension St
Ardeer Vic. 3022
Ph: (03) 9363 6841
Contact: Brian Barnett
Newsletter
Membership: $32—$45

SA Herpetology Group
c/- SA Museum
North Terrace
Adelaide SA 5000
Ph: (08) 8204 8772
Contact: Helen Owens
Membership: $28 standard; $24 concession; $32 family

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

ARE YOU A CLUB SECRETARY?
Nature Australia's Associate Society Scheme is designed to help your club or society with free publicity, funds and member benefits. Call Robbie Muller on (02) 9320 6119 for more details.

The Guide.

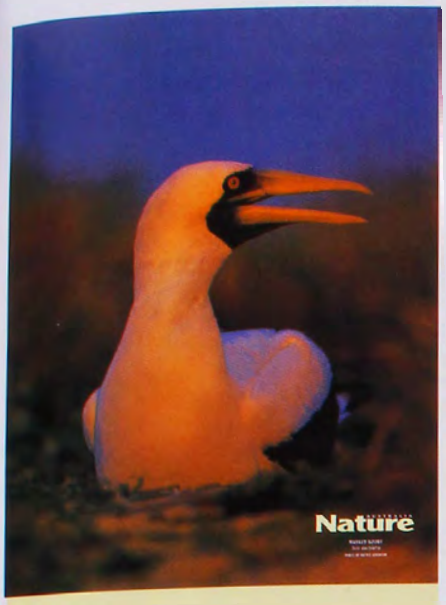
Welcome to **The Guide,** *Nature Australia's* marketplace.

Over 100,000 *Nature Australia* readers look to the guide for up-to-date information on travel destinations and equipment, wilderness tours; even 'bed and breakfasts'.

Our readers are a very special group – outdoor enthusiasts with a real interest in **Australian** nature. *Nature Australia* magazine is read in homes, libraries, universities and colleges—right across Australia and in over 30 countries worldwide.

Advertisers, you can reach these discerning readers for a surprisingly low cost with The Guide.

Call Robbie Muller on (02) 9320 6119 for more information.



SPECIAL NATURE AUSTRALIA FLAT POSTER COLLECTION

The 1999 collection of flat *Nature Australia* posters is available for the discount price of $12.00 (including postage & handling and GST).

These posters do not have any folds and are mailed to you in a rigid cardboard mailing tube.

The 1999 collection includes the following posters:

Brush-tailed Rock-wallaby *(Summer 1999–2000)*
Thorny Devil *(Spring 1999)*
Booby *(Winter 1999)*
Green and Golden Bell Frog *(Autumn 1999)*

If you would like to purchase this poster collection, just fill out the form in the back of this issue.

q&a

G.A. HOYE/NATURE FOCUS

The Green Tree Frog changes its colour depending on its background to camouflage it from predators.

Coloured Frogs

Q: *I remember when I used to keep tree frogs as pets I was fascinated by their ability to change colour. I had a male and female of both the Green Tree Frog* (Litoria caerulea) *and Giant Tree Frog* (Litoria infrafrenata). *The Giant Tree Frog took up a position in the corner of the tank and went from bright green to a mid-brown with dark brown spots—just like the colours of the poster on the wall behind it. At other times it would go an olive colour and, if a leaf was covering part of its back while it was sitting close to the heat lamp, then a pale silhouette of the leaf would appear. How do frogs do this and why?*

—Ellen Saunders
Oatley, NSW

A: The Green and Giant Tree Frogs have a fixed green colour, although surprisingly no green pigments. The green is produced by the combination of a yellow pigment and fine particles in the skin cells that cause the reflection of blue light (in the manner that fine particles in the atmosphere cause the blue colour of sky). However, it is other cells in the skin, called melanophores, that are responsible for the colour change. These cells can change their shape in response to environmental light conditions. They contain the brown/black pigment melanin and, by changing shape from broad to narrow, they can vary the area of melanin in each cell that can be viewed externally. When the melanophores are expanded, a brown colour is seen; when they are contracted, the brown colour disappears. Therefore different shades of green and brown can be achieved in different areas of the frog.

