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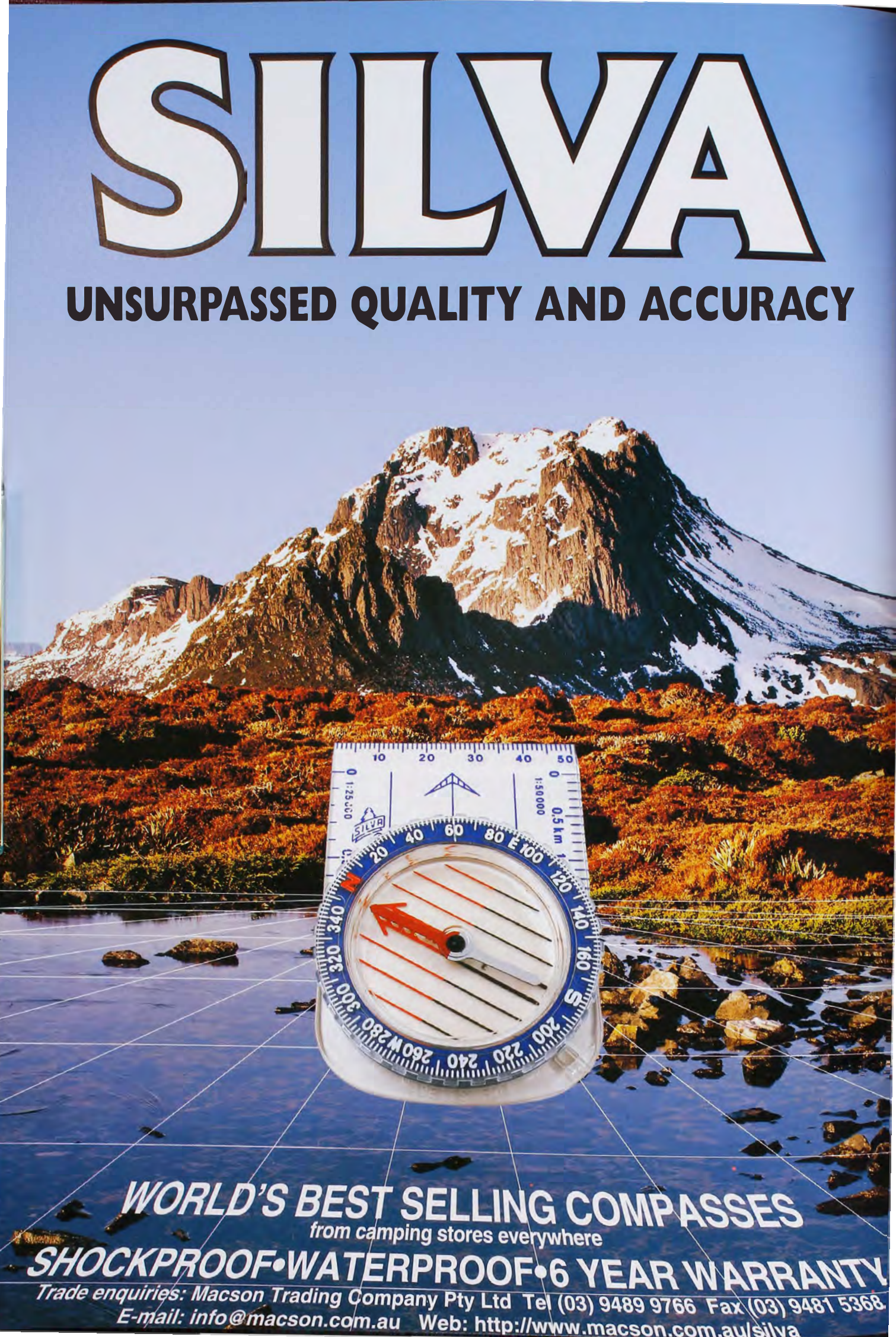

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Up Front

KATHIE ATKINSON

Unless you've spent time SCUBA diving, you're experience with octopuses is probably limited to those that have appeared on your dinner plate. And that is definitely not the same as the real thing, because an encounter with a live octopus is amazing. They're such unusual creatures, and so unlike anything on dry land. I remember one night, many years ago, when I was out diving around Sydney and met an octopus for the first time. It was a good-sized adult Common Sydney Octopus and I was both absolutely fascinated by it and a little frightened at the same time. But I quickly came to realise that the fear was unnecessary and from then on I never ceased to be captivated by the octopuses I encountered. And that's not surprising, because Australia's oceans are home to what appears to be the most diverse and rich octopus fauna in the world. So, in this issue, Dr Mark Norman will introduce you to posioners, arm-droppers, spindly giants, mimics, sand-swimmers and camouflage experts—just a few of Australia's extraordinary octopuses.

Spectacular or unusual fossil finds can be big news, but they always seem to be few and far between and certainly not from around the Sydney region. Why? Is this because Sydney doesn't have many good fossils or could it be that we are destroying them before they can be found? Dr Paul Willis digs up the past and shows us that Sydney has a rich history of fossil discoveries.

Then enter the wonderful world of mammals. There's Professor Uwe Proske's account of what goes on when an Echidna sticks its snout into something—and it's certainly more than you would imagine. Dr Graeme Newell's field work on Lumholtz Tree-kangaroo's, which has provided some much needed information on these beautiful and rare animals. And Drs Ross Goldingay and Sue Carthew's eye-opening insight into the vital pollinating role our mammals play. All this plus an underwater Photoart from the award-winning photographer Becca Saunders goes together to make this a very entertaining issue.

Oh, and whatever you do this Summer, don't miss the Australian Museum's new Spider exhibition—you won't be able to take your eyes off it!

—Jennifer Saunders

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Phone: (02) 9320 6000
Fax: (02) 9320 6073
Internet: jennys@amsg.austmus.gov.au
Web: http://www.austmus.gov.au
Trust President: Malcolm Long
Museum Director: Desmond Griffin

MANAGING EDITOR
Jennifer Saunders, B.Sc.

SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.

PHOTO & EDITORIAL RESEARCHER
Kate Lowe

DESIGN AND PRODUCTION
Watch This! Design

PRINTING
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ADVERTISING AND MARKETING
Phone: (02) 9320 6178

SUBSCRIPTIONS
Rebecca Kinsela
Phone: (02) 9320 6119
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Front Cover

Although the skin on an Echidna's snout is tough and relatively inelastic, it is still highly sensitive to both electrical and mechanical stimuli.

Photo by Reg Morrison.

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Lumholtz's Tree-kangaroos may be cute and furry, but we know very little about them—that was until Graeme Newell set off into the bush with some radio collars and a good deal of patience and curisoity.

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Now when we talk about the birds and the bees, we need to include the non-flying mammals as well.

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BY UWE PROSKE

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Regular Features

Columns

LETTERS

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

Butterfly Trees

I was very interested to read Tim Low's article on overseas eucalypts in the Summer 1996–97 issue of *Nature Australia*. Here in coastal California they've taken on an important ecological role by providing overwintering habitat for migratory Monarch Butterflies.

Monarch Butterflies (*Danaus plexippus*) belong to a tropical family and are not adapted to cold winters. Adults emerging in late summer migrate in the fall, with the western US populations heading for California. In addition to native Monterey Pines, eucalypts are favoured by butterflies. With their multistoried canopies the *Eucalyptus* trees provide a sheltered microclimate for the Monarchs, in addition to a nectar source. The long leaves are great for gripping, as these butterflies spend a good deal of time aggregated together. When their wings are folded and the tan undersurface exposed, the clusters of Monarchs are effectively camouflaged as dead eucalypt leaves to the untrained eye. These 'butterfly trees' are a popular winter attraction along the coast, with tours available at many locales.

—Susan J. Williams
Ventura, Ca. USA

Research on Corridors

Richard Hobbs recently described the difficulties involved in researching the value of corridors to flora and fauna (*Nature Aust.* Autumn 1997). His comment that it is impossible to obtain 'scientific' data on corridors, implies that research in this field offers wildlife managers little more than anecdotal speculations and/or personal prejudices. If conservation management decisions are to be based on credible data, then this research is largely irrelevant and the biologists should do something else.

We agree that it may not be possible to examine the value of corridors experimentally, but it is certainly possible to obtain credible data by conducting a fully replicated sampling program. Such data can be collected if the research biologist is willing to indulge in a little creative thinking before rushing into the field. Unfortunately, such thought has been absent in many studies, with the result that corridor management plans are rarely based on informed, scientific evidence. The key issues for obtaining reliable useful data are replication and sampling in non-corridor habitats. Data should be obtained from several similar corridor and remnant forest sites, and compared with data from areas in the surrounding altered landscapes. Such a task is not impossible; we demonstrated (*Conservation Biology* 11: 1–10; 1997) that corridors in the woodlands of northern Victoria are likely to be beneficial for some, but not all mammals, and perhaps more interestingly, that different kinds of individuals of the same species utilise corridors in different ways.

Conservation issues are too important to be resolved with inadequate or anecdotal information; mostly what is required is creativity to design statistically robust sampling programs.

—Sharon Downes
(University of Sydney),
Kath Handasyde & Mark Elgar
(University of Melbourne)

Who's to Blame?

It was interesting to read the angry letters written in response to Tim Low's Last Word article "Cats: Scoundrels or Scapegoats" (*Nature Aust.* Summer 1996–97). I find the borderline hysteria generated by the cat debate somewhat disturbing, as it seems that people are willing to lay the blame for loss of wildlife firmly with cats without even considering other possibilities or taking any responsibility themselves.

I work in bush regeneration and as part of my job I must sometimes remove large areas of lantana and other exotic weeds from degraded urban sites. Many of these weeds provide important habitat for small birds, and their removal often causes the loss of some species from an area. It is one of the depressing aspects of my job that insecurity of funding and lack of full community support often mean that we have to go into an area and remove all weeds in one fell swoop. Most of us would rather preserve habitat by removing a section of weeds

T. & P. GARDENER/NATURE FOCUS

In California, Monarch Butterflies overwinter in introduced eucalypts.

and allowing regeneration of natives before removing the next patch of weed infestation. However, once suitable native habitat has regenerated, many birds do come back so the loss is often only temporary, providing the species affected are not endangered. Habitat of endangered species is left well alone.

However, I must point out that bush regenerators are not the only ones responsible, or even the major reason, for native birds disappearing from an area. Our native birds lose out every time some resident removes trees and bushes to put in a swimming pool or garage. Native birds loose out every time some resident chooses to grow roses and agapanthus rather than native plants, or chooses to have a neat and ordered garden with vast expanses of lawn rather than a less tidy garden with some dense undergrowth and a small amount of lawn.

Our native animals also lose out every time some dog owner lets their dog off the leash to run free in urban bushland. Although dogs may not catch and kill as many native animals as cats, they are effective at disturbing animals, often causing them to abandon nesting sites permanently. It never ceases to amaze me how many people will not believe that domestic dogs kill or disturb native animals at all. Many native animals also lose out in competition with introduced pests such as rats and mice, and against native animals that are more adept at adjusting to urban life. Common Brushtail Possums, rats and currawongs are all able to eat bird eggs or kill young birds.

I'm not saying that cats aren't a problem in some areas and I wholeheartedly agree that both domestic cats and dogs should be more rigorously controlled, with all feral predators eliminated where possible. Nevertheless, it is interesting to note that there have been reports of the calicivirus causing feral cats to starve to death as their major prey, rabbits, have perished. Examination of the stomach contents of these cats showed that they had not increased their consumption of native fauna to compensate for the loss of their favoured prey. In his letter to *Nature Australia*, Peter Mirtschin includes rabbits with cats and foxes when he mentions the success of native wildlife in areas free of these species. It may therefore be possible that competition from rabbits is the driving force in reducing native wildlife in non-urban areas, and habitat loss the driving force in urban areas, with predation from cats having a lesser effect than many would have us believe.

However, whether the rabbit or cat or something else is the scapegoat, the loss of our native wildlife cannot be remedied by a single solution. Ridding Australia of cats, both feral and domestic, is unlikely to be the cure-all many cat haters presume it will be. Loss of habitat and food resources, and competition from introduced feral herbivores and omnivores are of equal, or even greater importance than the effects of domestic carnivores. We should be concentrating on dealing with every one of these factors, particularly loss of habitat and food resources, rather than wasting our energies becoming hysterical about one species.

Indeed, if we must indulge in any hysteria at all, it should be directed at what is perhaps the most destructive 'feral' animal Australia has ever known and the reason all other feral animals and plants are here—white *Homo sapiens*.

—Karen Bayly
Epping, NSW

Cats and Rats

Thankyou for the excellent, and very funny, "Ratbags of the Rafters" article by Steve Van Dyck (*Nature Aust.* Spring 1996). Our eight-and-a-half-year-old neutered moggy, Claude Depussy, catches one rat per week on average (three this week) and I've long harboured a concern that his victims may have been native rats. Van Dyck's article explained identification so cleverly and simply that my fears have been allayed. Claude's rodent catch has been 95 per cent *Rattus rattus*, interspersed with lots of House Mice and some big plain brown rats with smaller ears and shorter tails (not bandicoots, they're pets).

We live on the edge of a reserve and are conservationists. We are fully aware of the problems caused by domestic and feral animals and do not suggest that cats don't do enormous damage to our wildlife. But it's worth thinking about—Claude alone has killed 52 rats per year (I keep count) for the last seven-and-a-half years, which equals approximately 390 rats, and given that each rat produces about 80 babies per year, that means Claude has saved our reserve from 31,200 rats, not counting the young they would have borne *ad infinitum*.

I'd say Claude not only deserves his meals but a medal as well. The 'trade-off' has been two pardalotes and two Little Wattlebirds, and several exotics such as Spotted Turtle-doves, House Sparrows etc. caught during daylight hours. We've found that he does more harm to lizards and birds when curfewed and belled. He would sleep all night and hunt all day. During this period *Rattus rattus* had a great time wiping out our last remaining New Holland Honeyeater's eggs, and chewing through the wiring of my neighbour's expensive new fridge.

I do hope the politician who wanted all cats eradicated from Australia by 2010, worthy though his suggestion may seem, has figured out how to eradicate *Rattus rattus* first.

—Joy Hutton
Newport, NSW

Cock Sure

Yon tapir is an ugly hulk,
Prehensile trunk, right
pig-like bulk.
One has the firm suspicion
It's made up from reject,
cast-off bits.
Inamorata rarely meet,
Those dense rainforests are
off beat,
And thus it's left to fickle
fates
To find and woo putative
mates.

This is an awe-inspiring art
Because of mister's private
part.
A metre long, you would
agree
Is longer than it ought to be.
That length is not strictly
correct,
Except when it looms up
erect,
And what a wondrous
turnaround
To watch it drag along the
ground.

A club-shaped knob adorns
the tip
To obviate vaginal slip,
But once he's most securely
in,
The mating motions may
begin.
This joint pursuit is over
long
In keeping with that massive
dong.
My source for this lame
verse obscene?
Nature Australia magazine!

—Len Green
Rose Bay, NSW

Moving Forward

Australia is amazingly lucky to retain areas like the Franklin River, Fraser Island and the Great Barrier Reef, which are more or less untouched. This freedom from development can hopefully be maintained. It is a pity, however, that governments do not put more effort into the restoration of other preserves, spaces that are less pristine. Surely it is now time to carry out programs similar to Warrawong in South Australia, erecting exclusion fences around some conservation areas and bringing back species (otherwise long gone) to small pockets of the continent. That would be a real step forward.

—Steven Carr
North Adelaide, SA

NATURE AUSTRALIA **welcomes letters for publication and requests that they be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in each issue will receive a $20.00 gift voucher from the Museum Shop catalogue. The winner this issue is Joy Hutton.**

Nature Strips

COMPILED BY
GEORGINA HICKEY

Colour-blind Cuttlefish

How can you be a master of disguise if your eyesight is a bit dodgy? This is a question that could be asked about cuttlefish, which are able to blend almost magically with their surroundings but, like most cephalopods, are colour-blind.

Cuttlefish can conceal themselves by making interesting patterns on their skin that they can change to match their surroundings in seconds. These patterns, created by tens of thousands of tiny organs called chromatophores, may be uniform, stippled and mottled, or bold and disruptive. The skin patterns hide the cuttlefish by making their body appear continuous with their background and by obscuring their overall form.

Cuttlefish have eyes with only a single visual pigment that is most sensitive to blue–green light. What then are the cuttlefish responding to when they change their patterns? Two UK biologists, Justin Marshall (University of Sussex) and John Messenger (University of Sheffield), tried to find out by putting an Atlantic species, *Sepia officinalis*, into tanks with combinations of coloured gravels. They measured the brightness of these gravels and found that the red was very dark, the blue, green and yellow were of intermediate but almost identical brightness, and the white, obviously, was very pale.

On red and white gravel, the cuttlefish had a bold mottled pattern. On blue and red gravel, it was lighter and more uniformly coloured. On yellow and blue gravel, it had almost no visible pattern at all. To see what the cuttlefish saw, the researchers viewed the gravel through a blue–green filter. This confirmed that, to a cuttlefish, red gravel is much darker than white and about twice as dark as blue gravel, while yellow and blue gravel are almost indistinguishable.

It seems that the animal is responding to contrast in its background when it selects the pattern most likely to conceal it. In these experiments the cuttlefish were not responding to the colours of the stones, only to their relative brightness.

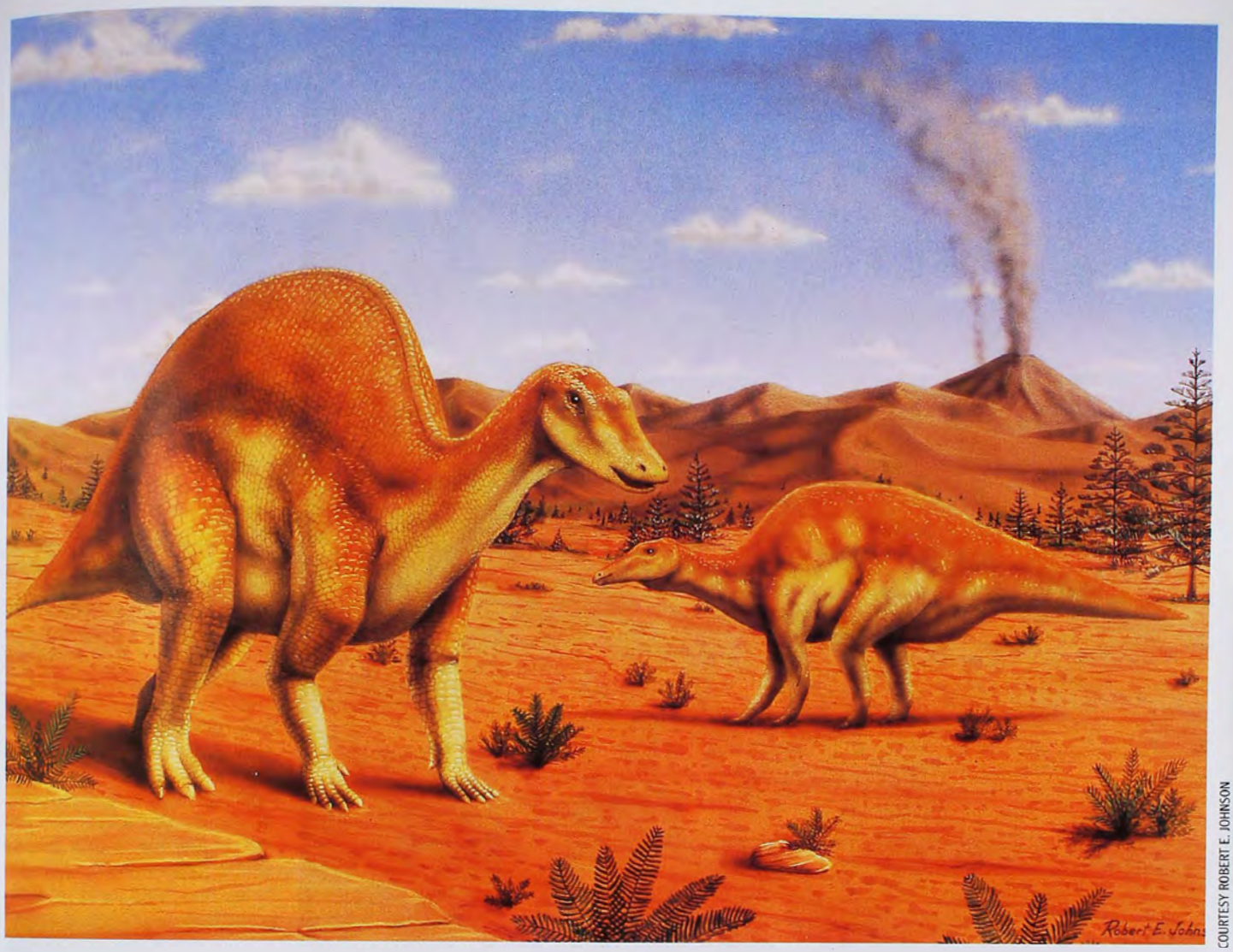
—C.B.

Semi-carnivorous Plants

Since 1875, when Charles Darwin first suggested that the plant *Roridula gorgonias*, a rare two-metre-tall shrub endemic to South Africa, was carnivorous, the issue has been open to contention: while the plant has sticky leaves that trap many insects, it possesses neither digestive enzymes nor the glands commonly associated with nutrient uptake found in other carnivorous plants.

Despite their often brilliant colour patterns, cuttlefish (*Sepia*) have limited colour vision.

GARY BELL/OCEAN WIDE IMAGES



COURTESY ROBERT E. JOHNSON

The new-look *Ouranosaurus*: out with the sail and in with the hump.

Also unusual about this plant is its association with the bug *Pameridea roridulae*, which has long been thought to pinch the prey items trapped by the plant's leaves.

Allan Ellis and Jeremy Midgley from the University of Cape Town have recently shed light on the mystery of *Roridula*. By providing the plant with vinegar flies that had been fed yeast laced with a nitrogen isotope, they were able to prove that nutrients from the flies were being absorbed by the plant. But how, if the plant had no digestive enzymes?

The researchers noted that the bugs attacked and, quite literally, sucked the sap out of the freshly trapped flies. Further, within only a few minutes, the bugs excreted a liquid onto the underside of the plant's leaves. Suspecting that the leaves may have been absorbing this liquid, Ellis and Midgley repeated their experiments, but this time with the bugs removed from the plant. Sure enough, the nutrients from the flies were no longer detected in the plant.

So it seems that the bug, rather than being a kleptoparasite, is actually doing the plant a service by digesting its food for it. This is the first report of this kind of mutualism between a carnivorous plant and an invertebrate, although the researchers suspect it may well be going on in other carnivorous species as well.

—R.S.

Dinosaurs Get the Hump

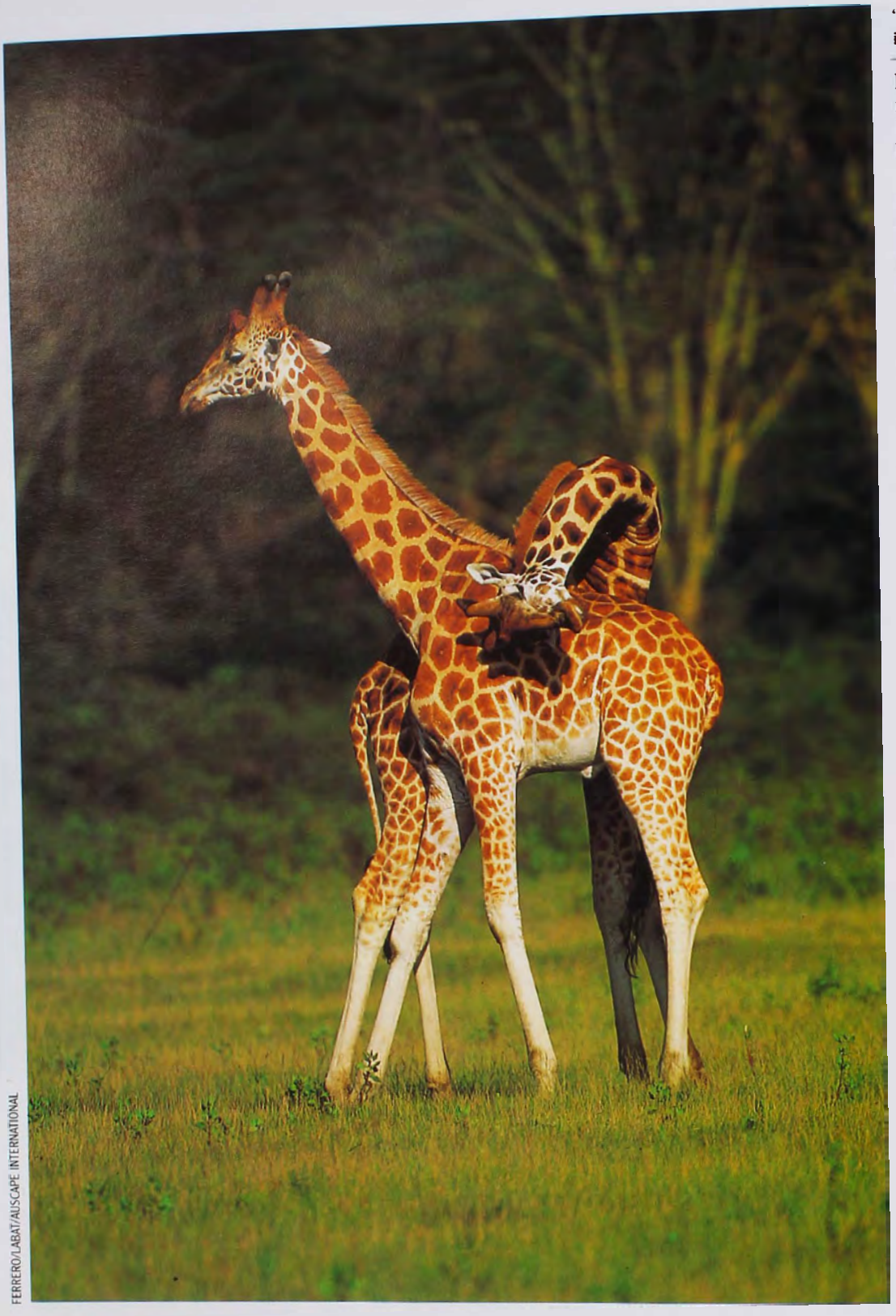
Take a look at one of those ubiquitous dinosaur wall charts that hang in primary school classrooms and there's bound to be at least one large reptilian creature represented with a crest or sail set elegantly along the length of its back. It might be the flat-headed herbivorous *Ouranosaurus*, or maybe the huge carnivorous *Spinosaurus*.

Whatever the species, the sail shouldn't be nearly as slender as it is invariably depicted, according to Jack Bowman Bailey, Professor of Geology at Western Illinois University. In fact, Bailey believes that it shouldn't be depicted as a sail at all.

For decades now, palaeontologists have been telling us that the spines sticking up from the backbones of the likes of *Ouranosaurus* and *Spinosaurus* were used as a framework to support a large thin sheath of skin used in thermoregulation—just as they were for *Dimetrodon*, a true sail-backed reptile. Popular thinking has been that, when a dinosaur with such a structure wished to warm up, it positioned the sail at right angles to the sun to maximise the amount of heat absorbed. To cool down, the sail was moved so that it received as little sun as possible.

Bailey argues, however, that close inspection of the structure of the vertebral spines tells a different story. Rather than being gracile and tapering to a point as in *Dimetrodon*, those of *Ouranosaurus* and *Spinosaurus* expand at the end to form wide blades and so would more likely have formed a framework to support thick masses of tissue, like the humps of modern-day bison, rather than sails. One possible function of these humps may have been as energy stores for long migrations between breeding and feeding grounds.

Bailey believes that, not only do we have to alter our perception about what these dinosaurs carried on their back, but what the rest of the animal would have looked like. The creatures carrying these humps would have been much stockier than we are used to imagining—certainly not the anorexic lightweights depicted in primary



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'Necking' between male Giraffes is a serious affair.

school wall charts—and would have had a quadrupedal gait, consistent with the probable forward shift in the centre of gravity due to the mass of the hump.

—K.McG.

