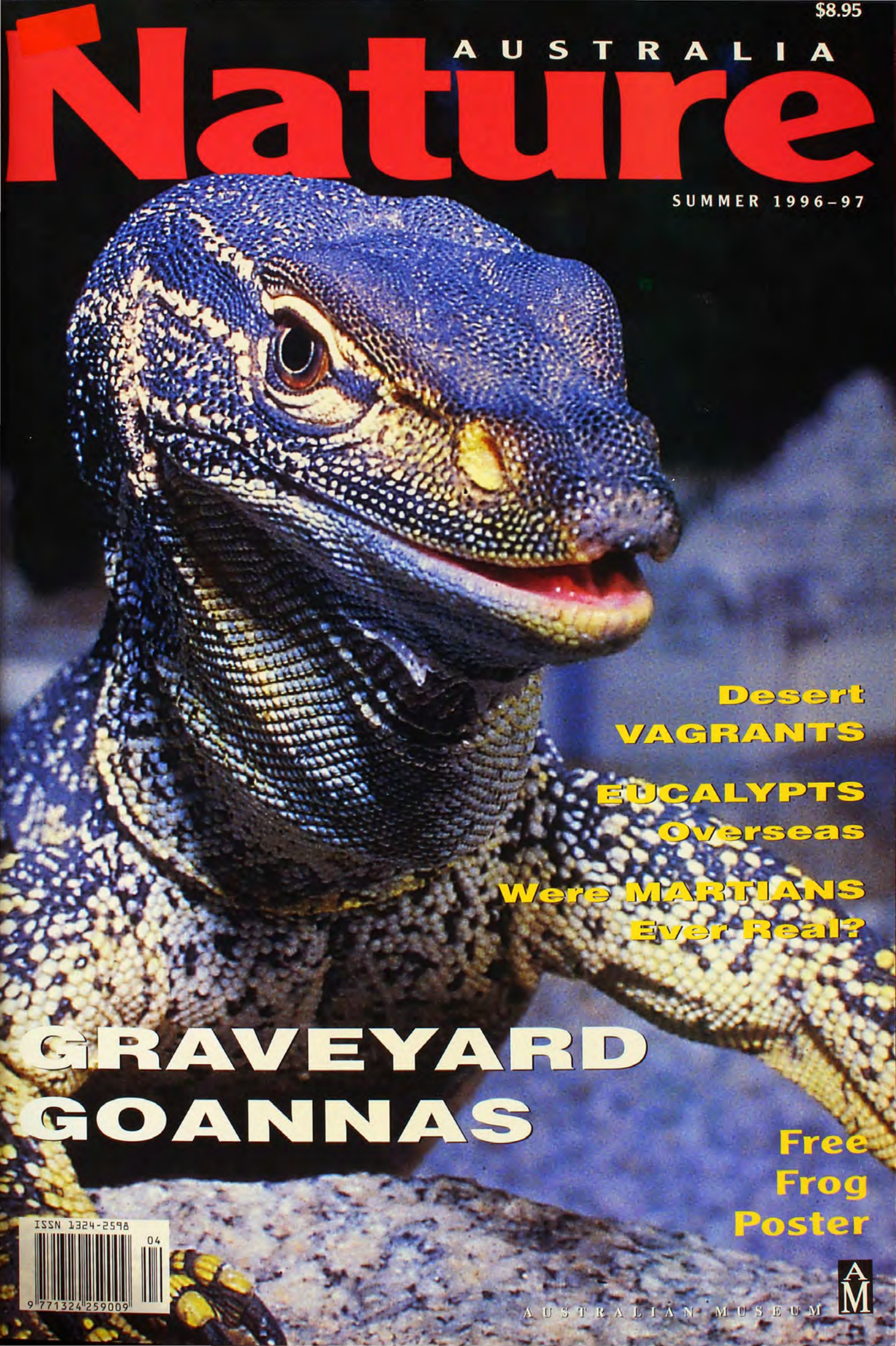
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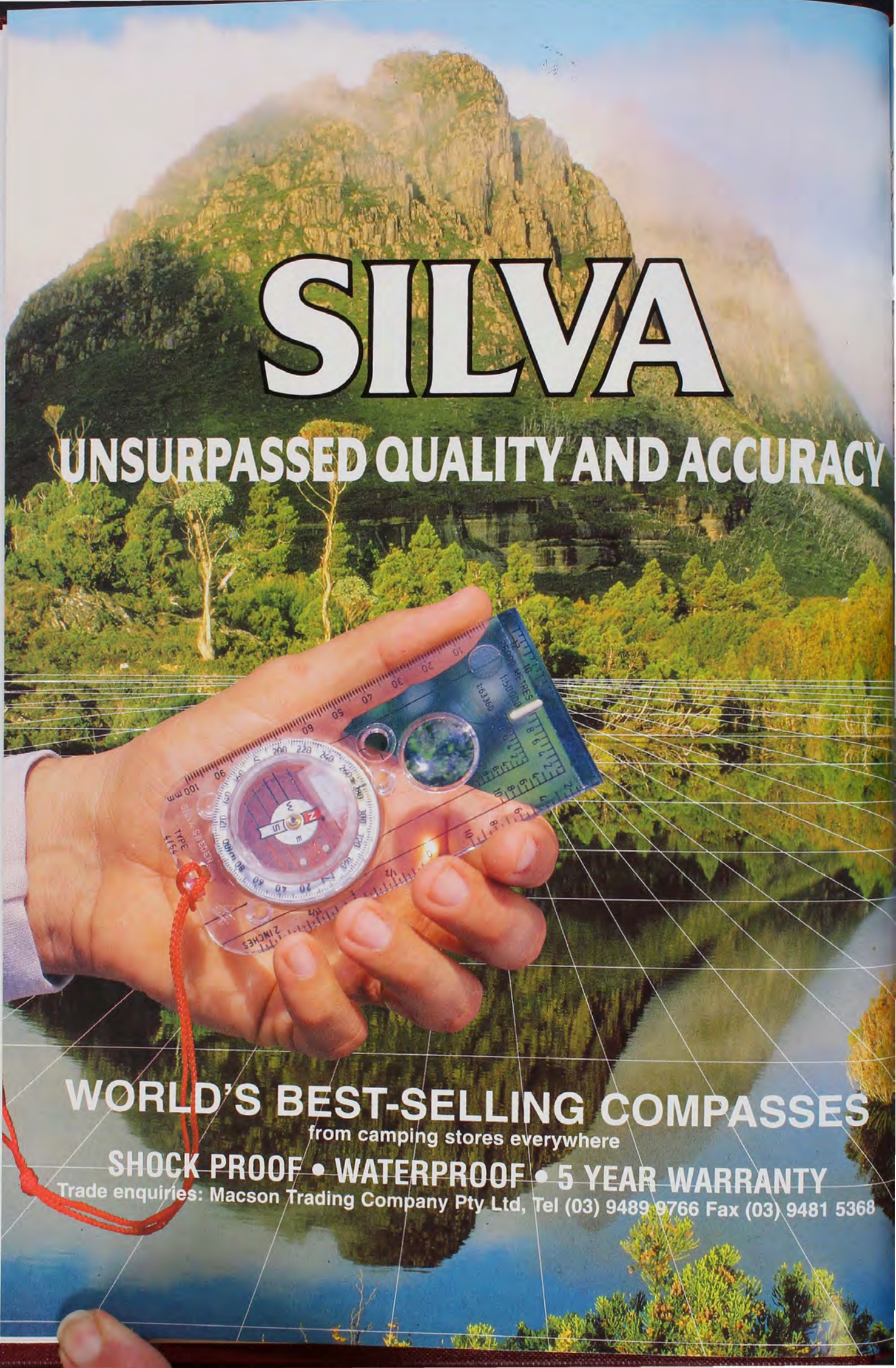
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Up Front

Quality. How is it achieved, how is it maintained and what do you do when it comes under threat? Geoff McNamara, author of our many astronomy articles, dropped into the office the other day for a chat about life, the universe and everything. He commented that he enjoyed writing for *Nature Australia* because of its quality. When people take pride and care in their work, always striving to do the best they can and never satisfied with less, then you get quality. But how do you maintain it when budgetary restraints and cost cutting demand that you sacrifice something in order to survive?

The Australian Broadcasting Commission (ABC) is currently facing this dilemma — having to cut quality programs in order to achieve the bottom line. As is too often the case, science will be one of the big losers, being left with even fewer vehicles through which it can inform you of the latest in scientific research. The Australian Museum is to be applauded for its determination to provide an environment in which such a journal as this one can continue to excel. And most important of all, you, our loyal reader, must also be applauded for placing value in science and the environment.

RUDIE KUITER

Spotted Handfish.

This issue's Last Word by Professor Ian Lowe, "Censoring Scientific Results", addresses another serious threat to science, this time from within, that has been borne out of an ever-shrinking resource base.

The National Aeronautics and Space Administration (NASA) is also labouring under budget restrains. But thankfully they've embraced the World Wide Web, which is where we found the images to illustrate Geoff's latest article, "Did Martians Ever Exist?". We downloaded the images, sent them off to the printer and you can check out the results on page 38.

Life after death? For a population of Perth Sand Monitors, a cemetery is the only place to live. Graham Thompson takes an interesting look at life among the headstones for these graveyard goannas on page 30. Dr Chris Dickman, on the other hand, has spent a great deal of time in arid Australia trapping small desert mammals. By chance he happened upon a discovery that has major implications for the conservation of these amazing mammals.

Follow the trials and tribulations of our eucalypts overseas, meet the unusual Spotted Handfish, learn of the efforts to save our spectacular Richmond Birdwing Butterfly and, in so doing so, continue to support our determination to care about quality and the importance of communicating science.

—Jennifer Saunders

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EDITOR
Jennifer Saunders, B.Sc.

SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.

PHOTO RESEARCHER
Kate Lowe

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Front Cover
A close encounter with one of the Sand Monitors that inhabit Karrakatta Cemetery, five kilometres west of Perth's CBD. Photo by John Green.

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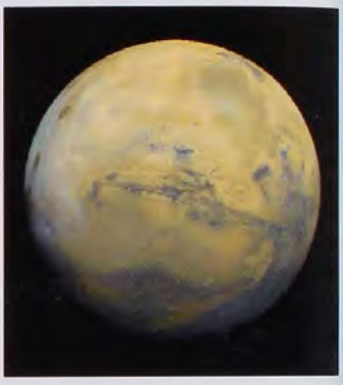

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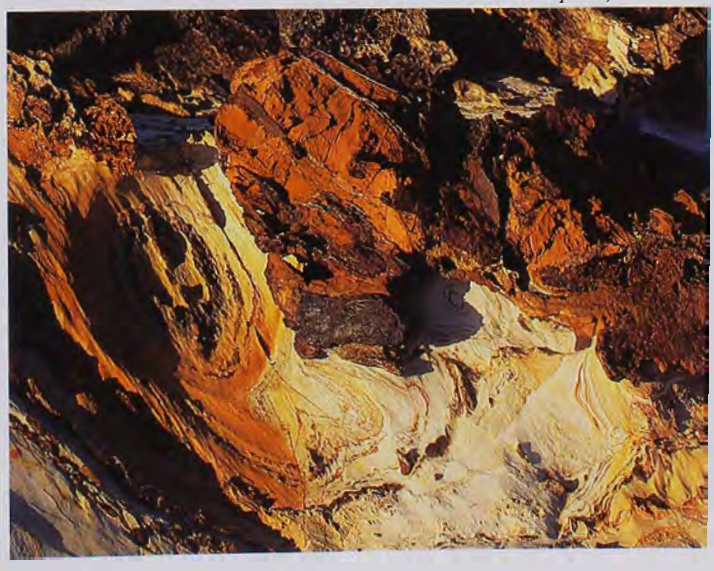

LETTERS

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

Plant Laxatives

In the Autumn 1996 issue of *Nature Australia* there was a Nature Strips article about a Costa Rican shrub that produces a laxative in its bird-dispersed fruit, the first time such a phenomenon has been recorded. I have long believed that a southern Australian shrub, the Nitrebush (*Nitraria billardieri*), produces a laxative-laced fruit. Nitrebush seeds are dispersed mainly by Emus and at the beginning of the fruiting season as many as 1,000 seeds may be excreted in a single Emu dropping. But as the fruiting season advances, the Emus appear to develop diarrhoea, and they leave a trail of individual seeds across the landscape. This must greatly benefit the Nitrebush, by scattering rather than clumping its seeds. I suspect that a laxative ingredient has evolved to produce this result.

—Tim Low
Chapel Hill, Qld

Nicotine Kills

I would like to comment on your Nature Strips story about the little Thorny Devil (*Nature Aust.* Autumn 1996). Some years ago when I was in the outback I was given one of them and kept it in a small box. The second day I had her, she laid the biggest egg I have ever seen come out of so small a creature. I could not believe it possible and she has earned my undying admiration ever since. I still think of her egg-laying effort with amazement.

I was also most interested in the Q&A story that mentions the killing of small animals using tobacco juice (*Nature Aust.* Autumn 1996). Many years ago I was in the Kalahari catching snakes for a museum so had to devise a method of killing them without damaging them and also despatching them quickly enough so they did not bite me. As I thought about this problem I noticed my husband puffing endlessly on his very smelly pipe and the thought went through my head that tobacco juice is nicotine and is very poisonous stuff. Perhaps it could help. The very next snake I caught I asked my bewildered and somewhat put-out husband to give me his precious pipe. I pulled it apart and from the smelly icky end I put a small drop of the brown gunk on each of the snake's nostrils and waited to see what would happen. Amazement! The snake was dead! Instantly. After that, killing snakes was a breeze and it was no trouble getting the pipe from my husband as he knew it would be returned unharmed in a few seconds. It is worth noting that, not even this dramatic demonstration of the poisonous nature of nicotine stopped my husband from smoking or even slowed him down.

I love *Nature Australia* magazine and have been getting it for many years. I find the articles interesting and appreciate the humour the writers often show. And, of course, it must be one of the highest quality magazine productions anywhere in the world. My grateful thanks for many hours of pleasure.

—Penelope Truscott
Upper Beaconsfield, Vic.

Cats Are a Problem

I would like to comment on the Last Word article titled "Cats: Scoundrels or Scapegoats" by Tim Low in the Autumn 1996 issue of *Nature Australia*.

In his first paragraph Low criticises campaigns against cats as wasting time and aggravating cat owners. As for aggravating cat owners I say it's about time. As for wasting time I say he could take a piece of his own advice. The article continues in the same vein, using illogical logic to champion cats. One would think the article was written by the President of the Cat Society.

What about the statement "Enormous numbers of birds are killed by pet cats in gardens, it is true. But while this may sound alarming, ecologically there is nothing wrong with it—predation is a fact of life"? Many birds and animals are just holding on in the urban environment and cats are just what is needed to finish them off. There are many that will never return, such as fairy-wrens, pardalotes, shrike-thrushes, yellow robins and ringtail possums. I speak from experience as this is what is happening in our area. It does not seem like much of a swap, fairy-wrens for cats.

He is right about one thing, though. There is a lot of anger towards cats in the community and it will not go away until cat numbers are brought down to controllable levels.

It is a shame that your magazine gives comfort to cat owners when there are many reasonable people trying to do something about this enormous problem.

—Norman Webb
St Georges Basin, NSW

Whether or not cats are a bigger problem than foxes, Cane Toads or rabbits, is only

TIM LOW

Do fruits of the Nitrebush contain a laxative to help Emus scatter their seeds?

D. & M. TROUNSON/NATURE FOCUS

Little Corellas (*Cacatua sanguinea*). Do they mate face to face?

of academic concern. The fact is, as a number of scientific surveys have shown, they do prey on our native fauna and therefore not only compete with our native predators but also threaten species they prey on. It is conservatively estimated that cats in Australia cull over 3.2 billion native animals per year.

One only has to compare areas where cats, foxes and rabbits have been excluded to observe the difference. Reevesby Island, now free of cats and rabbits, has a thriving population of the reintroduced endangered Greater Stick-nest Rat. Both Warrawong and Yookamurra sanctuaries, now free of cats, foxes and rabbits, have thriving populations of small endangered mammals such as bettongs, bandicoots, potoroos and Numbats and are release sites for further introductions of other endangered species.

In contrast with our indifferent past, over recent years we have seen vocal outrage expressed by many sections of the community at the problems caused by cats. This has resulted in a lowering of public support for cats and a call for something to be done to control these pests. I see this as a positive result, which hopefully in the future will lead to acceptance for the use of biological controls for cats.

I therefore disagree with Tim Low's Last Word article and urge that the negative campaign against cats (as well as other exotics) be maintained. Governments have been 'rabbiting' on for many years about the problem of feral animals. It is time to stop 'pussy-footing' about and develop good biological controls that will 'out-fox' our feral pests.

—Peter Mirtschin
Tanunda, SA

I cannot understand how Norman Webb thinks cats kill off tree-dwelling birds such as shrike-thrushes. I hardly ever see cats high up in trees and, when I do, they look rather too clumsy to be stalking birds, even sleeping birds. The idea is incomprehensible to me. Aggressive currawongs or Noisy Miners are more likely to be the villains. There are plenty of ringtails and pardalotes in my area, living among cats, and I know that fairy-wrens do very well in some inner city suburbs.

Peter Mirtschin does not provide a convincing case against cats as he uses examples where foxes (and rabbits) have also been removed. I agree that biological controls against cats would be desirable, but I don't believe politicians or the public will ever condone this.

—Tim Low
Brisbane, Qld

Avian Sex

New Zealand Stitchbirds may not be the only birds to copulate face to face (see *Nature Aust.* Winter 1995). While watching a mob of hundreds of corellas on a sandy bank adjacent to the Ord River, I noticed numerous occasions when one bird lay on its back with wings half extended while another bird stood on top. After a short period, about 10–15 seconds, the top bird waddled off into the crowd while the lower bird righted itself and did the same. Of course there may be some other explanation but it looked like they were mating to me.

—Robert Lethbridge
Kununurra, WA

Flora

When I grow up I want
to be a rainforest,
Not just an ordinary
bush or scrub,
My pride declared by
greens or some folk-lorist
And members of a
fauna–flora club.

My canopy would be
a cause for wonder
And little light would
penetrate my door,
But following the flash
and growl of thunder
I'd welcome rain to
saturate my floor.

Eventually I'd be
an old growth forest
A flourish of the
national estate,
But in the meanwhile
I supply the florist,
I've got a century or more
to wait!

—Len Green
Vaucluse, NSW

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 Penelope Truscott.**

Nature Strips

COMPILED BY
GEORGINA HICKEY

In a Flap Over Dinner

Cormorants and shags (*Phalacrocorax* spp.) are renowned for their habit of holding out their wings and flapping them as they perch on a rock or post. They do this to dry their wings after a swim, or so one line of thinking goes. Recent evidence suggests, however, that this behaviour has more to do with digestion than drying.