The main reason for this ability to change colour is to achieve camouflage, from predators, amidst a continually changing background. The possibility that the male frogs change their hues during courtship has also been reported. A third reason, although this requires further research, is that a colour change can allow thermoregulation. When the melanophores are expanded, the skin has a dark colour and can absorb more heat energy from the Sun. Consequently the frog will increase its internal temperature. Interestingly, frog skin has been preserved in the brown-coal deposits in the Geiselthal, Germany. It is quite amazing that, after 45 million years entombed in rock, melanophores have been preserved in an almost life-like state. Hopefully such finds will lead us to find the original colours of ancient, extinct animals.

—Andrew Parker
Oxford University

Spider Amputee

Q: *When a spider loses a leg, can it regrow the lost limb?*

—Mavis Thibou
Cronulla, NSW

A: If attacked by an aggressor, a spider may choose to lose a limb rather than lose its life. This voluntary amputation is called autotomy and is a spider's last means of defence, similar to when a lizard loses its tail.

A spider's leg has seven segments. Autotomy nearly always occurs at the weakest point of the limb, which is between the first and second segments (the coxa-trochanter joint). When the leg detaches, small muscles help to pull the remaining membrane over the opening. Haemo-lymph pressure inside the leg also helps to seal the wound.

Lost legs may be replaced as long as the spider can still undergo moulting. Regeneration is therefore usually restricted to juveniles, except in species that continue moulting as adults, like the trap-

door and funnel-web spiders. Whether the leg is replaced also depends on the timing of the amputation. A new leg is grown if the old one was severed within the first quarter of the intermoult phase (the period between moults). After this, no regeneration occurs.

The entire leg is regrown in one stage and it is thought to be controlled by hormones. The new leg has all the segments present in the correct proportions, although it is slightly thinner and shorter. Claws, spines, hairs and sensory organs are also replaced. The new leg has a reduced number of muscle fibres, however, and tends not to be used for walking.

—Danielle Louise Quinn

Are Two Penises Better than One?

Q: *Why do lizards and snakes have two penises?*

—Ian Gibson
Balmain, NSW

A: Lizards and snakes have two penises (hemipenes) instead of the usual one that occurs in turtles and crocodilians, as well as in mammals and some birds. Lizards and snakes probably evolved the hemipenes independently from a condition of no penises at all (see article, this issue). Why lizards and snakes evolved their two hemipenes can only be speculated upon, but there are two possible reasons. First, because males and females do not mate square on, that is, either directly front to front (missionary position) or behind to front (doggy style), but instead somewhat side by side, there may be an evolutionary advantage to having a hemipenis on each side. When lizards and snakes mate, it is the hemipenis on the near side that is generally used. Second, because the duct leading from each testis is aligned with the hemipenis on its same side, it may be that giving the most recently used testis a 'rest', may lead to a larger 'score' in a second rapid mating. Some lizards use the hemipenes alternately, but just how widespread this is is unclear.

—Allen E. Greer
Australian Museum

Answers to Quiz in Nature Strips (page 19)

1. *Jellyfish*
2. *Melville*
3. *Chimera*
4. *Chimpanzee*
5. *Lucy*
6. *They watch birds.*
7. *Nineteen million*
8. *Self-contained underwater breathing apparatus*
9. *Eugene Shoemaker*
10. *Alexandra*

Pic Teaser

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *Locating Koalas in the Australian bush*. Autumn's Pic Teaser was a sponge crab (*Austrodromidia octodentata*) using a piece of ascidian (sea squirt) as a 'hat' to help camouflage itself.

DENSEY CLYNE/MANTIS WILDLIFE

Pests, plagues & people

A deadly caliciviral disease spreading unchecked among us demands answers, but there are few.

THEY ARRIVED JUST 72 HOURS before and now they were dying. Lungs filled with blood clots, haemorrhages everywhere. No warning, no treatment, virtually no survivors, just rapid and bloody death. A haemorrhagic disease sweeping unchecked across Asia, Africa and Europe was killing within two days of exposure. This chronicles the spread of a new caliciviral disease originating in China in 1984. The dead bodies were those of Rabbits but the laws of contagion selecting that species were simply those of chance. Humankind and worldly wisdom did nothing to bring this plague to Rabbits. It just happened. Any species could have been the target but this time it was Rabbits.