Giraffes Win by a Neck

Why do Giraffes (*Giraffa camelopardalis*) have long necks? The traditional answer is that it enables them to outreach competing browsers during feeding. However recent observations by Robert Simmons and Lue Scheepers (Ministry of Environment and Tourism in Windhoek, Namibia) have challenged this theory. Instead, they believe the driving force behind the Giraffe's long neck is sex.

The researchers first examined the evidence for the conventional view. It turns out that, in the dry season when food is scarce, Giraffes feed mainly from low bushes, which are also within reach of other browsers. They do not take advantage of their long necks as competition for food would predict. Also, comparisons with fossil giraffes and the only other living member of the family, the Okapi (*Okapia johnstoni*), showed that the modern Giraffe's neck really is disproportionately long and leg length has not kept pace. If the object had been to reach higher, it might be expected that both legs and neck would grow longer.

The new explanation for the long neck is based on the method of fighting between bull Giraffes, called 'necking'. Males exchange blows by swinging their head and neck at each other. The top of the skull is used to strike the neck, chest, ribs or legs of the opponent with a force capable of knocking him off balance, breaking limbs and in some cases causing death. Bulls with the biggest heads and longest necks are the dominant animals. They court more females and are more frequently chosen as mating partners. Long necks can therefore be advantageous, and passed on to future sons (and daughters).

Having a long neck does not come cheaply, however. Not only does it require a high blood pressure (the highest known in mammals) to ensure that blood reaches the brain, but trying to run while supporting a massive head and long neck is difficult. Indeed, twice as many male Giraffes are killed by Lions as females.

But why do female Giraffes also have long necks (albeit not as long as males') if they don't fight? Of the two sexes, females spend more time feeding with their necks at or below shoulder height, so there's no advantage there. One suggested explanation is that it is simply a neutral by-product of the selection of genetic factors favouring a long neck in males. Long necks, unlike elaborate tail feathers in birds, for example, are an integral part of the skeleton and factors that select for long necks are inevitably expressed in both sexes.

—Uwe Proske
Monash University

Bringing Home the Baleen?

What you see might not always be what you get, as a recent study of whale meat products bought in Japanese and Korean retail

markets and restaurants found. C. Scott Baker (University of Auckland, New Zealand) and colleagues visited these establishments and bought products labelled variously as bacon, marinated steak strips, smoked bacon, lean meat and salted blubber (remember, these are English translations). They then sequenced mitochondrial DNA from the bought 'test' samples and compared these with 'type' sequences obtained earlier from known whale and dolphin species. A number of cetacean species were identified, including a beaked whale, two dolphins (sold as whale meat), and several species of baleen whales. This is disturbing, considering that there has been a moratorium on the commercial hunting of all baleen whales since at least 1987 and only one species, the Minke Whale (*Balaenoptera acutorostrata*), is hunted by the Japanese under an exemption for scientific research.

One baleen whale species that was for sale in a South Korean restaurant has since been identified as the small, coastal form of Bryde's Whale (*Balaenoptera borealis*) from tropical waters of the Indo-Pacific. Little is known about this animal. How it ended up on a plate in a restaurant is still a mystery and a concern.

The researchers politely noted the difficulty of reconciling current catch records, reported to the International Whaling Commission, with what is available for sale in the markets!

—Leo Joseph
Universidad de la República
Uruguay

Sonic Symmetry

In the world of crickets, researchers are finding that females are very choosy about their mate's calling card.

Many things determine how female crickets select a mate—and the lucky males are usually larger, older and, mysteriously, have fewer gut parasites. Yet the only thing a female has to go on is a potential mate's song. So how do they tell if he's their kind of guy?

Leigh Simmons (University of Western Australia) and Mike Ritchie (University of St Andrews, UK) played computer-generated male songs to female field crickets (*Gryllus campestris*) and found that the crickets were mostly drawn to lower-pitched songs. This reflects larger sound-producing structures on the cricket's forewings, and thus a larger cricket. Crickets make their songs by scraping a plectrum on the left forewing over a file-like object on the right forewing. This causes a small triangular

COURTESY LEIGH SIMMONS

Crickets in love prefer symmetry in sound.

COURTESY MICHAEL A. HUFFMAN

Worm medicine for chimps: rough leaves taken whole.

'harp' on each forewing to resonate—the larger the harps, the lower the frequency.

But Simmons and Ritchie also found females respond well to sonic symmetry. Cricket chirps are made up of pulses. Each pulse has two distinct phases—the first is produced by the left harp, the second by the right. Any difference in harp size will show up in a change in frequency between the first and second phases. The researchers found that, for low-frequency songs, females preferred those with the smallest drop in 'pitch' between phases, in other words those produced by crickets with more symmetrical harps. Such symmetry is thought to reflect an individual that is fitter and more able to survive environmental stress. So it seems that a top priority for female crickets is to keep an ear out for well-balanced males.

—A.T.

Worms, Take your Leaves

A Chimp chomping leaves is not unusual, but scientists are puzzled about why these primates sometimes swallow and excrete leaves whole, with no obvious nutritional benefit.

Michael Huffman (Kyoto University) and his Tanzanian colleague Mohamedi Kalunde regularly track a group of Chimpanzees (*Pan troglodytes*) through Mahale Mountains National Park, Tanzania, to record their eating and excreting habits. Over the years they have seen the Chimps swallow leaves from at least nine different plant species. They also noticed, for the first time in 1994, that dung samples containing whole leaves also contained the largest loads of the nematode worm *Oesophagostomum stephanostomum*. When Jonathan Page (University of British Columbia) analysed the leaves, however, he found no nematocidal chemical compounds. Indeed, worms found in the dung were active and very much alive. The only thing these leaves did have in common was their rough texture.

Examination of the leaf surfaces under an electron microscope showed them to be equipped with tiny hooks called trichomes. The leaves may therefore act as a kind of natural Velcro, scraping the worms off the intestinal wall and trapping them in the folds of the leaves as they pass through the gut.

Huffman *et al.* think there may also be a more subtle interaction going on between the parasite and its Chimp host. In some species of parasitic worms, including those expelled by leaves in this study, the presence of adults in the gut inhibits the maturation of the larvae, which burrow into the gut wall causing irritation and pain to the host. The researchers suggest that this abdominal pain acts as a stimulus to leaf swallowing, thus removing the adult worms and allowing the larvae to migrate from the gut wall, and so relieving the pain.

—A.T.

In Support of Menopausal Women

Menopause is the exhaustion and ageing of a woman's egg supply, which is fixed at birth and not added to thereafter. But why do women live beyond menopause? What is the point of old, non-reproductive women? Any way you put it, it sounds like some horribly ageist challenge from a brave new world.

But think about the issue from the perspective of an evolutionary biologist. Jared Diamond from the University of California, Los Angeles, argues that natural selection essentially favours genes for

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How does this Giant Crab (*Pseudocarcinus gigas*) keep its shell so clean?

those characters that increase the number of one's descendants bearing those genes.

When you think about it like that, the questions above sound quite legitimate. Diamond is not implying that the sole purpose of women is to stay at home and have kids. But if you use, as he puts it, "narrow evolutionary reasoning", menopause stands out as a bizarre biological trait.

The only other animals in which menopause is known to occur naturally are the Short-finned Pilot Whale (*Globicephala macrorhynchus*) and possibly also the Killer Whale (*Orca orcinus*). In most other animals, it seems, females are reproductive until they die as, of course, are human males.

Diamond argues that the evolutionary advantage of menopause, and therefore the reason why it has been favoured as a trait by natural selection, may be related to the valuable knowledge women accrue as they age. As a woman gets older, she may be able to do more to increase the survival of people already carrying her genes, by devoting herself to her existing children, grandchildren and even great grandchildren, than by risking the rigours of bearing more children herself. The same argument would apply to certain whale species.

In most other animals, it seems, females are reproductive until they die as, of course, are human males.

Traditionally, post-menopausal women have had a significant role in many preliterate cultures as critical fonts of knowledge and keepers of wisdom crucial to the survival of whole family groups. Perhaps the notion we often have of our mothers and grannies as wise old women comes as much from our biological heritage as it does from our hearts.

—K.McG.

Crab Cleansers

Personal hygiene is a constant problem for many marine crabs. Unwanted pests, ranging from bacteria to barnacles to algae, queue up to hitch a ride on their shells. Some crabs just let themselves go, using the resultant growth for camouflage. But, for those that feel the need for speed, a smooth shell is de rigueur, as any additions create drag as the crabs move through the water.

Without the option of twin-blade pivoting head razors or depilatory cream, how do crabs keep their shells clean? Do they use mechanical methods such as moulting and grooming? Do they produce chemicals that repel the fouling organisms, or use behavioural methods such as burying? Or do they use grazing gastropods as a sort of biological razor?

German biologists Klaus Becker (Biolab Research Institute) and Martin Wahl (University of Kiel) set out to answer these questions by investigating seven crab species that inhabit the Gulf of Thailand. They extracted chemicals from the crabs' shells and tested them on a variety of colonisers without effect. They immobilised the crabs in mesh to stop them

Suckers or scrapers? How do Turtle-headed Sea Snakes harvest their food?

COURTESY M.L. GUINEA

from grooming themselves and placed them in cages to stop snails from grazing on them; still their shells remained clean. Moulting was also ruled out, as free-living crabs that had not sloughed their shells remained free of unwanted growth.

It was only when the researchers placed the crabs in cages to prevent them from going about their routine activities that their shells started sprouting. In fact it seems that the myriad day-to-day behaviours of crabs are what keeps their shells clean. They bury themselves in the sand, hide under stones and in rock crevices, remain active only at night and expose themselves to the air at low tide.

By burying themselves, crabs restrict the colonising organisms' access and might even scrape some of them off. Nocturnal activity and hanging out under stones and in crevices reduces the growth of algae and, by spending time out of the water, crabs can dry out their unwanted guests. Although not all species indulge in all of these activities, the combinations they employ are apparently sufficient to keep them smooth and streamlined.

—G.T.

Scaly Scrapers

To make a living as a sea snake you must use your head. At least that's how it is for the non-venomous Turtle-headed Sea Snake (*Emydocephalus annulatus*) of tropical Australia. This species is known for the peculiar modifications to its head scales. In addition to males sporting a blunt 'rostral spine' at the tip of their snout, thought to be involved in tactile stimulation during courtship, the species has only three (rather than six or more) scales along the upper lip (supralabials), with the second one, situated below the eye, very elongate.

While it was previously thought that Turtle-headed Sea Snakes fed by sucking up fish eggs, direct observations by Michael Guinea (Northern Territory University) of wild sea snakes on Ashmore Reef have revealed quite a different feeding method. A male Turtle-headed Sea Snake was seen scraping the eggs of a Neon Damsel Fish (*Pomacentrus coelestis*) from a coral head, using the enlarged supralabial scale like a trowel. The damsel fish repeatedly attacked the head of the sea snake, but to no avail. Once the eggs were dislodged and started drifting away, the snake snapped at them with an open mouth. No suction was involved.

Not only is this mode of feeding unique among snakes, but it is the first record of these snakes eating damsel fish eggs. They were previously only known to eat the eggs of blennies and gobies.

—K.B.

'Feets' of Strength

Teamwork is a must in modern workplaces. In a model of corporate behaviour, teams of African Weaver Ants (*Oecophylla longinoda*) can join forces to immobilise and kill prey much larger than themselves. Individual ants latch onto the legs of their normally insect prey and they all pull in different directions, killing the prey in an insect version of the medieval rack. They then either cut the prey up or carry it whole back to the nest. Such team efforts were recently recorded by Janusz Wojtusiak of the Zoological Museum of Cracow (Poland) and colleagues Ewa Godzinska (Nencki Institute of Experimental Biology, Poland) and Alain Dejean (University of Paris Nord, France).

African Weaver Ants, like their relatives the Australian Green Tree Ants (*Oecophylla smaragdina*), live in large colonies and make huge arboreal nests by weaving leaves together, hence their name. Although Australian Green

COURTESY ALAIN DEJEAN

The secret to this African Weaver Ant's display of strength lies in its feet.

Tree Ants are known to act in large groups when carrying prey, African Weaver Ants were thought, until now, to act alone or in only small groups.

Carrying prey in groups is not unique. 'Army ants' are noted for it. However, Wojtusiak *et al.*'s observations were unusual in the large number of ants involved (between about 70 and 100—never before recorded in African Weaver Ants) and in the ruggedness of the terrain over which the prey was carried. Previous sightings have usually been of prey being carted over level ground. But the researchers saw the ants carrying a dead bird up a vertical tree trunk, even manoeuvring it over a branch that blocked the way.

When the researchers looked at the ants' feet under an electron microscope, the secret of their strength was revealed. Special adhesive structures called 'arolia', present on the feet of worker ants, enable the ants to successfully hold on to struggling prey and to drag it back up to their nest. So well developed are these arolia on African Weaver Ants that a single ant was observed suspending a seven-gram dead bird over the edge of a shelf!

—C.B.

Pee and Flee

Frogs have to work hard to conserve water in the desiccating terrestrial environment. By absorbing water through the skin and storing it as urine in the bladder, these amphibians can survive in dry, arid conditions. Yet, when threatened by a predator many frogs discard this precious commodity of water by emptying their bladders before leaping to safety (literally 'pissing off'!).

Bryant Buchanan (University of Missouri) and Ryan Taylor (Florida International University) examined this 'pee and flee' behaviour in the North American Squirrel Tree Frog (*Hyla squirella*). They found that when a frog urinates it lightens its load, and therefore can jump farther. In laboratory tests, frogs that 'leak before they leap' jumped 26.4 per cent farther—that is, at least two extra body lengths more—than frogs that held their bladders.

Such an increase in distance may be the difference between life and death when evading predators such as snakes. It may be a leap of faith, but if it works then it is well worth expelling the valuable store of water.

Emptying the bladder may also enhance the chances of escape if the urine contains chemicals that repel or confuse the predator. This hypothesis is yet to be tested for the Squirrel Tree Frog.

—K.B.

The Aardvark and the Cucumber

From the little we know so far, Aardvarks (*Orycteropus afer*) are bizarre creatures. These secretive sub-Saharan African mammals grow to the size of a large pig. With their tubular fold-over ears, open-and-shut nostrils, strong limbs and clawed feet, they are superbly adapted to a burrowing lifestyle. They spend most daylight hours underground, venturing out at night to forage mainly for ants and termites. Their teeth too are quite peculiar. They have no enamel and grow continuously from open roots.

It has now been confirmed that, to the list of unusual Aardvark features and behaviours, we can add an extraordinary symbiotic relationship with a cucumber.

Cucumis humifructus is the only one of the cucumber family's 735 or so species that, like the peanut, adopts the rare reproductive strategy of fruiting deep in soil, a fact that has only been established during the past few years.

The fruit, protected from rotting by a tough, water-resistant rind, develops between 15 and 30 centimetres under ground, meaning that it has to be brought to the surface somehow for its seeds to get the glimpse of sunlight they need to germinate. Enter the Aardvark.

Jeremy Hollmann and Susan Myburgh (University of Pretoria) have recently verified suspicions that the animal supplements its normally insectivorous diet with the cucumber fruit, which it digs up and eats, passing the seeds out in its dung. In doing so it creates what appears to be the only way in which the cucumber seeds can germinate.

No other animal is known to dig up or consume the cucumber. And it is not known how the Aardvark

COURTESY BUCK BUCHANAN

When threatened, the Squirrel Tree Frog lightens its load before leaping to safety.

FERRERO/LABAT/AUSCAPE INTERNATIONAL

The Aardvark supplements its normally insectivorous diet with an underground-fruiting cucumber.

locates the underground fruit or why it feels compelled to eat it.

It seems, however, that the fate of the plant is intimately linked with the large mammal. Should the Aardvark, regarded as a threatened species, disappear, then it is likely that so too would the cucumber.

—K.McG.

The Ghost of Death Valley?

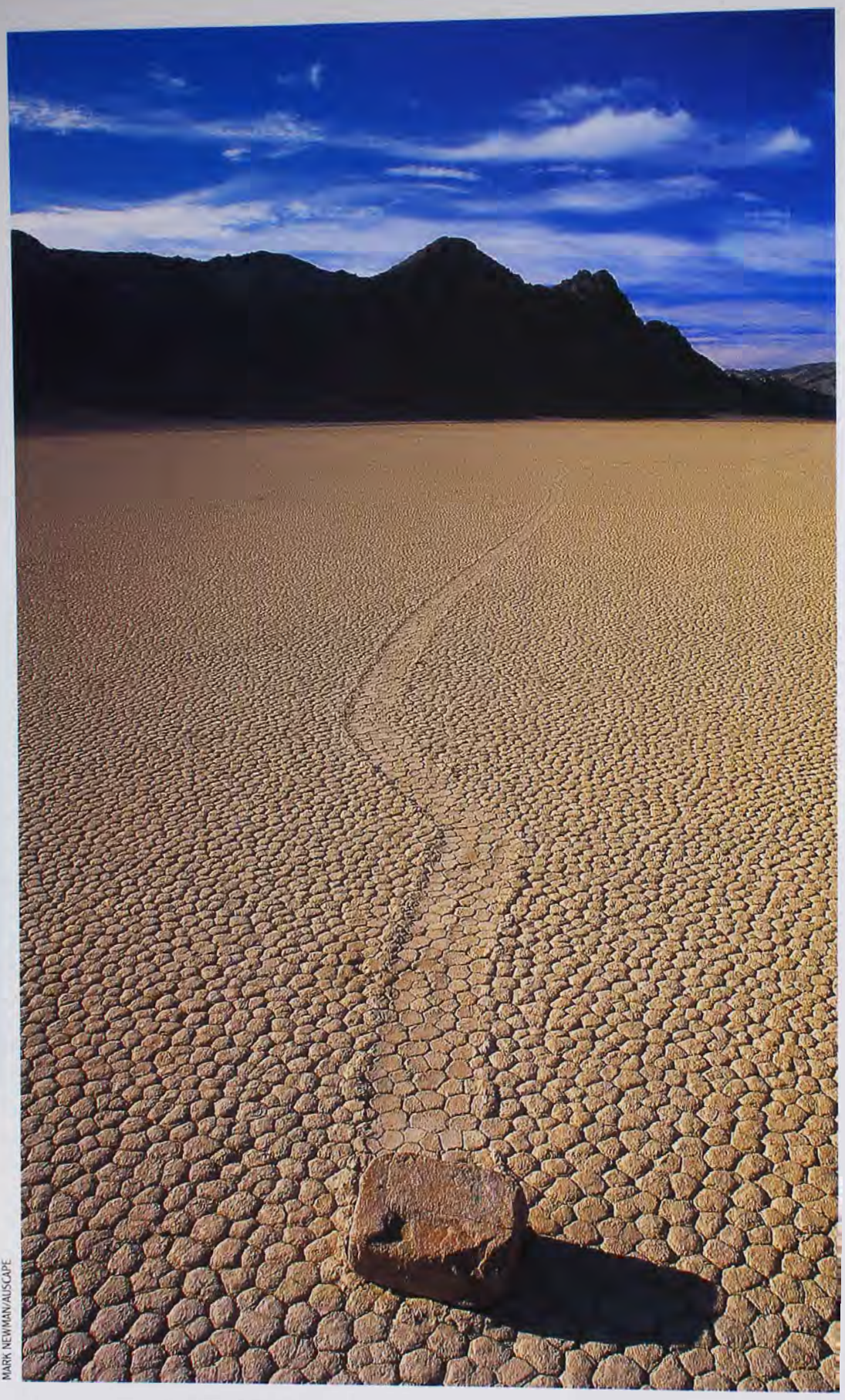
Mysterious tracks hundreds of metres long scar Racetrack Playa, a dried lake bed in Death Valley, California. They are produced by moving rocks weighing up to 320 kilograms, but the ghostly phenomenon has never been observed.

Geologists have speculated that wind moves the rocks, but when John Reid Jr from Hampshire College, Massachusetts, and colleagues mapped a large number of widely spaced tracks, they found that many maintain a constant degree of separation at the start, no matter how large the individual rocks are and how much the tracks curve—an unlikely scenario if only wind was responsible.

Instead they believe that ice carries the boulders across the playa. Following winter rains, the area is covered by a shallow lake and, in certain meteorological conditions, a sheet of ice forms on top. The researchers believe that even light winds may cause the ice sheet to glide over the muddy lake bed, taking the embedded boulders with it, and only when the ice sheet breaks up do the tracks begin to diverge.

According to the researchers, the reason the movements haven't been observed is because the very specific conditions required for rock sliding occur so rarely. These are sufficient rain for a lake, followed by cold, relatively calm weather to allow the formation of a thick enough layer of ice to move the embedded boulders.

Still, the controversy over the moving rocks continues.



MARK NEWMAN/AUSCAPE

Scientists remain baffled over the case of the moving rocks at Racetrack Playa in Death Valley, California.

On return visits to the playa, geologists have noticed how, among rocks that had not moved, there would be one or two that had shifted. As Reid explains, it is hard to imagine how ice could be that selective. On the other hand, experiments that measured the wind speeds necessary to move a 320-kilogram rock over a wetted section of the playa indicated that steady winds up to 450 kilometres per hour were required. If you consider this would be equivalent to a wind speed of 930 kilometres per hour at an elevation of ten metres (the usual way to express wind speeds), it appears unreasonable to expect that wind alone can move these rocks. Meanwhile the ghost continues to haunt the playa.

—R.S.

Bumblebees Shun Lopsided Flowers

The natural world is full of symmetry and, in many cases, evolution actually favours the retention of balanced features in species. Over and over again it has been shown to be a design concept that somehow conveys fitness during mate selection.

Female Barn Swallows, for example, prefer mates with evenly balanced tails. Even we humans are said to (subliminally) steer away from mates with lopsided features. But for many years there has been no similar proof of the significance of symmetry in the Plant Kingdom. Now, howev-

QUICK QUIZ

1. Lichens are made up of two sorts of organisms. What are they?
2. Name the faunal (animal) emblem for New South Wales.
3. In which country was *Sinosauropteryx prima*, the first 'feathered' dinosaur, discovered?
4. What is the name given to the 5,300-year-old hunter that was found, in 1991, thawing out of the Alps that border Austria and Italy?
5. Adult male Budgerigars have blue 'noses' or ceres. What is the colour of the cere of adult females?
6. With what type of organism do clownfishes live in close association?
7. Name the Strait that lies between the North and South Islands of New Zealand.
8. What are the larvae of cossid moths more commonly known as?
9. In which State of Australia would you find the archaeological site known as Jinmium rock-shelter?
10. How many forward-pointing toes do parrots have?

er, Anders Møller from Copenhagen University has reported on a preference for symmetrical flowers among bumblebees (*Bombus terrestris*).

Møller carried out a series of experiments involving visits by bumblebees to *Epilobium angustifolium*, a perennial herb that produces a simple flower with two pairs of petals. He found firstly that the bigger the flowers were, the more popular they were with the bees, presumably because they tended to contain more nectar. Far more interesting, however, was Møller's discovery that the bees preferred flowers in which the petals of each pair were evenly matched in shape and size.

Møller observed this preference for symmetrical over lopsided flowers repeatedly. And when he used scissors to modify the petals of symmetrical flowers that had been favoured by bees, Møller found that their new lopsided form failed to attract the insects.

The reason bumblebees prefer flowers with symmetrically patterned petals may relate to the fact that, as Møller found, they produce more nectar than their unbalanced counterparts. Thus symmetry, in animals as well as plants, appears to be a reliable indicator of an individual's quality.

—K.McG.

Bumblebees prefer symmetrical flowers.

Further Reading

Bailey, J.B., 1997. Neural spine elongation in dinosaurs: sailbacks or buffalobacks? *J. Paleontol.* (in press)

Baker, C.S., Cipriano, F. & Palumbi, S.R., 1996. Molecular genetic identification of whale and dolphin products from commercial markets in Korea and Japan. *Molec. Ecol.* 5: 671–685.

Baker, C.S. & Palumbi, S.R., 1994. Which whales are hunted? A molecular genetic approach to monitoring whales. *Science* 265: 1538–1539.

Becker, K. & Wahl, M., 1996. Behaviour patterns as natural antifouling mechanisms of tropical marine crabs. *J. Exp. Mar. Biol. Ecol.* 203: 245–258.

Buchanan, B.W. & Taylor, R.C., 1996. Lightening the load: micturition enhances jumping performance of squirrel treefrogs. *J. Herpetol.* 30: 410–413.

Diamond, J., 1996. Why women change. *Discover* July 1996: 130–137.

Ellis, A.G. & Midgley, J.J., 1996. A new plant–animal mutualism involving a plant with sticky leaves and a resident hemipteran insect. *Oecologia* 106: 478–481.

Guinea, M.L., 1996. Functions of the cephalic scales of the sea snake *Emydocephalus annulatus*. *J. Herpetol.* 30: 126–128.

Hollmann, J., 1996. A fruitful affair. *BBC Wildl.* Nov. 1996: 28–30.

Huffman, M.A., Page, J.E., Sukhdeo, M.V.K., Gotoh, S., Kalunde, M.S., Chandrasiri, T. & Towers, G.H.N., 1996. Leaf-swallowing by chimpanzees: a behavioral adaptation for the control of strongyle nematode infections. *Internatl J. Primatol.* 17: 475–503.

Marshall, N.J. & Messenger, J.B., 1996. Colour-blind camouflage. *Nature* 382: 408–409.

Møller, A.P., 1995. Bumblebee preference for symmetrical flowers. *Proc. Natl Acad. Sci.* USA 92: 2288–2292.

Reid, J.B., Bucklin, E.P., Copenagle, L., Kidder, J., Pack, S.M., Polissar, P.J. & Williams, M.L., 1995. Sliding rocks at Racetrack, Death Valley: what makes them move? *Geology* 23: 819–822.

Simmons, R.E. & Scheepers, L., 1996. Winning by a neck: sexual selection in the evolution of giraffe. *Amer. Nat.* 148: 771–786.

Simmons, L.W. & Ritchie, M.G., 1996. Symmetry in the songs of crickets. Proc. *R. Soc. Lond. B* 263: 1305–1311.

Wojtusiak, J., Godzinska, E.J. & Dejean, A., 1995. Capture and retrieval of very large prey by workers of the African weaver ant, *Oecophylla longinoda* (Latreille 1802). *Trop. Zool.* 8: 309–318.

Carrie Bengston, Karina Bull, Karen McGhee, Rachel Sullivan, Abbie Thomas and Geordie Torr are regular contributors to Nature Strips.

L.F. & O.G. SCHICK

It is incredible how much more appealing we find those insects that have a flashbulb in their bottoms.

BREAKING THE FLASHER'S CODE

BY STEVE VAN DYCK

IN HIS SOCK DRAWER, MY FATHER used to keep a small box of seductive wartime trinkets that included two smelly brass medals (one for lying his under-aged way into the fracas, the other for getting out alive), some parachute cords souvenired from the back of a pilot his unit shot down, a tusk from a runaway boar that almost escaped the spit on Christmas Day, and a small vanilla bottle with two beetles and some metho in it.

The two insects looked like hard-winged flying termites that had dipped their rumps in Wite-out. If Dad closed his eyes and sniffed the metho, the fumes, like an opiate, would waft him back to New Guinea, to muggy black nights where he'd be alone on guard duty. He'd tell us how he'd sometimes nod off at the post, only to be woken with lights flashing around the camp, his hair standing on end, and his finger straining at the trigger.

Those tense moments of flashing, cold sweat, adrenalin and indecision proved to be the stuff returned soldiers could weave into nightmares. It wasn't always simple to pick the foe from the firefly, although a quick look at his two pickled flashers could easily leave you wondering what all the fuss was about.

The truth is, for all their spectacular pyrotechnics, fireflies in the flesh are about as unimpressive as hand-made fireworks before they explode. Most Australian and New Guinean fireflies are soft-bodied and frail, scarcely a centimetre long, and with the males more inclined toward flight than females. The females are a mixed bag, some being almost identical in appearance to their mates, while others have degenerate wings or look like small, soft grubs. Females, however, generally suffer from chronic airsickness at mating time and keep their six legs firmly on the ground or around the top of a grass stalk from where they can survey the night sky and pray for love from above.