David Grémillet from the Institute for Marine Research in Germany recognised that cormorants and shags flap their wings *after feeding*. He reasoned that flapping may help a bird digest cold fish. Grémillet tested the idea by feeding cormorants in Neumunster Zoo various amounts of fish at 12°C, the temperature they would be at if caught in nature. He fed other cormorants the same amounts of fish warmed to 40°C. He then observed the post-feeding behaviour of the two groups.

All the cold fish eaters flapped but only 23 per cent of the warm fish eaters did. The cold fish eaters also flapped for longer—6.2 seconds per gram of cold fish versus 1.8 seconds per gram of warm fish.

In a separate experiment, Grémillet observed individual wild cormorants spreading and flapping their wings for 10–20 minutes. He predicted, using calculations based on his earlier findings, that they must have caught around 100–200 grams of fish. This figure turns out to be the average catch for wild cormorants.

So, how does the flapping help digest cold fish? Grémillet suggests that, as the birds flap, their wing muscles produce heat, which in turn warms the fish in their stomachs. Interestingly, flapping also helps other cormorants because it signals where the fish are.

—C.B.

Lost and Lungless

Breathing is such an unconscious act that we tend to take it, and our lungs, for granted. It may come as a surprise then to learn that there are vertebrates (other than fish, of course) that have no lungs at all. One whole family of salamanders, the Plethodontidae, does completely without lungs, breathing through their skin instead.

Now Ronald Nussbaum of the University of Michigan and Mark Wilkinson of the University of Bristol have discovered a new type of lungless amphibian, and it's by far the largest lungless tetrapod ever found. *Atretochoana eiselti* is a caecilian, one of a group of strange limbless amphibians found mainly in the tropics. But *A. eiselti* is a caecilian with a difference.

Like snakes, most caecilians have a well-developed right lung and a left lung that may either be well developed, smaller than the right lung or absent altogether. Nussbaum and Wilkinson decided to investigate the lungs of *A. eiselti* when they noticed that the internal openings of the nostrils of the one known specimen were sealed. Most caecilians inflate their lungs through their nostrils so the researchers knew something strange was going on. Sure enough, it lacked lungs and

KATHIE ATKINSON

Wing-drying, or an aid to digestion? Why do perching cormorants, like this Great Cormorant (*Phalacrocorax carbo*), flap their wings?

COURTESY RONALD A. NUSSBAUM

A female caecilian (*Schistometopum thomensis*) from São Tomé Island in the Gulf of Guinea shortly after giving birth to three young. This species, like all other known caecilians (with the exception of *Atretochoana eiselti*) has well-developed lungs.

further study showed that it had a dense network of capillaries close to the surface of the skin, a necessary feature for animals that breathe through their skin.

Unfortunately, the single known museum specimen wasn't properly labelled so, although they know it comes from somewhere in South America, Nussbaum and Wilkinson don't know exactly where. The fact that it is very large (over 70 centimetres long), has a weird flattened skull and lacks lungs suggests that it lives in cool, fast-flowing, well-oxygenated upland streams, but as the specimen was probably collected sometime in the second half of last century and none has been collected since, the chance of a living specimen ever turning up is slim.

—G.T.

Surfing Clams

They may not wear lurid shorts, nor speak an impenetrable beach dialect, nor even have arms for carrying a board; but clams can still surf. Olaf Ellers of Duke University in North Carolina investigated the tidal migration of the Coquina Clam (*Donax variabilis*) and found that, far from being passive passengers on the tidal waves, these small clams actively rode the waves and even picked the biggest ones to catch.

With each tidal cycle Coquina Clams migrate up and down the beach, maintaining their position in the region of the beach that is alternately exposed to air and inundated by the arriving waves every few seconds. Ellers wanted to know just how much control the clams had over their migrations. Other workers had hypothesised that clams were eroded from the sand by the falling tide and had to ride the waves of the rising tide to return to their preferred position. By comparing the motion of live and dead clams after a falling tide, however, Ellers showed that they were actively migrating during both tides.

But how do they achieve this movement? Ellers calls it 'swash-riding'. As a wave approaches, the clam jumps out of the sand and into the flow, by pushing its shell upwards with downward thrusts of its foot. As the direction of the water changes, the clams dig in and wait for another wave. They even know which waves to catch, jumping out to ride only the largest 20 per cent of the waves. Experiments in the laboratory showed that clams were using the low-frequency sounds produced by the collapsing waves to time their jumps and that they jumped preferentially for the loudest 20 per cent of the sounds.

—G.T.

COURTESY OLAF ELLERS

Millions of Coquina Clams jump out of the sand in advance of large incoming waves. A beach seemingly devoid of life one minute will be paved with clams a few seconds later.

Hot Rex?

Adding fuel to the long-running debate about whether *Tyrannosaurus rex* was hot or cold blooded, two scientists have calculated how heat was distributed over the animal's body while it roamed the Earth.

Using a near complete *T. rex* skeleton, Reese Barrick and William Showers from North Carolina State University measured the relative ratios of the oxygen-16 and oxygen-18 isotopes in the fossilised bones. From these measurements they calculated which body parts were warmest: they found that *T. rex* had a fairly uniform body temperature, similar to a modern bird or mammal.

STEVEN KIRK/DISCOVER

A fall for the king would have been lethal but at lower speeds *T. rex* would have had a chance to recover his footing.

This technique works on the principle that the cooler the bone-water when the bones are formed, the more oxygen-18 there is relative to oxygen-16. This is because the atoms of oxygen-18 are heavier and, as the phosphate is precipitated from the body fluids during growth, the less energetic oxygen-18 is trapped.

While this technique cannot reveal absolute body temperatures because the water consumed by the animals affects the isotope ratios in the bone, the researchers say that the overall body temperature variation for *T. rex* would have been less than 4°C. Like modern mammals and birds, its feet were slightly colder than its body core and the base of the tail slightly warmer than the end.

These results suggest that, while *T. rex*'s metabolism may not have been as high as that of modern birds or mammals, it was high enough to maintain body temperatures, unlike modern reptiles. This would have allowed *T. rex* enough energy and stamina to be an active hunter independent of outside temperature fluctuations.

But just when you were finally convinced that *T. rex* was warm blooded, researchers in Oregon have looked up the snouts of some dinosaur fossils and found that they lack respiratory turbinates (or at least the bony ridges to which they would have been attached to). Respiratory turbinates are small scrolls of bone possessed by all warm-blooded animals and used to eliminate excess water loss. This suggests that perhaps the dinosaurs, including *T. rex*, were cold-blooded after all...the debate continues.

—R.S.

Careful Rex

Over the decades the image of *Tyrannosaurus rex* has changed from a stupid sluggish beast to a speedy terrorist. New research demands this image be toned down however, because had the dinosaur fallen at high speed it would probably have been killed.

The dinosaur would have had to trade off the benefits of running fast against the potentially lethal consequences of falling at high speeds.

Palaeontologist James Farlow teamed up with physicist John Robinson (both from Indiana–Purdue University) and Matt Smith, a specialist model-maker, to calculate the consequences of a fall at high speeds. Estimating *T. rex*'s mass at 6,000 kilograms and assuming the tiny front legs could do little to break a fall, the researchers calculated that a falling *T. rex* would have hit the ground with a force equal to six times the acceleration due to gravity. The head, coming from a height of between three and five metres, would have hit the ground even harder, with a force over double that of the rest of the body. It would have suffered further injuries from sliding along the ground, propelled by its own forward momentum.

Farlow says that a fall at any speed may have been lethal, but at high speeds there would have been less time for *T. rex* to recover its footing. He argues that the dinosaur would have had to trade off the benefits of running fast against the potentially lethal consequences of falling at high speeds. Taking calculations of leg bone strength and other factors into consideration, Farlow estimates *T. rex*'s top speed to have been around 35 kilometres per hour, more than enough to catch most Cretaceous herbivores.

—R.S.

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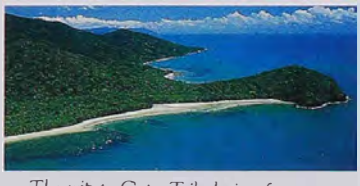

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JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

The Red-and-Green Kangaroo Paw (*Anigozanthos manglesii*) is one of many species whose seeds have been shown to germinate in response to 'cold' smoke.

Smoking or Non-smoking?

Bushfires have been a recurring influence on the evolution of the Australian flora for millions of years. In fact, the seeds of many native plants will germinate only after a fire. Attempts, however, to encourage germination in such species by simulating bushfire heat in laboratories and glasshouses often fail. What is it then about fire that triggers development in the dormant embryos of many Australian plants?

Recent studies by Kingsley Dixon of West Perth's Kings Park and Botanic Gardens, and Shauna Roche and John Pate from the Botany Department of the University of Western Australia, reveal that, for many species, the answer is smoke.

In glasshouses, the researchers exposed the seeds of 94 species of Western Australian plants to 'cold' smoke created by burning native vegetation. All of the plants tested had reputations for being difficult to grow from seed. However, smoke treatment enhanced germination rates significantly in 45 species used in the trial.

Similar results were achieved with other smoke treatments. Germination rates increased when seeds were sown on filter paper exposed to cold smoke or soaked with water through which smoke had been bubbled. The researchers also managed to trigger germination in some plants in the field by exposing small areas of bushland to smoke without the heat of fire.

The results of the research will be critical for the horticultural and nursery production of many Australian native plants. Further studies are needed to identify the chemical or chemicals in smoke that trigger germination. There are indications already that ammonia could be important.

—K.McG.

D. LAWRENCE VENABLE

When a leaf from the succulent Mexican plant *Bursera schlechtendalii* is broken, a high-pressure stream of toxic resin is squirted out.

Plants on the Warpath

The succulent plant *Bursera schlechtendalii* grows in arid and semi-arid parts of Mexico. This plant doesn't give up its leaves to predators without a fight. It squirts them with a sticky toxic concoction. Research by Judith Becerra of the University of Arizona shows that the relationship between this plant and one of its predators, the larvae of beetles in the genus *Blepharida*, is a nail-biting adventure of attack and counterattack with losses on both sides.

Plants use a number of natural repellent chemicals to protect themselves from predation. Some are well known,

like the pyrethrins found in chrysanthemum plants. The repellent chemical in *Bursera schlechtendalii* is a resin that is stored in special leaf vessels under high pressure. When the vessels are broken, such as by a sheep, goat or insect chewing through them, the resin may squirt a distance of 150 centimetres, just like water from a water pistol.

Blepharida larvae are able to 'defuse' the plant's squirt response by biting the mid-vein that supplies resin to the high-pressure vessels, 'bleeding' the plant, as it were, of its toxin. However, it's a tactic that isn't always successful. Sometimes while cutting the mid-vein, the larvae get coated in the resin and are killed.

And even when the larvae are successful, the cost to them is high. Becerra noticed how the larvae that survived grew slowly and were quite small, possibly because they spent so much time 'defusing' the plant instead of feeding. It could take up to one-and-a-half hours for a larva to deactivate the resin canals in one leaf. By comparison, actually eating the leaf took only 10–20 minutes. —C.B.

The Cost of Being Fat

Small birds increase their fat reserves in winter as insurance against unpredictable food supplies, but the cost of being fat is reduced manoeuvrability, and birds often maintain smaller reserves of fat than expected. However, while its major predator is away one small bird does play—and eat!

Andrew Gosler (Edward Grey Institute of Field Ornithology) and colleagues recently examined changes in body mass (roughly equivalent to fat reserves) that have occurred in British populations of the Great Tit (*Parus major*) since 1950, a period when the numbers of its principal predator the Sparrowhawk (*Accipiter nisus*) changed markedly.

Sparrowhawks were widespread and abundant throughout Britain until the late 1950s when populations in eastern and central England were severely reduced by organochlorine pesticide poisoning. By correlating weight data for populations of Great Tits in the periods before, during and after the pesticide poisonings occurred, the researchers showed that the Great Tits in central England were markedly heavier in the years when Sparrowhawks were absent, but became lighter (leaner) as the predators recolonised their former territories, even when there was plenty of food around. In areas unaffected by the pesticide, no significant changes in mass occurred.

This seems to indicate that predation risk is a major cost determining the optimal fat levels carried by small birds, and that individual birds can adjust their fat levels according to a trade-off between the risks of starvation and predation.

—R.S.

Diving Turtles

When Yellow-bellied Pond Slider Turtles (*Trachemys scripta*) go looking for a new home they're after one thing: water views. But how do they find them without the help of turtle real estate agents?

As turtles are quite long-lived, it's more than likely that at some time they're going to have to face the

LABAT JEAN-MICHEL/PH.O.N.E./AUSCAPE INTERNATIONAL

Great Tits whack on the weight when major predators disappear.

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Sleepy or Shingleback Lizard.

prospect of their pond drying up. Rebecca Yeomans of the Savannah River Ecology Laboratory in South Carolina decided to try to find out if homeless turtles simply set out in a random direction in search of somewhere to live, or whether they could somehow detect water and would orient towards it.

She released turtles at three sites to the north, south and west of a large pond—well away from their home pond—with a spool of cotton thread attached to their shell. An hour later she followed the cotton trails to see which way the turtles had oriented.

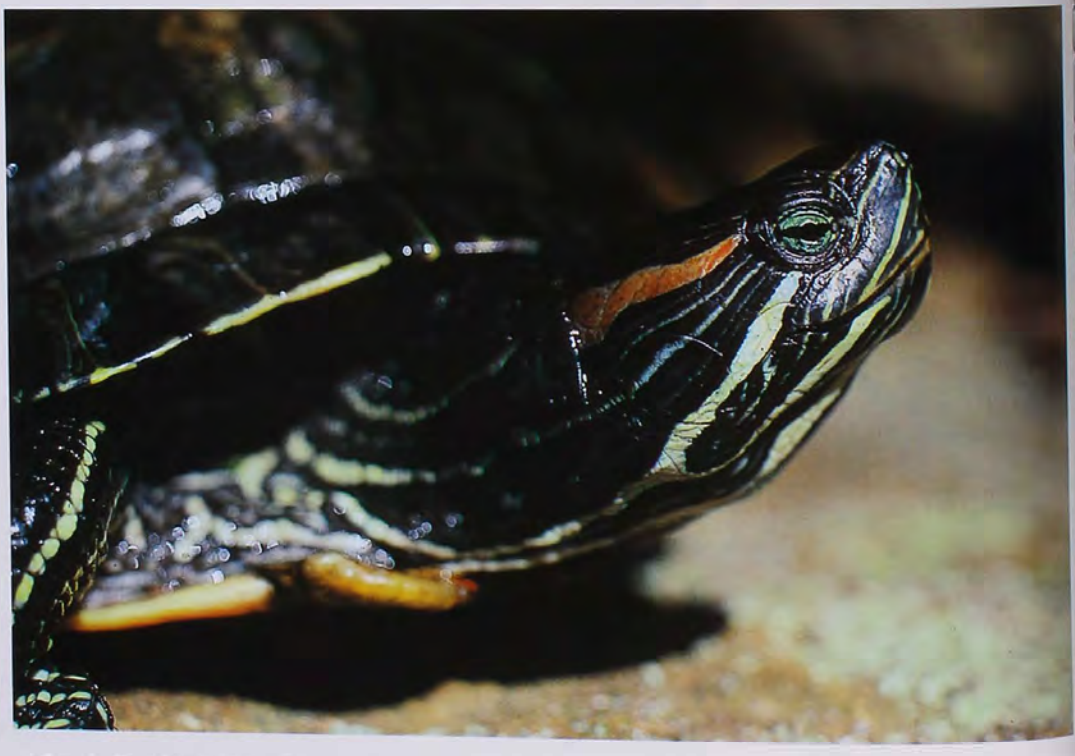
Yeomans found that on clear days a significant number of the turtles did in fact orient towards the water body. The release points were chosen such that vegetation or the terrain obscured the turtles' view of the pond, so what cues were they using to detect the water body?

Orientation was found to be random on rainy or overcast days and Yeomans suggests that light may be an important cue. When sunlight strikes a body of water the light waves tend to become oriented in one plane, an effect known as polarisation. Turtles may be able to detect polarised light reflected from a water body and orient towards it, but such an ability has yet to be demonstrated. Yeomans also suggested that the poor performance on wet days may have been due to rain interfering with other cues such as smell, sound or moisture gradients.

—G.T.

An Evolutionary Dead End

While driving along the South Australian coastline, not far from Arno Bay, Robert Sharrad (University of South Australia) and colleagues came across an unusual sight: a male Sleepy or Shingleback Lizard (*Tiliqua rugosa*) attempting to mate with a freshly road-killed female. Necrophilia is rarely reported in reptiles, or any other animals for that matter. And not surprisingly, since necrophilia is, quite literally, an evolutionary dead end.



Yellow-bellied Pond Sliders have a nose for water.

The internal temperature of the dead female was 34.5°C, which was within the normal temperature range of active individuals. It is thus reasonable to assume the male had not realised his partner was dead. And, because Sleepy Lizards are known to form strong lasting pairs year after year (see *Nature Aust.* Spring 1996), perhaps the male was simply reluctant to give his mate up for dead.

—G.H.

Tent-pitching Bats

We've all heard of bats in the belfry but bats in tents? In fact, 18 species of bats are known to construct various sorts of tents in leaves and other plant parts to roost in during the day. Previous accounts of tent-making were largely anecdotal but now, for the first time, researchers have caught one species of home-makers in the act.

Johnson Balasingh and John Koilraj from St John's College in India, and Thomas Kunz from Boston University in the United States, studied tent construction by the Short-nosed Fruit-bat (*Cynopterus sphinx*). They found that these hard-working bats take between 30 and 50 days to construct their shelters, which may consist of up to 300 severed stems.

And why do they go to so much trouble? For the age-old reason of course: to attract females. The researchers' observations support the idea that only single males construct tents. Tent building occurs twice a year and coincides with the reproductive cycle of the female bats. Soon after a tent is built, pregnant females move in. The males then defend these harems against other males, especially just after the pups are born when the females come into oestrus.

Some tents are apparently more attractive than others. Those with greater vertical length appear to be favoured by females, perhaps because these are easier for males to defend. Females also like a

COURTESY THOMAS H. KUNZ

Short-nosed Fruit-bats in a tent shelter made from the severed stems of *Vernonia scandens*.

PHIL OSHEL, COURTESY JIM McCLINTOCK

An SEM photo of a five-millimetre Antarctic amphipod *Hyperiella dilatata* carrying the shell-less snail *Clione antarctica*.

male that keeps his tent tidy, pruning the new growth to keep the entrance to the tent clear. These insights came when researchers counted the numbers of bats in six tents for several months. Some of the tents had few bats but one highly successful male actually had 19 females living in his tent with him, along with their pups. Time to move to a bigger tent?

—G.T.

QUICK QUIZ

1. What is a mihirung?
2. How many years are there in a millenium?
3. What happens during a solar eclipse?
4. Which has the biggest testes: a Chimpanzee, Gorilla or Human?
5. What do myrmecophages eat?
6. Name the sea between New Zealand and Tasmania.
7. What are substances usually soaked in to form a tincture?
8. Which geologist and Antarctic explorer is depicted on Australia's first $100 note?
9. Is a salamander a fish, amphibian or reptile?
10. What was *Apatosaurus* formerly known as?