A deadly caliciviral disease spreading unchecked among us demands answers, but there are few. We know that Rabbit Haemorrhagic Disease (RHD) can kill 95 per cent of the population within 48 hours of exposure. The virus can survive weeks in the environment and be spread by contact, contaminated animals, clothing and food. It is one of the most mutagenic life forms on planet Earth where no two viruses are expected to be exact duplicates. A single infected Rabbit liver can contain up to one billion viruses, each genetically different. The virus carries two deadly factors. One destroys the liver; the other causes massive blood clotting followed by haemorrhages; and neither factor had been described previously for any calicivirus. The RHD calicivirus is not species specific, and not even genus specific. It infects animals from at least two different genera (the European Rabbit and Hare), but what about risk to others?

Scientists do not know how to grow the virus in the laboratory and therefore cannot characterise host cell range. The genetic determinants that destroy liver cells and disrupt normal blood clotting are unknown. Even the species of origin for the virus is unknown, but virtually certain not to be the European Rabbit. Viruses that cause rapid and deadly plagues in their natural host would soon threaten their own survival. The full spectrum of animal species that can be infected is unknown but presumed to be broad. Eleven of 34 species tested at the Geelong Laboratory in Victoria developed antibodies after being given relatively few infective viruses. This strongly infers infection. And what about human risk of RHD infection and disease?

A single infected Rabbit can contain up to one billion viruses.

Two teams of scientists have examined the same data from Australia. One, an Australian Government team under pressure of a politically motivated decree, which proclaimed that RHD would not infect humans, reported no risk to humans. The other from outside Australia, and independent of political pressures but with their professional reputations on the line, found evidence suggesting both infections and adverse health effects in humans.

Now that RHD has spread across the Australian continent and is beginning to adapt to its new-found Rabbit host by becoming less deadly with longer periods of infection and less illness, what can and should be done? First, recognise that rampant viral plagues in any mammalian species increase the risk of exposure and infections in alternate species (including humans), and that such infections can amplify into plagues among the newly infected species. Therefore, Australians should do nothing to encourage spread of RHD. The lower the RHD viral load in any ecosystem, the less chance there is of the virus adapting to new host species. Especially, do not spread RHD in baits where whole new species groupings will become exposed.

Disregard simplistic proclamations of what caliciviruses will and will not do, especially when such pronouncements are made by people whose understanding of ecology does not extend into the intracellular spaces and macromolecular world where caliciviruses survive and multiply by the billions. There the virus generates new variants, which by sheer numbers seek and find new hosts and host relationships. The haemorrhagic disease plague in Rabbits proves this general rule.

Remember too that, by removing the offending species from overpopulated tracts of land, be they Rabbits, Sheep, Cattle or humans, native flora and fauna can and often do return in abundance. Finally, be suspicious when a profusion of eloquence is used by any official to describe the success of their own personal and bureaucratically mandated programs. In science, such evaluations are left to unbiased peers.

BY ALVIN W. SMITH

FURTHER READING

Jarvis, B.E.W. & Lynch, E.R., 1998. Proceedings of the Rabbit Control, RCD: Dilemmas and Implication Conference. Wellington, New Zealand, 30–31 March 1998. *New Zealand Association of Scientists and the Royal Society of New Zealand: Wellington, NZ.*

The Laboratory for Calicivirus Studies web page: www.vet.orst.edu/research/calicivi.htm

PROFESSOR ALVIN W. SMITH IS HEAD OF THE LABORATORY FOR CALICIVIRUS STUDIES AT OREGON STATE UNIVERSITY, USA. HE HAS STUDIED CALICIVIRUSES SINCE 1972.

BACK ISSUES AND SUPPLEMENTS

23/6

23/7

24/1

24/2

24/6

24/10

25/1

25/2

25/3

25/4

25/5

25/6

25/7

25/8

25/9

25/11

26/1

26/2

26/3

26/4

26/5

26/6

26/7

26/8

Supplement

$2

Tracks through Time

NatureAustralia library box

Holds 12 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

Thank you,

for letting us get bitten,
blasted, stung, stabbed, stranded,
hospitalised, lost, dragged, dropped,
suffocated, shot, frostbitten, arrested,
trampled; attacked and threatened.

While shooting Galapagos Beyond Darwin, one of the Discovery team realised the extinct giganturid fish was not so extinct when it bit him on the thumb.

5 incredible years