When conditions are right they don't have to wait long. With the air warm, the humidity high and the sky dark, for those patient females the glorious end is soon in sight. With perfect self-control the flashing Jack-o'-lanterns cruise overhead, their fiery rumps set to a narrow band of visible wavelengths (500–650 nanometres) and a strict beat between *prestissimo*, *moderato* and *largo* depending on the species, their enormous hemispherical eyes on the lookout for land-locked lovers with their derrières aloft, blazing with passion and expectation, and pulsing in an appropriate (but not necessarily the same as the male's) frequency.

Then, when the throb of flashes from below signals a match, the male bails out and homes in on the female like a heat-sensing missile. The rest is splendour in the grass...that is unless he has zeroed in on the cheating lips of a particularly nasty type of cannibalistic female firefly (genus *Photuris*) that has specialised in impersonating the irresistible love-pulse of the female of a different species, luring not lovers but lunch (this clever trick is known as 'aggressive mimicry'). Usually firefly species, while often looking very similar from the outside, are discouraged from interbreeding by innate courtship rituals that see males of different species flying at different heights, in different flight designs, and with light bursts differing in intensity and frequency.

Fortunately for little Australian flashers these odd-bods occur only in America, but the grub-like, carnivorous progeny of our fireflies are almost as gruesome in their love of fresh flesh and their bizarre *modus operandi*.

These little light-producing larvae, with sharply pointed fangs and eyes only for escargots, crawl onto a passing snail and, while biting it, inject a secretion that paralyses the snail and digests the bitten part. The larvae then suck up the soupy liquid and eventually, when enough has been consumed, change into fully fledged fireflies.

Sometimes here in south-eastern Queensland we wake up on steamy nights to the kitchen pulsating with light as a dozen male fireflies succeed in drawing together their collective pulses

PAUL ZBOROWSKI

Despite such an unassuming appearance, fireflies are the subject of much human fascination.

PAUL ZBOROWSKI

A firefly turned over to expose its flashing equipment.

AUSTRALIAN FIREFLIES

Classification
Order Coleoptera (beetles), family Lampyridae (fireflies), 1,700 spp. worldwide, 25 Australian spp. in 3 genera, *Luciola* (most common genus), *Pteroptyx* and *Pyrophanes*.

Identification
Soft-bodied, cigar-shaped, 4–12 mm long, very large eyes in males, short antennae. In subfamily Lampyrinae the head is hidden by the shoulders (prothorax) and the females are grub-like; in the Luciolinae, to which all Australian species belong, the head is often visible and many females resemble males and have wing covers. Bioluminescence in adults and more faintly in larvae, pupae and sometimes in eggs. (Australian 'glow-worms' are not firefly larvae, but larvae of certain fungus gnats.)

Distribution
Northern Territory, northern Australia and along the eastern coast of Australia, mostly in northern rainforest and mangroves to as far south as Kiama in New South Wales.

Food
Larvae are predators of snails and slugs. Adults probably do not feed. Little is known of their life cycle.

into an eerie but perfect synchrony. However, by far the most spectacular display I have seen involving fireflies occurred on the banks of the Herbert River near Ingham many years ago. Not long after sunset, while I was watching some flying-foxes squabbling in a tree, a few fireflies began pulsing out their pale yellow–green light. Suddenly, in a wave like falling dominoes, the crown of the tree exploded in a burst of silver spangles that fell in a surge from the tip of the tree down to its roots.

There was no repeat performance and the lights were on and off within four seconds. Such astonishing displays of synchronised male flashing from high vantage points may increase the chances of mate-finding in those tropical species where adults might live for only a few days.

Production of a firefly's light (bioluminescence) takes place in specialised fat bodies that lie over masses of reflective urate crystals in the last few transparent segments of the insect's abdomen. This is reminiscent of the process of light amplification that goes on in the mirror maze at the top of old-fashioned lighthouses. In the insect's rump a luminous substance called luciferin (after Lucifer, the 'bearer of light'...in cooler days) combines with oxygen in the presence of water and an enzyme, luciferase, to produce a pulse of cold light. It has been estimated that in American fire beetles (*Pyrophorus* spp.) the heat generated in such a reaction is less than 1/80,000th that produced by a candle of equivalent brightness. The brilliance of the light depends on how much oxygen is available to the reaction. Stationary beetles may emit a yellowish light whereas flying individuals whose muscles are pumping air in and out of the abdominal air tubes will produce the brightest display.

Wherever the flight paths of fireflies and children cross, catching and cramming the former into bottles for a good imitation of Florence Nightingale has always been irresistible sport. But adults (apart from returned soldiers) take fireflies seriously too. In 1932 entomologist Evelyn Cheesman wrote that certain ladies of South America and the West Indies "who are in the habit of fastening these big living fireflies to their hair and frocks in the evening with fine chains get the most brilliant light from them, because as the beetles are struggling to escape all the time their temperatures are high from the excitement".

The closest I ever came to imitating this cosmetic subtlety was in quietly tying a blowfly to the end of a long hair attached to the girl sitting in front of me in Grade 6. It may have done little to enhance her desirability but there was a perceptible rise in temperature that spread well beyond the flailing lasso as the bloated bomber thrashed around her scarlet face in tight convex arcs.

It is incredible how much more appealing we find those insects that have a flashbulb in their bottoms. Fireflies become coveted beetles of adornment, blowies are just party jokes. But perhaps the joke is on us...I have a sneaky feeling that fireflies only flash when humans are watching. And then they do it just to see our eyeballs go red like they do in most of my Instamatic colour prints taken with the flash. I'm confident that one night soon, if I strain my ears while watching them flashing away, I'm going to catch them giggling between the signalling. ■

Further Reading

Cheesman, E., 1932. *Hunting insects in the South Seas.* Philip Allen & Co. Ltd: London.

Lawrence, J.F. & Britton, E.B., 1991. Coleoptera (beetles). Pp. 543–683 in *The insects of Australia.* Melbourne University Press: Melbourne.

Matthews, R.W. & Matthews, J.R., 1978. *Insect behaviour.* John Wiley & Sons: New York.

Steve Van Dyck is a Curator of Vertebrates at the Queensland Museum where he has worked since 1975.

Black-chinned Honeyeaters are sending a warning to ecologists about the danger of potential bird extinctions in South Australia.

BLACK-CHINNED HONEYEATER

BY TAMRA CHAPMAN

BLACK-CHINNED HONEYeaters (*Melithreptus gularis*) are small, olive-coloured birds that have something in common with Canaries. Both have melodious calls and both can alert humans to impending tragedy. While Canaries were used to warn miners about dangerous air quality in mine shafts, Black-chinned Honeyeaters are sending a warning to ecologists about the danger of potential bird extinctions in South Australia.

There are two subspecies of Black-chinned Honeyeaters, but their ranges do not overlap. The northern form, known as the Golden-backed Honeyeater (*Melithreptus gularis laetior*), occurs in north- and mid-western Australia, and its plumage differs from that of the other subspecies by having a golden back and green-yellow skin above the eye. The eastern subspecies (*M. gularis gularis*) is characterised by a black crown and chin, white cheek and nape, and pale blue skin above the eyes. These birds occur in Victoria, New South Wales and parts of Queensland, and a small, remnant population occurs in the Mount Lofty Ranges and Adelaide plains. This South Australian population has fallen to critically low numbers as a result of habitat loss and fragmentation.

South Australian ornithologists have been documenting the decline of bird species in the Mount Lofty Ranges since the early 1900s. In 1919, for example, well-known ornithologist Samuel A. White noted that only "a pair or two" of the Black-chinned Honeyeater (which he considered to be very common 30 years earlier) remained in the Reedbeds district, which is now Adelaide Airport. Alarm about the status of the Black-chinned Honeyeater in the Mount Lofty Ranges has been growing since the late 1970s, so in 1994 I set out to establish its distribution and status.

Historical records show that, since European settlement, the Black-chinned Honeyeater had been recorded at 79 separate locations in the Mount Lofty Ranges, but this had reduced to 11 sites by the early 1990s. Members of the South Australian Ornithological Association had been recording declining numbers of Black-chinned Honeyeaters in each of these 11 locations over the past 20 to 50 years. I searched all potential areas by listening for the species' distinctive call and, from a likely population of thousands of birds at the time of settlement, I counted only 40 birds at six of the 11 sites.

The Black-chinned Honeyeater's sensitivity to environmental change may be an indication of the health of bird habitats in the Mount Lofty Ranges and eastern Australia.

The principal reason for the decline is likely to be loss of the tall savanna woodlands and dry sclerophyll forests, dominated by large mature eucalypts. Black-chinned Honeyeaters rely on eucalypts such as Pink Gum (*Eucalyptus fasciculosa*), Blue Gum (*E. leucoxylon*) and River Red Gum (*E. camaldulensis*) for food, which consists of a variety of arthropods, honeydew (sugary plant secretions) and nectar. They also build a pendulous nest in the eucalypt foliage made from grass and bark fibre, and hair or fur. Only about five per cent of the original vegetation of the Mount Lofty Ranges remains, in the form of small isolated 'islands' of vegetation. These habitats have been disproportionately cleared because they occur on soils with good agricultural potential.

Black-chinned Honeyeaters exhibit many of the biological characteristics that make them vulnerable to inbreeding and extinction after habitat loss. For example, they have small flock sizes

T. & P. GARDNER/NATURE FOCUS

(6-14 birds) and low recruitment rates (producing only one clutch of two or three eggs per year). Other factors include the tendency of family groups to remain in the same small patch of habitat, year after year. As a result, the species has become one of the rarest and most endangered in South Australia.

Bird extinctions from fragmented habitats are common in many woodland areas across Australia, such as the New England area of New South Wales and the Western Australian wheatbelt. The Mount Lofty Ranges is an isolated area of woodland that supports many of the bird species that are also present in the woodlands of eastern Australia. Therefore, declines in species such as the Black-chinned Honeyeater and other woodland birds may be more easily detected than in larger, more intact habitats and may indicate that similar declines are likely to be taking place throughout the species' range.

Researchers predict that, if no effort is made to protect habitat, 35 to 50 species (including the Black-chinned Honeyeater) will become extinct in the Mount Lofty Ranges before reaching equilibrium. While the prognosis for the Black-chinned Honeyeater is not good, its sensitivity to environmental change may, like the Canary, be an indication of the health of bird habitats in the Mount Lofty Ranges and eastern Australia. Any management action implemented to protect this species is therefore also likely to benefit a variety of other avifauna.■

Further Reading

Chapman, T.F., 1995. *The ecology and management of the Black-chinned Honeyeater in the Mount Lofty Ranges.* MSc thesis: University of Adelaide.

Longmore, W., 1991. *Honeyeaters and their allies of Australia.* Angus and Robertson: Sydney.

Tamra Chapman is a PhD student at Adelaide University and has a background in conservation, ecology and management. She is now researching Glossy Black-Cockatoos on Kangaroo Island.

I suspect that many of the spines seen on shrubs today are ancient defences once deployed against these animals.

THORNY THOUGHTS

BY TIM LOW

WHAT CAN THORNS TELL us about the extinct animals that once strutted the Australian stage? Many of Australia's shrubs are armed with thorns, presumably for defence against browsing animals, but what animals? Our kangaroos, wallabies and wombats are grazers, living mainly upon grasses and herbs; they do not tackle shrubs, spiny or otherwise. Only the Swamp Wallaby (*Wallabia bicolor*), hare-wallabies (*Lagorchestes* species) and, to a lesser extent, the Common Wallaroo (*Macropus robustus*) are specialised browsers, but there are many habitats where spiny plants are common and these browsers don't occur.

Only 100,000 years ago, Australia was home to giant kangaroos and diprotodontoids (including *Diprotodon*, *Palorchestes* and *Zygomaturus* species), whose fossilised teeth tell us they lived mainly upon leaves of shrubs and trees. I suspect that many of the spines seen on shrubs today are ancient defences once deployed against these animals.

We need to be careful when speculating about thorns. Are they really there as deterrents, or for some other reason, such as climbing aids (on vines), dew collection (on American cacti), or seed dispersal (on prickly seed pods)? We need to be sure the spines did not evolve overseas, as defence against foreign animals, on plants that later spread to Australia, as in Cockspur Thorn (*Maclura cochinchinensis*), Prickly Moses (*Acacia farnesiana*) and Holly-leaved Mangrove (*Acanthus ilicifolius*). We should also keep in mind that thorns are only one line of defence available to plants, and that many plants have evolved poisons or very tough tissues as alternative, or additional, deterrents.

To gain a really good understanding of spines, Africa is the place to visit. More browsing animals live there than anywhere else—the African Elephant, Giraffe, Black Rhinoceros and various antelope—and the plants are amazingly thorny. The Nile Acacia (*Acacia nilotica*) sprouts thorns as long as fingers—up to nine centimetres long. Australia has nothing like this.

A number of studies in Africa show how thorns work. Susan Couper and Norman Owen-Smith, from the University of the Witwatersrand in Johannesburg, found that thorns did not prevent browsing by antelope, but greatly reduced the bite size, and therefore the speed at which leaves were eaten. Thorns were also more effective if leaves were small. Large antelope such as Greater Kudus (*Tragelaphus strepsiceros*) were deterred by big straight thorns, while smaller Impala (*Aepyceros melampus*), for example, were more dis-

PHOTOS: TIM LOW

The ferociously armed Gin's Whiskers (*Solanum inaequilaterum*), found in wet rainforests in New South Wales and southern Queensland was presumably a food of now-extinct, rainforest-dwelling wallabies.

Vicious Hairy Mary is the most savagely armed Australian plant. The spines provide strong evidence that it was a favoured food of giant herbivores, of which *Zygomaturus* is the most likely candidate.

couraged by small hooked spines, which tore their lips and tongues. This size difference is important. Most of the thorny plants in Australia have fine straight spines only a centimetre or so long, and we can reasonably assume they evolved to repel smaller animals, up to Common Wallaroo size, not gigantic diprotodons or large browsing kangaroos. Plants like this, which also have small leaves, include Australian Blackthorn (*Bursaria spinosa*), Prickly Currant-bush (*Coprosma quadrifida*) and Spiny Fanflower (*Scaevola spinescens*).

To find Australian plants with larger thorns, we must turn to the rainforests in the east and the shrublands of the outback. The northern Queensland lawyer vines, such as Vicious Hairy Mary (*Calamus radicalis*), are striking examples of plants armed against something much bigger than wallabies.

In the outback, strongly defended plants include Blue Devil (*Eryngium rostratum*), Desert Lime (*Eremocitrus glauca*), Tangled Copperburr (*Bassia divaricata*) and Cotton Bush (*Maireana aphylla*). There is very little in the outback today that poses a threat to these plants (apart from introduced stock) and I can only conclude that the spines are evidence of animals now extinct. As in Africa, many of these plants grow mainly in claypans where water settles, and the spines may be a deterrent both against browsing, and against trampling by animals sheltering near water.

The prickliest habitats I have seen in Australia are the dry rainforests (vine thickets) of Queensland. Nearly all of the shrubs in these forests are thorny, for example the orange thorns (*Citriobatus* species), Native Holly (*Alchornea ilicifolia*), Prickly Alyxia (*Alyxia ruscifolia*) and wild limes (*Microcitrus* species). These shrubs either have small leaves produced along spiny stems, or larger leathery leaves with spiny margins or tips. Such shrubs sometimes form a dense thicket bordering a small patch of rainforest, and resemble the thorny fences used to protect African villages from big animals. Within these rainforests are trees such as Flintwood (*Scolopia braunii*) and Yellow Tulip (*Drypetes deplanchei*) that are spiny only as saplings, the only time they are low enough to be browsed from the ground. Some of the plants, including the capers (*Capparis* species) and Scrub Guava (*Siphonodon australis*), produce fruits designed to appeal to large mammals, which presumably dispersed the seeds in the past. These rainforests, once very widespread, grow on fertile soils, and the foliage is presumably nutritious, so it makes sense that diprotodons and other browsers would have been attracted. Cattle today are very fond of this foliage.

I am only speculating, but let me offer the following suggestions, based upon my thoughts about thorns so far. Diprotodons and other giant browsers probably targeted the dry rainforests and outback claypans and drainage lines, where the vegetation, growing on relatively fertile soils, would have been nutritious. Large mammals did inhabit the wetter rainforests of the east, but not (in the recent past) the monsoon rainforests of the Northern Territory, where spiny plants are surprisingly scarce. Giant mammals did not occur in the numbers seen today in Africa, where plants are much spinier. Apart from the giant mammals, Australia supported a range of smaller browsing wallabies (a point confirmed by fossil evidence), for all of the smaller spines seen in eastern Australia today, on bitter peas (*Daviesia* species), wattles (*Acacia* species) and hakeas (*Hakea* species) for example, would not have evolved solely as defences against the Swamp Wallaby.

I hope these ideas encourage more thoughts about thorns. They are telling us *something* about the past; we just have to work out what. ■

Further Reading

Cooper, S.M. & Owen-Smith, N., 1986. Effects of plant spinescence on large mammalian herbivores. *Oecologia* 68: 446–455.

Tim Low is an environmental consultant, natural historian, and author of four books on wild foods and medicines.

SYDNEY'S FOSSIL TREASURES

BY PAUL WILLIS

Each time an excavation takes place in Sydney, there is the potential for fossils to be unearthed.

A SYDNEY BRICK PIT MIGHT seem an unlikely place to find some of Australia's best preserved fossil fish specimens, but indeed the inner suburbs of Australia's largest city have produced some of our most notable fossils.

Fossils of fish and other animals from the Triassic Period (250–210 million years ago) have been found in the Sydney Region since at least the 1860s. Initially fossils were only occasionally uncovered, during excavations for building stone, foundations, railways etc. But when numerous brick pits were opened up around St Peters, fossils really began to turn up in abundance. These brick pits occur in shale lenses in the Hawkesbury Sandstone or in the overlying Ashfield Shales. This shale, when baked, produces the ubiquitous bright red bricks and roof tiles that Sydney is famous for.

Over the next 40 years the St Peters brick pits turned up nine species of fish and two specimens of labyrinthodonts (a group of extinct amphibians). One of these was a three-metre-long skeleton of *Paracyclotosaurus*, among the most complete labyrinthodont specimens known from anywhere in the world. This, along with many fish from St Peters and other sites around Sydney, was sent to England for study where it remains to this day in the collections of the Natural History Museum, London. (A replica of this *Paracyclotosaurus* skeleton is on display in the Australian Museum's "More than Dinosaurs..." gallery.)

During the 1910s and 1920s another important brick pit on Beacon Hill near Brookvale produced many fine fossils. Among these were several hundred fossil fish, a labyrinthodont, insects, and other arthropods, including a rare horseshoe crab.

Excavations for railway cuttings and track ballast also produced fossils from at least two localities: Gosford on the central coast and Bowral in the Southern Highlands. Gosford was to prove particularly productive with over 400 fish and three labyrinthodont specimens recovered in the years 1886 and 1887.

The Gosford area's potential for exciting fossils was confirmed earlier this year with the discovery of a well-preserved skeleton of a two-metre-long Triassic amphibian. It was in a massive sandstone block from a quarry at Kincumber, near Gosford, which was being used to build a retaining wall in a local garden. The skeleton is of a brachyopid (short-headed) labyrinthodont amphibian. Whether or not it represents a form new to science will not be known until the specimen is acquired by a museum and the head region, which is still buried, is uncovered for study.

A particularly large fossil deposit occurs right in the heart of Sydney and is known as the Sydney Harbour Shale Lens. This deposit, up to seven metres thick, extends under Sydney Harbour in the vicinity of the Harbour Bridge. It crops out at various localities on the lower north shore as well as sites from

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The Australian Museum's Robert Jones inspects the fossil of a large labyrinthodont amphibian recovered from a garden retaining wall in early 1997. Currently in private hands, negotiations are being conducted to secure this specimen for a national collection.

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Fossil footprints also tell an important part of the prehistory of the Sydney Region. These footprints, from a small dicynodont reptile, were found during coal mining operations near Wollongong.

Rushcutters Bay to Balmain and Cockatoo Island.

With the decline of hand-operated quarries through the 20th century, reports of fossils also declined, with some notable exceptions. In 1974 the Australian Museum held excavations in an abandoned quarry site in Hornsby Heights, uncovering at least six species of fish. In 1986, the Museum was given temporary access to part of a large sandstone quarry near Somersby on the central coast (see *Nature Aust.** Autumn 1987). With the help of a small army of volunteers, Alex Ritchie and Robert Jones recovered over 700 specimens of fish from the quarry. Almost 600 of these specimens represented a single species of fish, a 25-centimetre-long fish called *Promecosomina* that looks something like a mullet.

WITH SUCH A LONG LIST OF SITES throughout the Sydney Region, it might seem they can be found everywhere. In fact, fossils are only found in relatively small, restricted deposits dotted across the Sydney Basin but, where the conditions are right, the fossils can be abundant and of the highest quality. So why is the Sydney Region such a good place for fossils, particularly fossil fish?

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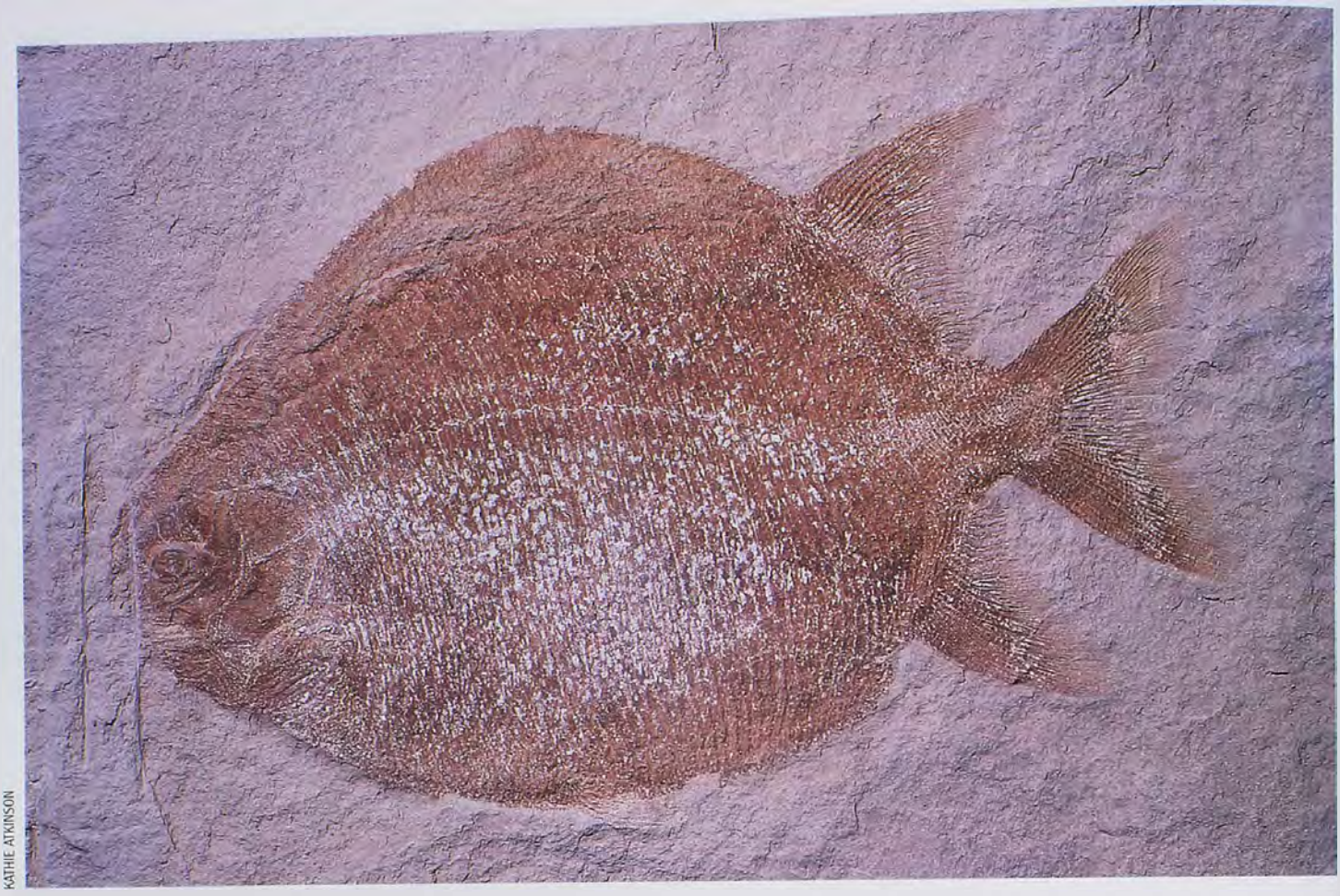
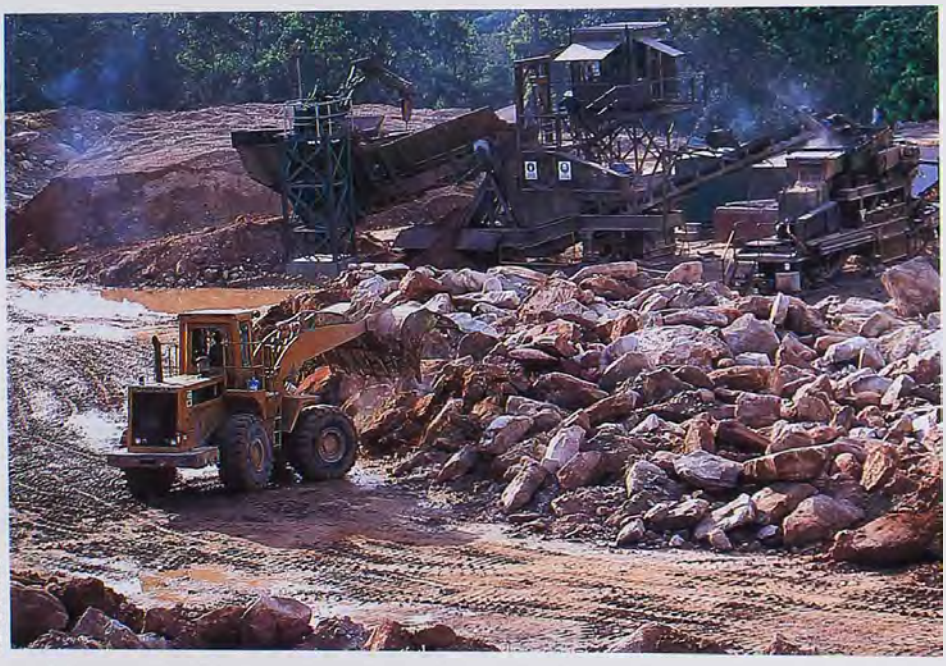


KATHIE ATKINSON

Ranging up to the size of dinner plates, *Cleithrolepis* has been found in many fossil sites across Sydney.



KEN GRIFFITHS

Sandstone quarries like this one are scattered across the Greater Sydney Region and produce building stone. Occasionally these quarries intersect shale lenses that represent the bottoms of ancient lakes and may contain fossils of fish and other vertebrates.

To answer this we have to go back to when the bedrock of Sydney was being formed. For some 40 million years, from about 250 to 210 million years ago, the Sydney Region was an enormous estuary for a river system that has its origins deep in Antarctica (at that time Antarctica and Australia were still joined as a single landmass). The mouth of this estuary stretched from the central coast south to Nowra and west to Lithgow.

The estuary slowly filled with sands that the river system had washed across two continents. In the estuary, the sands formed a network of connected channels that changed with each flood. There would occasionally be a cut-off billabong—a quiet pond temporarily isolated from the rest of the estuary. These ponds were home to large populations of fish and other animals but, if the pond was too small or was isolated from other waters for long periods of time, the oxygen in the water would be used up and all life in the pond would die. Carcasses would settle into the soft mud at the bottom of these ponds and, because of the oxygen-poor environment, they would not be torn apart by other scavenging animals. Such pools were themselves eventually buried under sands from the ever-filling estuary. Today these muds form the shale lenses in the thick beds of sandstone that Sydneysiders know so well.

The variety of life in this freshwater river estuary was astounding. Most common among the fishes were the mullet-like *Promecosomina* and the dinner-plate-sized *Cleithrolepis*. Rarer, predatory fish include the barracuda-like *Saurichthys*, which could grow to more than a metre in length. Primitive freshwater sharks have been found, as well as more than a dozen other fish species and at least four species of labyrinthodont amphibians ranging in size from 15 centimetres to around three metres.