(Answers in Q&A)

Repellent and Sunblock in One

Several years ago a five- to ten-millimetre-long amphipod (*Hyperiella dilatata*) was observed hijacking small shell-less snails (*Clione antarctica*) and holding them firmly to its back. When the significance of this unusual relationship was investigated it was found that amphipods carrying snails were rarely attacked by predatory fish, while those that were snail-less, or that had dropped theirs, were quickly eaten.

Chemicals exuded by the snail were analysed to determine what made them so unpalatable. The research team, led by Bill Baker (Florida Institute of Technology) and Jim McClintock (University of Alabama at Birmingham), first extracted the chemicals using solvents and, after mixing with fish food, presented these 'seafood cocktails' to the amphipod's natural predators. The solvent extract stopped the fish from feeding, indicating the presence of an anti-predatory agent.

These compounds were then purified using a technique called High Performance Liquid Chromatography, and the researchers were able to identify the particular chemical that caused the fish to stop feeding. The molecule, called pteroenone, was found to have a similar structure to that of the ultra-violet light-absorbing chemicals carried by some other planktonic creatures.

So, not only can the hijacking amphipods zip through the water column predator-free, but they don't even have to worry about getting sunburnt!

—R.S.

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Carrie Bengston (a science communicator for the CSIRO), Karen McGhee and Rachel Sullivan (freelance science writers living in Sydney) and Geordie Torr (a zoologist at James Cook University) are regular contributors to Nature Strips.

Tree Kangaroos

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REED

Not even the most despicably cold-hearted person could fail to have his spirits lifted by the sight and sound of a blue-bonneted male.

WRENS THROUGH THE EYE OF A SCEPTIC

BY STEVE VAN DYCK

I CAN REMEMBER A TIME WHEN HAVING Superb Fairy-wrens (*Malurus cyaneus*) in your Sydney backyard depended largely on what went into your septic tank. This was during the housing boom at the end of the '50s when Great Australian Dreams were becoming a reality for many in the form of a £4,000, unpainted chamferboard home built on a mire-pit in the middle of a blackberry patch.

Depending on how level or rocky the block was, your state-of-the-art septic tank could be installed anywhere from 30 centimetres to an impressive three metres out of the ground. Because they were all constructed by the same battle-fatigued builder, most backyards in our estate boasted a great exposed concrete silo churning with bugs unimaginable. From the top of the tank, a pipe as thick and stiff as a telegraph pole ran up to a hole in the back of the house, where it connected within the bowels of the wall to the WC. The span could be as much as four or five metres, and a view across the neighbours' backyards would show a whole garrison of tanks lined up for war, their huge gun barrels propping up the houses—a monstrous collection of flying buttresses rivalled only by the Cathedral of Notre Dame.

Some people, my parents included, chose to leave their magnificent septic arch unadorned. Others did a sensible thing and covered the span with passionfruit vines. Nurtured to an extent by the fruity tricklings through which their roots tiptoed, the vines grew and grew until, in festoons, they covered both the cauldron and the great pipe that fed it. These were the backyards that got the Superb Fairy-wrens, and these were the families to be rewarded with all the delights that the cock-tailed parties could bring, because when all the blackberries were cleared, a rampant passionfruit vine was as close to heaven as a low-flying tom-tit could get.

Each family of wrens patrolled over a number of backyards (the area defended during the breeding season has since been shown to be as large as about one hectare), and in that space they would chase insects, flutter across the clearing from one bush to another, and sit in long huddled rows where each would have a gentle pick among its neighbour's feathers.

Not even the most despicably cold-hearted person in the street could fail to have his spirits lifted by the sight and sound of a blue-bonneted male tinkling out his trilling call from the top of a frosty fence post in mid-winter. And in the early spring when they went to nest, it was the passionfruit growers who were rewarded with a bird's-eye view of all the nesting activities from one of their back windows.

In the past it was generally thought that the brilliantly coloured male Superb Fairy-wren lived the life of a sheik in a harem of four to 12 homely looking brown ladies. When it was demonstrated that each group actually contained but one reproductive female, pantheistic nature-lovers breathed a collective sigh of relief...soon to be choked, however, by much more incriminating research showing that adult males go on sneaky, sex-seeking sorties into adjacent territories ('furgling raids'), carrying brightly coloured flower petals to flummox the soon-to-be cuckolded toms of other paddocks.

In any group, those brown individuals, apart from the one breeding female, are none other than the pair's offspring of the previous year, or earlier in the current season. This mixed-sex work force of uncoloured males and females is so ready to assist with their parents' efforts that, about three weeks after hatching her eggs, the matriarch may actually move on to produce a new nest and a new clutch in the knowledge that her wrenlets will be fed and protected by their older siblings. In this way, two or three nests of up to four eggs each may hatch out in a single breeding season.

The tolerance of the breeding female for her teenage daughters is, however, short-lived. The nesting jenny quickly becomes jealous of her maturing female daughters at the beginning of the next breeding season. The old tom, which may be permanently blue after his fourth year, is totally tolerant of his relatively drab sons and, even when they break into the more challenging full blue breeding colours after their first year, he is still long-suffering with their reluctance to leave the happy family. He does, however, quietly ensure his position of reproductive and hierarchical dominance by coming into breeding condition just a few weeks before the rest of the younger talent.

So most of the daughters are driven away, and thereafter the sons, tolerated by both parents, form the body of the wet-nursing fraternity.

The ousted females, hounded out of

SUPERB FAIRY-WREN

Malurus cyaneus

Classification
Family Maluridae (Australo-Papuan fairy-wrens, emu-wrens, grasswrens); genus *Malurus* (fairy-wrens).

Identification
Females always biscuit-brown with brownish white breast, brown tail, an orange ring around the eye, and red-orange bill. Young males, during April to July, like females but with dark blue tail. Males in breeding plumage (usually July to March) have sky-blue cap, cheeks and saddle on a dark blue background; off-white breast, black stripe through eye and no orange on shoulders; black bill. Breeding plumage acquired earlier with age, some old males remaining blue throughout the year.

Distribution and Habitat
South-eastern Australia within 300 km of the coast. Roughly from Brisbane to Adelaide and throughout Tasmania, in woodland, mangroves, grasslands, shrublands, parks and gardens.

Food
Insects and other small invertebrates.

Life Cycle
Lays 3–4 eggs in small, neat domed/roofed nest of grasses, cobwebs, feathers etc. usually no higher than 1 m from ground. Eggs hatch in 2 weeks, young leave the nest at 2 weeks old, are independent after another 4–5 weeks.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Members of a Superb Fairy-wren family feeding the young in the nest.

their mother's territory with as much vigour and flying spit as is meted out to those challenging reflections in car rear-vision mirrors, may fall prey to such predators as butcherbirds, snakes, currawongs, goannas, kookaburras, rats and the occasional web-spinning spider. These same predators also take their share when the fledglings leave the nest and begin their next phase of life fluttering around on the ground. But the most infuriating and persistent suburban killer of Superb Fairy-wrens is the domestic cat to which time and time again these Snugglepot-and-Cuddlepie fairies lose their chicks. Ian Rowley, responsible for so much of what is known about wren behaviour from a long-term study at rural Gungahlin, Canberra, noted in 1965 "There is little doubt that the feral cat was by far the most significant predator on Wrens".

A rampant passionfruit vine was as close to heaven as a low-flying tom-tit could get.

Where I now live in south-eastern Queensland, Red-backed (*Malurus melanocephalus*) and Variegated Fairy-wrens (*M. lamberti*) are plentiful, although neither is as common to, or as tolerant of, suburbia as the Superb Fairy-wren from a bit farther south. To our great good fortune, however, the southern cousin now appears to be creeping up along mangrove corridors and establishing itself in some Brisbane gardens. I sit among my geraniums twiddling my thumbs in nervous expectation praying that, given the vagaries of fashion and vogue living, the tide will turn and above-ground septic tanks will again become the in-thing. I, for one, will then be ready to plant vines with a passion.■

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

It was discovered by the French explorer Péron, and formally named in 1804, making it one of the earliest described fishes from Australia.

SPOTTED HANDFISH

BY PETER R. LAST & BARRY BRUCE

HANDFISHES BELONG TO THE primitive anglerfish family (Brachionichthyidae) and are endemic to southern Australia. They are highly unusual marine bottom-dwelling fishes with a tadpole-shaped body and leg-like pectoral or side fins. The extremities of these fins resemble a human hand (hence their common name). Rather than swim, handfishes prefer to 'walk' or 'gallop' slowly over the bottom, using these 'legs' and modified finger-like pelvic fins.

Almost all of the anglerfishes have a 'fishing apparatus' or 'illicium' (actually a modified dorsal-fin spine) with a fleshy 'lure' at the tip. This moveable structure is located on the snout and can be projected forward over the mouth to attract prey. Handfishes are distinguished from other anglerfishes by the form and position of the second dorsal fin above the head. This fin is made up of two spines connected by a membrane and, when raised, the handfish somewhat resembles an American Indian chief in headdress.

Little is known about the biology of handfishes. Indeed, all but three of the eight species are still formally undescribed. Handfishes mainly live on the continental shelf, but some species live only in deep water. Most of the inshore species have very restricted distributions and are considered to be potentially at risk due to their small population sizes. One such species, the Spotted Handfish (*Brachionichthys hirsutus*), appears to have undergone a significant recent population decline and has the dubious honour of being the first Australian marine fish to be listed as 'endangered'.

PHOTOS: RUDIE H. KUITER

The Spotted Handfish, which grows to a maximum length of 12 centimetres, is confined to soft bottom habitats of Tasmania's Derwent River and adjoining bays. It was discovered by the French explorer Péron, and formally named and described in 1804, making it one of the earliest described fishes from Australia. There are only sporadic records of this handfish from the Derwent River in the 19th and early 20th centuries but, with the availability of SCUBA equipment in the 1960s, specimens were recorded and the species was considered common throughout its range. During the last decade, however, the Spotted Handfish has suffered a dramatic decline in distribution and abundance, and has only been reliably reported from a few sites within the Derwent.

The cause of the apparent reduction in Spotted Handfish numbers is uncertain, however the timing and extent of the decline coincides with the increase in abundance and spread of the introduced Northern Pacific Seastar (*Asterias amurensis*) into the Derwent system. This seastar (or 'starfish') was probably introduced from Japan via ships' ballast water, and is a voracious consumer of invertebrates and anything else on the seabed, such as fish eggs. Although no direct evidence has been obtained, we suspect the seastar has been decimating Spotted Handfish numbers by eating the eggs.

The female Spotted Handfish lays about 80–200 large eggs (approximately four millimetres in diameter) that are held together in a bunch by fine threads and attached to shells or small invertebrates on the substrate. Spawning appears to occur in late winter–early spring with the egg mass being guarded after spawning. Nothing is known about the time of hatching, nor the dispersal capabilities of the larvae. However, based on the low temperatures during the spawning period and their large egg size, it is suspected that the period of incubation is drawn out, with larvae hatching at an advanced stage of development and possibly with limited dispersal capabilities. Limited dispersal of larvae is significant as it may restrict the ability of the species to repopulate its previous range without assistance, even if the cause of the decline (the seastar?) is removed. Research is needed to establish the present range and numbers of the Spotted Handfish, evaluate the suspected cause of decline, and learn more of its reproductive requirements so that it can be bred in captivity. ■

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Dr Peter R. Last is a fish taxonomist, and Barry Bruce a larval fish biologist, at the CSIRO Division of Fisheries in Hobart.

Some kinds of seeds are so well designed they can float for two-and-a-half years or more.

THE AMAZING VOYAGES OF SEA BEANS

BY TIM LOW

AMONG THE MOST REMARKable of all world travellers are the seeds of seashore plants. Their voyages on the open oceans are the stuff of legends. Coconuts (*Cocos nucifera*) have found their way up to the fiords of chilly Norway, and Nicker Nuts (*Caesalpinia bonduc*) from the West Indies have crossed the North Atlantic Ocean to reach Spitzbergen, hundreds of kilometres inside the Arctic Circle.

In Australia, tropical Nicker Nuts sometimes wash up on our southern shores, and one was collected on Macquarie Island in the sub-Antarctic. Coconuts have reached southern New South Wales and Western Victoria. Moreton Bay Chestnuts (*Castanospermum australe*, produced by a riverine rainforest tree) have journeyed from eastern Australia to New Zealand. As well, our northern shores receive many international seed visitors from Asia and the South Pacific. Captains Cook and Bligh and other mariners found barnacle-encrusted Coconuts on northern beaches long before the palms were cultivated here. Some of these Coconuts would have come from villages on the islands of Torres Strait, but others no doubt journeyed here from much farther away.

Some kinds of seeds are so well designed they can float for two-and-a-half years or more, but eventually they lose buoyancy. In deep-sea trenches near Puerto Rico the sunken seeds of Sea Almonds (*Terminalia catappa*) and mangroves have been found below 7,500 metres of water. Seeds often die long before they sink. Fruits of the tree *Parinari glaberrimum* often journey from the South Pacific to northern Queensland, but never establish in Australia, probably because the seeds die before completing their journey.

Tropical beach seeds sometimes germinate well outside their climatic range. Sir Joseph Banks was once sent a drawing of a Nicker Nut plant grown in Ireland, and Matchbox Beans (*Entada phaseoloides*) cast up in New Zealand have been germinated and grown in glasshouses. Nicker Nuts from the tropics sometimes sprout on beaches in southern Queensland but the shrubs do not last long, probably because the temperate winters are too cold.

Because their seeds are such doughty travellers, seashore plants are often remarkably widespread. Many of the plants that characterise tropical

PHOTOS: TIM LOW

The largest pods in Australia are probably the enormous 'beans' of the Matchbox Bean, growing a metre or more long. The hard seeds were sometimes hollowed out to store matches, hence the name.

Part of a prized collection of beach seeds, gathered over a 12-month period at Cape York. The smaller grey seeds are Nicker Nuts.

So widely spread are the seeds of the Goat's-foot Convolvulus, it can be seen growing on tropical and warm temperate beaches throughout the world. The shoots and taproot of this creeper are edible.

Australian beaches, including Goat's-foot Convolvulus (*Ipomoea pescaprae*), Beach Bean (*Canavalia rosea*), Sea Fanflower (*Scaevola taccada*) and Nicker Nut can be seen on beaches throughout most of the tropics. The tropical seashore flora is the most cosmopolitan in the world.

When such seeds appeared in Europe long ago, they inspired myths and legends. Columbus was supposedly driven to discover America by the sight of seaborne Matchbox Beans. In 16th-century Cornwall, sea seeds were attributed to underwater trees, and in the Hebrides in the 18th century, peasants wore Nicker Nuts as amulets to ward off the evil eye. The Crucifixion Bean (*Merremia discoidesperma*) was especially revered because of its cross-like pattern.

In Florida collection of beach seeds became a serious hobby, and around the turn of the century some jewellers specialised in polishing the seeds—known as 'sea beans'—to a high lustre. In Australia, beachcombers often keep Matchbox Beans as souvenirs of tropical holidays. These giant beans, looking like chocolate-coated biscuits, were the remarkable oceanic travellers in David Attenborough's "The Secret Life of Plants". They are borne in dangling pods up to 1.2 metres long.

The floating seeds of seashore plants are often very big—size being no barrier to oceanic travel—and some contain enough starch to be worth harvesting as food. All around the tropics, Sea Almonds and Coconuts are gathered and eaten. Coconuts, being one of the world's biggest seeds, are especially important, as a single seed is large enough for a meal. Aboriginal groups in northern Australia exploited a wide range of seashore seeds and pods, including the Grey Mangrove (*Avicennia marina*), Orange Mangrove (*Bruguiera gymnorhiza*), Velvet Bean (*Mucuna gigantea*), Matchbox Bean and Beach Bean (none of which is edible raw). Unripe Beach Beans were also a food of Captain Cook during his sojourn at Endeavour River, although the raw seeds poisoned Governor Phillip near Botany Bay.

If you would like to know more about seashore seeds, consult the chapter on flotsam in Alan and Joan Cribb's book *Plant life of the Great Barrier Reef and adjacent shores*. These hardy travellers of the open oceans deserve our admiration and respect. Long may they sail the open seas. ■

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Tim Low is a Brisbane-based environmental writer and consultant with an interest in seed dispersal.

RICHMOND BIRDWING

BY DON SANDS & SUE SCOTT

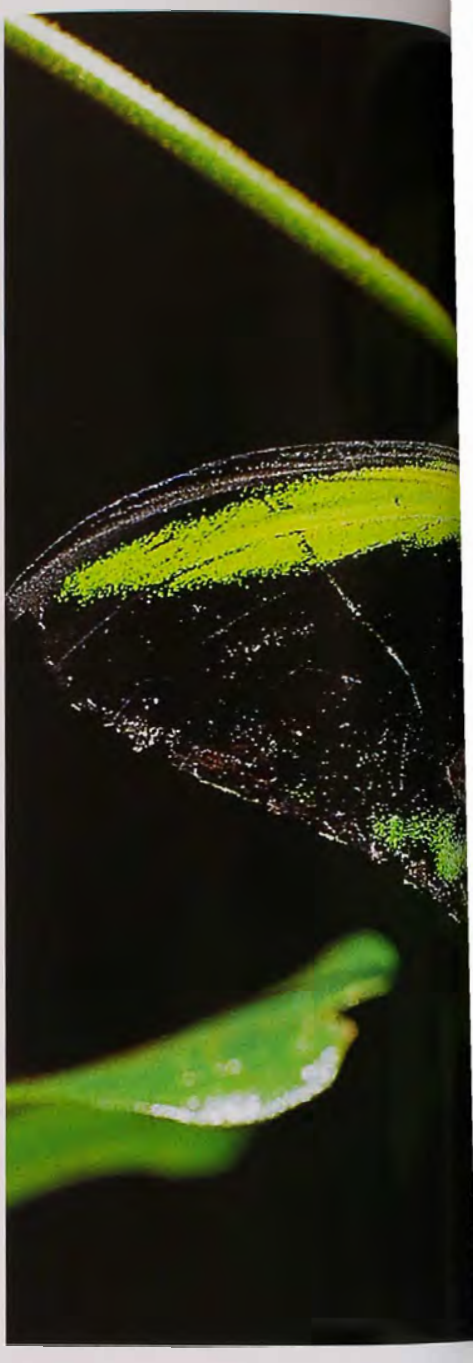
The favoured haunt of the adult Richmond Birdwing is the tree-top canopy where they feed on the nectar of a variety of flowers.

PEOPLE IN THE EASTERN STATES of Australia have become accustomed to seeing butterflies like the Orchard Swallowtail (*Papilio aegeus*) and the Blue Triangle (*Graphium sarpedon*) in their gardens, but this wasn't always the case. Without exotic plants as food for their larvae, these butterflies would be far fewer, sustaining themselves only on native vegetation. However, many butterflies have not been so fortunate, having caterpillars that are restricted to native plants and bushland habitats. Although no species of Australian butterfly is known to be extinct, many local populations have disappeared and the survival of several is seriously threatened. One such species, the Richmond Birdwing (*Ornithoptera richmondia*), has become much scarcer since European settlement, and particularly so during the last 15 years. This is the largest butterfly in subtropical eastern Australia, with the iridescent green and black males sporting wingspans of 13 centimetres and the brown and white females up to 15 centimetres.

In 1870, the Richmond Birdwing was reported to have occurred in large numbers in the streets of Brisbane but, by the 1920s, sightings near the city had become scarce. Today the Richmond Birdwing is only rarely seen in urban south-eastern Queensland, and in national parks its numbers have declined markedly. Since the turn of the century its distribution has shrunk by about two-thirds of its original range, with only two areas containing viable breeding colonies. One occurs across the eastern border between the Richmond River in New South Wales and Mount Tambourine in Queensland, and the other lies about 110 kilometres to the north between the Glasshouse Mountains and Yandina in Queensland.

The demise of the Richmond Birdwing is mainly due to the decline in abundance of the particular plants that provide food for the caterpillars. In coastal regions and in ranges up to about 600 metres altitude, the Richmond Birdwing is dependent on *Aristolochia praevenosa*, a tough-leaved rainforest vine that can climb 20 metres into the canopy and originally occurred from near Grafton in New South Wales to Maryborough, Queensland. This vine occurs either on steep slopes over basaltic soils or on rich alluvial loams bordering rivers and streams. Areas with such soils were eagerly sought for agricultural purposes where most forests were cleared even on the embankments of water courses, the favoured sites for the vine and the butterfly.

At higher altitudes, mainly above 1,000 metres, and only in the New South Wales–Queensland Border Ranges, a second species of aristolochia vine, *A. deltantha* var. *laheyana*, is an important food plant for the caterpillars. This vine is abundant on ridge tops where it is safe from agricultural disturbance since it occurs mostly in national parks. It has slender stems that ramble in shrubs



A male Richmond Birdwing butterfly. Richmond Birdwings are the largest butterflies in subtropical eastern Australia and males can have a wingspan of 13 centimetres.

COURTESY DON SANDS

beneath the rainforest canopy and softer leaves than the coastal species.

The tough leathery leaves of the coastal food plant, *Aristolochia praevenosa*, are unsuitable for feeding by the newly hatched caterpillars. Only the first two or three leaves growing from the terminal shoot are soft enough for their minute mandibles. Starvation and even cannibalism among the caterpillars can be a common occurrence on *A. praevenosa* vines, especially during dry periods when the soft leaves are in short supply. By contrast the montane food plant, *A. deltantha* var. *laheyana*, although smaller, has softer leaves and can therefore support many more caterpillars. At Binna Burra Lodge, O'Reilly's Guest House and other localities in the Border Ranges, it is not uncommon to see ten or more adult birdwings in a day. But the butterflies are not always abundant in the mountains. Every three to seven years the mountain populations disappear or become very scarce,

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A Richmond Birdwing in its pupal stage.

RICHMOND BIRDWING

BY DON SANDS & SUE SCOTT

The favoured haunt of the adult Richmond Birdwing is the tree-top canopy where they feed on the nectar of a variety of flowers.

PEOPLE IN THE EASTERN STATES of Australia have become accustomed to seeing butterflies like the Orchard Swallowtail (*Papilio aegeus*) and the Blue Triangle (*Graphium sarpedon*) in their gardens, but this wasn't always the case. Without exotic plants as food for their larvae, these butterflies would be far fewer, sustaining themselves only on native vegetation. However, many butterflies have not been so fortunate, having caterpillars that are restricted to native plants and bushland habitats. Although no species of Australian butterfly is known to be extinct, many local populations have disappeared and the survival of several is seriously threatened. One such species, the Richmond Birdwing (*Ornithoptera richmondia*), has become much scarcer since European settlement, and particularly so during the last 15 years. This is the largest butterfly in subtropical eastern Australia, with the iridescent green and black males sporting wingspans of 13 centimetres and the brown and white females up to 15 centimetres.

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A male Richmond Birdwing butterfly. Richmond Birdwings are the largest butterflies in subtropical eastern Australia and males can have a wingspan of 13 centimetres.

The Cairns Birdwing is the Richmond Birdwing's closest relative but, unlike the Richmond Birdwing, it has not become scarce.

AS HAS BEEN THE CASE WITH SO much of our native fauna, it is the loss of habitat through clearing that has led to the butterfly's rarity, shrinking distribution and local extinction. But for the Richmond Birdwing another factor is threatening its survival: the introduced Dutchman's Pipe (*Aristolochia elegans*). This vine, originally from South America, is a popular garden climber. It was cultivated for its large purple-veined, pipe-shaped flowers but has escaped to become a weed in forest reserves and national parks. Female birdwings are attracted by the plant's particularly strong odour and are stimulated to lay their eggs on its leaves. However, when the young caterpillars hatch and start to feed, they are poisoned by the plant's toxic compounds. The Dutchman's Pipe is also responsible for poisoning the caterpillars of the Cairns Birdwing as well as several other aristolochia-feeding butterflies in northern Queensland.

Other exotic vines that threaten survival of the Birdwing Butterfly are morning glory (*Ipomoea* spp.), Madeira Vine (*Anredera cordifolia*) and Cat's Claw Creeper (*Macfadyena unguis-cati*). These have also escaped from gardens, become weeds and are now smothering native vines, shrubs and trees, including *Aristolochia praevenosa*, the Richmond Birdwing vine. These exotic vines need to be removed from cultivation and disposed of carefully (not thrown into the bush!).

The Richmond Birdwing Conservation Project was set up to encourage members of the community and school children to actively participate in arresting the decline of the Richmond Birdwing. In 1992, the Balunyah Nursery at Coraki, New South Wales, with the assistance of the New South Wales National Parks and Wildlife Service, began cultivating seedlings, cuttings and seeds of *A. praevenosa*. To date more than 15,000 vines have been distributed to retailers, community and conservation groups, and schools for planting.

The CSIRO's Double Helix Club began coordinating the project in 1993. By combining the scientific and educational expertise of officers from the CSIRO, New South Wales National Parks and Wildlife Service and others, school students and members of the community are now helping with research needed to ensure the survival of the Richmond Birdwing. More than 130 schools, hundreds of householders and many conservation groups are currently involved. Dispersing female birdwings have already laid eggs on cultivated vines near Brisbane, at Beerwah on the Sunshine Coast, and at Alstonville.

School students are also assisting with identifying insect pollinators from the flowers of aristolochias and in evaluating a new version of the leaf penetrometer—a portable instrument for measuring leaf toughness, a critical factor affecting survival of young caterpillars. Already a number of government departments and commercial organisations have indicated their willingness to help financially, recognising the importance of this project as a practical conservation project for all members of the community.■

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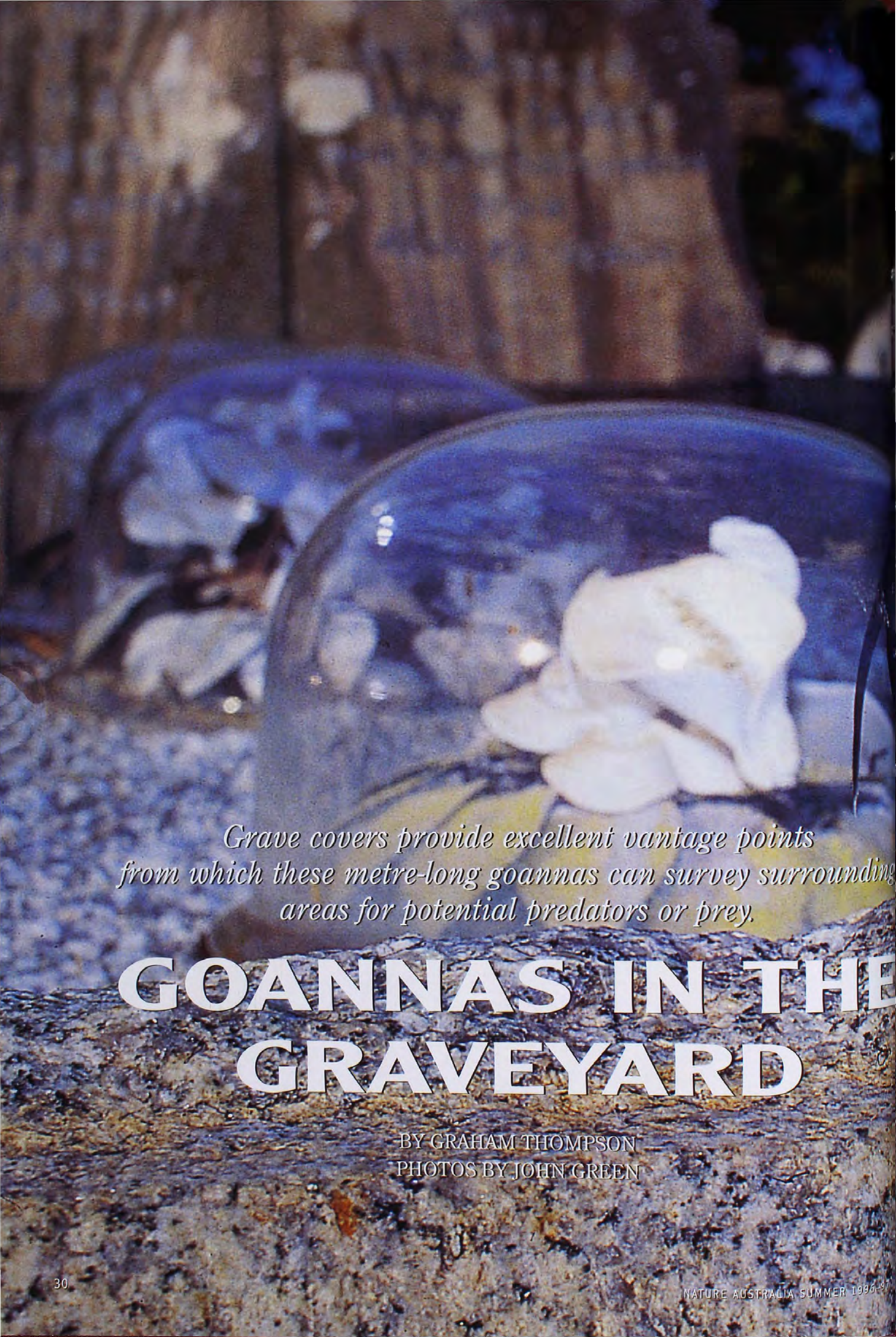
Dr Don Sands is a Senior Principal Research Scientist with CSIRO's Division of Entomology in Brisbane where he studies insect pests of tropical horticulture. He is also interested in taxonomy and conservation of butterflies. Sue Scott is South-east Queensland Double Helix Officer with CSIRO's Education Programs. She is involved in coordinating science activities for local individual and school group members of the club.

COURTESY DON SANDS

Grown in gardens for its attractive purple pipe-shaped flowers, and now invading the bush, the introduced Dutchman's Pipe vine threatens the survival of the Richmond Birdwing Butterfly.



Grave covers provide excellent vantage points from which these metre-long goannas can survey surrounding areas for potential predators or prey.

GOANNAS IN THE GRAVEYARD

BY GRAHAM THOMPSON
PHOTOS BY JOHN GREEN

The Sand Monitor's long, snake-like tongue plays a sensory role in locating prey by transferring odours into a sensory organ, Jacobson's organ, located in the roof of the mouth.

IF YOU SAW A PERSON WITH A THREE-metre-long fishing rod crawling on hands and knees between the head stones in a metropolitan cemetery, you could be excused for thinking something was seriously amiss. This, however, is the best way I know of catching large goannas in a graveyard. Catching goannas of any size, anywhere, is difficult and requires skill and cunning. These lizards are very wary, cryptic, have good eyesight, can run at great speed and are constantly vigilant against potential dangers.

Twenty-four species of goannas (or monitor lizards, *Varanus* spp.) occur in Australia. Western Australia has 18 species, three of which—Rosenberg's Monitor (*V. rosenbergi*), the Black-headed Monitor (*V. tristis*) and Gould's Goanna or the Sand Monitor (*V. gouldii*)—were apparently common on the Swan River coastal plain prior to settlement. Goannas still occur in the large urban conservation reserves in the Perth metropolitan area or in surrounding bushland but, with the development of roads, houses and formal parklands, sightings are becoming much less frequent. If you are patient though, one place you can usually be guaranteed to see a goanna is in Karrakatta Cemetery. A sample of the 75 or so Sand Monitors that live in this area has been the subject of a four-year study of mine.

Karrakatta Cemetery is located five kilometres west of the central business district of Perth. This 106-hectare site has been used as a burial ground since the late 19th century and, as a consequence, almost all the original vegetation has been removed. Like most cemeteries, graves are arranged in rectangular plots separated by bitumen or gravel roads. Before the cemetery was developed, it contained banksias and eucalypts. Today, some areas have been landscaped with a range of exotic shrubs and trees, while others have been grassed and are surrounded by large and attractive rose gardens.

Sand Monitors were relatively abundant in the cemetery in the late 1980s, although extremely difficult to find and catch, given their wariness.

Sand Monitors were relatively abundant in the cemetery in the late 1980s, although extremely difficult to find and catch, given their wariness. At the slightest disturbance they retreat to holes that they have dug under the stone grave covers, or into cracks in the slabs that have resulted from soil subsidence. Grave covers provide excellent vantage points from which these metre-long goannas can survey surrounding areas for potential prey or predators (humans, dogs, cats, raptors). The heat-absorbing, dark grey slabs also provide excellent sites on which to rest early in the morning while the lizards warm up.

Sand Monitors are seasonally active. They emerge from hibernation around late September to early October, having spent the previous six months in a burrow some 70 or 80 centimetres underground. As you would expect, they are relatively thin, not having eaten since late March. During the first couple of days they remain near their holes, but each day after that they move off in search of food and, presumably, mates.

Sand Monitors exploit visual, olfactory and auditory cues to detect prey. As a goanna approaches a patch of leaves, it moves its head and neck slowly from side to side, using its snout to shift the leaf litter while flicking its tongue in and out. Like snakes, their very long forked tongue is used to transfer odours into a sensory organ located in the roof of the mouth called the Jacobson's organ. The front feet are used to scratch away the leaves or to dig into the ground for spiders and small skinks, while their pointed snout and sharp teeth are poised for a quick attack. In contrast to other large lizards, which are often herbivorous, most *Varanus* species are active predators. Using a simple stomach-flushing technique I found that the Sand Monitors at Karrakatta Cemetery feed largely on mole crickets (family Gryllotalpidae) with spiders and insect larvae being the next most abundant items on the menu. (No human remains have been found in their diet!)

The number of goanna sightings in Karrakatta Cemetery has decreased in recent years, suggesting that the overall numbers there are in decline. The reason for this is unknown, but it may be due to the clearing of unwanted grasses and leaf litter from between the graves, which reduces the number of inverteb-

Sand Monitors in Karrakatta Cemetery dig their burrows under the broken stone or concrete grave covers on the loose sandy soil. Soil subsidence under these grave covers also provides a warm place where these goannas can locate prey items such as crickets, spiders and cockroaches.

rates available for foraging. The use of herbicide to kill unwanted plants may also directly affect goanna numbers, as a total of five adults have been found dead within one week of spraying operations over the last couple of years.

To ensure the long-term survival of goannas in Karrakatta Cemetery requires a detailed knowledge of the species' biology. Apart from their diet, this includes information on such things as the size of their activity area, retreats, foraging sites, breeding behaviour and seasonal activity patterns. A series of studies has been undertaken since 1990 to collect data on these topics.

IN THE FIRST STUDY, GOANNAS WERE located early in the morning after they had emerged from their overnight retreats and were basking in the sun on

Karrakatta Cemetery, just five kilometres from Perth's CBD.

The exceedingly wary and generally unapproachable Sand Monitors in Karrakatta Cemetery use their excellent vision and an elevated position to detect the presence of people long before they themselves are observed.

SAND MONITOR

Varanus gouldii

Classification
Family Varanidae. Two recognised subspecies: *V. g. gouldii* (from continental Australia except the arid interior) and *V. g. flavirufus* (arid interior of Australia). Also known as Gould's Goanna.

Identification
Large (up to 1.6 m) terrestrial lizard, with males generally larger than females. Colour pattern and size vary across geographical range. Dorsal pattern a combination of black, brown, yellow and greens making up numerous small circular patterns (ocelli), usually arranged in a transverse band. Dark temporal band extending back from behind eye. Tail laterally compressed, often with a yellow tip.

Habitat and Distribution
Widespread from coastal dunes to forests and sandy deserts. Found throughout most parts of continental Australia, except in the lower half of Vic., extreme southern section of NSW and southern WA.

Behaviour
May dig own burrow, or shelter in hollow logs or burrows of other animals. Will retreat to trees if threatened or to forage. Eats lizards, small mammals and insects.

Reproduction
Breeding occurs during the wet season in northern Australia, and late spring and early summer in southern Australia. Between 4 and 10 eggs laid once a year, either in a burrow or termite mound. Hatching occurs approximately 8–9 months after laying, depending on incubation temperature. Body mass at hatching 15–20 grams.

the grave covers. During this period I found it easiest to stalk them by crawling on my hands and knees between the graves. Once within noosing range, I would gently place the noose over a lizard's head and tighten it. Goannas initially struggled but generally remained calm and made no attempt to bite if held gently but firmly in two hands.

After being weighed, a fine spool of white nylon thread was attached to the base of each lizard's tail. At the point where the goanna was captured, the free end of the thread was tied to a fixed object and the lizard released. I could determine the exact path the animal had taken by following the unravelled nylon thread the following morning. These paths were then recorded onto a plan of Karrakatta Cemetery.

During October and November, goannas weighing less than 600 grams travelled about 180 metres per day, while goannas (usually males) over 600 grams travelled much greater distances,

The slope and east-facing orientation of most of the gravestones in Karrakatta Cemetery provide an ideal basking site for Sand Monitors wanting to rapidly increase their body temperature when they first emerge from their burrows.

To avoid detection, a basking Sand Monitor will often quietly move around a headstone.

possibly in search of a mate. The goannas each effectively foraged over an average area of about 300 square metres each day, focusing on areas that had an accumulation of leaf litter on the ground. The same one or two holes were used for their nightly retreats while foraging in a particular area, but when the available source of prey was diminished, they would move off to a more productive area.

Because their foraging areas changed every couple of days, it was important to establish the total size of the area over which the goannas foraged in a particular season. By attaching a miniature radio-transmitter to the side of each goanna's tail just behind the back legs, I was able to monitor the goannas' locations on a daily basis. From this information I could estimate the total area occupied or visited over an entire season.

Four males with an average body mass of about 600 grams had activity areas of approximately 19 hectares, while six females with an average body mass of about 370 grams had activity areas of just two hectares. The difference between the size of activity areas may be related to either the sex or size of these goannas, or it could be a combination of both. The two largest males had activity areas of approximately 32 hectares. On a couple of days, these large males travelled much greater distances than had been recorded during previous weeks of monitoring. This behaviour was probably associated with searching for mates, although females were never seen. During the spring--summer breeding season at Karrakatta Cemetery, male Sand Monitors follow scent trails released by females and probably venture well outside their normal activity area. Males also used a larger number of burrows than females during the breeding season, which is probably associated with their larger activity areas. Activity areas overlapped and goannas were recorded retreating to overnight burrows previously used by other goannas. On no occasion, however, did two goannas use the same burrow overnight, although other researchers have found Rosenberg's Monitors sharing a burrow.