KATHIE ATKINSON

An excavation run by the Australian Museum in 1986 resulted in the collection of over 700 specimens of fossil fish from a sandstone quarry at Somersby on the central coast. Almost 600 of these were represented by the 25-centimetre-long *Promecosomina*, one of which is shown recently exposed in the foreground.

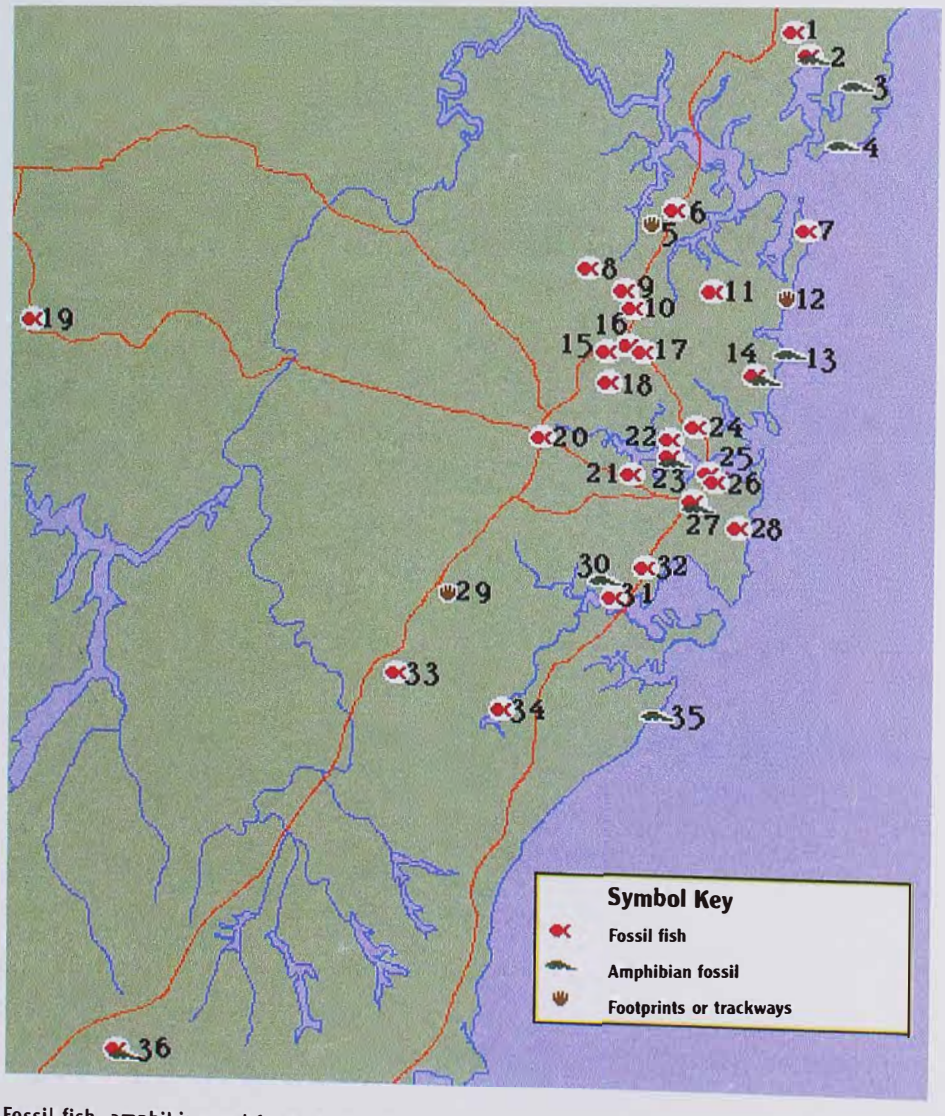
Fossil plants found in abundance at some sites indicate that the ponds were lined with bamboo-like plants (horsetails) and a variety of ferns. Seeds of conifers indicate that stands of pine trees existed within the basin. There was also a variety of insects including a dragonfly-like creature whose 20-centimetre wings have been found at Brookvale.

The fossils of the Sydney Basin offer more than a static look at a single past environment. Because the estuary took 40 million years to fill, the fossils illustrate the changes in environment over an extended period.

The rocks produced by the ancient river are divided into three basic groups. The oldest rocks belong to the Narrabeen Group, including such units as the Collaroy Claystone and the Terrigal Formation. Overlying the Narrabeen Group is the younger Hawkesbury Sandstone, which is best exposed along the Hawkesbury River to the north of Sydney and in the valleys to the south of Sydney around Sutherland and Woronora. The youngest rocks belong to the Wianamatta Group but fossils have only been found in the lowest part of this group, the Ashfield Shale.

Who knows what rare treasures of Sydney's distant past are being wantonly destroyed.

Taken together, these three groups present a thickness of almost three kilometres of rock representing 40 million years of river deposits. Although changes in the fossils found through this sequence have been noted, the significance of these changes is not well understood. For example, fossil deposits in the Narrabeen Group, such as the Gosford Railway site, are dominated by the fish *Cleithrolepis* but, higher up in the sequence, sites such as Somersby near the top of the Hawkesbury Sandstone are around 95 per cent *Promecosomina*, with *Cleithrolepis* present in only small numbers. Why this pattern and other faunal changes occurred remains a mystery.



Fossil fish, amphibian and footprint localities from around the Sydney region: 1 Somersby, 2 Gosford, 3 Kincumber, 4 Bouddi National Park, 5 Berowra, 6 Cowan, 7 Whale Beach, 8 Galston, 9 Hornsby Heights, 10 Asquith, 11 Duffys Forest, 12 Turimetta Head, 13 Long Reef, 14 Brookvale, 15 Thornleigh, 16 Wahroonga, 17 Turramurra, 18 Epping, 19 Katoomba, 20 Chapel Hill, 21 Homebush, 22 Tambourine Bay, 23 Cockatoo Island, 24 Gore Hill, 25 The Rocks, 26 Woolloomooloo Bay, 27 St Peters, 28 Coogee, 29 Macquarie Fields, 30 Mortdale, 31 Oatley, 32 Kogarah, 33 Parsonage Hill, 34 Woronora Spillway, 35 Bundeena, 36 Bowral.

A volunteer proudly displays a fine specimen of the barracuda-like fish *Saurichthys* in a quarry at Somersby.

LATE LAST CENTURY AND FOR THE EARLY part of this century, quarrying of shales and excavations for roads, railways and buildings were mostly done by hand. Men working close to the rocks were likely to spot any fossils that might be revealed by their hammers. As the 20th century proceeded and quarrying became more mechanised, fossils were less likely to be seen and reported. This trend is clearly evident from the record

AUSTRALIAN MUSEUM

of finds over the last 100 years. The reason fewer fossils are turning up today is not because the fossils are not there, but because they are not seen in the mechanised operations that can remove in a single scoop what a man and a hammer would take a week to dig through last century. And even when fossils are seen, we have been told that some quarry workers promptly bulldoze them into the rubble, rather than report them to scientists. This is done on orders from management, afraid that their project may be held up. If true, this is not only short-sighted but immoral, and who knows what rare treasures of Sydney's distant past are thus being wantonly destroyed.

We are also losing access to the original sites where fossils are known to have occurred. Quarries are large holes in the ground that, when their working life has come to an end, are unsightly, dangerous and unwanted in urban environments. Their only subsequent use is for land fills. This is what has happened to many of Sydney's most important fossil sites, including the St Peters pits and the Beacon Hill brick pit. Potentially important fossils have been reburied under tonnes of rubbish and playing fields have been built over the top.

We will never exhaust the fossils in the Sydney Basin. Locked away in the deep sediment piles where they are entombed, most of these fossils are unlikely ever to see the light of day. But each time an excavation takes place in Sydney, there is the potential for fossils to be unearthed. If measures are not taken to recover these fossils, they will be destroyed and reburied; lost forever. Currently environmental impact studies for proposed projects are not required to consider the identification and recovery of any fossils encountered during excavations.

Perhaps our only measure against this loss is the vigilance and efforts of a few people interested in the fate of these fossils. Staff at the Australian Museum, although not charged or funded for the task, regularly inspect new building sites and excavations in case fossils have been encountered. Various amateurs are also on the look-out for new fossil occurrences across Sydney. Together, these efforts may uncover new species of animals that inhabited the Harbour City in a time before the dinosaurs. ■

Further Reading

Cosgriff, J.W., 1973. *Notobrachyops picketti*, a brachyopid from the Ashfield Shale, Wianamatta Group, New South Wales. *J. Paleont.* 47: 1094–1101.

Retallack, G., 1976. *Geological excursion guide to the sea cliffs north of Sydney*. University of New England: Armidale.

Wade, R.T., 1935. *The Triassic fishes of Brookvale, New South Wales*. British Museum (Natural History): London.

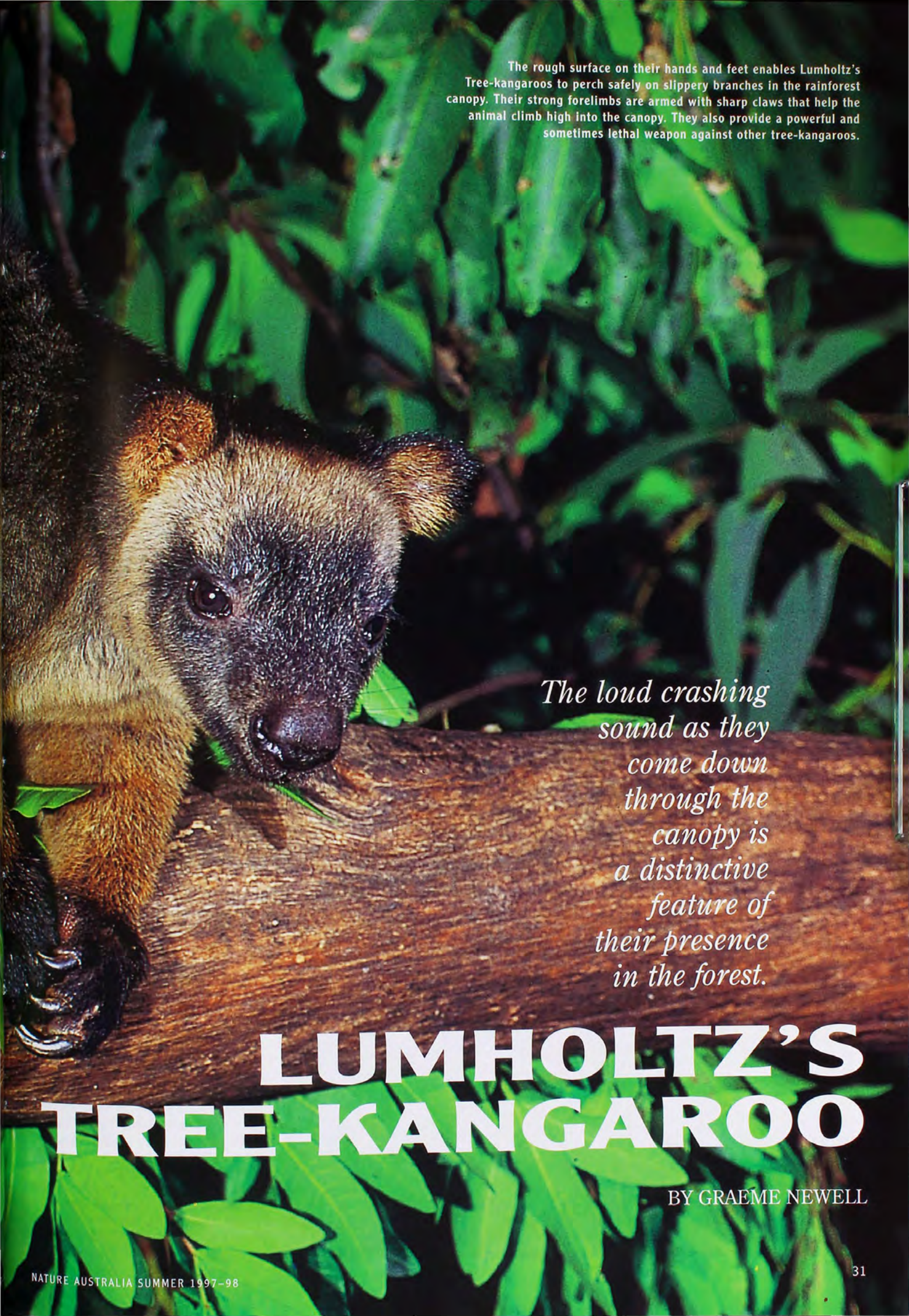
Wade, R.T., 1939. The Triassic fishes of Gosford, New South Wales. *J. Roy. Soc. N.S.W.* 73: 206–217.

Wade, R.T., 1941. Australian Triassic fishes. I. The Triassic fishes of St. Peter's, Sydney, New South Wales. II. The relationships of the Australian Triassic fishes to each other and to other bony fishes. *J. Proc. R. Soc. N.S.W.* 74: 377–396.

Watson, D.M.S., 1958. A new labyrinthodont (*Paracyclotosaurus*) from the Upper Trias of New South Wales. *Bull. Brit. Mus. (Nat. Hist.) Geol.* 3(7): 235–263.

Dr Paul Willis received his PhD for studies on Australian fossil crocodilians and has been working as a freelance technical advisor and author. He is now a Trainee Science Broadcaster with the ABC.

DAVE WATTS/NATURE FOCUS



The rough surface on their hands and feet enables Lumholtz's Tree-kangaroos to perch safely on slippery branches in the rainforest canopy. Their strong forelimbs are armed with sharp claws that help the animal climb high into the canopy. They also provide a powerful and sometimes lethal weapon against other tree-kangaroos.

The loud crashing sound as they come down through the canopy is a distinctive feature of their presence in the forest.

LUMHOLTZ'S TREE-KANGAROO

BY GRAEME NEWELL

THERE IS A TENDENCY AMONG biologists and naturalists to concentrate research efforts on the cute-and-cuddly animals rather than the less pretty ones. With this pervasive doctrine you would think that we would know an awful lot about our appealing mammals. Well this is true for some species, but not for all. Tree-kangaroos are a specialised subgroup of the macropod marsupials, and are surprisingly more diverse in Papua New Guinea than in Australia. But irrespective of where they come from, our knowledge of even their most basic biology is still rudimentary.

Two species of tree-kangaroo are restricted to the rainforest areas of northern Queensland. Both considered rare, Bennett's Tree-kangaroo (*Dendrolagus bennettianus*) is found in mostly difficult terrain north of the Daintree River, while Lumholtz's Tree-kangaroo (*D. lumholtzi*) is found south from the Daintree River to the Cardwell Range. Although they mainly occur in rugged and inaccessible areas, Lumholtz's Tree-kangaroos are also relatively abundant in some forest fragments on the more gently undulating parts of the Atherton Tablelands. The easy access to these fragments presented me with an excellent prospect for investigating some basic ecological questions about this species—information that would hopefully also provide insights into the ecology of the more remote species of this fascinating group.

Like all tree-kangaroos, Lumholtz's Tree-kangaroo can look ungainly in the forest canopy. With a long tail, they resemble their close relatives the rock-wallabies (*Petrogale* spp.). This long dangling appendage is likely to be important in aiding their balance on precarious branches, and is often the only visible sign of an animal high in the canopy. Since the tail is not prehensile and cannot grip, it helps them little when climbing. For this task they rely instead on their well-developed forelimbs and claws. The similarities to rock-wallabies extend to their amazing escape techniques. When threatened they can easily jump ten metres or more to the ground without injury, and bound off. The loud crashing sound as they come down through the canopy is a distinctive feature of their presence in the forest, where they feed on a wide variety of rainforest foliage along with occasional flowers and fruits.

When animals are anaesthetised they can be easily handled and fitted with radio-collars. After about two hours the tree-kangaroo will have recovered and can be released at the site where it was first captured.

From the little that is known about their distribution, it seems that Lumholtz's Tree-kangaroos are present in higher densities in rainforests on fertile basalt soils, rather than the forest types associated with lower-nutrient granite or rhyolite soils. Unfortunately, the largest areas of fertile soil types are relatively flat, and also sustained large stands of Queensland Red Cedar (*Toona ciliata*), prized as a cabinet timber. Following the 'cedar-getters' of the mid 1800s, the Atherton Tablelands area was opened to general farming, so that now only small blocks of remnant and regrowth rainforest of between one and 100 hectares remain on these rich basalt soils. This fertile soil is still sought after today, and clearing continues for cropping and

LUMHOLTZ'S TREE-KANGAROO

Dendrolagus lumholtzi

Classification
Order Diprotodonta, family Macropodidae.

Distribution and Habitat
Endemic to the 'Wet Tropics' of northern Qld, from Daintree River south to the Cardwell Range. Found in rainforest and occasionally in associated wet sclerophyll forest.

Identification
Populations are disjunct from Bennett's Tree-kangaroo (*D. bennettianus*), which is found north of Daintree River. Pelage highly variable in colour, even at one location, ranging from pale cream–brown to grey and rusty brown. Paler on ventral surface. Tail and face black. Mean weight of adult females about 7 kg, adult males regularly over 9 kg. Strong forearms with sharp claws, with no opposable digits.

Behaviour
Cryptic and nocturnal behaviour creates difficulties in detection. Arboreal habits. Usually found high in the canopy during the day, often in the sun. Generally lower in the canopy at night, feeding in the mid and understorey. Moves between trees on the ground generally at night. Eats leaf material from a wide variety of rainforest trees and vines. Ingestion of flowers and fruits less common. Will jump from canopy to escape predators or avoid human disturbance.

Reproduction
Very little data. Promiscuous mating system producing single young. Pouch life probably 300–350 days post partum, followed by an extended period 'at heel' with the mother for perhaps another two years.

Status
Currently listed as rare under Queensland's Nature Conservation (Wildlife) Act (1994).

P. TROTT

A bulldozer at work, clearing the rainforest from the fertile basalt soil. The 'nudge' bar hanging over the top of the blade makes it much easier to push over large trees.

G. NEWELL

grazing land. Despite the level of clearing and long history of fragmentation, Lumholtz's Tree-kangaroos are still found in the area in isolated remnants and in patches of regrowth rainforest.

It was in one of these blocks of mixed remnant/regrowth forest near Yungaburra on the Tablelands, about 50 kilometres inland from Cairns and 760 metres above sea level, that I set out to investigate the habits of this shy and cryptic animal. Of all the sites I inspected, a 20-hectare block of private land already well known to the locals for its tree-kangaroos seemed the most promising for studying these creatures. With the land-holder's

G. NEWELL

Lumholtz's Tree-kangaroos don't usually spend a lot of time at ground level, and especially not during the day. This animal sits among the devastation of its former home range. Tree-kangaroos are moderately safe from canid predators within the tangle of branches, but not so on the edge of the felled area.

permission I intended to find out how the resident animals used their habitat in this forest block, and whether they moved regularly to other fragments in the immediate landscape. I reasoned that, if I knew how much space individual animals used, and how they moved through the area over time, then it would become easier to identify high-quality forest areas for their future conservation. If I could discover what tree species they liked to 'hang out' in and what other features of their environment they used, then this information could be incorporated into local tree planting schemes to accommodate more tree-kangaroos in the future.

Tree-kangaroos have a reputation for being formidable opponents of humans and dogs.

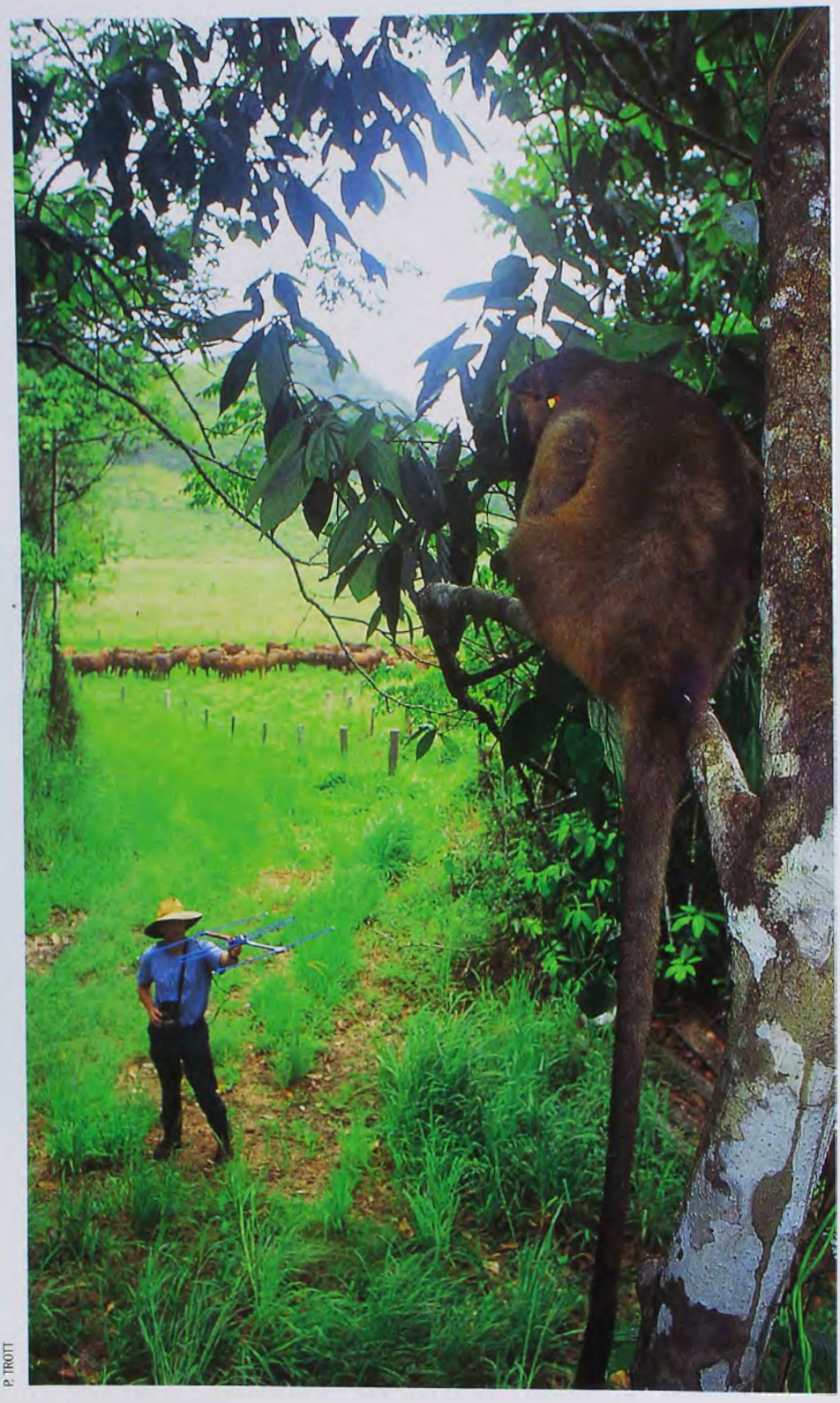
TO LOCATE ANIMALS ON A REGULAR BASIS meant that I had to capture and fit radio-collars to them. But how? Tree-kangaroos have a reputation for being formidable opponents of humans and dogs, and have been both prized and feared by Aboriginal and Papua New Guinean hunters alike. I didn't fancy tackling irate tree-kangaroos with their long, sharp claws. Therefore, to minimise the stress on the animals, as well as for my own sake, I decided to anaesthetise them first, using an impressive dart gun made by Roger Martin from Monash University. This was usually done at night when they were easier to find by their ruby red eyeshine in the glare of a spotlight. With a willing assistant I would then wait for the animal to nod off to sleep and then catch it, as it dropped off the branch, in a large fishing net held out below. This description makes the process sound easy, but often it wasn't, as the animals would move away as I approached to dart them.

When captured, each animal was measured, weighed and its breeding status determined. Since little is known of breeding systems in tree-kangaroos, a small tissue sample was taken for genetic analysis to establish family links between individuals and relationship to other Lumholtz's Tree-kangaroos throughout their distributional range. Each animal was also fitted with a radio-transmitter, and marked with a small tattoo on the inner thigh to identify them if captured later without the radio-collar. Male tree-kangaroos of several species are known to be very aggressive to each other and can induce fatal wounds with their powerful forearms and sharp claws. On several occasions I found two collars at the same site where adult males had obviously had a large brawl.

From July 1996 onwards I managed to collar one or two animals per week—a surprising success rate given that Lumholtz's Tree-kangaroo is such a secretive species. Within a matter of weeks I was collecting information on between seven and ten animals at least

FRITH/GIANELLI

All tree-kangaroos have a long tail that helps them balance on branches. Unlike monkeys and some other arboreal mammals, a tree-kangaroo's tail is not prehensile. When hopping over open ground, Lumholtz's Tree-kangaroos use their tail in a similar mode to their terrestrial cousins.



P. TROTT

A tree-kangaroo's perspective on what it is like to be radio-tracked. This adult male warily hides in a Grey Bollywood Tree and waits for the author to 'find' him (and then to go away and leave him alone).

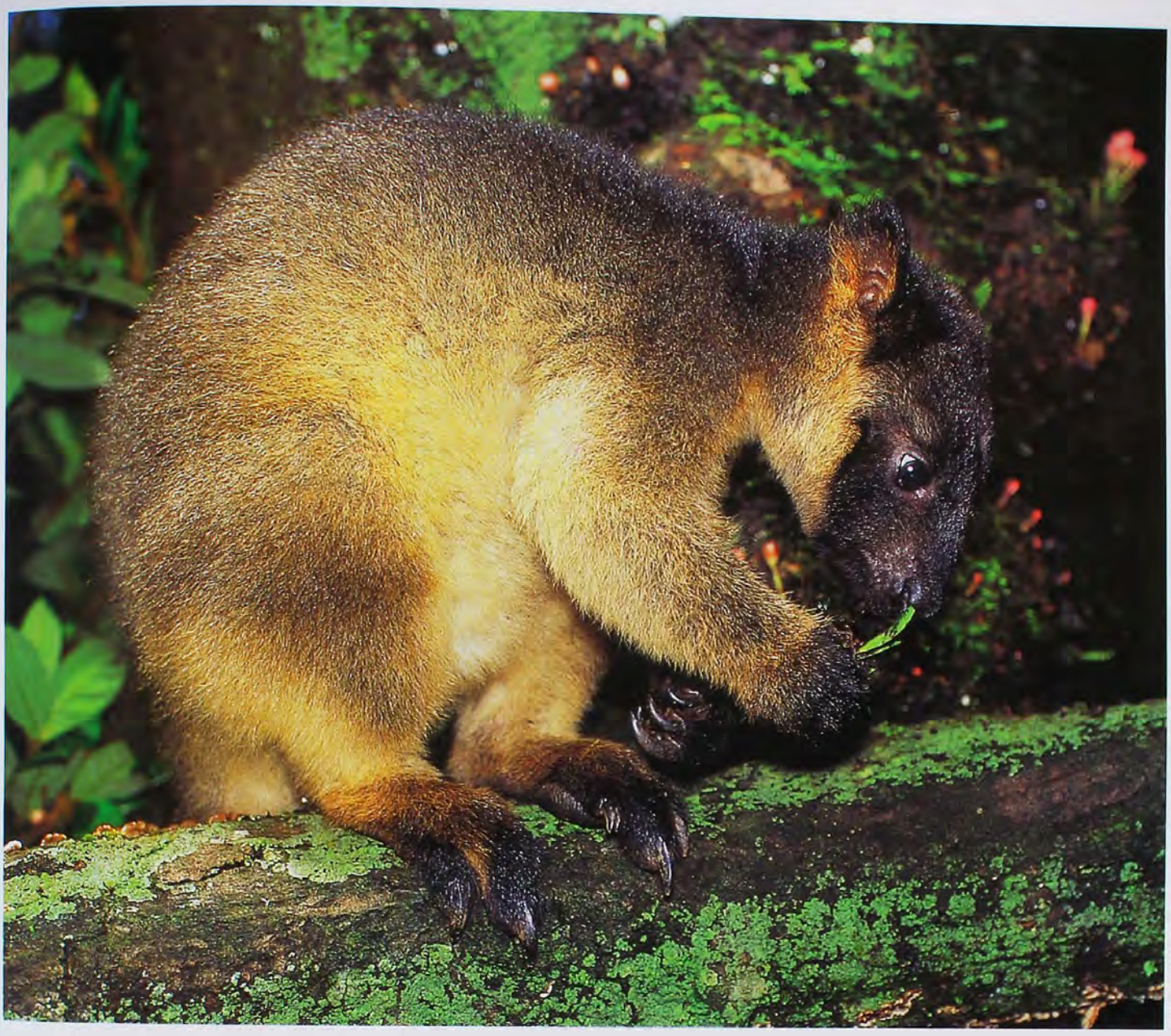
once each day using a hand-held antenna and telemetry receiver. With each sighting I recorded the time of day, grid position, and species of trees and vines associated with the animal. In the course of this monitoring I came to realise just how cryptic these animals were. Occasionally after searching from many different angles they could be seen 'sunbaking' at the top of a tree—a popular tree-kangaroo pastime. More often they would remain hidden in clumps of foliage even when only a few metres above my head. The radio-signal would indicate where they were, and I could often smell their peculiar musky odour, but mostly the animal remained invisible. Not a bad feat for such a large animal in often quite sparse foliage!

With data accumulating quickly, I began to get a pretty good picture of how Lumholtz's Tree-kangaroos used this patch of regrowth rainforest. They were regularly associated with trees such as Blackbean or Moreton Bay Chestnut (*Castanospermum australe*), Candlenut (*Aleurites mollucana*), Grey Bollywood (*Neolitsea dealbata*) and Milky Pine (*Alstonia scholaris*), and with the spiny creeper known as Cockspur Thorn (*Maclura cochinchinensis*). Most animals used surprisingly small areas, with females using around 0.7 hectare of the regrowth rainforest. Males had larger ranges that covered an average of 1.8 hectares, and these overlapped those of the females. When collating the radio-tracking data with the other animals I knew to be in the area, I worked out that the density of tree-kangaroos was probably between 1.5 and two individuals per hectare—a very high density for such a large animal and in such a small patch of forest.

It also became obvious that individual animals have a number of favourite trees within their home range, and that some of these animals were eating plants known to be toxic or at least unpalatable. While some people view a rainforest as Nature's pharmacy, the reality may be closer to Nature's poison cabinet. Many plants contain dangerous toxins in their leaves and fruits, thought to discourage folivorous animals from eating them. Other species are considered unpalatable because of their sticky sap, or contain large amounts of fibre that make the absorption of the leaf nutrients difficult. Unfortunately, the cryptic nature of tree-kangaroos makes it difficult to determine exactly what they were eating. Whether Lumholtz's Tree-kangaroos only eat some species sparingly, or use different tree or vine species in certain sequences to avoid or counteract some of the toxic effects of the chemicals, remains unclear.

Many local people have described how tree-kangaroos travel across paddocks and feast on cultivated trees and fruit. Radio-tracking, along with the collation of data from road-killed animals by a local wildlife carer, Margit Cianelli, suggest that the animals roaming the countryside are almost always juvenile and subadult males. In common with other species, these young males are probably evicted by their mothers and probably have a difficult time from antagonistic males at their home site. The best prospects for these young animals seem to be finding a home some distance away in a different patch of forest. Unfortunately for these young males on the Atherton Tablelands, this means running the gauntlet of bitumen roads and fast vehicles, and many, perhaps a dozen or more, are killed in this manner each year.

AFTER THREE TO FOUR MONTHS OF work, the land-holder informed me that he was about to clear half of the study site to increase the number of cattle he could run. Who said that knocking down rainforest for cattle only occurred in Brazil or in Asia? The bulldozing began immediately, and it posed an agonising dilemma. Should I pack up and find another site? Or should I accept it as a valuable opportunity to assess the



FRITH/CIANELLI

A juvenile female Lumholtz's Tree-kangaroo cautiously investigates a leaf before eating it. The bulk of their diet is composed of leaf material from a wide variety of plant species. In areas bordering rainforests animals will often enter paddocks, orchids and gardens to feast on cultivated crops such as maize, pumpkins and even mandarins!

Occasionally after searching from many different angles they could be seen 'sunbaking' at the top of a tree—a popular tree-kangaroo pastime.

effects of habitat loss on this rare species, being aware that the process and the results were both likely to be distressing?

During September and October 1996 approximately ten hectares of the forest were felled so that the trees could be burnt prior to the on-coming Wet Season. Intuition might have suggested that, if a tree-kangaroo's home is destroyed, then it would leave the area and look for another. Surprisingly, this was not the case. None of the five tagged animals resident in the cleared area moved out of its original range to other blocks of forest nearby. Some made short forays of several hundred metres, but they always returned to their flattened home territory. This response of maintaining 'normal' behaviour in the face of losing their home surprised locals and biologists alike. However, large arboreal animals become vulnerable to predation when there are no trees to climb. Some animals became prey within weeks for roaming dingoes and dogs, which can move easily around the edge of the felled area but not into the tangle of fallen trees. Two collared animals met with this fate, and it is likely that several other uncollared animals living in the area did also.

Not all animals fell prey to the local dogs. Animals that could escape predation had other dangers to contend with, such as finding the right kind of food. Some were probably forced to eat toxic plants not usually part of their diet rather than starve. Several animals rapidly lost body condition, and one male animal lost more than 15 per cent of his body weight in a week. This same animal was observed behaving strangely on the ground where he was feeding on Hoya vine (*Hoya australis*), a plant with an undescribed toxin that is known to be poisonous to cattle. The following day I

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While Lumholtz's Tree-kangaroos are good climbers, they do have their limitations, as this young animal is discovering on a Bumpy Satin Ash. Large tree trunks can make it difficult for the animal to get a claw hold on the often slippery and mossy surface. Perhaps for this reason, tree-kangaroos are often associated with vines that can be climbed more easily.

found him semi-comatose, and he died soon after of an undetermined cause at a local veterinary surgery.

Thankfully the 1997 Wet Season soon arrived and this had several benefits. Growth from the coppicing stumps and seedlings that germinated provided food for the animals within the cleared area. Several months after clearing, those tree-kangaroos whose ranges included both cleared and uncleared forest continued to regularly use both areas. Only one collared animal made the transition to an adjacent area of rainforest, but even so, she still returned every now and then to her original home and eventually she too succumbed to predation. Had the landowner burnt the area before the rain as planned, a very different situation would have eventuated. The remaining animals may have perished in the fire or been unable to find food or shelter in its aftermath. Alternatively, the fire may have eventually forced them to shift to another patch of forest, although the data collected so far suggest this would have been unlikely.

Translocation has been considered by some to be a panacea for the constant problem of habitat loss and what to do with the resident wildlife—simply shift the 'beasties' to live somewhere else. Superficially, this seemed an easy solution for these tree-kangaroos. However, time and other circumstances didn't allow this. Only one day's warning was given prior to the bulldozer starting work, and capturing wary animals from tangled flattened forest would have been almost impossible and very stressful on those animals. Translocation works well for some territorial species such as the Koala (*Phascolarctos cinereus*), but for others like the Common Brushtail Possum (*Trichosurus vulpecula*) it is thought to be futile. Many translocated Brushtails die as a result of not being able to establish a territory among individuals already resident in the area. How Lumholtz's Tree-kangaroo and other tree-kangaroo species would cope with a sudden relocation of their 'home' is not known. Translocation certainly needs to be fully investigated as a contingency for future loss of important habitat areas, but it should never be used as a cynical tool to cram more wildlife into smaller habitat areas while clearing continues unchecked.

FROM THIS RESEARCH WE KNOW THAT Lumholtz's Tree-kangaroos can survive in fragmented and regrowth forest,

although we don't exactly understand why they do in such abundance. Perhaps their density relates to the plant species present, or to the age of the forest since clearing. Regrowth forest is known to provide foliage high in nutrients, but correlating that with tree-kangaroo densities may be a little simplistic. Whatever the case, the larger picture of the habits of Lumholtz's Tree-kangaroos and how they behave in other forests will not be known until further research is undertaken.

The research also suggests that, with the exception of young males, tree-kangaroos are real homebodies. Once a home is established they are very reluctant to leave it, even when it is destroyed. Thus at an individual level, clearing of even small fragments will in most cases result in the death of resident animals, as they will not move to other habitat and are therefore vulnerable to attacks by dingoes or dogs. Unfortunately almost no data from studies on other species are available to either support or contradict these observations.

The high concentrations of Lumholtz's Tree-kangaroos in fragments of rainforest on private freehold land on the Atherton Tablelands suggest that the long-term conservation of this species is intimately connected with the fate of these fragments. Queensland currently does not have legislation covering the clearing of freehold land, as in some other States, and in most shires where Lumholtz's Tree-kangaroos are found there are no local by-laws governing clearing of native vegetation.

On the positive side, however, it would appear that relatively small fragments, including recently regenerated forest, may be able to provide some suitable habitat for these animals. This information provides a valuable incentive for not only preserving strategic blocks of the remnant and regrowth rainforest, but also for revegetating suitable areas that are unviable for agriculture. In the future these could provide valuable corridors to join existing areas of tree-kangaroo habitat and ensure the conservation of this rare species in the agricultural landscape of the Atherton Tablelands.■

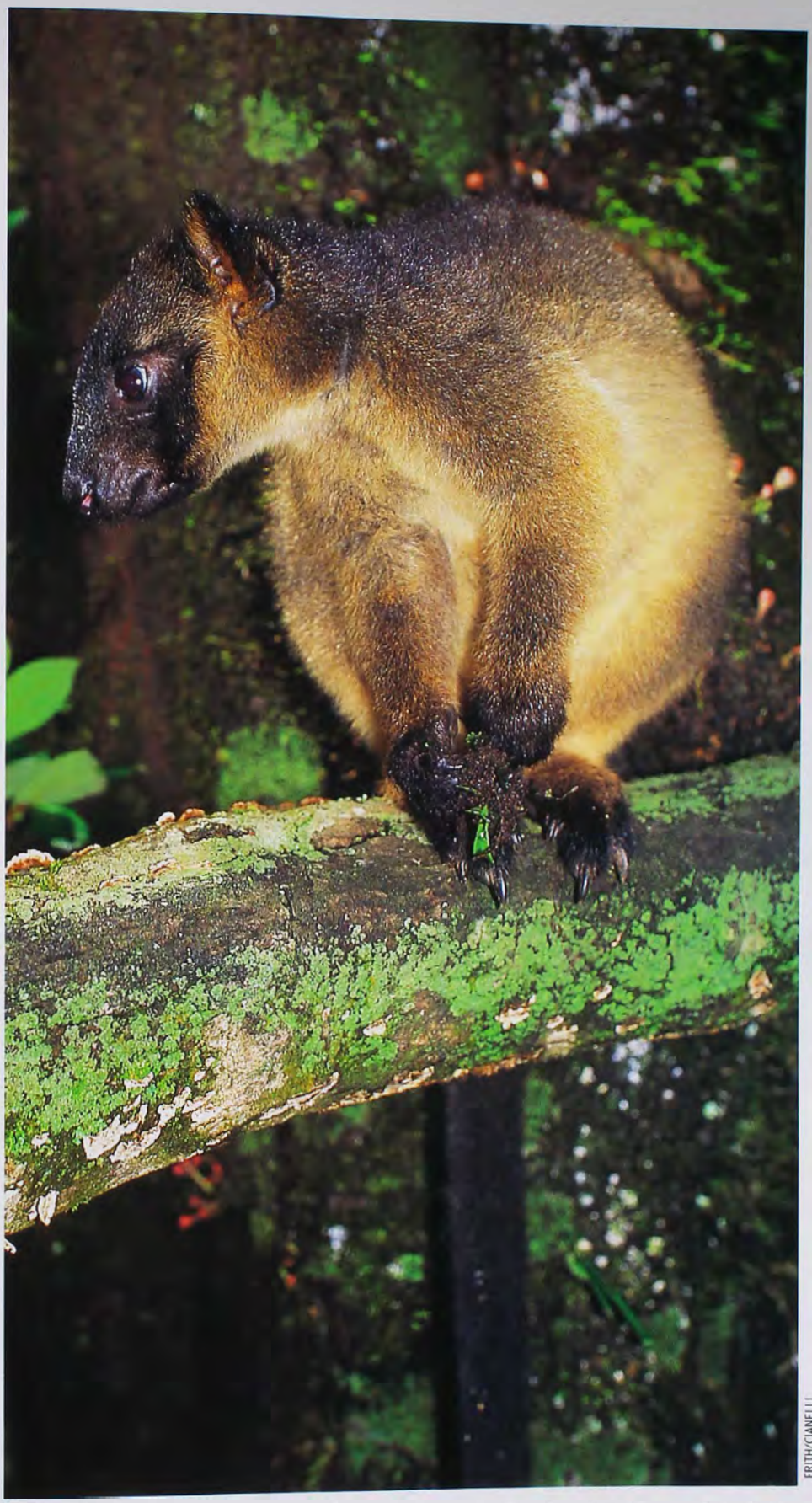
Further Reading

Flannery, T.F., Martin, R. & Szalay, A., 1996. *Tree kangaroos. A curious natural history.* Reed Books: Melbourne.

Procter-Gray, E., 1984. Dietary ecology of the Coppery Brushtail Possum, Green Ringtail Possum and Lumholtz's Tree-kangaroo in North Queensland. Pp. 129–135 in *Possums and gliders,* ed. by A.P. Smith and I.D. Hume. Australian Mammal Society: Sydney.

Procter-Gray, E. & Ganslosser, U., 1986. The individual behaviours of Lumholtz's tree-kangaroo: repertoire and taxonomic implications. *J. Mamm.* 67: 343–352.

Procter-Gray, E., 1990. Kangaroos up a tree. *Nat. Hist.* 1/90: 61–66.

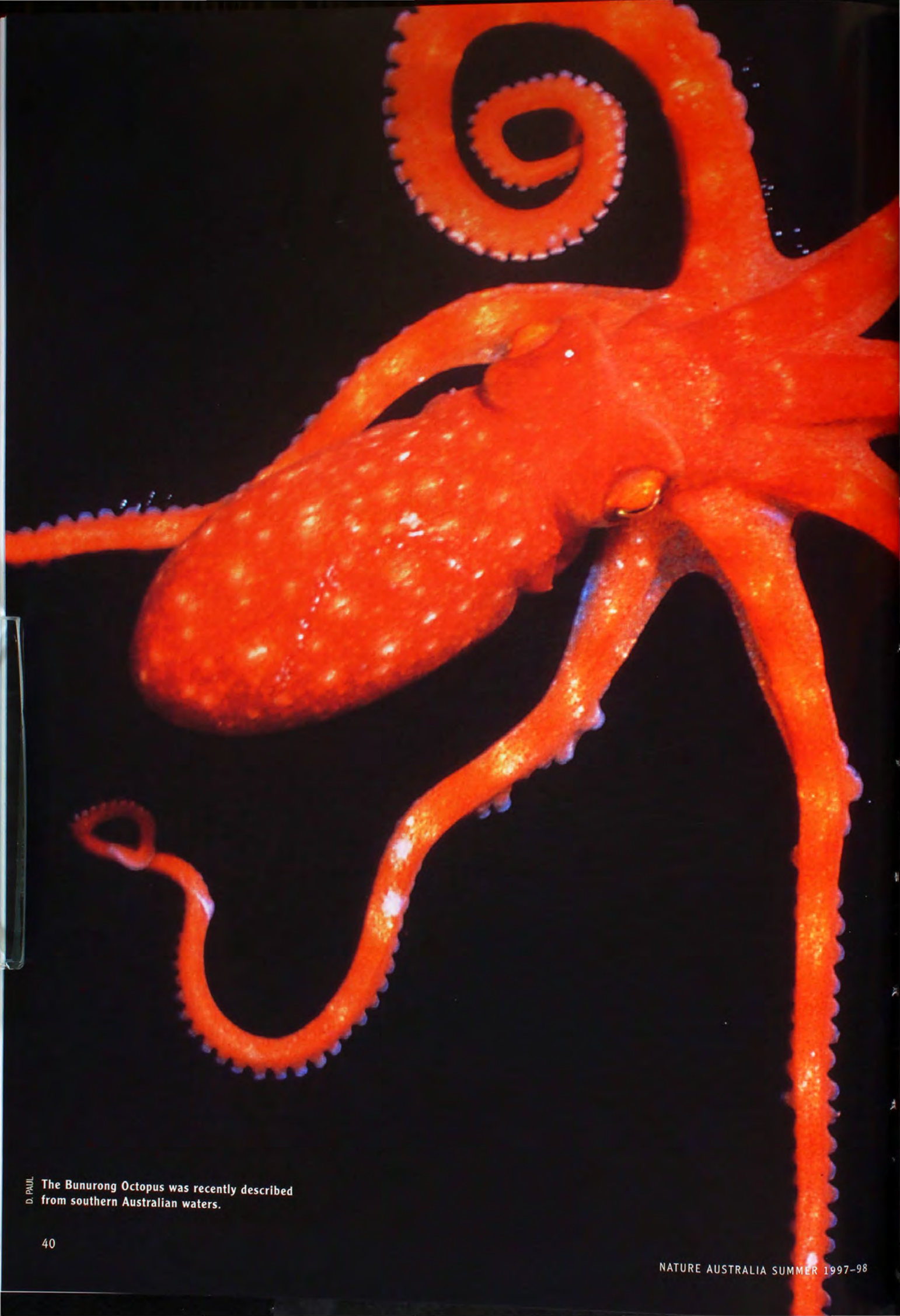


FRITH/CIANELLI

Dr Graeme Newell is a research fellow at CSIRO's Tropical Forest Research Centre in Atherton, Queensland.

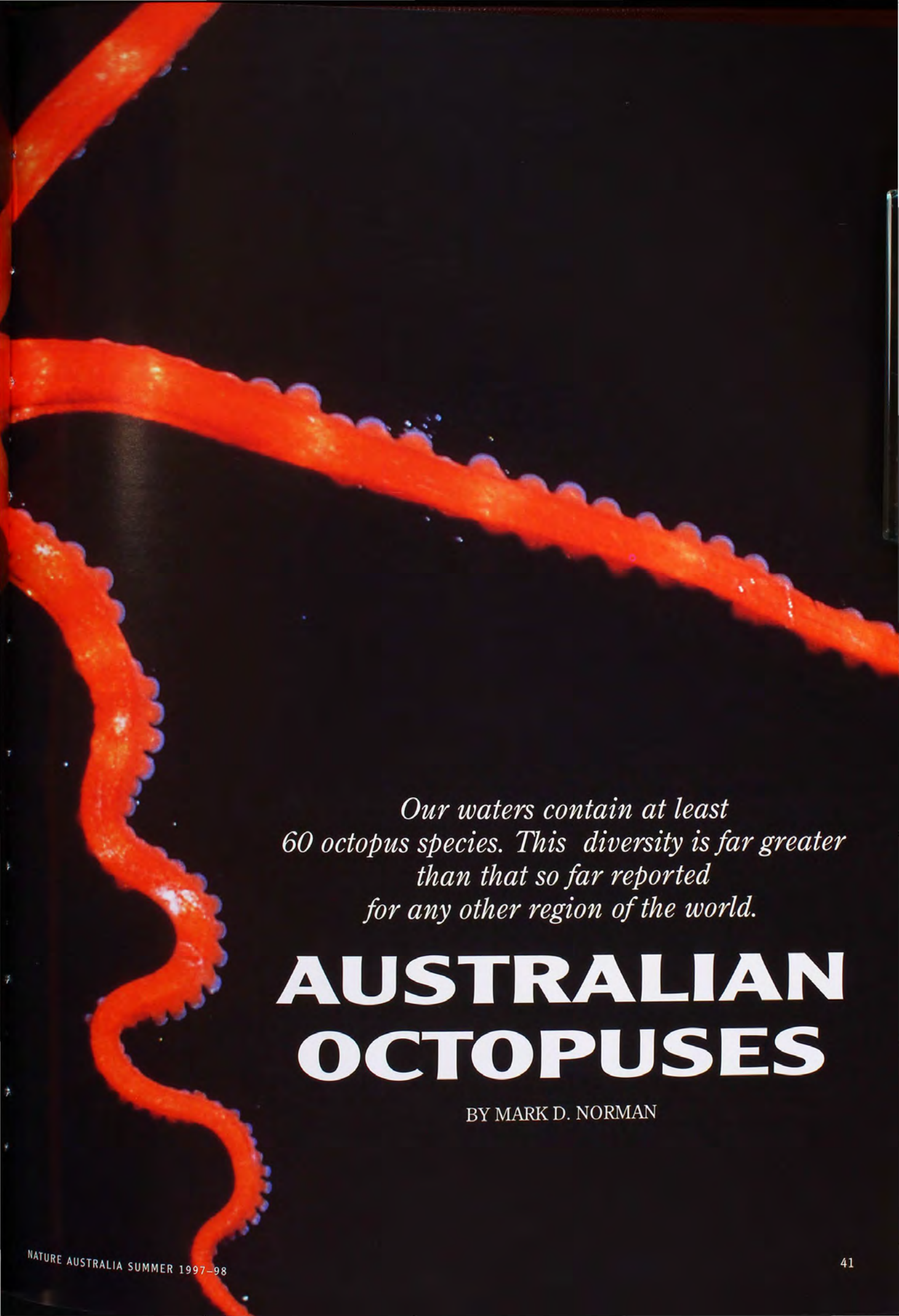
The project described here was funded by the Co-operative Research Centre for Tropical Rainforest Ecology and Management. He wishes to acknowledge the valuable assistance of Peter Trott, a journalist who worked in Perth and Sydney before joining the CSIRO Division of Wildlife and Ecology's Atherton team as their communication officer.

Lumholtz's Tree-kangaroos have a characteristic black mask covering their face, as well as black fur on their front paws and hind feet that creates a 'mittens-and-socks' effect. The colouration of the body coat can vary widely from pale cream through shades of grey to a deep, russety red. The underneath of the tail is darkly coloured and, when viewed from high in the canopy, it can look like a slender branch.



D. PAUL

The Bunurong Octopus was recently described from southern Australian waters.



Our waters contain at least 60 octopus species. This diversity is far greater than that so far reported for any other region of the world.

AUSTRALIAN OCTOPUSES

BY MARK D. NORMAN

DWARFS, ARM-DROPPERS, POISONERS, spindly giants, sand-swimmers, smokers, camouflage experts and mimics. This list sounds like a circus side-show or a plot for a good science fiction movie. Instead it refers to the behaviours and lifestyles of Australia's extraordinary array of octopuses, which range from pygmies the size of a fingernail to muscular giants with arms spanning three metres. Recent research suggests that our waters contain at least 60 octopus species, of which more than two-thirds are new to science. This diversity is far greater than that so far reported for any other region of the world. By contrast the Caribbean and Mediterranean Seas contain around 10 species each.

Little is known of Australian octopuses. The majority lack formal descriptions and many are known only from a few photographs or poorly preserved museum specimens. Recent advances in diving and underwater photography techniques are now providing our first glimpses of the incredible diversity in form and behaviour of these poorly known animals.

One of the best known features of all octopuses is the fact that they have eight arms. These arms can be considered 'super lips' as they are modified appendages surrounding the mouth. The inner surface of each arm is lined with one to two rows of adhesive suckers, which are used to seize prey and, for bottom-dwelling species, to 'walk' along the substrate. The individual suckers and the muscles of the arms are very strong, capable of prizing apart bivalve shells or pushing weighted lids off aquariums. In some species, an individual sucker can hold weights in excess of two kilograms. All the body organs and gills are stored in a muscular bag (the mantle). Expansion and contraction of the mantle pumps water in and out of a cavity in the mantle, allowing oxygen to be absorbed through the gills. The exhaled water can be harnessed to provide jet propulsion by forcing water through the funnel.

Many studies have examined the intelligence of octopuses and demonstrated learning and problem-solving skills.

The mouth is made up of a parrot-like beak and a toothed tongue, the radula. The radula is used to drill holes into the shell of crabs, shrimp, even clams and snails, through which paralysing saliva is injected. For bivalve molluscs, the toxins in the octopus' saliva relax the muscles that hold the shells together, and the octopus can then prize them apart. Octopuses may control more active prey like crabs by nicking one of the crab's eye tips with the radula and injecting toxins straight down the optic nerve into the animal's brain. It is a quirk of evolution that the brain of octopuses and other cephalopods developed surrounding the oesophagus. This means that, to avoid serious migraines, octopuses must chew their food into a puree before swallowing it.

The well-developed eyes of octopuses are similar to the eyes of humans with an image-forming lens and large retina, which enable excellent vision, although not in colour. The brain is very large for an invertebrate. Many studies have examined the intelligence of octopuses and demonstrated learning and problem-solving skills. For example, octopuses soon learn to screw the lids off glass jars in order to capture prawns or crabs placed inside. There are even reports from the last century of tool use by an octopus, which used small stones to wedge open clams before squeezing inside to devour the shellfish.

The iridescent blue false eye-spots of the Poison Ocellate Octopus are used to startle would-be predators and may advertise a venomous nature. The ancestors of the venomous blue-ringed octopuses (which are covered in such rings) may have been similar to this octopus.

M. NORMAN

BEING SOFT-BODIED (LACKING AN external shell or internal skeleton), octopuses make a perfect meal for predators, particularly larger fishes, sharks or seals. Many octopuses take advantage of their lack of skeleton by squeezing themselves through tiny holes into crevices or burrows. An octopus with a 30-centimetre arm span can squeeze through a hole the size of a five-cent piece. Still octopuses have had to develop a wide range of other defences to escape predators.

The greatest array of defence strategies occurs in shallow-water, bottom-living (benthic) octopuses in the family Octopodidae. Diurnal octopuses such as the common Day Octopus (*Octopus cyanea*), which emerge and forage during daylight hours on coral reefs, have developed exceptional camouflage capacities. They produce elaborate colour patterns and highly complex skin textures capable of matching a wide range of backgrounds from sand and reef rubble, through to spiked corals and seaweeds. Their skin changes almost instantaneously as they move over different substrates on the sea floor. Colour changes are carried out by small, elastic, pigment-filled sacs, known as chromatophores. A square centimetre of skin may contain hundreds of chromatophores, in up to five colours in certain species. Each chromatophore is surrounded by a ring of muscle fibres, all of which are under the rapid and coordinated control of the large optic lobes of the brain. As a backup defence, most octopuses also have an ink sac that produces highly concentrated black, red or brown pigment. Small amounts of ink are squirted out the funnel to produce either a dummy decoy or, in some species, a full smoke screen that can mask a volume of water up to several cubic metres, leaving predators chasing their own tails. The ink is also thought to dull the senses of the predator.

When threatened, many octopuses try to bluff the predator by appearing larger or more robust than their real size. They do this by flaring or flattening the body, arms and web of skin between the arms. At the same time they darken the edge of the web and also the area around the eyes. A number of octopuses have further developed this strategy of appearing big by adding false eye-spots or ocelli to their patterns. As in many insects, these 'false eyes' make the octopus look like the head of a much larger animal, deterring would-be attackers. Such octopuses are known as 'ocellate' or 'two-spot octopuses'. Certain species, when startled, can display an iridescent blue ring within each ocellus, making these false eyes even more obvious. The Poison Ocellate Octopus (*Octopus mototi*), for example, is normally a dull orange-brown, but when disturbed it produces a dazzling display of maroon stripes and flashes brilliant blue rings in the ocelli. This species was described

PHOTOS: SIMON FOALE

The Southern Sand Octopus quickly draws itself under the sand to flee from predators. It can form 'chimneys' in the sand by coiling two arms over its body to form pipes through which water can be pumped to the mantle and gills.

CLAY BRYCE/LOCHMAN TRANSPARENCIES

The Greater Blue-ringed Octopus occurs in northern Australia and has been responsible for at least one human fatality.

from Rapa Island in the South Pacific, where it is known locally as *fe'e mototi* (= poison octopus), hence the scientific name. The nature of its poison, however, has not yet been examined.

Octopuses similar to the Poison Ocellate Octopus may have given rise to the poisonous 'blue-ringed' octopuses of Australia and Asia. It is possible that they replicated the iridescent rings of the false eye-spots all over the body and arms to produce this brilliant colour pattern advertising their poisonous nature. We know very little about the blue-ringed octopus group. A number of species are reported to occur from Japan to southern Australia, including at least three species in Australian waters.