The goannas at Karrakatta Cemetery appeared to have a good 'mental map' of their activity area. If, for example, they were swooped on by a Rainbow Bee-eater (*Merops ornatus*) trying to protect its foraging site or nest hole dug into the sand, the goannas invariably took the shortest unobstructed route to a safe burrow. Similarly, goannas returned regularly to specific foraging sites used on previous days that, in some cases, were hundreds of metres from their burrow.

DURING SUMMER 1993–1994 MY colleagues and I followed two goannas over a period of six weeks to record their daily patterns of behaviour. Goannas emerged in the morning, generally between 6 and 9 a.m., poking their heads out from under a grave cover for a while before bringing their whole bodies out into the sun. They would then climb onto a grave cover, absorbing heat from the sun and from the dark coloured slab, to increase their body temperature from around 15° C when they were in their burrow to about 37° C. This would normally take between 15 and 30 minutes depending on the ambient temperature. Sand Monitors have a maximum body temperature of around 44° C, but they

Sand Monitors show early signs of annoyance by inflating their neck (gular pouch) and abdomen and hissing. This is often followed by side-swipes of the tail, an erect posture or aggressive lunges with their mouth open.

probably cannot sustain this temperature for an extended period. After warming up, they would move off in search of prey.

These goannas like to maintain their body temperature within a narrow band of about 36–39° C. To do this they use a number of behavioural strategies. When initially warming up in the morning or after a period in the shade, they will flatten their bodies and direct the largest surface area toward the sun, while remaining ever vigilant. On days when ambient temperatures are in the high 20s, grave covers can be over 40° C and surface soil temperature in the high 30s. To avoid overheating, goannas will often shift their foraging areas from full sunlight to filtered sunlight or shaded areas. In the hottest part of summer, many goannas are active only in the early morning and late afternoon, retreating to burrows during the heat of the day. These goannas are not active at night.

The goannas displayed a number of interesting body postures. The most common was the vigilant posture, characterised by a motionless body, the abdomen in a prone position, and with head and neck held high. The head is slowly turned to obtain a clear view of the surrounding area. If the view is obstructed, they stand erect, balancing on their hind limbs and tail. Goannas also wag their tail like a dog. On one occasion when a Sand Monitor was seen wagging its tail, it was busy chasing a small skink in a patch of grass; on another occasion, a goanna approached to within about three metres of an observer, wagged its tail a couple of times and moved off to forage. The purpose of this tail wagging is unknown.

Many species of goanna also engage in a combat ritual. Male Sand Monitors have been observed wrestling while standing belly to belly on their hind limbs, using their tail as a prop, and with forelimbs wrapped around their opponent. These struggles can last for many minutes with their sharp teeth occasionally cutting through the skin of their opponent during the fight. The purpose of these combat rituals is probably to defend territories or determine access to females. However, although I have observed goannas at Karrakatta Cemetery over four summers and have talked to many gardeners who work the area, no-one has ever seen any combat ritual at this locality.

General maintenance of the grave sites, and maintenance of the goanna population at Karrakatta Cemetery, could be seen as a conflict of interest for the management staff at the cemetery. On the one hand, people that visit the graves expect the grounds to be kept neat and tidy, with the soil around them raked and removed of weeds. However, goannas do not fare well in such a situation since they require a certain amount of shelter and leaf litter for successful foraging. A compromise has been adopted, whereby low-growing native shrubs (such as bottlebrushes) are being planted in a number of areas and the leaf litter underneath them is allowed to accumulate. The shrubs, while being an attractive addition to the cemetery, provide shelter for the goannas, and the leaf litter provides extra foraging sites. Also, there are plans to minimise the weed-spraying program in those areas most frequently used by goannas, and to erect signs explaining to the public why leaf litter and weeds have been allowed to accumulate. With sensible and sensitive planning, based on the information obtained from the studies at Karrakatta Cemetery, managers will not only be enhancing the aesthetics of the cemetery but they will also be helping to maintain a very special population of goannas.■

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Graham Thompson is a lecturer at Edith Cowan University in Western Australia. He has a long-standing interest in the metabolism, ecology and shape variations in goannas.

This mosaic of Mars is composed of Viking Orbiter images and is similar to the view you would see from a spacecraft. The centre of the scene shows the entire Valles Marineris Canyon system, which is over 4000 kilometres long and up to seven kilometres deep.

DID MAR

With three planets

so similar in

the early days,

the natural question is:

could life have begun

on Venus or Mars,

only to be snuffed out

at some later time?

ANS EVER EXIST?

BY GEOFF McNAMARA

© NASA/JPL

AS THE LIGHTNING FLASHES OVERhead, the thunder cracks deafeningly, rolling over a barren wasteland that quivers in the clear, dense atmosphere. The carbon dioxide 'air' crushes down with a pressure 90 times that felt on Earth. Despite the lack of sunlight, the rocks are almost plastic in the searing 470°C heat. Around you a gentle breeze mocks your discomfort, while overhead hang clouds of concentrated sulphuric acid that whip around the globe at hundreds of kilometres an hour. Welcome to Venus. Goddess of love; hell on another Earth.

Life here? It's difficult to think of a more inhospitable planet. Yet that's just what the Earth would have been like if it weren't for one simple fact: the Earth formed some 40 per cent farther from the Sun. Out here, in what's known as the 'habitable zone', life not only began but seems difficult to stamp out. The habitable zone represents a range of distances from the Sun at which the temperature is not too hot and not too cold, but just right to permit the existence of one of the essential ingredients for life: running water. Any closer to the Sun and the oceans of the Earth would have boiled away, just as they've done on Venus. Any farther out and the Earth might have frozen solid. So suited is this planet to life that, after several global catastrophes leading to mass extinctions, life in one form or another clings on.

There are no demarcation lines identifying the limits of the habitable zone, however. It isn't just a planet's distance from the Sun that determines whether or not it can support life. The geology, atmosphere and climate of a planet also play key roles, just to name a few. The question is: can these factors compensate for a planet being just outside the habitable zone? The truth is, while life on Earth may appear to be uniquely alive, at least one other planet in our solar system came close to spawning life of its own...maybe even close enough.

TO HELP UNDERSTAND WHY THE EARTH IS SO easy to live with, let's look at why the others are not. Let's start with the innermost planet. Mercury is considered far too close to the Sun for life ever to have begun. It's not just the heat, or even the lack of an atmosphere that makes Mercury an inhospitable place. Being so close to the Sun, Mercury's rotation is slowed by the Sun's tremendous gravity pulling on slightly 'heavier' regions of its crust. While Mercury orbits the Sun every 88 days, it takes 59 of those days to rotate once on its axis. The same effect keeps the same side of the Moon facing the Earth. After spending a month in shadow, Mercury's night side temperature can drop to −180°C. During the following day, Mercury's surface bakes under a furnace-like heat of up to 450°C. It's these extremes that make Mercury an unlikely place for life to begin.

Farther out in the solar system are the gas giants Jupiter, Saturn, Uranus and Neptune. These four planets are much

An artist's impression of the Magellan spacecraft orbiting venus. By the end of its 243-day mission, Magellan had mapped 99 per cent of the planet using a high-resolution radar. The radar used bursts of microwave energy to cut through the dense atmosphere and illuminate the planet's surface.

more massive than the Earth. Giant spheres of gaseous and liquid hydrogen and helium, they have no solid surfaces and are incapable of supporting any type of life that might remotely resemble that found on Earth. Their attendant moons are inhospitable places, too: if they're not covered in active volcanoes and lava, they're frozen spheres of ice. Even cloud-covered Titan—Saturn's largest moon—is a poor contender. Although warmed by a small greenhouse effect, the surface temperature on this distant world is 180°C below the freezing point of water.

That leaves Venus and Mars, the two planets that flank the Earth's orbit—and

Venus is the one place in the solar system where you could be simultaneously asphyxiated, crushed, roasted and dissolved.

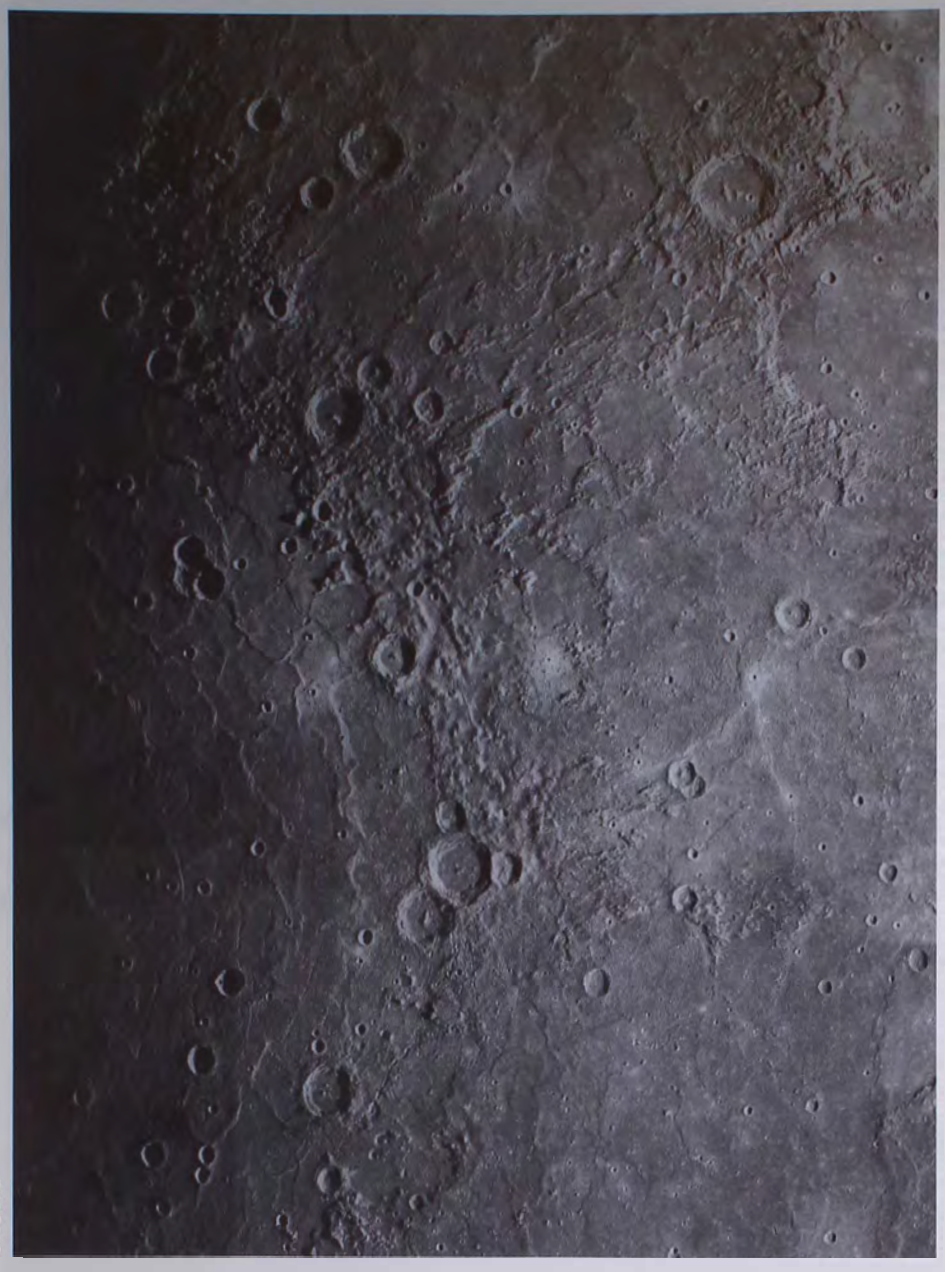
the habitable zone—about the Sun. Astronomers in the last century speculated Venus could support life, and for good reasons too. After all, Venus is about the same size as the Earth; it has a dense atmosphere; and it's not too much closer to the Sun, or so they thought. But, as we've seen, you're less likely to find life on the surface of Venus than you are in the depths of space itself. Venus is, as the late British astronomer David Allen was fond of saying, the one place in the solar system where you could be simultaneously asphyxiated, crushed, roasted and dissolved.

So what about Mars? Like Venus, Mars has an atmosphere. In fact it has seasons, weather patterns, and polar ice caps that advance and recede with the local summer and winter. Mars has long been the host of fictional life forms, some less benevolent than others, but it hasn't been just fiction writers that wrote about intelligent Martians. In a famous case of wishful thinking persuading scientific objectivity, the American astronomer Percival Lowell recorded 'canals' on Mars built by a desperate Martian race in a bid to irrigate their desolate planet. But when astronomers took a closer look at this small world they found that, at least in terms of life, Mars hadn't fared much better than Venus. This time, however, instead of a global pressure cooker like Venus, astronomers discovered a frozen world with an atmosphere a thousand times thinner than Earth's. About the only thing Mars has in common with Venus—aside from a lack of life—is an atmosphere composed mainly of carbon dioxide.

Despite the present differences between the three planets Venus, Earth and Mars, astronomers suspect they began under almost identical conditions: they each formed at the same time, at comparable distances from the Sun and with roughly the same chemical make-up. With three planets so similar in the early days, the natural question is: could life have begun on Venus or Mars as well as the Earth, only to be snuffed out at some later time? Perhaps more importantly, if life did develop, why did it perish there while persisting on Earth? To answer these questions we need to go back a few billion years to the birth of the solar system.

ILLUSTRATIONS BY DON DAVIS/FROM *THE NEW SOLAR SYSTEM*

An artist's portrayal of the terrestrial landscapes of, from top to bottom, Mars, Venus, Mercury and Earth as they would appear with the sun 20° above the horizon.



© NASA/JPL

The surface of the planet Mercury as revealed by Mariner 10. In 1974 the spacecraft made three flybys and mapped about half the planet's surface.

This false-colour, high-resolution image of Venus is the result of four years of highly detailed mapping by NASA's Magellan spacecraft.

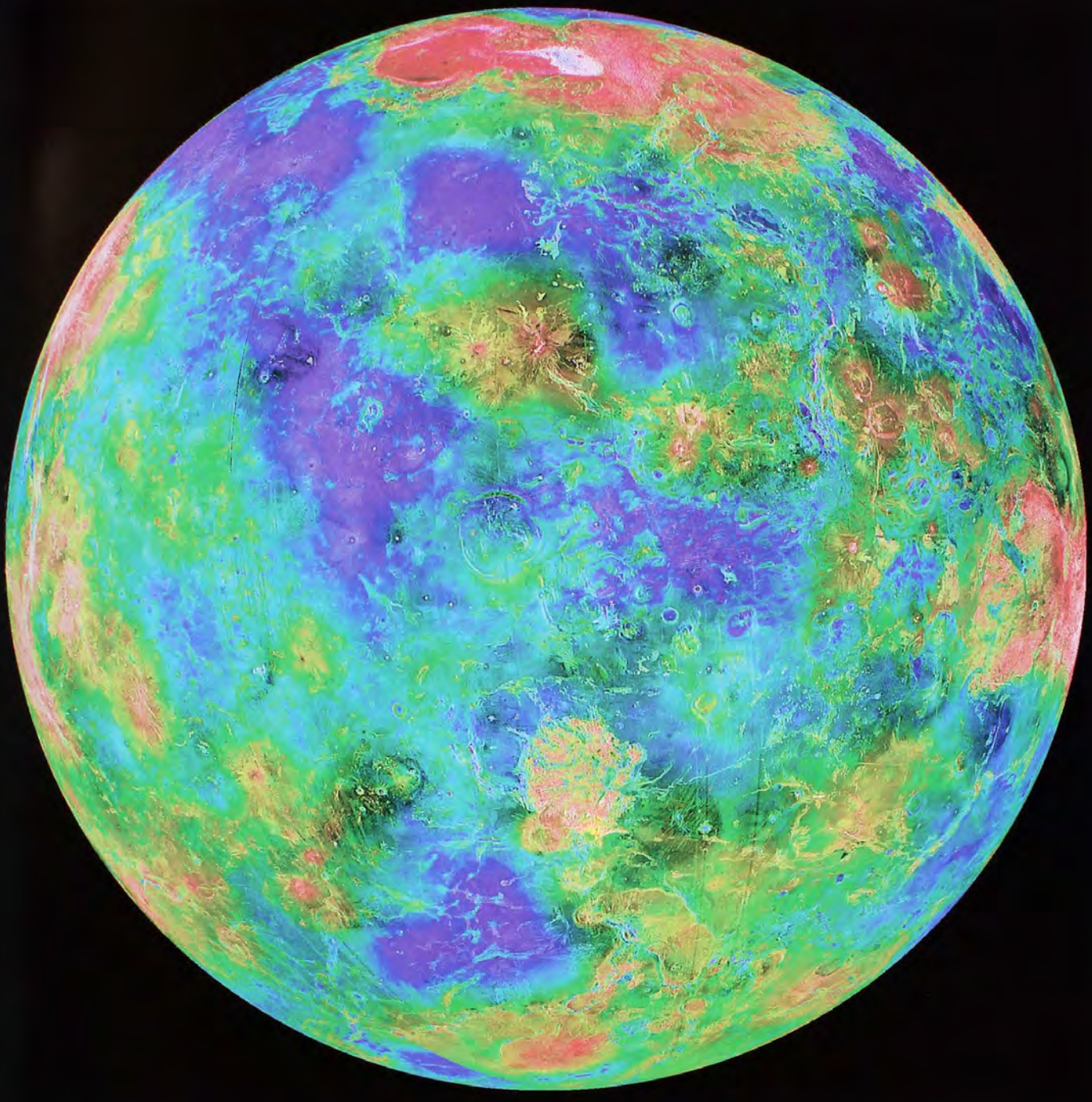
The Sun and its family of planets began some 4.5 billion years ago in a swirling disk-shaped cloud of gases and dust known as the solar nebula. In the centre of the cloud lay the embryonic Sun, a huge sphere of hydrogen slowly collapsing under its own weight. But the crushing weight of so much material—over 330,000 times the mass of the Earth—caused the atoms of hydrogen in the core to fuse into the heavier element helium. This nuclear fusion gave off tremendous amounts of energy, which prevented further collapse: the outward radiation pressure kept the Sun inflated against the pull of gravity. With enough hydrogen 'fuel' to last ten billion years, the Sun began to warm the solar system.

Orbiting silently around the young Sun were large, rocky spheres that had condensed out of the dust in the solar nebula. These were the bodies that would evolve into the major planets. Clinging tenuously to these 'proto-planets' was the leftover hydrogen and helium from the solar nebula. As the Sun began to shine, the excess hydrogen and helium was blown away by an intense stream of particles called the solar wind. The four inner planets were swept bare of any atmosphere, leaving them completely exposed to the light and heat of the Sun. Farther out in the solar system where the pressure of the solar wind was weaker, the giant planets Jupiter, Saturn, Uranus and Neptune retained their gaseous shrouds.