The Southern Blue-ringed Octopus (*Hapalochlaena maculosa*) occurs in southern Australia and is recognised by small blue rings covering the upper body and arms. The Greater Blue-ringed Octopus (*H. lunulata*) has larger rings and occurs in northern Australia and farther north in the tropical western Pacific Ocean. Other species are recognised by different patterns of blue on the body. The Blue-lined Octopus (*H. fasciata*) from New South Wales has blue lines instead of rings on the body, but blue rings elsewhere on the arms.

Blue-ringed octopuses are thought to harness bacteria in their salivary glands to produce tetrodotoxin—the same paralysing neurotoxin found in the poisonous puffer fishes. Several human fatalities in Australia have been attributed to bites from these small octopuses. The powerful venom acts on the victim's voluntary muscle, paralysing the muscles required for body movement and breathing. When bitten, the victim's heart continues to beat and he/she remains conscious. Mouth-to-mouth resuscitation can keep the victim alive and the poison gradually wears off after 24 hours, apparently leaving no long-term side effects. Some patients that have survived such an experience talk of the terror of lying immobile and conscious while people around them are convinced of their demise.

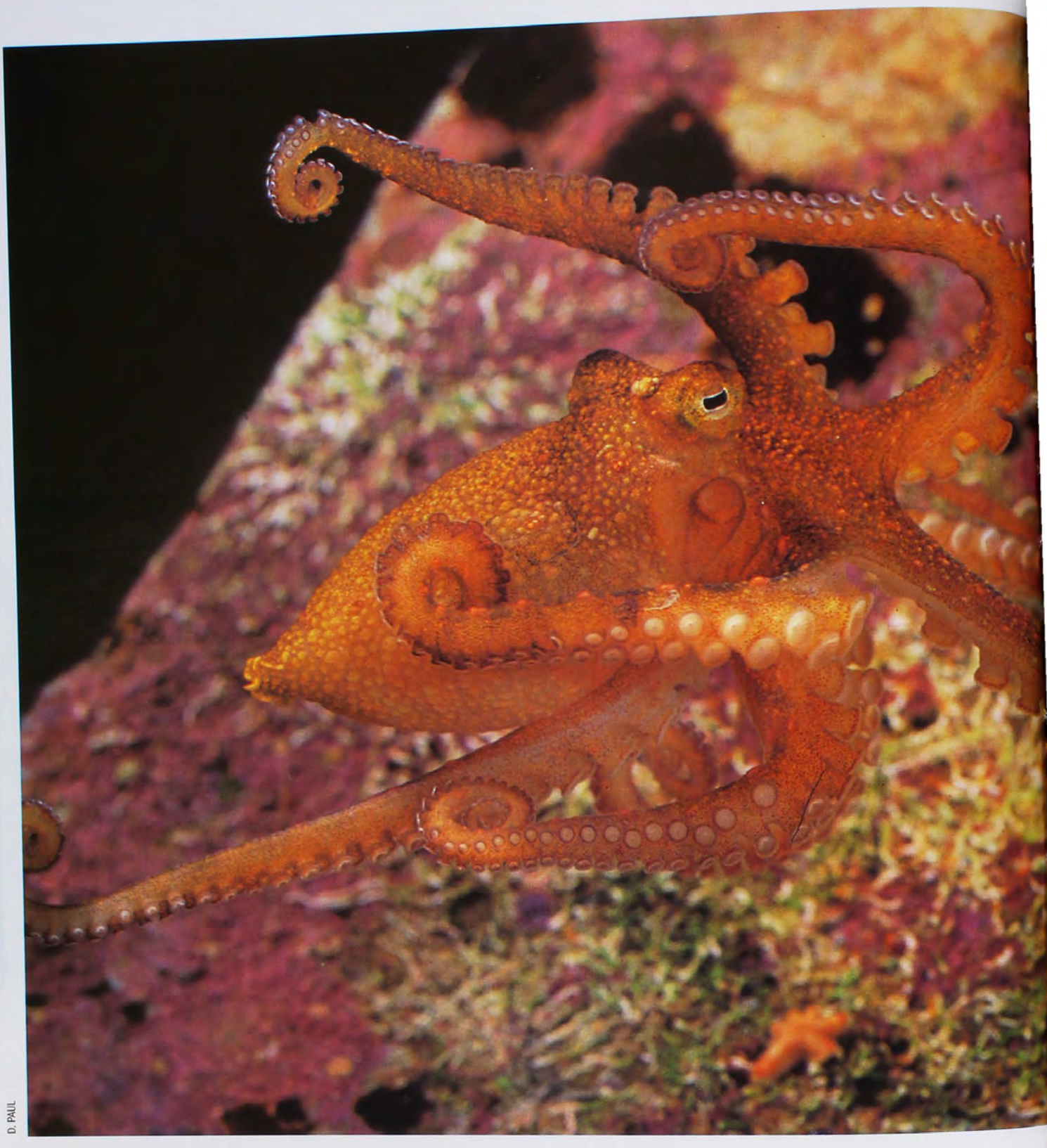
The powerful venom paralyses the muscles required for body movement and breathing. When bitten, the victim's heart continues to beat and he/she remains conscious.

A number of long-armed octopuses have developed the ability to drop arms as a decoy to attackers. This defensive strategy is known as autotomy. It is perhaps best known in certain lizards that drop their tails when threatened. The arm of the octopus, severed at the base, continues to writhe, in some cases for up to four or five hours, distracting (and feeding!) the attacker while the octopus makes its getaway. Occasionally an octopus is found in the wild with only two intact arms. The lost arms, however, do grow back. In some species they can fully regenerate within six to eight weeks. The Banded Drop-arm Octopus (*Ameloctopus litoralis*) of northern Australia has arms up to ten times its body length. Autotomy in this octopus must be a very effective deterrent as it is one of the few shallow-water species in the world that has dispensed with an ink sac. Perhaps ink decoys or 'smoke screens' don't hide such long arms.

Many octopuses restrict their activity to the cover of night. Members of one group of nocturnal octopuses are recognised by red-and-white colour patterns and longer front arms (those in front of the eyes). They forage for prey down crevices and lairs, and under rocks or coral heads. Some species, such as the

M. NORMAN

The Day Octopus, which forages during daylight hours on coral reefs, reaches weights of six kilograms and has arm spans over two metres wide.



D. PAUL

Bunurong Octopus (*Octopus bunurong*) of Southern Australia, are generalist feeders, eating a wide range of prey. One tropical octopus in this group was encountered carrying the night's catch: several crabs, two bivalve shells, a shrimp, a polychaete worm and a freshly decapitated octopus. Other members of this group are more specialist in their diets, one—the White-striped Octopus (*Octopus ornatus*)—having developed a taste for other octopuses.

A different defensive strategy is to avoid most predators by living intertidally. Tropical Australia has many octopuses that are only known to live on intertidal rocky reefs or sand flats. Such animals emerge to feed during the short periods of low tide, when these habitats are uncovered and big predatory fish are forced into deeper water. These octopuses feed in and between the shallow pools exposed at low tide, even dragging themselves over dry, exposed ground when moving between pools. Certain intertidal species feed only at night, while others, such as an undescribed species from the Great Barrier Reef, only emerge during low tides during the day.

Lairs or dens are used by many species of octopus as refuges. These can be holes in corals or rocks, empty mollusc shells or coconuts, excavations into rubble, sand or mud made by other animals, or tailor-made dens prepared by the octopus. Lairs are often recognised by the 'kitchen scraps' (midden shells and other food debris) scattered around the mouth of a hole. The Common Sydney Octopus (*Octopus tetricus*) typically sits in the mouth of its lair, often closing the entrance by holding rocks or shells on the suckers.

Other octopuses seek refuge within the sand. The Southern Sand Octopus (*Octopus kaurna*) inserts its fine arm tips deep into the sand and uses these as

The Pygmy Club Octopus, which weighs less than five grams, is one of many pygmy species recently discovered in Australia. Some species are mature at under one gram.

In certain octopuses, the male develops a few very large suckers that may be flashed at females during courtship displays to advertise his maturity.

an anchor to pull itself quickly below the surface. Such species have no true lair and hide in the sand during the day. Some can even 'swim' through the sand, occasionally surfacing for a 'breath' or using a single periscopic eye to see if the coast is clear.

One of the least studied groups is the pygmy octopuses, some of which are fully mature at weights less than one gram and with a body the size of a fingernail. Pygmy octopuses are rarely encountered live. The majority have been collected during scientific surveys when chemical immobilisers are used to flush these animals from their refuges. The little-known Pygmy Club Octopus (*Octopus warringa*) is one such species that lives among seaweed and rubble in southern Australia. The modified arm tip in the males of this species is swollen like a club, hence the name. Other tropical species spend their entire life cycles within the safety of small coral heads. Evolutionary pressures may have acted on the ancestors of these dwarf species, selecting octopuses that mature at smaller and smaller sizes so that they do not outgrow either their refuge or the food supply living within their haven.

OTHER VERY DIFFERENT OCTOPUSES spend their entire life in the open ocean, never touching the sea floor. These are the argonauts (family Argonautidae) and their relatives. Argonauts (also known as paper nautiluses) are a type of octopus in which the female produces a delicate white brood shell or egg case in which to live and lay her eggs. Males are very different, being a tenth (or less) the size of the female and lacking the delicate brood shell. Southern Argonauts (*Argonauta nodosa*) periodically wash ashore in southern Australian waters, possibly blown in from the open ocean by wind-driven surface currents.

The Blanket Octopus (*Tremoctopus violaceus*) is an open-ocean creature related to the argonauts but is bizarre enough to warrant its own family (Tremoctopodidae). On the front arms it has long veil-like webs, the tips of which can be shed in segments, like sheets of toilet paper. The function of these webs is unknown but they may be used as lures to attract prey. Females may be up to two metres long but the males are dwarfed and lack the veil-like webs of the female. The Blanket Octopus has no shell like the paper nautiluses; instead the eggs are attached to small rods made by the female and carried in her arms. For defence, the Blanket Octopus

OCTOPUS SEX

Male octopuses are distinguished from females by the presence of a modified third arm, the third right arm in most species. This arm has a groove running along the edge and a leaf-shaped grasping structure at the tip. When octopuses mate, the male moves elongate sperm packages, called spermatophores, along the groove to the arm tip. The male places the copulatory arm into the mantle cavity of the female where the tip of the arm inserts spermatophores into the female's oviducts. In some long-armed rock-pool octopuses, the male remains hidden, snaking a long modified arm across the rock pool to transfer spermatophores to the hidden female.

During courtship males of some species use complex postures and skin patterns to put on spectacular displays of colour and texture. Often these patterns are only displayed on the side facing the female, while the opposite side of the animal remains camouflaged, presumably as a means of not alerting passing males to the presence of a receptive female in the area. In certain octopuses, the male develops a few very large suckers that may be flashed at females during courtship displays to advertise his maturity, or at males in territorial disputes.

Females of some octopuses can store sperm in special glands for periods of up to three months, until the eggs are mature and ready to be fertilised and laid. Females of all octopuses tend their eggs, continually cleaning them and jetting them with clean water. Females remain with the eggs until hatching, and then die soon after.

In the argonauts (paper nautiluses) and the Blanket Octopus, the miniature male's entire copulatory arm with its store of sperm breaks off inside the female's body cavity. Females have been observed with arms from up to six past suitors, each tip still holding packages of live sperm.

KATHIE ATKINSON

M. NORMAN

has been reported to hold the stinging tentacles of bluebottles in its arms. Virtually nothing else is known about the behaviour, feeding, or life span of this octopus. It has been collected in open ocean around Australia, with one unusual record of a female that was caught in a crayfish pot off Victoria.

Other strange jelly-like octopuses live in very deep waters (below 1,000 metres). Unlike typical octopuses, these forms have fins on the body and small sensory filaments (cirri) along the arms between the suckers, presumably used to find prey along the dark, muddy sea floor. These 'cirrate' or 'finned octopuses' have webs that extend to the arm

The White-striped Octopus is a large tropical species with arms up to one metre long. This aggressive nocturnal species is found from Hawaii to east Africa and has a taste for other octopuses.

The Common Sydney Octopus is found along the coast of New South Wales and southern Queensland. It is frequently seen by divers at the mouth of its lair during the day or out hunting at night.

tips. When they spread their arms they look like a rubbish bin lid as they drift or glide through the dark depths. Some species are known to have arm spans that reach three metres. Cirrate octopuses are generally only encountered in deep-sea research trawls, or observed from underwater submersibles.

We still know very little about many of the octopuses from Australasian waters. Many species are collected both by commercial and recreational fishers, for the dinner table and/or as bait, but virtually nothing is known of their biology, behaviour, early life stages, or stock sizes. Some species are known to science only from photographs or individual museum specimens. One such species from muddy waters of northern Australia is known only from two museum specimens. These animals, although shrivelled from the preservation fluid, have delicate spindle-shaped bodies and thin elongate arms each over a metre long. In life this animal must be very impressive, foraging like a giant daddy-longlegs spider over the soft sediments of the Gulf of Carpentaria. Researchers have nicknamed it 'Spaghetti-pus'! Other remarkable reports, particularly from tropical waters, are trickling in of spectacular mimics: new species of octopuses impersonating hermit crabs (complete with shell!), and even flatfishes, lionfishes and sea horses.

When they spread their arms they look like a rubbish bin lid as they drift or glide through the dark depths. Some species are known to have arm spans that reach three metres.

For the scientist, some of the most exciting information is coming from divers, particularly underwater photographers, who are witnessing the complex behaviours of these animals in the wild. If anyone has such information on octopuses, from the Australian Region or from anywhere throughout the Pacific and Indian Oceans, please send it to me*. Images, specimens and anecdotal information all help us to expand our knowledge and appreciation of these fascinating and alien creatures.■

Further Reading

Hanlon, R.T. & Messenger, J.B., 1996. *Cephalopod behaviour.* Cambridge University Press: Cambridge.

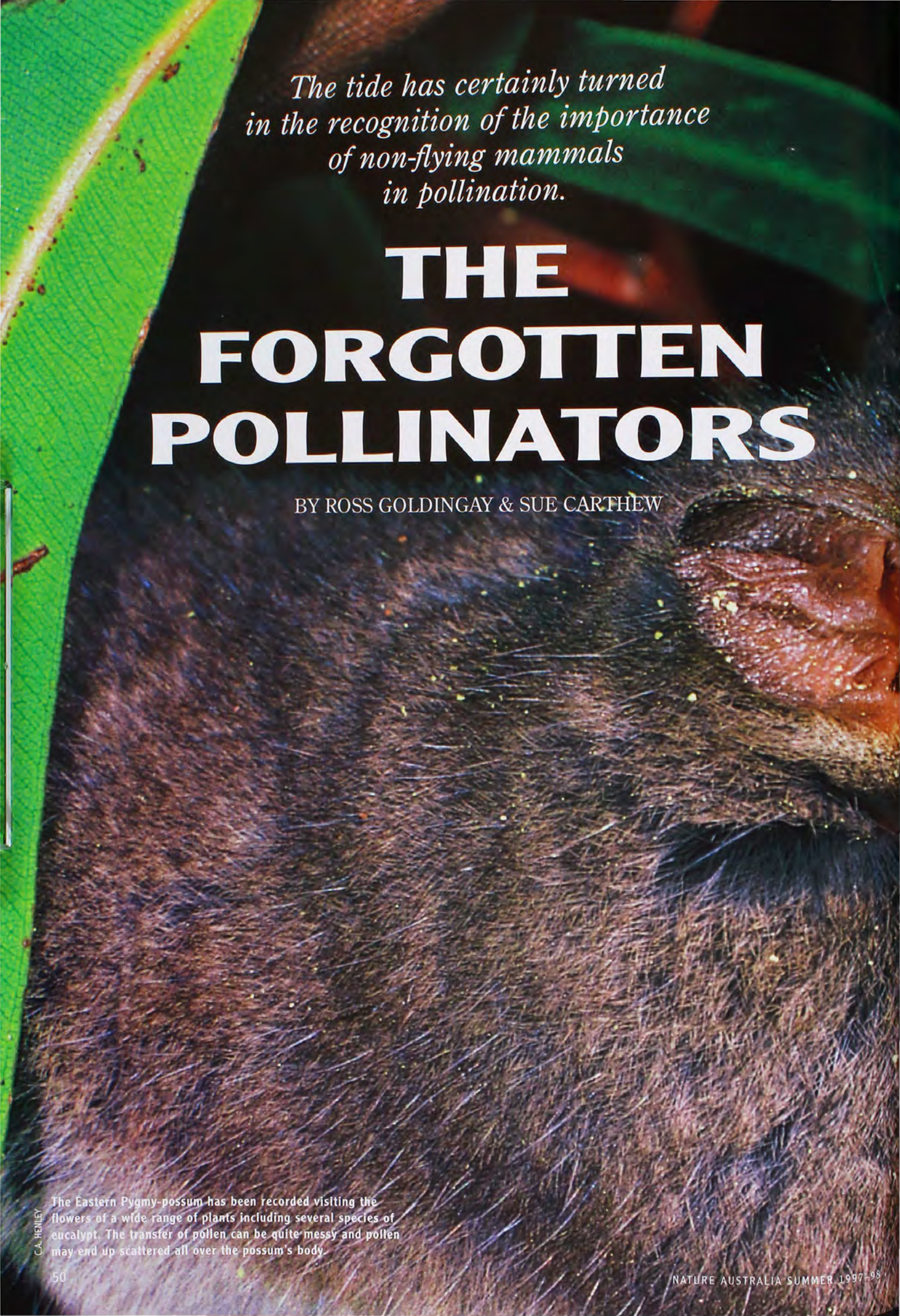
Lane, F.W., 1957. *Kingdom of the octopus.* Jarrolds Publishers: London.

**Dr Mark Norman is a Research Fellow at the University of Melbourne, co-sponsored by the Museum of Victoria. His research interests include the biology, behaviour and evolution of cephalopods, ranging from pygmy octopuses to giant squids. Specimens, photographs and/or information on the behaviour of octopuses in the wild can be sent to the author c/- Department of Zoology, University of Melbourne, Parkville, Vic. 3052.*

The tide has certainly turned in the recognition of the importance of non-flying mammals in pollination.

THE FORGOTTEN POLLINATORS

BY ROSS GOLDINGAY & SUE CARTHEW



C.A. HENLEY

The Eastern Pygmy-possum has been recorded visiting the flowers of a wide range of plants including several species of eucalypt. The transfer of pollen can be quite messy and pollen may end up scattered all over the possum's body.

WHEN WE THINK OF pollination we think mostly of birds and bees. Some of us may recognise that many insects visit flowers, and a few may be aware that bats, particularly the large fruit bats, are also involved in pollination. However, it appears we have sold some of our native fauna short in the pollination stakes. The animals we commonly overlook are the small ground- and tree-dwelling mammals, collectively referred to as 'non-flying mammals'.

The first suggestion that Australian non-flying mammals were likely to be involved in pollination was published over half a century ago. However, it was not until the mid 1970s that research began on the possible role of non-flying mammals in pollination. This work occurred almost simultaneously in South Africa and Australia, where the large flower spikes of African proteas and Australian banksias were found to attract the attention of non-flying mammals. More detailed studies in the early 1980s concluded that several small rodents in South Africa were very effective pollinators but the Australian species fared rather poorly, particularly when compared to their avian counterparts, the honeyeaters. Thus, the Australian non-flying mammals were relegated to second-class pollinators and once again largely forgotten.

ROSS GOLDINGAY

The placement of honey-baited mammal traps alongside banksia flowers produced high capture rates. The pollen loads sampled from mammals shortly after capture were very high.

The Honey Possum is the world's only non-flying mammal with a diet consisting solely of nectar and pollen. Detailed studies are yet to be done to determine the actual importance of this species in pollination.

THERE ARE PROBABLY TWO REASONS WHY non-flying mammals have been undervalued as pollinators. The first is that most of these species are nocturnal, which makes it very difficult to observe their raids on flowers. The second is that mammals are generally perceived as being less careful when they feed at flowers; some may appear to be destructive as they feed, and they groom regularly, which would remove any pollen sticking to their fur.

With colleagues at the University of Wollongong, we have spent over ten years studying several species of non-flying mammals in order to understand their role in pollination. We felt from the outset that there was strong anecdotal evidence for these mammals being important pollinators, but to convince others of their effectiveness, we had to show that they were, in fact, regular visitors to flowers and fed non-destructively; that they actually carried more than trivial amounts of pollen on their fur; and, perhaps most importantly, that their visits led to the production of seed.

We could tell that the animals had actually visited the flowers from the pollen on their heads or in their faeces.

The first part of our study was conducted along the New South Wales coast at five sites from Wollongong, just south of Sydney, down to Batemans Bay. We set live traps near the flower spikes of six different *Banksia* species (both summer- and winter-flowering varieties) as well as near the spectacular crimson inflorescences of the Waratah (*Telopea speciosissima*). These plants were chosen because they grow as shrubs (as opposed to tall trees) and were thus easier to access. We devised a simple stand for the traps that enabled us to place them right beside flowers dripping with nectar.

We were surprised to capture mammals visiting all seven plant species surveyed. We could tell that the animals had actually visited the flowers from the pollen on their heads or in their faeces. Also surprising was that the Brown Antechinus (*Antechinus stuartii*) was

REMORRISON

SUE CARTHEW

A photographic device with an infra-red trip was used to quantify flower visitation by non-flying mammals. Here an Eastern Pygmy-possum tucks into the nectar of the Waratah, a supposedly bird-pollinated plant.

the most common visitor, followed by the Sugar Glider (*Petaurus breviceps*) and the Eastern Pygmy-possum (*Cercartetus nanus*) and then the native Bush Rat (*Rattus fuscipes*). The Brown Antechinus has long been regarded as an insectivore, so to witness its penchant for nectar shows there is still much to be discovered about this common marsupial.

With much-needed assistance from Ederic Slater (a retired CSIRO wildlife photographer), we also set up cameras in the field that would be activated by an infra-red trip when the flowers were being visited. This photographic technique provided compelling evidence that these small mammals were important in pollination. Photos showed mammals feeding non-destructively with their heads buried among flowers. Visits occurred throughout the night and individual visits lasted from two to six minutes.

Another way we tried to assess the frequency of visits was by direct observation, using a spotlight. This proved rather tricky when the animals were in small shrubs, but a detailed study in the tall Spotted Gum (*Eucalyptus maculata*) forests near Batemans Bay revealed that flowering eucalypts were targeted for food (pollen and nectar) by Yellow-bellied Gliders (*Petaurus australis*), Feathertail Gliders (*Acrobates pygmaeus*) and Sugar Gliders whenever such trees were present. When hundreds of flowering trees were present, gliders regularly moved among trees to feed. When few such trees were present, several of each glider species would often feed in the one tree and for hours at a time. An important observation was that Yellow-bellied Gliders did not groom when they moved from one tree to another, suggesting they could carry significant pollen loads.

Photos showed mammals feeding non-destructively with their heads buried among flowers.

JEAN-PAUL FERRERO/AUSCAPE

The Sugar Glider behaves true to its name and seeks out natural sources of sugar in its habitat. Nectar from the flowers of eucalypts and banksias is highly favoured, resulting in Sugar Gliders being important pollinators of these plants.

NOW FOR THE SECOND LINE OF evidence. Just how much pollen do Australian non-flying mammals carry? Is it really trivial as earlier studies had implied? We decided to study the pollen loads carried by Sugar Gliders and Brown Antechinuses that were visiting banksias in the Barren Grounds Nature Reserve, near Wollongong. From the earlier trapping studies it was clear that sampling the fur for pollen the morning after capture would not provide an accurate assessment of the amount of pollen carried, simply because mammals sitting in traps have little to do other than groom. So, over a period of several months we stayed out at night, checking traps and sampling pollen at one-to-three-hour intervals. We also hand-captured any Sugar Gliders we saw in plants as we patrolled the traps.

There are various techniques available for sampling pollen from animals. We settled on perhaps the simplest, which involved dabbing a piece of sticky tape onto the animal's head and snout and then sticking the tape on a microscope slide for counting. These pollen counts provide an index of the total size of the pollen load present on an animal, and are useful when comparing relative pollen loads carried by different animals.

Earlier studies on honeyeaters using similar techniques reported counts of

SUE CARTHEW

A Brown Antechinus caught in the act of nectar-feeding on the summer-flowering Old-man (or Saw) Banksia (*Banksia serrata*). This mammal was found to be the most regular banksia visitor in our trapping survey.

thousands of pollen grains. We obtained counts of over 2,000 pollen grains for Sugar Gliders and over 400 for Brown Antechinuses. However, sampling of pollen from Eastern Spinebills (*Acanthorhynchus tenuirostris*), the most abundant honeyeater in our study area, revealed counts of less than 40 grains. This was a curious reversal of the earlier studies but the spinebill data were not surprising given the bird's long bill, which often doesn't touch the pollen as the bird feeds. Our pollen counts demonstrated that at least some of the non-flying mammals associated with banksias had the potential to be effective pollinators.

In addition to the pollen counts, we examined the movements of these mammals as they foraged among banksias. For this we used a spool-and-line tracking technique, whereby a spool of thread is attached to the back of the mammal. One end of the thread is held when the animal is released so that the thread unwinds passively as the animal moves through its habitat. A spool contains 100–250 metres of thread, which can be followed the day after the animal has been out foraging. Even though the spool could be used up in a very short period of time, we found it revealed important insights into how these mammals moved among the flowering banksias; it was common, for example, to follow the thread from a Sugar Glider along its gliding path from tree to shrub, and to find it encircling flower spikes near the ground. Distances moved between flowering banksias ranged up to 59 metres for Sugar Gliders, 31 metres for Brown Antechinuses and 23 metres for Eastern Pygmy-possums.

The mesh was necessary because in earlier studies we found mammals would chew straight through the shade-cloth to get to the nectar.

The final part of our study was designed to assess the relative contribution to pollination of the different animals by regulating their visits to flowers of the Hairpin Banksia (*Banksia spinulosa*). For this 'exclusion experiment' we constructed special bags to go over the flower spikes to keep out the visitors we didn't want. Bags were made from shade-cloth and had a protective mesh of wire or hard plastic. The mesh was necessary because in earlier studies we found mammals would chew straight through the shade-cloth to get to the nectar. The experiment, which we ran in two different years, consisted of removing bags from one set of plants during the day and replacing them at night, and removing bags from another set of plants at night and replacing them during the day. The first set of plants thus excluded visits from all nocturnal non-flying mammals (no bats were present in this study), while the second set only allowed visits from these animals. The results were conclusive: not only did we prove that nocturnal visits by non-flying mammals led to the production of seed, but the plants that were visited at night produced about three times as many seeds as those that were visited only by diurnal pollinators (birds and insects).

SO AT LAST WE HAD DEFINITIVE EVIDENCE that non-flying mammals were important pollinators of at least one native plant, the Hairpin Banksia. A similar result was obtained by Saul

Cunningham (Monash University) in another exclusion experiment involving the Coast Banksia (*Banksia integrifolia*) at Wilson's Promontory. Given the frequency of visits by non-flying mammal species to a wide range of banksias and eucalypts, it is likely that these mammals are pollinators of considerable importance in most Australian forest, woodland and heathland communities.

The tide has certainly turned in the recognition of the importance of non-flying mammals in pollination. Over the last ten years, studies in other countries (Central and South America, Africa and Madagascar) have revealed that over 40 species of non-flying mammals are involved in the pollination of about 25 plant species but many more plants are likely to be identified as studies continue. Australia has 12 species of non-flying mammal pollinators presently documented as regular flower visitors. In what appears to be an evolutionary coup, however, Australia is endowed with the only non-flying mammal species to have a diet consisting solely of nectar and pollen. This is the Honey Possum (*Tarsipes rostratus*) and it has evolved several adaptations for nectar feeding, including an extremely pointed snout, reduced dentition and a brush-tipped tongue.

All other non-flying mammals (in Australia and elsewhere) derive a substantial part of their nutrition from sources other than flowers. These 'competing interests' have apparently prevented these mammals from developing specialisations for nectar feeding. On the other hand, the plants upon which these mammals feed have traits that are thought to specifically promote pollination by non-flying mammals.