It wasn't long, however, before secondary atmospheres developed around the inner worlds of Venus, Earth and Mars. This occurred through out-gassing, where vast amounts of gases were belched out of huge volcanoes that dotted their surfaces. These secondary atmospheres were based on a mixture of nitrogen, methane, carbon dioxide and water vapour. Back then, the three planets all looked pretty much alike. All had carbon dioxide atmospheres and were inundated with water either from complex chemical reactions on their surfaces, or from the impact of icy comets hurtling in from the outer solar system, a process that continues today.

All three planets started out with plenty of water, but only one hung on to its fair share. What happened to the other two? Being so close to the Sun, Venus was so hot the water vapour in its atmosphere could never condense. In other words, it never rained. Volcanoes added increasing amounts of carbon dioxide to the primordial atmosphere increasing its density. To make matters worse, the Sun slowly increased in brightness as part of its natural evolution as a young star, raising Venus' surface temperature even more. The dense carbon dioxide atmosphere and intense solar radiation led to a runaway greenhouse effect. The planet's day-side would warm in the sunlight, but at night the infra-red radiation was unable to penetrate the

All three planets started out with plenty of water, but only one hung on to its fair share. What happened to the other two?



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Is Earth the only planet capable of supporting life?

carbon dioxide atmosphere, preventing the planet from cooling. At dawn, with Venus' surface still warm from the previous day, it would begin to get even hotter, day after day, millennia after millennia. Venus' surface temperature levelled out at just under the softening point of the rocks that litter its surface. With no running water and a noxious atmosphere, life on Venus never stood a chance.

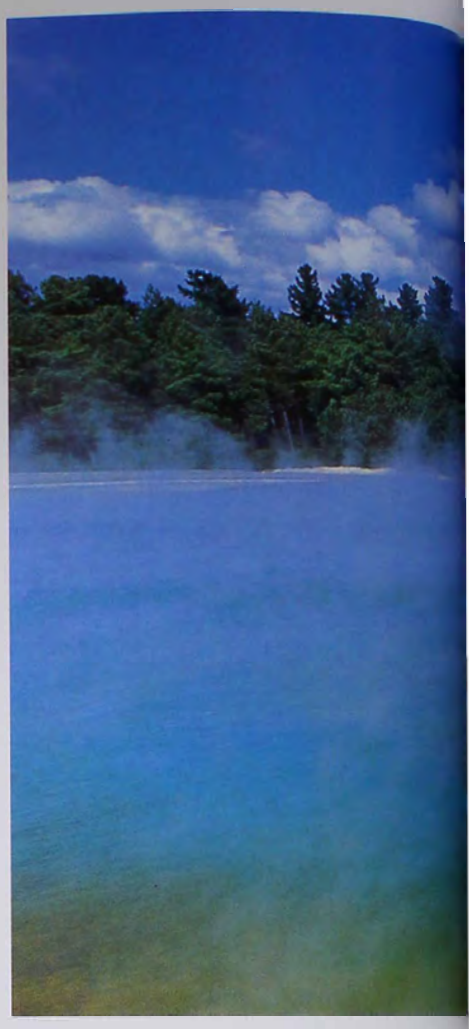
One important question is what happened to Venus' water? There are a number of possibilities, but each leads to the water rising high into the atmosphere where ultraviolet radiation dissociated the molecules into hydrogen and oxygen. Being a lighter element, the hydrogen rose even higher, eventually escaping into space.

On Earth, the story was different. The lower level of solar radiation allowed water to condense in the early atmosphere. While volcanoes added carbon dioxide to the atmosphere, and continue to do so, it was leached by the rain. When it rains, water reacts with the carbon dioxide in the atmosphere to form carbonic acid. This in turn reacts with silicates on the ground to form carbonate rocks. Over millions of years, the carbon dioxide is released from the silicates and vented back into the atmosphere through volcanoes. The evolution of plant life decreased the carbon dioxide levels even further. In this way, the current level of atmospheric carbon dioxide is maintained by a natural cycle of rain, erosion and volcanic eruptions.

The correct balance of carbon dioxide in the atmosphere is necessary for the Earth to stay at the right temperature. At night, the planet cools by allowing a certain amount of infra-red radiation to carry energy back into space. Too much carbon dioxide in the air would prevent this infra-red radiation from escaping and the Earth would never cool down, the so-called 'greenhouse effect'. Too little, and the Earth would cool so much that the oceans would freeze. This 'silicate-carbonate cycle' has a natural control mechanism. If the temperature begins to fall, the rain tends to slow down, which allows the carbon dioxide levels to go up. This in turn warms the oceans and encourages more rain. Too much rain, on the other hand, depletes the carbon dioxide levels and allows the planet to cool. This retards the evaporation and precipitation of water. In this way, volcanoes and the Earth's weather balance out on a global scale permitting running water, life, and eventually the question: what happened to Mars?

Being farther out in the solar system, Mars received only a fraction of the sunlight Venus and the Earth were exposed to and so had a much colder global climate. Nonetheless, there is ample evidence that great rivers flooded the Martian surface billions of years ago. Mars was able to trap the feeble solar energy in a dense carbon dioxide atmosphere, formed by its enormous volcanoes*. With giant volcanoes belching out voluminous amounts of carbon dioxide into the primordial Martian sky, the planet was able to stay warm. Clouds formed and the rain fell.

**Mars' volcanoes were the biggest of them all. Olympus Mons, Mars' largest volcano, towers some 27 kilometres above the surrounding plains. For comparison, the peak of Mount Everest is nine kilometres above sea level, while Earth's tallest volcano, Mauna Kea in Hawaii, rises ten kilometres above the sea floor.*



But in a sense Mars signed it's own death warrant: the torrential rain leached the carbon dioxide out of its atmosphere. This wouldn't have been a problem if it weren't for the fact that Mars lacked the radioactive elements needed to drive its volcanoes, and sufficient gravity to hold its atmosphere for long. The planet's geological life soon ended. With no more active volcanoes to replenish the carbon dioxide, the continuing rain depleted the atmosphere of carbon dioxide so that the planet soon began to cool. Despite the brightening Sun, the water and remaining carbon dioxide condensed at the poles and froze. As Mars died, any life forms that might have gained a foothold also perished, or retreated into the subsurface environment.

WHILE IT'S UNLIKELY THAT LIFE exists on Mars today, is there any hope of finding evidence for past life on the red planet? One scientist who thinks so is Malcolm Walter, a Professorial Fellow in the School of Earth Sciences at Macquarie University near Sydney. According to Walter, finding evidence of primordial life in the form of fossils is not only possible, but probable. If the early conditions on Mars and Earth were the same (sunlight, heat, an atmosphere and, of course, running water), then there seems no reason why life

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Martian hunting? Places where there used to be hot springs, similar to this Earthly one in Rotorua, New Zealand, would be a good starting point.

should not have at least begun on Mars before it eventually froze.

Among the earliest life forms on Earth, 3.5 to 2.5 billion years ago, were bacteria—cyanobacteria, or blue-green algae. These have been found as fossils in many places, including Western Australia. Walter thus proposes that we look for the fossilised remains of similar primitive Martians and has even helped choose the sites on Mars to look: places where there used to be hot springs; places similar to Rotorua in New Zealand or Yellowstone in Montana. According to Walter, hot springs are good places to live if you're a bacterium: there's plenty of water, the water is bringing up nutrients leached out of the rocks, and there's sunlight as a source of energy. Bacterial life around hot springs on Earth is common because of the sources of nutrients and energy around them. Hot springs are also good places to make fossils: the rapid precipitation of minerals such as silica and calcium carbonate entomb the bacteria and fossilise them fast and effectively.

The possibility of fossilised life on Mars is being taken seriously. Over the next ten years, NASA is launching a series of spacecraft towards the red planet in an attempt to answer questions about whether life ever began on Mars. Walter was chosen to work with a NASA research team to select the best places to search for life. Beginning with remote sensing by orbiting spacecraft, the scientists will identify the most likely sites to search for Martians—either alive or fossilised. Later, robots will land near these sites and analyse soil and rock samples in ways different from those done by the Viking landers on Mars in the 1970s. The next step will be to go for a sample return so that Martian rocks can be analysed for evidence of life using a wider range of techniques than can be carried out on an unmanned spacecraft. Planning has started for a sample-return mission to be launched in 2005.

A sample return may not be necessary, however. Recent NASA researchers David McKay and collegues analysed Martian rock samples that had been blased from the Red Planet by a meteorite impact millions of years ago and were found buried in the Earth's Antarctic ice. These were found to contain at least circumstantial evidence for primative life. This 'discovery' of Martian life will be debated over the next few years while NASA's spacecraft takes a closer look at Mars itself.

If Mars turns out to be barren, will it mean life is unique to the Earth? 'Unique' is a hard word that excludes all other possibilities, something impossible to do in science. However, already both Mars and Venus point to the uniqueness of the Earth in terms of human habitability. While it's unlikely the Earth would ever become truly barren within the lifetime of the Sun, it is the only planet capable of supporting human beings. Further, the Earth is subject to the same physical laws that left Venus and Mars desolate. While it is beyond current and foreseeable technology to create a suitable planetary atmosphere, it is entirely possible to destroy one. And as we've seen from studying our neighbouring worlds, there's nowhere else to go.■

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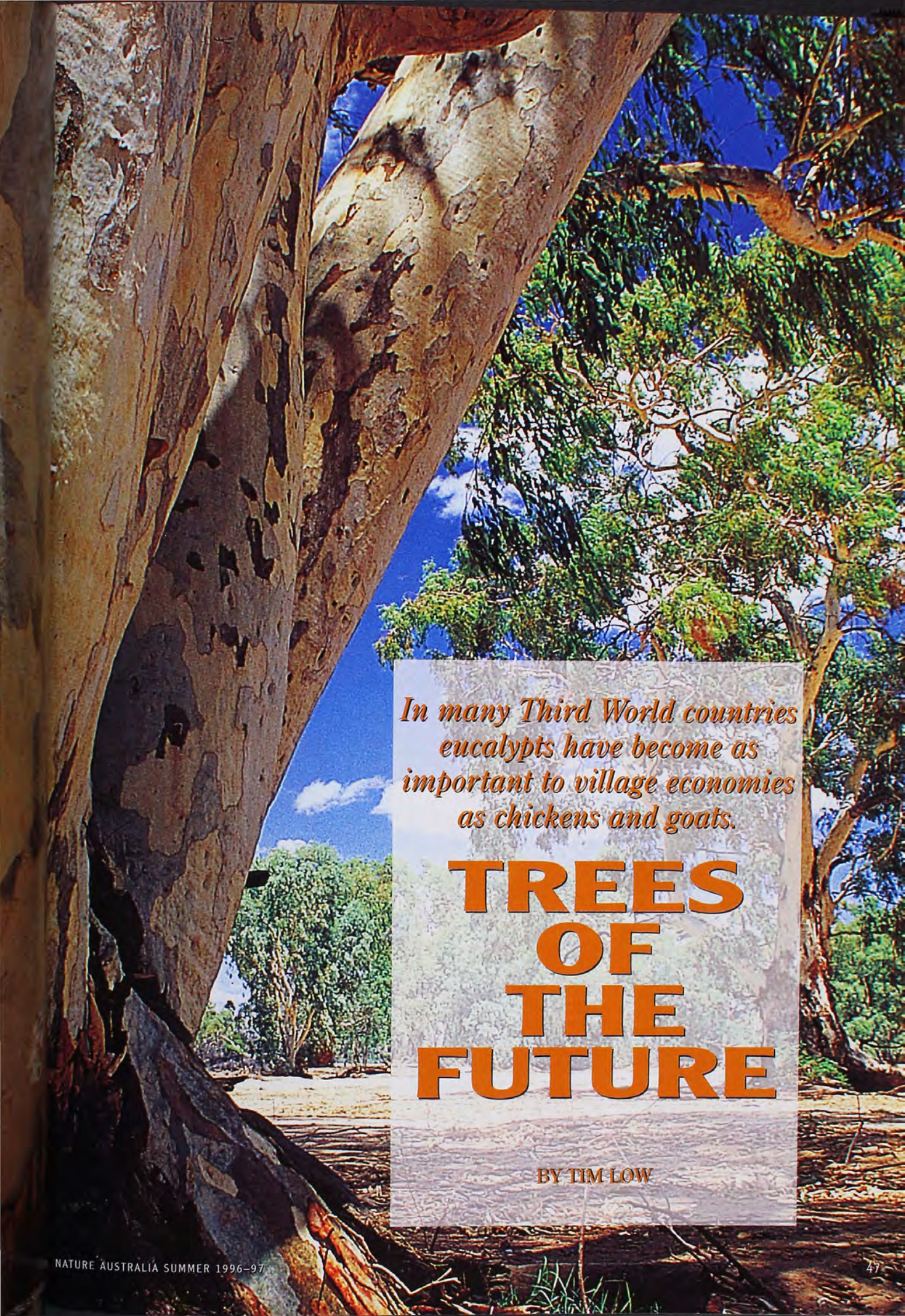
Geoff McNamara is a freelance astronomy writer who contributes regularly to various science and technology magazines. He is Associate Editor for Sky & Space *magazine and a columnist for Garuda in-flight magazine.*

He would like to extend special thanks to Malcolm Walter for his assistance in preparing this article and for helping to find out what we all want to know.

REG MORRISON

Since the early 1800s eucalypts have been grown overseas. Indeed, Australia's River Red Gum is named after the Camalduli Gardens of Naples where it was described in 1830.



In many Third World countries eucalypts have become as important to village economies as chickens and goats.

TREES OF THE FUTURE

BY TIM LOW

AUSTRALIA'S EUCALYPTS HAVE conquered the world. No other group of trees is grown so widely by so many people. Across Africa, Asia, the Mediterranean region and South America, hundreds of millions of peasants grow eucalypts for wood; and vast eucalypt plantations are farmed by timber and mining companies. As the world grows hungrier for fuel, eucalypts look more and more like the trees of the future.

The statistics are staggering. Two thousand million eucalypts are grown in Brazil, 60 million in Argentina, 200 species are cultivated in China, and even in tiny Guatemala 150 kinds are grown.

Eucalypts have become important because half the world's population still relies on wood for fuel. Wood supplies 15 per cent of the world's energy, more than nuclear and hydro-electric power combined. Native forests have disappeared from vast tracts of Africa, Asia and Latin America, and Australian eucalypts are taking their place.

Eucalypts are preferred because they grow very fast on degraded soils, producing strong, straight wood that burns well. They yield excellent sawn timber and very strong poles, and they resprout from cut stumps to produce repeat harvests. They are low in maintenance and their leaves yield aromatic oils valued in medicine.

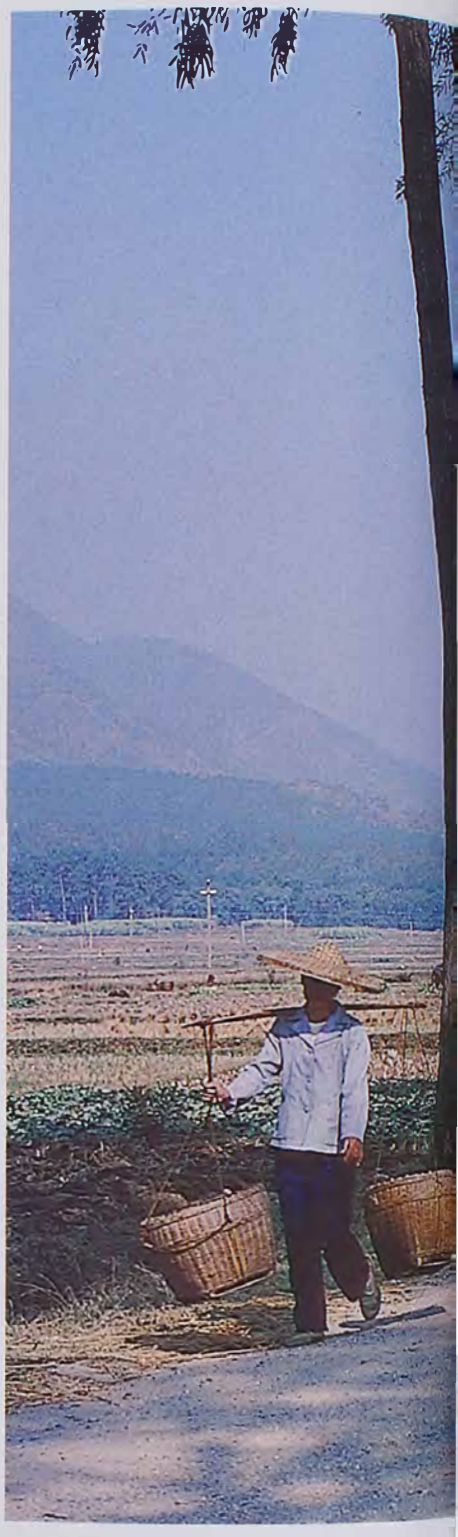
But eucalypts have their critics. In Thailand and India they stand accused of lowering water tables and inhibiting crops. In southern Africa they have become weeds. Over-enthusiastic foresters have felled native forests to grow them, with devastating results. On a more positive note, eucalypts provide nectar and nesting sites for an enormous range of overseas birds. Their ecological impacts are intriguing.

PROMOTION OF EUCALYPTS AS MIRACLE trees began in the mid 19th century, when Baron Ferdinand von Mueller, the Victorian Government botanist, enthusiastically promoted the Blue Gum (*Eucalyptus globulus*) as "The Prince of Eucalypts". Eucalypts had been grown in the early 1800s in Europe and Africa; indeed the River Red Gum (*E. camaldulensis*) is named after the Camalduli Gardens of Naples, from where it was described in 1830. But the big push came after Frenchman Prosper Ramel visited Australia in 1854 and encouraged plantings in France, Algeria and Tunisia. In Italy, Trappist monks planted 55,000 Blue Gums in the Pontine Marshes of Rome in a bid to eliminate malaria, and the success of this venture led to plantings of the 'fever tree' in Spain and elsewhere. The water-hungry Blue Gums apparently drained the swamps where the malarial mosquitoes bred.

By the turn of the century Frenchman Henri Carreron had witnessed a botanical transformation, writing: "A Provencal who has not seen the Cote d'Azure for the last forty years would not recognise it, so changed is the aspect of its vegetation. No more of those characteristic, stunted, greyish bushes. They have been replaced on at least one-fourth of the surface of the land by cooling and fragrant forests of huge Eucalypts, which tower high above the thousand-year-old Olive and mastic trees. Australia is invading the ancient Provence; the antipodean forest is gradually taking the place of the indigenous species of the Old World."

Similar claims could be made for California, southern China, sub-Saharan Africa and many other lands. Millions more Blue Gums are grown overseas than in their native lands. They are even credited with saving Ethiopia from cataclysmic deforestation. Dr Robert Zacharin writes: "Beyond question this tree, with its rapid growth rate and remarkable powers of regeneration when lopped, has been one of the most important factors permitting the development of modern Ethiopia and the creation of a fixed capital city, Addis Ababa ('new flower'). This change in the living habit of a nation [from nomadism] is due almost entirely to the Tasmanian blue gum, and the influence of this species upon Ethiopian survival is without parallel in the history of reafforestation."

The only regions untouched by the eucalypt revolution are the colder zones of the world. Tasmanian Cider Gums (*E. gunnii*) do well in northern Scotland, but plantations of eucalypts are viable in Europe only in the Mediterranean region, south of 45° latitude. In California, gum trees are so numerous that many Americans assume they are native, but they do not fare well farther north. In equatorial regions of Asia, Africa and Latin America their cultivation is confined mainly to highlands.



AUSTRALIANS OVERSEAS ARE OFTEN surprised to see eucalypts with dense shady crowns, developed in the absence of most of their native insect pests. Yet plantations overseas can be plagued by an extraordinary variety of pests, mainly overseas insects adopting a

EUCALYPTS OVERSEAS

The most widely planted eucalypts overseas are the Tasmanian Blue Gum (*Eucalyptus globulus*), River Red Gum (*E. camaldulensis*), Flooded Gum (*E. grandis*) and Forest Red Gum (*E. tereticornis*).

The Blue Gum is especially important in the Mediterranean region, East Africa, southern India and Brazil. It is the major overseas source of eucalyptus oil. Regions dependent on the River Red Gum include North and South Africa, India, China, Brazil and Vietnam. The Flooded Gum is favoured at high altitudes in the tropics, for example Uganda, where it grows very rapidly, but it is also grown in South Africa for mine prop timber. Forest Red Gums are widely grown in South Africa, China and Brazil. In Peru they line the sacred valley of the Meso-American Indians that leads to Machupicchu.

Many other eucalypts are grown and some are locally important. *Eucalyptus erythrocorys*, for example, is a significant nectar source for Honey Bees in Israel, and the Narrow-leaved Ironbark (*E. crebra*) is favoured for farm woodlots in South Africa.

C.A. HENLEY

A eucalypt-lined road in China.

eucalypt diet. In Brazil, where four million hectares are grown, more than 220 Brazilian insect species have become eucalypt pests. China has recorded 96 indigenous pest species and India 94.

The pests include Brazilian leaf-cutting ants (*Atta* and *Acromyrmex* species) that defoliate whole plantations. A 1976 report of the Food and Agricultural Organisation warned that: "Should eucalypt plantations be abandoned as production units in north central Brazil it is quite likely that large sections of them would disappear as eucalypt stands because the *Atta* ants would destroy all the regeneration."

Termites are probably the worst problem, killing up to 80 per cent of eucalypt seedlings by attacking their roots. Other pests include moth larvae, beetles, aphids, crickets, bugs, snails, slugs, nematodes, fungi, bacteria, viruses and even monkeys.

Adding to these problems are Australian insects that have spread overseas. More than 20 species are known pests, although most of these are confined to New Zealand. They include a ferment fly (*Drosophila flavohirta*) that has appeared in southern Africa, where it threatens the honey industry. It breeds within the blossoms of the Flooded Gum (*E. grandis*), South Africa's most important nectar source for the industry, and the honey yield from these trees has slumped from 28 kilograms per hive in

C.A. HENLEY

1976 to 15 kilograms today.

The Eucalyptus Weevil (*Gonipterus scutellatus*) and the Common Eucalypt Longicorn (*Phoracantha semipunctata*) are the worst of the pests from Australia. Eucalyptus Weevils were found defoliating eucalypts in South Africa in 1916 and spread to northern Africa and Europe; the longicorn ranges across Africa, Europe, the Middle East and the Americas. Eucalypt Weevils threatened the very viability of plantations until brought under control by the parasitic wasp *Patasson nitens* from Australia. Another parasitic wasp (*Bracon* sp.) was released in New Zealand to control an outbreak of the Leaf-mining Sawfly (*Phylacteophaga froggatti*) near Auckland.

With so many insects feeding on eucalypts overseas, the trees are often attractive to parties of insectivorous birds. The flowers also lure in nectar-feeding hummingbirds and sunbirds, and their tallest branches are favoured by large birds such as vultures for roosting and nesting. In all, eucalypt plantations with native undergrowth can support a moderately diverse range of birds.

During a ten-week trip to Africa I recorded 28 bird species perching or feeding in eucalypts. They included very big birds such as the Grey-cheeked Hornbill (*Ceratogymna subcylindricus*), Great Blue Turacos (*Corythaeola cristata*) and Black Eagles (*Aquila verreauxii*, nesting in a Narrow-leaved Ironbark, *E. crebra*, in Zimbabwe), right down to tiny Yellow White-eyes (*Zosterops senegalensis*) and sunbirds feeding at Flooded Gum blossoms. In Zimbabwe I watched Red-billed Wood-hoopoes (*Phoeniculus purpureus*) probing behind strips of curled bark with their long curved bills. Later I peeled back this bark and found tiny beetles, spiders, bugs, a scorpion, a Striped Skink (*Mabuya striata*) and Cape Dwarf Geckoes (*Lygodactylus capensis*). I saw Samango Monkeys (*Cercopithecus albogularis*) climbing high into Flooded Gums and Black-and-white Colobus Monkeys (*Colobus guereza*) chewing the bark. Eucalypt plantations are also a habitat of the Greater Bushbaby (*Otolemur crassicaudatus*).

My impression is that eucalypts overseas have become especially important for two groups of birds: nectar-feeders, and large birds that roost or nest in tall trees.

Eucalypts are very unusual among dominant trees in having flowers pollinated by birds as well as insects. When planted overseas they usually replace insect- or wind-pollinated trees. Since a variety of eucalypts is often grown, a new source of nectar may be available over much of the year. This is sought out by sunbirds, hummingbirds and white-eyes.

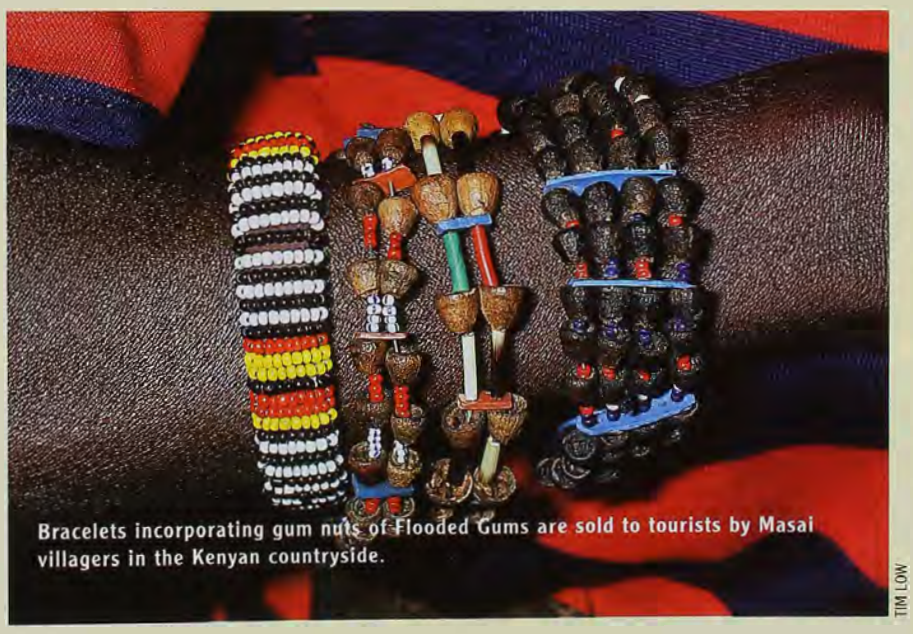
A weevil (*Gonipterus* sp.) feeds on a eucalyptus leaf.

Eucalypts are very unusual among dominant trees in having flowers pollinated by birds as well as insects. When planted overseas they usually replace insect- or wind-pollinated trees.

In Argentina, ornithologist Noberto Montaldo found that Blue Gum nectar is important to White-throated Hummingbirds (*Leucochloris albicollis*) and Gilded Hummingbirds (*Hylocharis chrysura*). He suggests that flowering of these trees in winter may allow hummingbirds to avoid migrating north. Similar findings have been made in California.

Eucalypts grow taller than most trees overseas, and birds of prey and waterbirds consistently prefer them for roosting and nesting. Doug Laing, an Australian diplomat in Zimbabwe, showed me a massive waterbird roost in six Flooded Gums in Harare, occupied by Cattle Egrets (*Ardea ibis*), Black-headed Herons (*Ardea melanocephala*), Sacred Ibis (*Threskiornis aethiopicus*) and Great Cormorants (*Phalacrocorax carbo*). Another roost in three suburban gums was occupied by more than 5,000 red-footed kestrels (*Falco amurensis* and *F. vespertinus*). Elsewhere in Africa eucalypts provide nest sites for a wide range of raptors and other birds—124 species were listed in one survey by K.D. Smith, including weavers, barbets and the Common Paradise Flycatcher (*Terpsiphone viridis*).

The Bat Hawk (*Machaerhamphus alcinus*) of Africa and Asia prefers gum trees, not only because they are tall, but also because they are white. This bird of prey hunts bats at dusk, returning to its stick nest in the dark. It likes to nest on the pale horizontal branches of tall eucalypts because they are easy to see at night. But birdwatchers in Africa have told me its nests often fall off the smooth



Bracelets incorporating gum nuts of Flooded Gums are sold to tourists by Masai villagers in the Kenyan countryside.

TIM LOW

AFRICA: PAINTED WITH AN AUSTRALIAN BRUSH

Africa is one continent where eucalypts have 'Australianised' the landscape. They can be seen almost everywhere. A 99-metre Mountain Ash (*Eucalyptus regnans*) in Tanzania now takes the honours as Africa's tallest tree, even rivalling that found in Australia. Flooded Gums (*E. grandis*) have become vigorous roadside weeds in the eastern highlands of Zimbabwe, and Spider Gum (*E. lehmannii*) and Tuart (*E. gomphocephala*) are significant weeds in the Cape Province of South Africa.

At the Lion Park near Johannesburg, Lions can be seen sleeping in the shade of eucalypts and even perching in their lower branches. In Harare tourists watch traditional African dances performed beneath massive eucalypts, and in Kenya the Masai sell gum nut bracelets from villages on the edge of the Masai Mara. Gum leaves are harvested in Chad to make tea and a sauce. In South Africa, ten different wattles (*Acacia* spp.) have also become weeds, and these are contributing to the Australianisation of the landscape.

River Red Gum seedlings. This species of eucalypt is one of the most widely planted overseas.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

branches and that populations are suffering as a result.

In southern Brazil, Uruguay and north-eastern Argentina, the Monk Parrot (*Myiopsitta monachus*) has extended its range by nesting in eucalypts planted around ranches. Unique among parrots, it builds a large nest of sticks. In South Africa the Hadada Ibis (*Bostrychia hagedash*) and Helmeted Guineafowl (*Numida meleagris*) have also extended their range into previously treeless areas.

Eucalypts in Africa may also be important to some insectivorous birds because they are evergreen, providing a source of insects year round, unlike most African trees, which lose their leaves in the dry season, forcing birds to migrate.

But birds overseas have not taken to nesting in the hollow limbs and trunks in eucalypts, because, as one Zimbabwean naturalist complained to me, eucalypts overseas do not develop hollows. Perhaps the trees are just too young—a Western Australian study found that parrots bred mainly in eucalypts more than 270 years old. If hollows do develop in future, the ecological implications will be enormous. But I suspect that termites overseas do not excavate suitable holes. I have seen massive eucalypts in Africa showing no sign of decay at all.

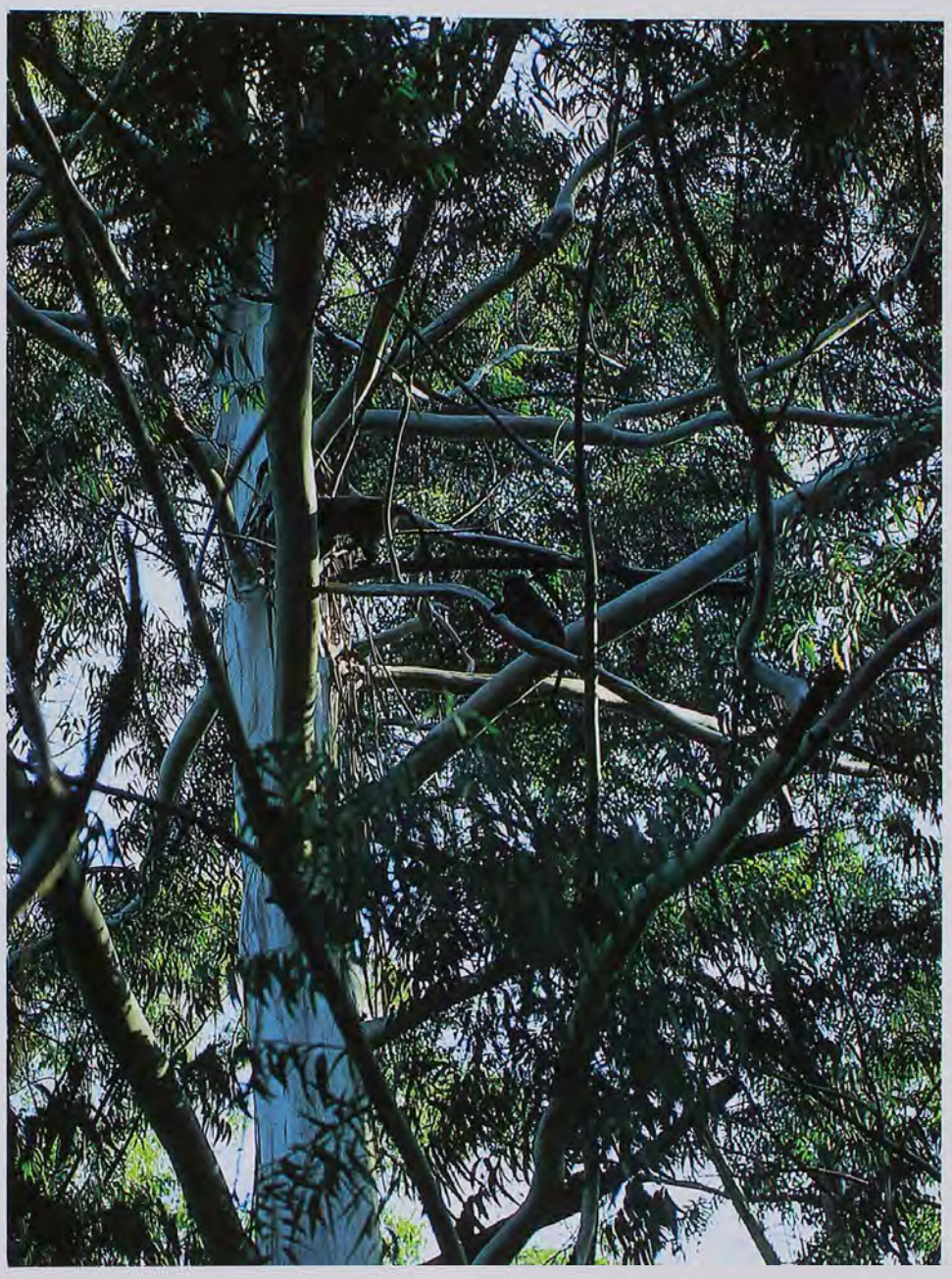
WHILE THE IMPACTS OF EUCALYPTS ON fauna overseas are of much interest, it is the impact of eucalypts on Third World communities that has attracted most attention. Eucalypts are widely condemned for exacerbating land degradation.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

The Common Eucalypt Longicorn is a major pest of eucalypts and has followed their spread overseas. It now ranges across Africa, Europe, the Middle East and the Americas.

Much of the problem has arisen where overzealous foresters have felled native forest to plant gum trees. One proposal in Karnataka, India, provoked protests from half a million peasants in 120 villages until it was shelved. Another plan, in Ubon Ratchathani Province of Thailand, drew the ire of local monks, who ordained native trees with saffron robes to protect them from felling. The *Bangkok Post* of 21 March 1990 reported of this incident: "Villagers call eucalypts demon trees because of the way they suck up ground water, harden the land, and kill other trees in the vicinity with their strangling roots." The head monk complained: "Now the villagers are going hungry. The creeks have gone dry. The rains are scarce and irregular. It was never like this before the eucalyptus."

These complaints should be heeded in



TIM LOW

Samango Monkeys are very agile in the tall branches of Flooded Gums in Zimbabwe.

Australia, where our government promotes eucalypts as part of overseas aid. More effort should be put into finding local alternatives, and to studying the impacts of eucalypts on hydrology and ecology.

That said, eucalypts will continue to play a major role in the future of the world. Having evolved on the most eroded and infertile soils on Earth, they are perfectly adapted to lands degraded by farming overseas. In many Third World countries they have become as important to village economies as chickens and goats. Although they behave like weeds in some respects, especially in their thirst for water, they are often grown in landscapes that are so terminally degraded they are only fit for weeds; and a gum tree is better than no tree at all. As more and more soil is lost by farmers around the world, our eucalypts will assume even greater importance. They are truly the trees of the future.■

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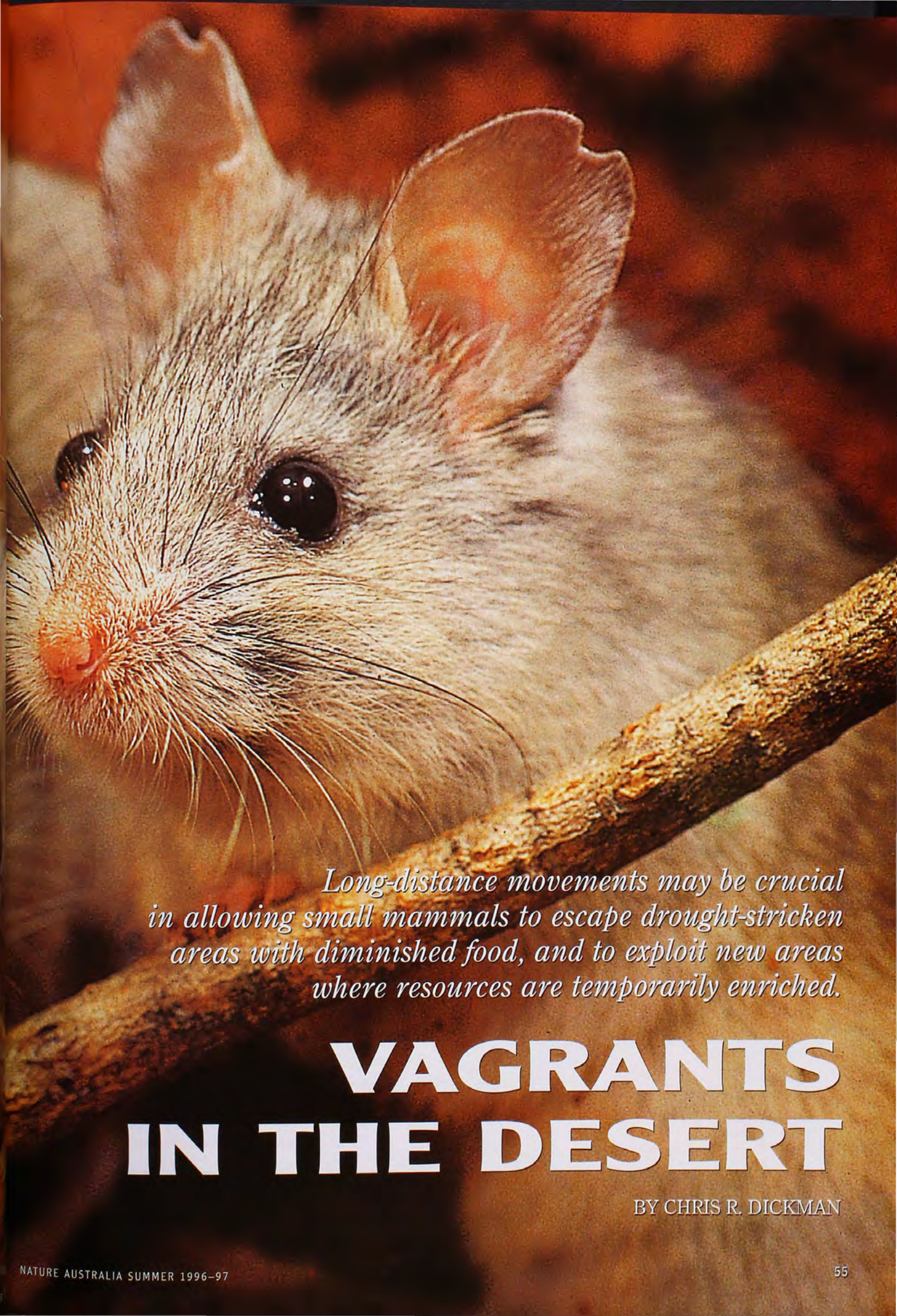
Tim Low is a nature writer and environmental consultant. He has travelled widely overseas, observing eucalypts growing in China, India, Hawaii, Honduras, Kenya, New Zealand and many other places.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

The Ash-grey Mouse occurs in sandy areas on the fringe of the arid zone in south-western Australia. Previously thought to be sedentary, this species has been found to be one of the most mobile of native desert rodents.