Many of these plants, for example, have dull-coloured flowers with pungent nectar, traits thought to attract nocturnal mammals which lack colour vision but which rely heavily on smell. Production of nectar and pollen is often also greater at night. Some plants produce flowers hidden within a dense canopy and close to the ground, which suggests specialisation for ground-dwelling non-flying mammals. However, caution is required when interpreting these traits because too few studies have been conducted to know whether such traits are indeed more attractive to non-flying mammals than other animals. In addition, recent studies in Africa, Madagascar and South America have revealed that a number of lemurs and monkeys may be important pollinators of particular plants and such diurnal mammals appear to respond to a very different set of plant traits.

Further studies are required before we fully understand the interaction between plants and non-flying mammal species. We cannot be allowed to forget these important pollinators if we are to adequately conserve the ecosystems to which they belong.■

KEN GRIFFITHS

Studies have shown that Feathertail Gliders target flowering euclypts as a food source.

Further Reading

Carthew, S.M., 1993. An assessment of pollinator visitation to *Banksia spinulosa*. *Aust. J. Ecol.* 18: 257–268.

Carthew, S.M. & Goldingay, R.L., 1997. Non-flying mammals as pollinators. *Trends Ecol. Evol.* 12: 104–108.

Cunningham, S.A., 1991. Experimental evidence for pollination of *Banksia* spp. by non-flying mammals. *Oecologia* 87: 86–90.

Goldingay, R.L., Carthew, S.M. & Whelan, R.J., 1991. The importance of non-flying mammals in pollination. *Oikos* 61: 79–87.

Wiens, D., Rourke, J.P., Casper, B.B., Rickart, E.A., LaPine, T.R., Peterson, C.J. & Channing, A., 1983. Non-flying mammal pollination of southern African proteas: a non-coevolved system. *Ann. Mo. Bot. Gard.* 70: 1–31.

Dr Ross Goldingay lectures in wildlife biology at Southern Cross University in Lismore, New South Wales. His interests are in the behavioural ecology of marsupials, conservation biology, forest management and pollination ecology. Dr Sue Carthew lectures in population ecology at the Roseworthy Campus of the University of Adelaide, South Australia. Her interests are in pollination ecology, population genetics, conservation biology and vertebrate ecology.

Given that the skin of the snout is reasonably tough and therefore relatively inelastic, this kind of sensitivity is unexpected, unless, of course, it is achieved through a special mechanism.

ECHIDNAS ON THE NOSE

BY UWE PROSKE

WHAT IS SO special about an echidna's nose? Well, I was lucky enough to be a member of the team that discovered that the Short-beaked Echidna (*Tachyglossus aculeatus*), like the Platypus, has specialised nerve endings at the tip of its snout that are selectively sensitive to minute electric currents. Remember, humans have nothing like that. We might get a mild shock from touching the terminal of a torch battery with the tip of our tongue, but the Platypus and Echidna can detect with their noses sources of electricity a thousand times weaker, such as the electric signals produced by moving prey. But the story of electroreception has already been told (*Nature Aust.** Autumn 1990). Here I want to talk about another structure that is unique to the noses of the Platypus and Echidna,

The enigmatic Short-beaked Echidna.
Photos by Reg Morrsion (above) and Dave Watts/Nature Focus (right).
**Previously ANH*

REG MORRISON

KATHIE ATKINSON

Top: When foraging, the Short-beaked Echidna periodically probes the soil with its snout. Bottom: Here it feeds on termites by poking its snout and long sticky tongue into a termite mound.

but one that is thought to be selectively sensitive to mechanical stimuli.

Before I begin, though, I need to say some general things about our own sensitivity to mechanical stimuli. We have in our skin the senses of touch, pressure and vibration (as well as other non-mechanical senses such as warmth, cold and pain). It has been possible to associate certain specialised nerve endings in the skin with particular sensations. Stimulating a structure called a Merkel cell complex, for example, produces a sense of pressure. Stimulating another structure that looks like a miniature onion, called a Pacinian corpuscle, evokes a sense of vibration. We all know the sense of vibration—what we feel through our legs when we stand at an intersection and a tram rattles across it. However, Pacinian corpuscles and Merkel cell complexes are thought to do more than just signal vibration and pressure. They are also involved in our perception of texture. When we feel a piece of fabric, for example, the intermittent mechanical stimulus provided by the ribbing of the material is signalled by these and other mechanically sensitive nerve endings in the skin of our fingers.

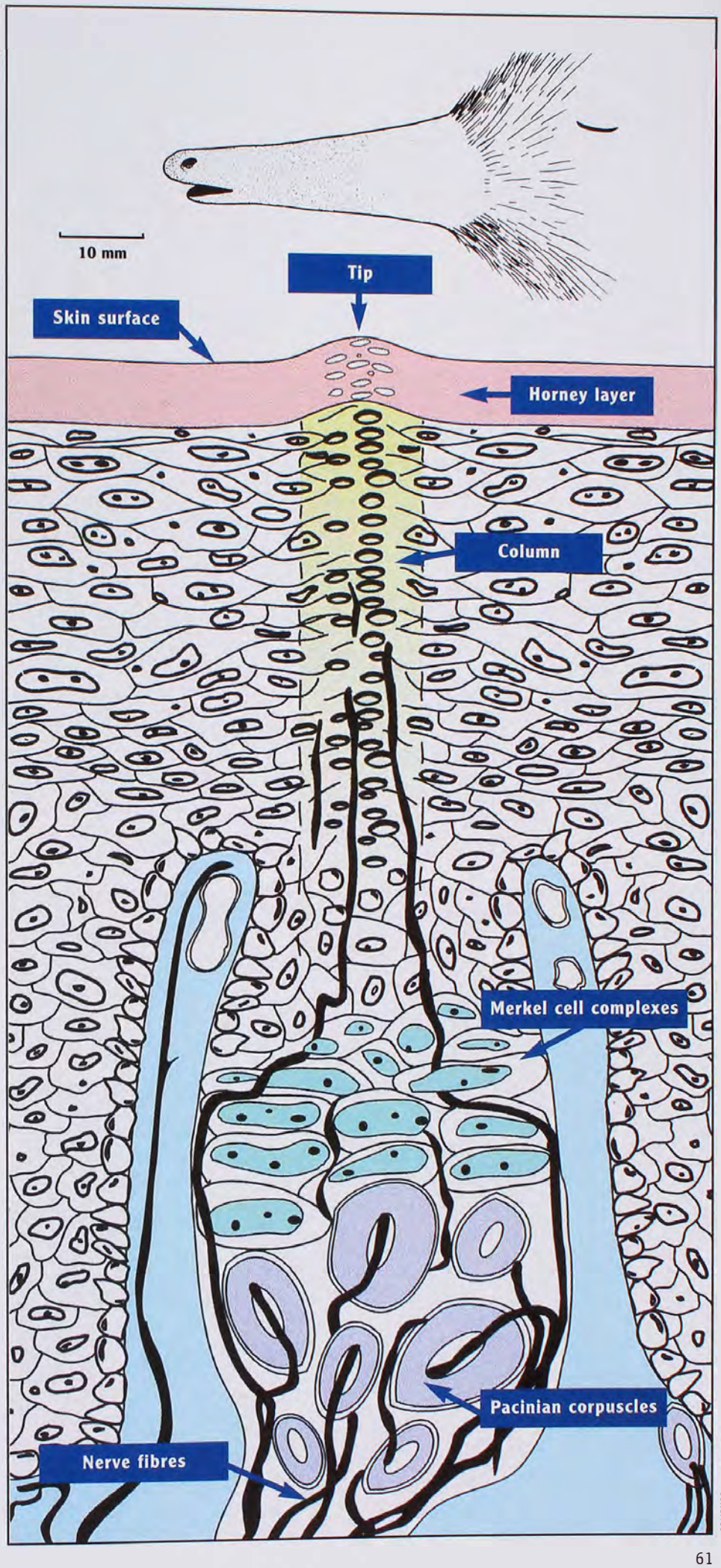
A colleague recently did an ingenious experiment on this topic. He asked blindfolded subjects to compare the coarseness of surfaces embossed with plastic dots, which he presented to each hand. By rubbing their fingers across the surfaces, subjects were able, with great accuracy, to match roughness. A difference in grain spacing of about 0.2 of a millimetre was readily detected. Then one arm was cooled over about ten centimetres at the elbow by wrapping around it the inner tube of a bicycle tyre, through which ice-cold water was flowing. With the cooled arm everything felt much smoother and only relatively large differences in grain spacing (0.4–0.7 of a millimetre) could be detected. Cooling the arm slows the speed of conduction of nervous impulses as they travel up the arm on their way to the brain, leading to a reduction in the ability to judge texture.

Now returning to monotremes. Recent anatomical studies of nerve endings in skin of the Echidna snout have revealed that it too contains Pacinian corpuscles and Merkel cell complexes. But there are two additional structures that are

found only in the Echidna snout and Platypus bill. These are the push rods and the sensory mucous glands. In our earlier experiments we were able to show that the sensory mucous gland was the electroreceptor, the structure in the skin responsible for the sensitivity to weak electric currents. More recently we have studied the sensitivity of nerve endings in the Echidna snout to mechanical stimuli in an attempt to assign a function to the push rods.

A PUSH ROD CONSISTS OF A TINY, TIGHTLY packed column of cells lying in the uppermost layers of the skin. Under a good light the tip of the rod, which is only about 20 micrometres in diameter, can be seen as a rounded dome pushing up from below the skin surface. There are many push rods in the skin of the Echidna snout, particularly around the lips where there can be as many as 30–40 per square millimetre. An important aspect of the structure of push rods is that at the base of each column is a number of Merkel cell complexes as well as two to three Pacinian corpuscles. It is the association of the push rods with these nerve endings that has led to the proposal that they are concerned with transmitting mechanical stimuli. As the discoverer of the push rod, E.B. Poulton, wrote in 1885: "The obvious use of the rods is to supply special moveable areas yielding to surface pressure which is thus communicated to the terminal organs below". It is this hypothesis that we wanted to put to the test.

We therefore listened to the impulse traffic in the nerve that supplies the skin of the upper jaw in the Echidna, while we applied weak mechanical stimuli to the skin surface. We observed activity quite similar to that seen in skin of other animals, activity that was typical of Merkel cell complexes and of Pacinian corpuscles. On one occasion, when we were recording from what was probably a Merkel nerve ending, we marked with dye the spot on the skin surface from which the activity could be elicited most readily. Subsequently we saw under the microscope that there were two push rods within a few hundredths of a millimetre of the marked spot. But that, while suggestive, does not represent



COURTESY UWE PROSKE

Top: A close-up illustration of the head of an Echidna showing as stippling the distribution of push rods across the skin of the snout. Bottom: This diagram illustrates a high-power view of a longitudinal section of a single push rod. The skin surface is at the top. At the base of a column of compact epidermal cells (yellow) lies a number of encapsulated nerve endings—the Merkel cells (green) and Pacinian corpuscles (mauve)—each supplied by a myelinated nerve fibre (black). Other nerve fibres ascend into the epidermal column to terminate in what are called vesicle chain receptors. The width of the field of view is approximately 100 micrometres.

SHORT-BEAKED ECHIDNA
Tachyglossus aculeatus

Classification
Order Monotremata, family Tachyglossidae. The only other living echidna is New Guinea's Long-beaked Echidna (*Zaglossus bruijnii*).

Identification
Back covered in spines; long, tubular snout; 30–45 cm long; 2–7 kg. Male has spur on ankle of hind leg.

Habitat and Distribution
Sparse but ubiquitous in dry to cool temperate to tropical wet sclerophyll forest, rainforests and deserts, throughout most of Australia and Tasmania. Also occurs in lowlands of New Guinea.

Reproduction
Mating occurs in July/August; one soft-shelled egg laid about 2 weeks later into temporary pouch; hatches about 10 days later. Young initially suckle from pouch, but are later left in the burrow. Juveniles emerge from burrow when approx. 1 year old.

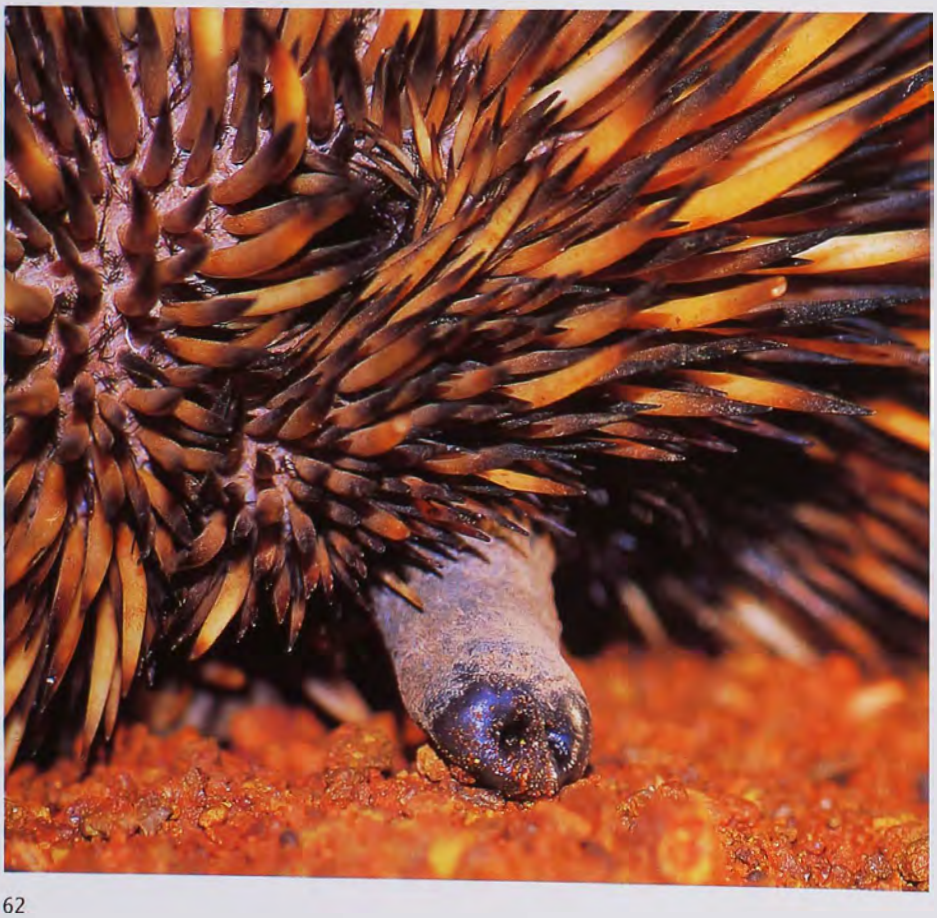
Behaviour
Solitary with overlapping home ranges. Eats ants, termites but also other invertebrates such as worms and beetle larvae.

positive proof that our stimulus was reaching the Merkel ending by depressing a push rod. Another piece of circumstantial evidence was that sensitive Merkel endings could respond to skin indentations as small as four thousandths of a millimetre. Given that the skin of the snout is reasonably tough and therefore relatively inelastic, this kind of sensitivity is unexpected, unless, of course, it is achieved through a special mechanism such as a push rod.

Much of the problem of working with monotremes derives from the fact that there is nothing similar to compare with in other animals. Push rods as such have only ever been described in monotremes. However, there are structures in moles that resemble the push rods in several respects. These are called Eimer's organs and are found in the skin of their snout. They consist of a column of cells at the base of which lies a cluster of specialised nerve endings, much as in push rods. But there are some differences between push rods and Eimer's organs. Push rods have cell columns that appear to be able to move more independently of adjacent regions of skin than appears to be the case for moles, and they are associated with larger numbers of encapsulated nerve endings. It seems as though push rods are more specialised, more highly evolved structures than Eimer's organs.

Eimer's organs, which appear to be present in the snout of all moles (we don't know about Australia's Marsupial Mole, *Notoryctes typhlops*), have recently been described in detail in the skin of the North American Star-nosed Mole (*Condylura cristata*), whose nose has a star-shaped appendage used to probe mud and soil for prey items such as beetles and worms. The surface of the skin of each ray of the star consists of a densely packed array of Eimer's organs and, importantly, very few other kinds of nerve endings. Recordings made from the brains of Star-nosed Moles during tactile stimulation of the skin of the star revealed responses resembling those of Pacinian corpuscles and Merkel cell complexes. So for moles, a mechanosensory function of Eimer's organ has been established. Given the similarity in structure between Eimer's organ and push rods, this is the best evidence yet in support of a tactile function of the push rods. Incidentally, it has been suggested that Star-nosed Moles, like monotremes, have electroreceptors (see *Nature Aust.** Spring 1994). However, it now appears that the skin of the star contains only Eimer's organs and no nerve endings suggestive of electroreceptors. In addition, work on the Pyrenean Desman (*Galemys pyrenaicus*), a type of aquatic mole not unlike the Platypus in its habits, has shown no evidence of electrosensory behaviour.

A fascinating feature of mole snouts, as well as the Platypus bill and Echidna snout, is that they have an extensive system of blood vessels just below the surface of the skin. The only vaguely comparable structure in humans is the penis. And it has been speculated that, like the penis, the Echidna snout can become engorged with venous blood producing a swelling and outward bulging of the skin. Perhaps the swelling leads to protrusion of the tips of the push rods like a series of tactile fingers. That, of course, would greatly improve contact between an external object and the skin surface. In addition the accompanying local rise in temperature produced by the circulating blood would have the opposite effect to that of cooling the skin. It would speed up impulse transmission in skin nerves and therefore lead to greater sensory acuity. In fact, measurements carried out on flaccid and erect cat penises suggest that erection is accompanied by a several-fold increase in sensitivity of the skin to mechanical stimuli. But who would have thought otherwise?



DENNIS SARSON/LOCHMAN TRANSPARENCIES

An Echidna's snout has an extensive system of blood vessels just below the surface that enables the snout to be engorged with blood. Could the resultant swelling increase the snout's sensitivity to mechanical stimuli?

WHENEVER I AM IN ECHIDNA TERRITORY down here in southern Victoria, the first tell-tale signs of their whereabouts are the numerous nose pokes in the soil. A foraging Echidna ambles along, from time to time making probes in the soil with its snout. Occasionally, presumably when it encounters some-

*Previously *ANH*

DAVE WATTS/NATURE FOCUS

Although the skin on an Echidna's snout is tough and relatively inelastic, it is still highly sensitive to both electrical and mechanical stimuli.

thing of interest, it begins digging with its front claws, eventually excavating the source of interest—a beetle larva, or worm. The prey item is then squashed with the snout and finally licked up with the long, rough tongue. Similarly Echidnas will dig into a termite mound or ant's nest and lick up the ants as they pour from the nest. It is conceivable that, whenever the Echidna's interest is aroused during a nose poke, it is able to finetune its skin sense organs by engorging the snout with blood. It would be fascinating to try to test this hypothesis by recording from skin sense organs in an Echidna while controlling the blood flow to the snout. Perhaps that will be our next experiment.

Finally, I think it is worth reflecting on the fact that the skin of two sorts of animal as diverse as moles and Echidnas contains structures that are astonishingly similar. Is it just another example of convergent evolution, given that both types of animal are likely to be sticking their noses into similar places? It is tempting to suggest that, under conditions where an acute sensitivity of the skin is required against a background of massive mechanical stimulation associated with digging, a structure like the push rod has evolved. But we need to know a lot more about both Echidnas and moles before we can draw that kind of conclusion. In a wider context, the evolution of the push rod emphasises how little we know about the general principles involved in the conversion of a mechanical stimulus into a sensation. If push rods are so good at transmitting stimuli from the skin surface to deeper structures, why don't more animals have them?■

Further Reading

Andres, K.H. & von Düring, M., 1984. The Platypus bill. A structural and functional model of a pattern-like arrangement of different cutaneous sensory receptors. In *Sensory receptor mechanisms*, ed. by W. Hamann and A. Iggo. World Scientific Publishing Co.: Singapore.

Andres, K.H., von Düring, M., Iggo, A. & Proske, U., 1991. The anatomy and fine structure of the echidna *Tachyglossus aculeatus* snout with respect to its different trigeminal sensory receptors including the electroreceptors. *Anat. Embryol.* 184: 371–393.

Catania, K.C., 1995. Structure and innervation of the sensory organs on the snout of the star-nosed mole. *J. Comp. Neurol.* 351: 536–548.

Gregory, J.E., Iggo, A., McIntyre, A.K. & Proske, U., 1989. Responses of electroreceptors in the snout of the echidna. *J. Physiol.* 414: 521–538.

Iggo, A., Gregory, J.E. & Proske, U., 1996. Studies of mechanoreceptors in skin of the snout of the echidna *Tachyglossus aculeatus*. *Somatosensory and Motor Research* 13:129–138.

Manger, P.R. & Hughes, R.L., 1992. Ultrastructure and distribution of epidermal sensory receptors in the beak of the echidna *Tachyglossus aculeatus*. *Brain Behav. Evol.* 40: 287–296.

Phillips, J.R. & Matthews, P.B.C., 1993. Texture perception and afferent coding distorted by cooling the human ulnar nerve. *J. Neurosci.* 73: 2332–2341.

Poulton, E.B., 1885. On the Tactile terminal organs and other structures in the Bill of Omithorynchus. *J. Physiol.* 5: 15–16.

Schlegel, P.A. & Richard, P.B., 1992. Behavioural evidence against possible subaquatic electrosensitivity in the Pyrenean Desman *Galemys pyrenaicus* (Talpidae, Mammalia). *Mammalia* 56: 527–532.

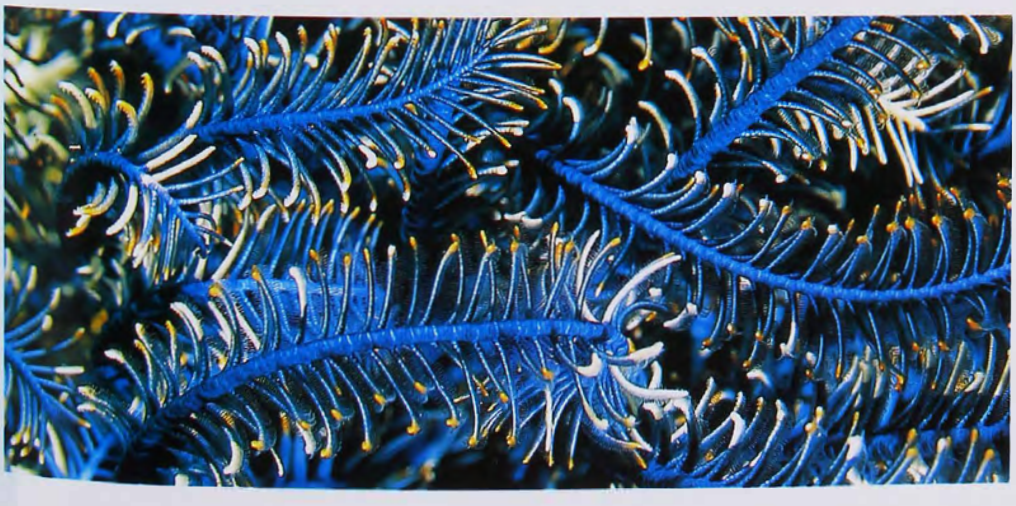
Uwe Proske is a Professor of Physiology at Monash University. He has been working for many years on the properties of sensory receptors in skin and muscle in humans and other animals including the Platypus and Short-beaked Echidna.

SEASHOTS

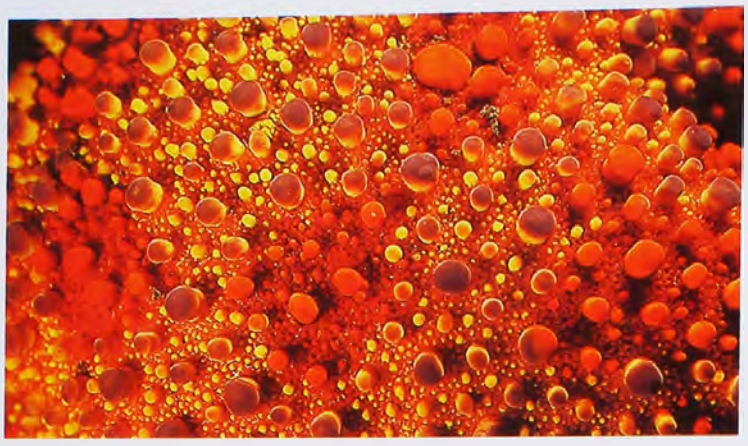
BY BECCA SAUNDERS
AUSCAPE PHOTO LIBRARY

Gorgonian fan.

Jellyfish (*Phyllorhiza punctata*).



Detail of a yellow-tipped, blue-and-white featherstar.

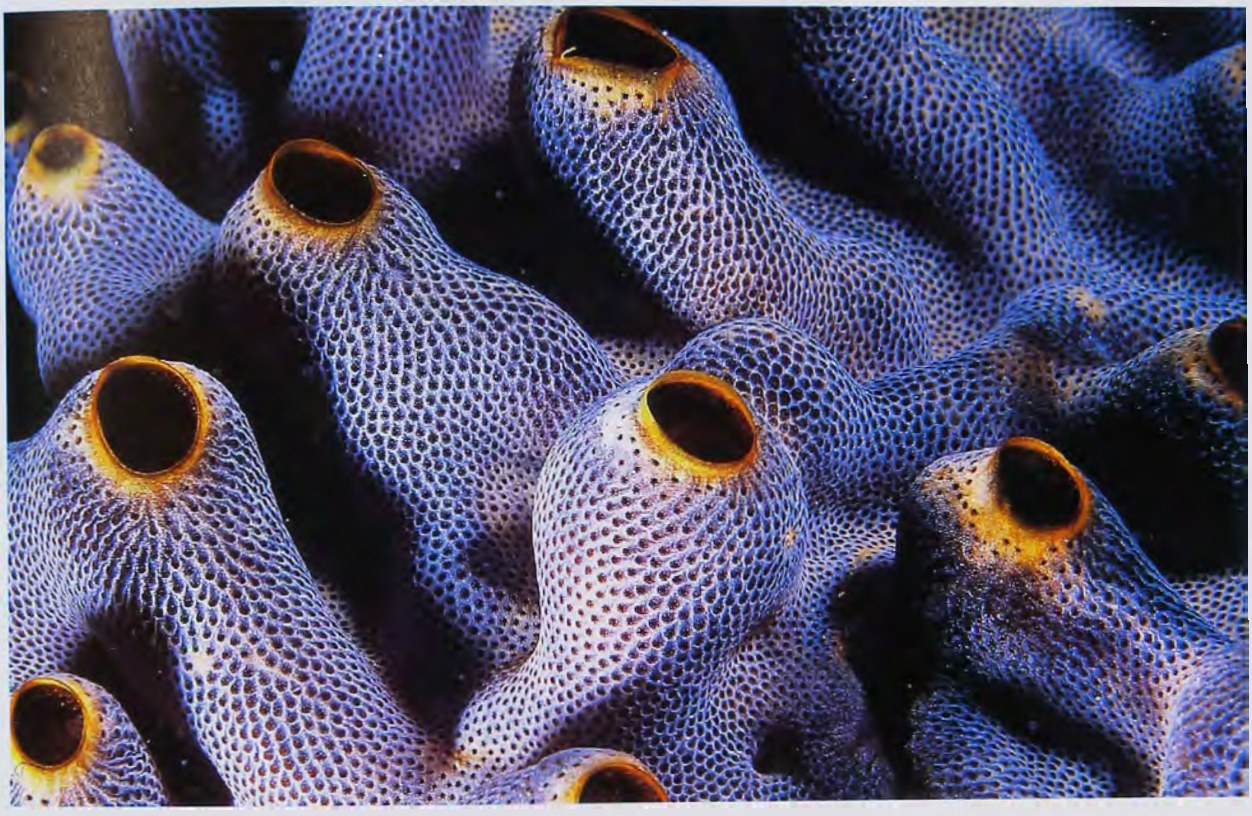


Close-up of sea star (*Asterodiscides truncatus*).

Ascidian.

Coral polyps (*Tubastraea faulkneri*).

Leafy Seadragon (*Phycodurus eques*).



Ascidian.

Bigeye Trevally (*Caranx sexfasciatus*).

What do Creation 'science' and Koalas have to do with one another?

KOALAS: APOSTLES VS FOSSILS

BY MICHAEL ARCHER

GEOLOGIST IAN PLIMER (University of Melbourne) is the latest in a long line of scientists who have had a go at publicly exposing the frontal-lobotomising brain virus that lurks below the crust of Creation 'science'. All of us hoped that the pseudoscience used by this religion to mislead people into parting with their money would be held up to public examination in the trial of Australian 'Arkeologist' Allen Roberts. Unfortunately, the trial devolved instead around relatively mundane matters such as breach of copyright—of which Roberts was convicted. Call me naive, but I cannot see why a minister of religion who uses deceit to solicit money to fund an expedition to find Noah's Ark should be any less liable to legal action than a con man who solicits money to get his Budgie's teeth capped. Failure of the Federal Court to accept responsibility for protecting a gullible public from parasites of this kind has cost Ian Plimer heaps including his house and now court costs. Worse, it sends a signal to all snake oil merchants waiting in the wings, from fork-benders to faith-healers, that deceit has the Federal Court's seal of approval as a legitimate method for soliciting money.

What do Creation 'science' and Koalas have to do with one another? In reality, nothing rational, but in the eyes of Creation 'scientists', plenty. They tell us that God popped Koalas into being along with everything else in one divinely creative week, some 10,000 years ago. After a brief period of benevolence, Adam and Eve's disappearing apple trick led to a corrupted creation and an infuriated Creator. As things went from bad to worse God declared that all except two of every living thing would be drowned by zillions of tonnes of floodwater from somewhere. The lucky two of everything, including two of all their parasites and disease organisms, were shoehorned into the Ark to bob about on the floodwaters for a year. Presumably on the passenger list were at least two very prolific gum trees to provide the half tonne of leaves a healthy pair of Koalas would need to survive. At the end of the cruise, the floodwaters, which had been deep enough to cover Mount Everest, went away to somewhere and the Ark settled on top of Mount Ararat in Turkey. (As support for the truth of this legend, 'Arkeologist' historian Allen Roberts claims to have identified the remains of the Ark on the slopes of Mount Ararat—in the form of what geologist Ian Plimer has shown to be a very large pile of dried mud.) After the Ark landed, everything from dinosaurs to Dodos disembarked onto the flood-devastated Earth and slipped, flopped, flapped or swam unerringly to appropriate parts of the globe, leaving no trace of their passage along the way. The two Koalas with their prolific gum trees then crossed the barren lands and oceans (all 'flesh' not in the Ark had been destroyed by the flood) to re-establish in Australia where they have lived happily ever after. Charming story, but it is this story that Creation 'scientists' want taught as science in schools throughout the world.

Fortunately, there are more testable sources of understanding about the origin of Koalas: the sciences of molecular biology, anatomy and palaeontology. Molecular biology and anatomy both demonstrate that, of living marsupial groups, Koalas are most closely related to wombats. Although koala fossils are rare, one of the first Tertiary mammals found in Australia was *Perikoala palankarinnica*. Teeth and jaw fragments of this leaf-eating cousin of the living Koala were found in 1953 in 24-million-year-old deposits in central Australia. In the years that followed, tonnes of central Australian fossil 'dirt' were processed and the number of kinds of fossil koalas grew to six.

Karen Black did her Honours research on the fossil koalas of Riversleigh. One of them appears to be the most 'primitive' koala yet known. Another, named *Nimiokoala greystanesi*, is so strange that it took Karen months to convince herself that it was a koala rather than a member of some new bizarre group. Unlike all other koalas, its molar teeth had enormously high, sheep-like cutting blades. Although this 'Koaleep' clearly ate plants, it is most unlikely that these were gum leaves. Homing in on the origins of the living Koala, Riversleigh also hosted the hip-pocket-size *Litokoala kanunkaensis*, previously only known from South Australia. Of all early Miocene (23–16-million-year-old) koalas, this one is probably most closely related to *Phascolarctos*, the genus that contains the living Koala (*P. cinereus*). Even closer to modernity is a single, larger tooth from Riversleigh's late Miocene (ten-to-five-million-year-old) Encore Site that may represent the first appearance of a species of *Phascolarctos*. *Cundokoala yorkensis*, a giant koala more than twice the size of the living species, was first found in a Pliocene (five-to-two-million-year-old) deposit in southern Australia. If accounts of soggy modern Koalas falling out of trees after days of soaking rain are true, no animal in its right mind would have camped in the wet under a gum tree laden with 'drop bears' this size.

Looked at overall, the fossil record suggests koalas have steadily declined in diversity, with at least six species known from the late Oligocene, four from the

If accounts of soggy modern Koalas falling out of trees after days of soaking rain are true, no animal in its right mind would have camped in the wet under a gum tree laden with 'drop bears' this size.

ILLUSTRATION BY DOROTHY DUNPHY, © REED BOOKS

One of Riversleigh's ancient rainforest koalas, already hooked on gums.

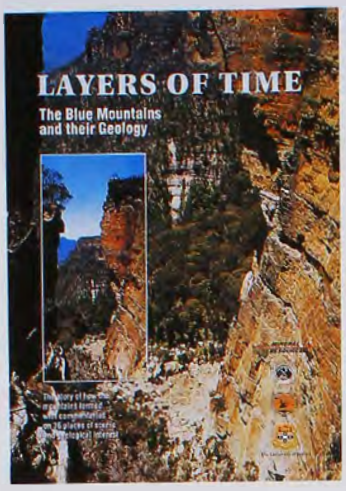
early Miocene, two from the middle Miocene, one from the late Miocene, two from the Pliocene and one from the Pleistocene/Holocene. This trend is uncomfortably similar to that of the ill-fated thylacines and as such it does not auger well for the long-term future of Koalas.

However, this worry is to some extent offset by the fact that the modern Koala is significantly more common in its preferred habitat than any of the fossil koalas appear to have been. How could this have happened? We have speculated that at least one of the rare koalas in Australia's ancient rainforests began to specialise on the equally rare gum trees, which in turn were specialists, as most gums are today, on nutrient-deficient soils within the rainforest. After Australia's climates began to deteriorate, from about 12 million years ago, nutrient-deficient soils increased, forests opened up and the gums began a spectacular rise to dominance. And lounging on those branches, grinning like lucky lottery winners, were the koalas whose fortunate ancestors had bet on gums.

Lucky they may be, but there also may have been a cerebral down side to munching toxin-laden gum leaves for millions of years. Odd as it sounds, neurobiologists have found that the Koala's brain fails to fill more than 60 per cent of the space available in its skull. Perhaps Koalas and the Creation 'scientists' who would pull Koalas out of an Ark in Turkey do have something in common after all. ■

Professor Michael Archer lectures in biology and geology at the University of New South Wales. Most of his non-teaching hours are devoted to the study of the fossil faunas of Riversleigh, north-western Queensland.

REVIEWS



Layers of Time: The Blue Mountains and their Geology

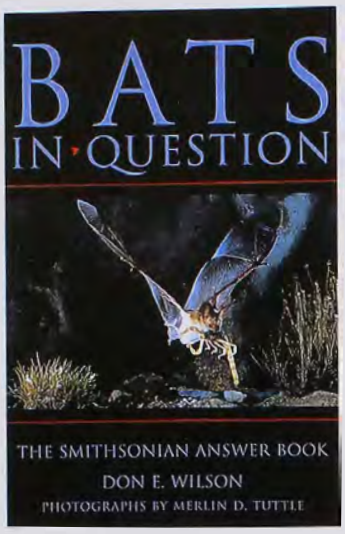
By J.W. Pickett and J.D. Alder. New South Wales Department of Mineral Resources, NSW, 1997, 34pp. $9.95rrp.

This little book, with almost as many authors and logos as pages, is a beautifully illustrated and well-designed field guide to the geology of the Blue Mountains. Following a brief introduction to the geology of the area, the book takes us on a 36-stop journey from the Nepean River along the Great Western Highway to Hartley, and then back via Bells Line of Road to view the city in the far distance from Bellbird Hill Lookout. All the well-known features—Wentworth Falls, the Three Sisters, Govetts Leap, Mount Banks and Mount Tomah—and many lesser-known are described in clear language. The key features at each stop are illustrated by superb colour photographs and diagrams, and a glossary of technical terms is provided on the last page.

Particularly excellent are the sections covering the scientific and mining history of the Blue Mountains, such as coal mining at Katoomba and oil shale mining at Hartley Vale, featuring historic photos and diagrams from the archives of the Department of Mineral Resources.

The book does great credit to all involved and represents a great first step in providing popular regional geologies. Hopefully other titles will follow.

—Armstrong Osborne
University of Sydney



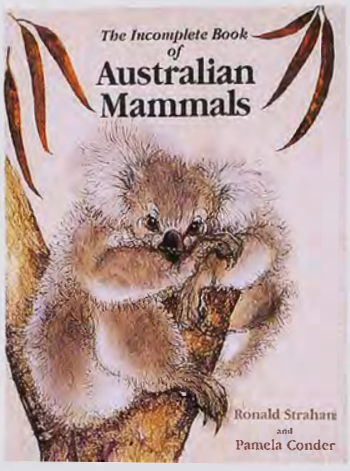
Bats in Question

Published by CSIRO Publishing, Vic., 1997, 184pp. $29.95rrp.

There has been an explosion of bat books during the past decade but this one is certainly worth a look if you want a good introduction at a reasonable price. This is the latest in 'The Smithsonian Answer Book' series, which has a question-and-answer format. It addresses many of the big questions about bats, such as why bats fly into peoples' hair, why bats hang upside down, and what good they are. There are some 60 interesting questions ably tackled by a highly readable text aimed at a wide audience. Over 120 colour photographs superbly enhance the text, by both their clarity and interesting composition, and illustrate the amazing diversity of bat species throughout the world. The North American bias does not hinder its relevance to a much wider audience because most of the information may be applied to bats worldwide.

The text covers three broad topics: questions of basic bat biology, evolution and diversity of the 900-odd world species, and issues of bat–human interactions. This is followed by an appendix listing ostensibly all known bat species by scientific name, common name and conservation status. Quite a few Australian species are omitted and the list is dated, but this does not detract from the book's value as a great introductory text.

—Harry Parnaby
Australian Museum



The Incomplete Book of Australian Mammals

By Ronald Strahan and Pamela Conder. Kangaroo Press, NSW, 1997, 56pp. $19.95.

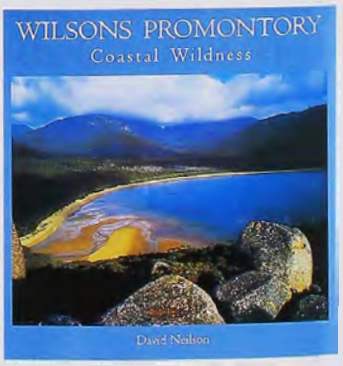
It's not often that you come across a book with such universal appeal. However, the combined talents of Ronald Strahan and Pamela Conder have done just that by producing a book that engages the interest of people of all ages and inclinations. *The incomplete book of Australian mammals* is a delightful artistic and poetic celebration of our well-known (and not-so-well-known) mammalian fauna.

The writer Ronald Strahan is a well-regarded academic who has spent a lifetime researching and writing about Australian wildlife. In 1983 he edited *The complete book of Australian mammals*. The book received great acclaim and has become a standard reference text. Only recently has he allowed the general public a glimpse of his impressive poetic talents. In *The incomplete book of Australian mammals* amusing poetical whimsy is spiked with quirky scientific fact, tempting us to explore some unusual facets of our unique mammalian heritage.

The colour paintings and sketches accompanying the poems were drawn by Pamela Conder, a well-known and respected wildlife artist. Her eye for detail and use of innovative techniques have enabled her to catch the essence of the animal. When you look at the illustrations, you feel as if the animal is truly alive, sniffing the air or bounding through the bush.

The incomplete book of Australian mammals is an attractive and informative book. The hilarious description of the planigale is worth the reasonable purchase price alone. All in all the book is well worthwhile and a recommended addition to your library.

—Cheryl Hook
Australian Museum



Wilsons Promontory Coastal Wilderness

By David Neilson. Snowgum Press, Vic., 1997, 72pp. $32.95rrp.

Wilson's Promontory is a high granite peninsula that juts out into the wild waters

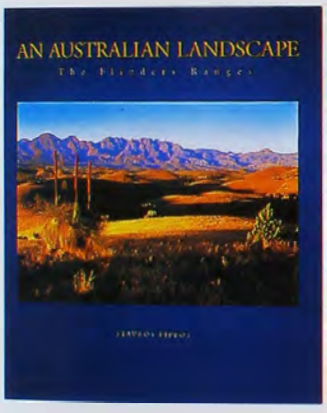
of Bass Strait on the southern-most tip of Victoria. David Neilson's photography covers the magnificent coastline of the Promontory in a diverse range of lighting and weather.

He outlines the natural history of the region, describing its geology, fauna and flora, and human inhabitancy. He also gives an account of the struggle to declare the land as a National Park. Only recently the Victorian Government released a new draft management plan for this park, which includes controversial proposals for development.

The powerful and moody pictures give us an idea of the vastness of this largely untouched wilderness and the need to protect it.

Through its stunning pictures, this book reveals the power and fragility of the Australian landscape.

—Kate Lowe
Australian Museum



An Australian Landscape: The Flinders Ranges

By Stavros Pippos. Endeavour Publishing, SA, 1996, 104pp. $44.95rrp.

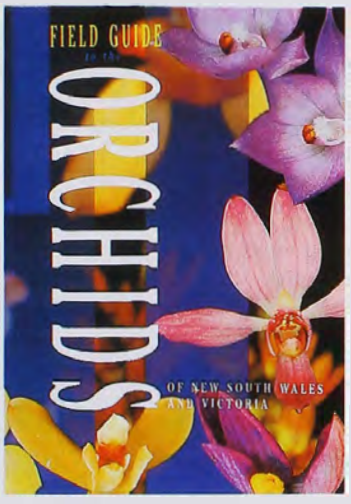
Stavros Pippos' affinity with the beautiful and hostile environment of the Flinders Ranges has led to this, his second book on the subject. The pictures illustrate the incredible colour and diversity of this particular region of South Australia. It includes places like Port Augusta in the south and Arkaroola in the north.

The production quality is excellent and enhances the impact of the images. The text that accompanies the pictures gives an interesting historical background and explains the various human enterprises that have occurred there, like the once vast pastoral leases and the many mining operations. He also gives some technical information on the film and equipment used.

Pippos also gives a personal account of his experiences while photographing particular scenes. He explains how he was concentrating on capturing a trickle of water just entering a dry river bed after rain, when to his surprise he was almost swept away by a flash flood. It is this consummate ability to capture the moment no matter how long it takes, that sets him apart.

This is an exquisite collection of images, by a master photographer.

—Kate Lowe
Australian Museum



Field Guide to the Orchids of New South Wales and Victoria

By Tony Bishop. University of New South Wales Press, NSW, 1996, 257pp. $27.95rrp.

I was thrilled when I encountered Tony Bishop's *Field guide to the orchids of New South Wales and Victoria*. It contains keys to species, illustrations of all the species described and is ideal for slipping into the daypack. This is an advantage over other orchid books currently available, which are either too expensive, unwieldily, don't have all the species illustrated, or are restricted to just one State.

The book is set out in two sections. The first section comprises the species descriptions. The genera and species are set out in systematic order, following the order set out in *The flora of New South Wales*. Under each species there is a detailed description of the plant, flowering times, distribution and habitat notes, distinguishing features for field identification, and notes on similar species and how they can be separated, as well as comments on observed variation. The plant descriptions are detailed and adequate. I found the notes on distinguishing characters for field identification most useful when identifying unknown specimens, and the notes on similar species has proven invaluable when a specimen has been narrowed down to two or three possible taxa.

The second section comprises keys to genera and species. The keys use vegetative and gross floral characters, and none requires the use of a microscope, although a hand lens would be useful when matching an unknown specimen with the species description. The keys are excellent and easy to use, and unlike some other orchids keys I have used in the past, I get an 80–90 per cent success rate, even in the more difficult orchid genera. Bishop has kept the botanical terminology to a minimum and supplies a concise glossary to assist those people still coming to terms with botanical jargon.

The added bonus is the excellent photography. All but two of the 550 taxa described have a colour plate (the two exceptions are quite rare and are instead represented by colour drawings). The bulk of the plates are close-ups of individual flowers highlighting the main features of each taxon. The plate numbers correspond with the species numbers in the first section, so by merely flicking through the plates, one can easily refer back to the species descriptions without having to work through the keys.

To all orchid enthusiasts, whether they be botanists or simply people who appreciate our orchid flora, I heartily recommend this book.

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

SOCIETY PAGE

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

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102 Bathurst St,
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PO Box Q277,
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Ph: (02) 9698 7263
Contact: Penny Drake-Brockman

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Level 4, 83–87 Castlereagh St,
Imperial Arcade
Sydney, NSW 2000
Ph: (02) 9233 4670
Contact: Kristi MacDonald

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Australian Trust for Conservation Volunteers
PO Box 423,
Ballarat, Vic. 3353
Ph: 1800 032 501
Contact: Madeline Townsend

Membership fee: $30.00

Victorian National Parks Association
10 Parliament Pl,
Melbourne, Vic. 3002
Ph: (03) 9650 8296
Fax: (03) 9654 6843
Contact: Doug Humann

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Ph: (03) 9841 0825
Contact: Angela Cheung

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Contact: Lynn Pulford

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PO Box 1594,
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Ph: (08) 8272 9015
Contact: Mr D. Kraehenbuel

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Wildlife Information & Rescue Service (WIRES)
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Contact: Reg Woodleigh

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Contact: Lorraine and Derek Girkin

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Contact: Mr David J Lane

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The Society for Insect Studies
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The University of Queensland,
St Lucia, Qld 4072
Ph: (07) 3365 1564
Fax: (07) 3369 1922
Contact: Dr David Evans Walter

Membership Fee: $55.00

ZOO INDUSTRY

Australian Society of Zoo Keeping (ASZK)
PO Box 248,
Healesville, Vic. 3777
Ph: (059) 624 022
Contact: Michael Taylor

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Q&A

Fish Balls or Beach Balls?

Q: *I saw some strange fibrous balls on a beach at Robe, South Australia, last August. There were a number of them and they were all different sizes. If they aren't fur balls from a cat fish, what are they?*

—Jean Goldberg
Hawthorn East, Vic.

A: These fibre balls are often found on the shoreline of beaches and may reach 30 centimetres or more in diameter. They originate from the leaves and stems of seagrasses. Seagrasses are flowering plants adapted for life under water in shallow marine or estuarine areas. Some seagrasses have long narrow leaves and are commonly known as strap weed. When the leaves and stems of these seagrasses decay they form deposits of fibrous material. Wave action can roll these fibres into the balls or oval masses found washed up on the beach.

—Stephen Keable
& Elizabeth Cameron
Australian Museum

COURTESY JEAN GOLDBERG

Could this be a fur ball from a cat fish?

Random Feast

Q: *I was recently watching two bulldog ants moving on the bare ground of a fire-trail in the bush. They travelled aimlessly over an area of about 20 square metres for at least three-quarters of an hour, never stopping, and without appearing to eat or do anything but walk.*

Can you theorise as to what this expenditure of energy was all about?

—E. Griffin
Tumut, NSW

A: These ants are looking for food. Bull ants (*Myrmecia* spp.) are members of a primitive group of ants. They have less developed social systems than many other ants and work as individuals. They wander about foraging for food at random. When they find food they take it back to the nest. Ants with more highly evolved social systems work in groups and when an individual finds food the information is passed on from it to others via pheromones (chemical messages or scent trails).

—Max Moulds
Australian Museum

Eating On the Run

Q: *I took this photograph of a goanna with a possum in its mouth on a bush block four kilometres south of Bermagui. I think the goanna caught the possum asleep in a hollow log in the middle of the day. On sighting me the goanna climbed to the top of the ironbark and presumably had his lunch while enjoying the view.*

COURTESY JOHN CREW

Lace Monitors can take prey representing half their body weight.

Would this be the usual prey for a goanna of this size?

—John Crew
Bermagui, NSW

A: Goannas are largely carnivorous and opportunistic feeders and larger species like this Lace Monitor (*Varanus varius*), tend to take larger prey, on occasions representing nearly half the body weight of the lizard. However, the prize for gluttony goes to a two-metre individual that was reported to have eaten four fox cubs, three young rabbits and three large Blue-tongues. Even smaller Lace Monitors eat rabbits, so swallowing an average size ring-tail possum, as your photo shows, is well within this lizard's capabilities. Being opportunistic feeders, Lace Monitors will eat both live prey and carrion from the road. A look at the photo shows what appears to be damage to the possum being swallowed, and I suspect that it was possibly a recent roadkill the goanna had come across.

—Ross Sadlier
Australian Museum

Tiny Hitch-hiker

Q: *During a field trip our attention was drawn to one particular wasp that was walking rapidly across the forest floor. Normally elusive, the agitated wasp did not fly away as was expected. Closer inspection of the wasp revealed what looked like a tick firmly attached to one of the wasp's rear legs. The tick was holding on with one crab-like foreleg, while questing with the other. Was the tick specific to wasps (or insects), was the wasp an intermediate host (and potential vector), or was the tick simply using the wasp as a convenient means of transportation to a new host?*

—K. Foley & P. Branwhite
Albury, NSW

A: The small creature attached to the hind leg of this wasp is not a tick (ticks only parasitise vertebrates), but a pseudoscorpion. Pseudoscorpions are generally fairly small (less than one centimetre in total length) and are included in their own order (Pseudoscor-

COURTESY P. BRANWHITE

A pseudoscorpion hitching a ride on the leg of a wasp.

pionida) within the Arachnida (a vast group that includes the spiders, mites and ticks, and scorpions, among others). They can be easily distinguished from other arachnids by the presence of pincer-like pedipalps at the front of the body. These pincers also occur in scorpions, but pseudoscorpions lack the long tail and sting found in their larger cousins.

Pseudoscorpions occur in virtually all terrestrial habitats around the world, even on the slopes of the highest mountains and the edges of the sea, where some species live in the intertidal zone. Incredibly, some pseudoscorpions reside in the fur and nests of small mammals, where they appear to feed upon other small arthropods such as mites and fleas, thereby ridding their host of parasites. Pseudoscorpions are often found in leaf litter, under stones, or under the bark of trees, and they usually lead a sedentary life. However, very occasionally, some species attach themselves to the legs of a flying insect, which apparently serves to transport them from one habitat to another. Although most pseudoscorpions possess venom that discharges through a small sharp tooth on the end of their 'pincers', they rarely kill their flying host during this hitch-hiking phase, and the insect lives to fly another day!

—Mark S. Harvey
Western Australian Museum

Answers to Quiz in Nature Strips (page 16)

1. Fungi and algae
2. Platypus
3. China
4. Ötzi
5. Brown
6. Sea anemones
7. Cook
8. Witchetty grubs
9. Northern Territory
10. Two

P I C T E A S E R

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a $20 gift voucher for the Museum Shop Catalogue. Spring's Pic Teaser was a Red Wattlebird (*Anthochaera carunculata*) at a banksia flower.

KATE LOWE/NATURE FOCUS

It took a full century to discover the cause of Lyme Disease.

DOES LYME DISEASE OCCUR IN AUSTRALIA?

BY BERNIE HUDSON

LYME DISEASE, A TICKBORNE illness caused by a spiral bacterium (spirochaete), has attracted controversy ever since it came to prominence in Connecticut, USA, in the 1970s. To understand the controversy, a brief review of its history is helpful.

The first published description of what we refer to today as Lyme Disease (LD) was from Germany in 1883—a report of an unusual skin lesion. In retrospect, the first North American case was described from Spooner, Wisconsin, in 1969. However, the disease was first described (and named) in the 1970s after the town of Lyme, Connecticut, where children thought to be suffering from juvenile rheumatoid arthritis were subsequently diagnosed by Allen Steere (Yale University) with LD.

In Steere's initial studies, a clinical definition of LD was based upon the presence of the classic skin lesion, erythema migrans (EM), often at the site of a tick bite. In addition, some cases had arthritis, meningitis, facial paralysis, or even a heart condition (heart block). Not all patients recalled a tick bite. In other words, Lyme Disease was a *clinical diagnosis* describing a constellation of signs and symptoms.

Despite extensive research over a number of years, Steere was unable to detect the causative bacteria. This was *fortuitously* discovered in 1982 by Willy Burgdorfer, while conducting tick research nearby. Spirochaetes, later called *Borrelia burgdorferi*, were cultured and, after some experimentation, a special culture medium was developed to grow them. Subsequently, the same spirochaetes were grown from EM lesions. Thereafter, European researchers demonstrated similar spirochaetes in ticks, and in skin and body fluids of European patients. It thus took a full century to discover the cause of LD.

We now know that LD occurs across the northern hemisphere. It can be caused by a diverse range of spirochaetes, all in the genus *Borrelia* (family Spirochaetaceae), with an increasing number of species being described.

So what relevance is this to Australia? Decades before the causative spirochaete was isolated, everybody in Europe and North America agreed on the existence of LD. In most areas the typical rash (EM) was used as an indicator of its existence. In Australia, the first report of EM was in 1982. Three more cases were reported in 1986 from the New South Wales south and central coasts. The original researchers from Westmead Hospital in Sydney collected some clinical data on suspected LD cases, noting on their initial survey that at least 13 patients (nine from New South Wales) fitted the North American LD case definition. Some cases may have acquired LD outside Australia, and the possible Australian cases all tested negative in LD blood tests. These used a method called western blotting, based on an interpretative criterion developed in North America. Subsequent studies attempted to detect and culture spirochaetes from ticks and EM lesions. There was only one positive isolate—from a skin lesion of a patient who acquired LD in Europe. They did detect 'pseudo-spirochaetes' but these were thought to be artefacts of the culturing process. Attempts by other workers to infect the Australian Paralysis Tick (*Ixodes holocyclus*) with a North American strain of *B. burgdorferi* were successful, however the ticks were unable to maintain and thus transmit the infection. So, 12 years after the first report of EM acquired in Australia, the researchers concluded there was no definitive evidence for the existence of *B. burgdorferi* or any other tickborne spirochaete that might cause LD in Australia.

As mentioned, several *Borrelia* species are found in ticks worldwide. Some are proven to cause LD. Others are not; but this may be related to the fact that the optimal detection methods for some of these species are unknown. The inability of *B. burgdorferi* to set up persistent infection in the Australian Paralysis Tick is not surprising. It is well known that ticks of certain species are quite particular about which *Borrelia* they can carry, just as they are about which animals they bite. Australian ticks may carry an indigenous *Borrelia* that causes LD, but may not be able to carry *B. burgdorferi*. The EM lesion, from data outside North America, may occur in as few as 20–50 per cent of LD cases. Patients can have LD without ever recalling either an EM lesion, or a tick bite. They may just develop arthritis, neurological disorders or a non-specific syndrome of tiredness and aches and pains. Not all clinical cases, including those with the classic EM skin lesion, are reliably diagnosed by blood tests.

From all of this, I believe there is *clinical* evidence of an indigenous form of LD in Australia, probably due to infection with a tickborne spirochaete(s) (unlikely to be *B. burgdorferi*), and that current laboratory methods require modification as they are inadequate to culture the causative organism(s) either from ticks or humans. Until this is done, controversy about the existence of an indigenous form of LD will continue.■

Lyme Disease has attracted controversy ever since it came to prominence in Connecticut, USA, in the 1970s.

Further Reading

Hudson, B.J., Barry, R.D., Shafren, D.R. *et al.*, 1994. Does lyme borreliosis exist in Australia? *J. Spirochetal Tickborne Diseases* 1(2): 46–52. [Includes clinical case studies.]

Dr Bernie Hudson is an infectious diseases physician and microbiologist in the Department of Microbiology at Royal North Shore Hospital, Sydney.

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

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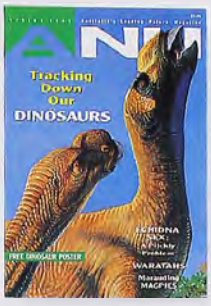

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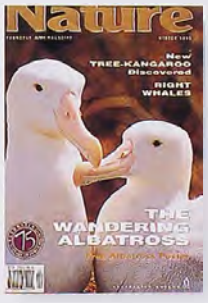

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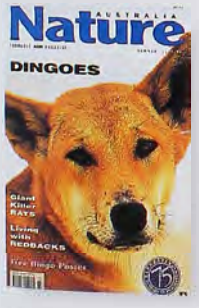

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