Long-distance movements may be crucial in allowing small mammals to escape drought-stricken areas with diminished food, and to exploit new areas where resources are temporarily enriched.

VAGRANTS IN THE DESERT

BY CHRIS R. DICKMAN

SMALL MAMMALS SUCCESSFULLY exploit arid environments throughout Australia, combating the extremes of the desert climate with an array of specialised and remarkable adaptations. Laboratory studies show that native rodents such as hopping-mice thrive on a diet of dry seed with no water, producing just a few drops of concentrated urine each day. Lactating females will even ingest the faeces and urine of their young, thereby recovering about a third of the water lost in milk production. Other studies have shown that small carnivorous marsupials (dasyurids) often store fat in their tails to help ride out periods of temporary food shortage. The smallest species also enter torpor on a daily basis, reducing energy expenditure until times improve.

Impressive as these adaptations are, recent field research has revealed that many small mammals respond to drought in a simple but dramatically effective way: they decamp and move to where conditions are better. Although long-range movements are well known in larger marsupials such as Red and Grey Kangaroos, and in migratory ungulates such as Wildebeest, the distances covered by small mammals in arid Australia appear unique. There is little evidence of great mobility in small mammals inhabiting temperate parts of Australia, and lifetime movements of the best-studied rodents in other deserts of the world appear never to exceed two to three kilometres.

As with many findings in biology, the extraordinary mobility of small mammals in arid Australia was discovered by chance. In the late 1980s I was working in the Goldfields of Western Australia on a long-term project that involved assessment of the number of small mammal species from independently spaced sites. The aim of the study was to compare species richness with habitat structure. The sites were separated by distances of 0.4 to 10 kilometres, to avoid any potential overlap of range. You can imagine our surprise when, 18 months later, we discovered that five species (two dunnarts, two ningauis and one native mouse) had made frequent excursions between the supposedly 'independent' trapping sites. Although startling and quite unexpected at the time, the results from the Goldfields were not aberrant. Since 1990, colleagues Fiona Downey, Paul Mahon, Martin Predavec and I have documented similar long-distance movements in a further four species of small mammals, this time from the arid dune fields of the Simpson Desert in western Queensland (see box). Indeed, of six species that have been captured regularly in this area, only one, the Mulgara (*Dasycercus cristicauda*), appears to be sedentary.

Long-distance movements may have been overlooked in previous research partly because they are recorded infrequently and partly because few studies have live-trapped at distant sites for long periods. During our work in the Goldfields and the Simpson Desert, for example, we recorded only 99 long-distance movements in 57,300 trap nights over a period of five years. However, this does not mean that such movements are infrequent. In our studies the probability of intercepting a marked animal far from its site of original capture was very small to begin with (less than three per cent if the nearest trapping site was 0.5 kilometre away, and assuming that movement could occur equally in all directions). Moreover, since recaptures could occur only when traps were open (up to a week every two months), the chance of recording any long-distance movements would have been much less than one per cent for each individual handled.

As with many findings in biology, the extraordinary mobility of small mammals in arid Australia was discovered by chance.

In contrast to many species of small mammals, we have found little evidence that movements in desert species are associated with reproduction, nor that they represent dispersal events in juveniles or adults. Instead, movements appear to increase during or after rainfall, with distances increasing by a fifth for the Sandy Inland Mouse (*Pseudomys hermannsburgensis*) and up to six-and-a-half-fold for the Lesser Hairy-footed Dunnart (*Sminthopsis youngsoni*). Intriguingly, some three-quarters of all long-distance movements recorded within a month of rain were directed toward the area of rainfall, even if this was 15 kilometres away. We do not yet know how small mammals might detect and respond to distant falls of rain, but suspect they may be sensitive to changes in atmospheric moisture or to the familiar 'rain smell' produced when the parched desert soils get wet.

Whichever way it is detected, rain can be used readily as a source of free water by small mammals, and should be important also in promoting the availability of food. In the short term, rain

LONG-DISTANCE MOVEMENTS OF SMALL MAMMALS IN ARID AUSTRALIA

Species	Maximum Recorded Size	Movement	Location
Hairy-footed Dunnart (*Sminthopsis hirtipes*)	15g	2.1km	WAG
Little Long-tailed Dunnart (*Sminthopsis dolichura*)	12g	6.4km	WAG
Lesser Hairy-footed Dunnart (*Sminthopsis youngsoni*)	10g	12.0km	SD
Wongai Ningaui (*Ningaui ridei*)	9g	3.3km 2.0km	WAG SD
Southern Ningaui (*Ningaui yvonneae*)	9g	7.5km	WAG
Spinifex Hopping-mouse (*Notomys alexis*)	30g	14.0km	SD
Ash-grey Mouse (*Pseudomys albocinereus*)	30g	7.2km	WAG
Sandy Inland Mouse (*Pseudomys hermannsburgensis*)	12g	14.0km	SD
Long-haired Rat (*Rattus villosissimus*)	120g	2.1km	SD

(WAG = WA Goldfields; SD = Simpson Desert)

Pitfall traps with drift fences are the most effective way to capture many species of small desert mammals. Here the author removes a dunnart from a pitfall trap set on a sand dune in the Simpson Desert.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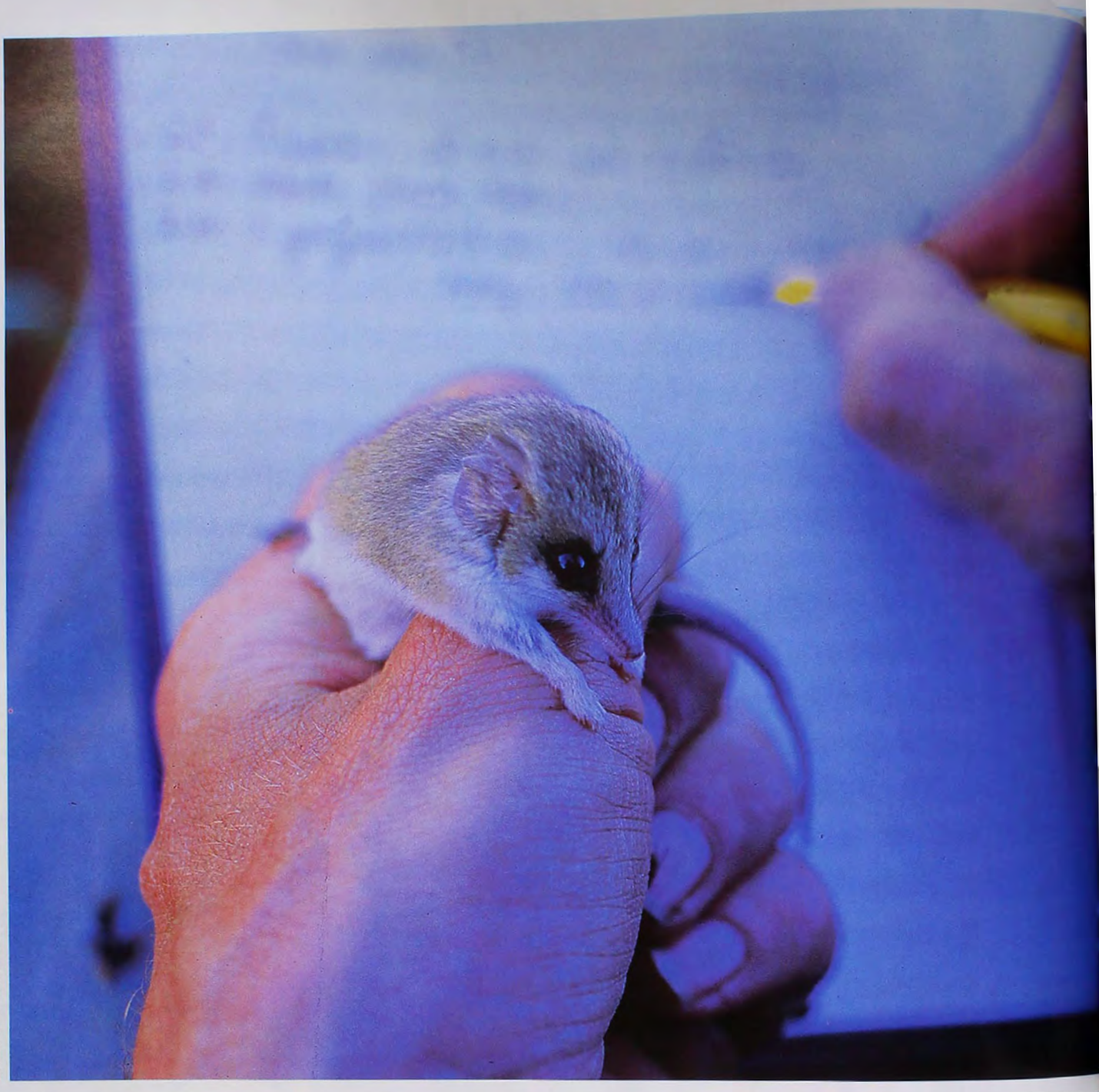


ESTHER BEATON/TERRA AUSTRALIS

Described only in 1982, the Lesser Hairy-footed Dunnart is now known to occur widely in sandy deserts across northern Australia.

hydrates buried seeds, apparently increasing their smell and thus making them easier to find by foraging rodents. In the longer term, rain should promote growth of green plants, fungal fruiting bodies and invertebrates, and hence provide an increased supply of food for both omnivorous rodents and insectivorous dasyurids. If these interpretations are correct, long-distance movements may be crucial in allowing small mammals to escape drought-stricken areas with diminished food, and to exploit new areas where resources are temporarily enriched.

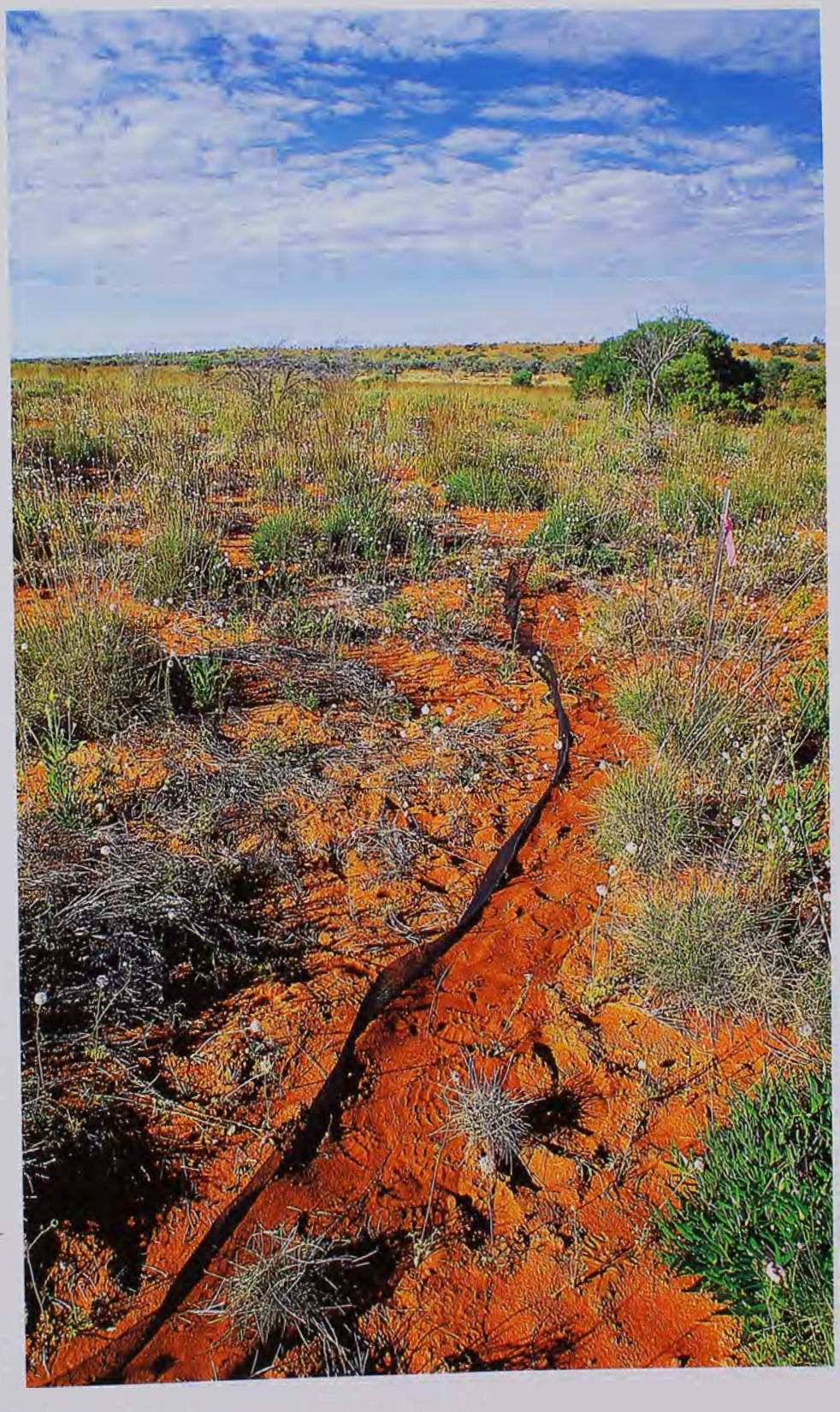
TO OBTAIN MORE CRITICAL INSIGHT INTO the effect of food on patterns of movement in small mammals, we followed the trails of one species in detail, using radiotelemetry. This species, the Lesser Hairy-footed Dunnart, was chosen because it is one of the smallest of the dasyurids but apparently also one of the most mobile. Because of its small size we were constrained to tracking only adults, and using the smallest radio-tags commercially available. The tags, weighing only 0.5 gram, were glued to the nape fur of the dunnarts, and allowed us to follow animals for up to six days. The tracking results astonished us.

Within an hour of nightfall, dunnarts emerged from burrows in the valleys between sand dunes, and sprinted 200–300 metres to the crest of the dunes to forage. After foraging for four to five hours the animals returned to a dune valley to rest in a burrow for an hour or two, before sprinting again to another dune crest for a pre-dawn hour of further feeding. Males seldom returned to the same burrows by day and, over the course of four to five nights, would cross

the crests of four to five different sand dunes. Their nightly movements ranged up to three kilometres. Females were only slightly less nomadic, returning to the same burrow on about 25 per cent of occasions and ranging up to 2.5 kilometres per night.

By watching the animals directly and by analysing droppings of captured individuals, we confirmed that dunnarts prefer large invertebrates such as beetles, cockroaches and spiders that are available mostly on dune crests, and that animals hunt most effectively in the open vegetation there. By providing supplementary food in the dune valleys (in the form of shredded beef), we found that dunnarts could be persuaded to reduce the time spent on dune crests, hence further confirming the importance of food in dictating patterns of movement.

These insights into the extraordinary mobility of the Lesser Hairy-footed Dunnart raise a host of further questions. Why, for example, do dunnarts not shelter on dune crests to reduce the commuting distance to where they forage? On the one hand, the reduced vegetative cover and less stable sand on dune crests probably make this option unattractive. On the other, it has become evident that dunnarts do not construct their own burrows, but depend for shelter exclusively on the burrows of other desert denizens. We have found radio-tagged dunnarts hiding by day in the disused burrows of bird-eating spiders, scorpions, rodents and dragons; these burrows are constructed mostly in the dune valleys. This casual exploitation of the burrows of other organisms probably facilitates



ESTHER BEATON/TERRA AUSTRALIS

The Simpson Desert is characterised by long, parallel red sand dunes with broad valleys between the dune ridges. Here a pitfall trap and drift fence are set amid hummocks of spinifex grass (*Triodia basedowii*), the dominant vegetation of the region.

ESTHER BEATON/TERRA AUSTRALIS

Lesser Hairy-footed Dunnarts shelter opportunistically in the burrows of large whistling spiders (*Selenocosmia* spp.). Empty burrows are preferred, as dunnarts that enter occupied burrows risk being killed by an invertebrate predator larger than themselves!

nomadism in the dunnarts, and other small dasyurids, by freeing them of the costs of digging.

It is perhaps interesting to note that, in both the Lesser Hairy-footed Dunnart and especially the bigger Hairy-footed Dunnart (*Sminthopsis hirtipes*), the hind feet are broad and the soles are covered conspicuously with fine bristles. These features provide traction on loose sand and increase the ability to move long distances. The forepaws are only slightly less hairy and the five fingers are strong but slender, allowing deft handling of prey but providing poor ability to dig burrows in soil.

Given the evident advantages of mobility, a particularly perplexing question is: why aren't all small desert mammals itinerant? In the Simpson Desert, the Mulgara is conspicuously sedentary. We have captured some individuals repeatedly within areas of less than a hectare, and have recorded few movements between trapping sites. Radio-tracking has shown further that individuals move no more than 900 metres on any one night, and that only three to four burrows are used over extended periods. For the Mulgara, mobility may simply confer little benefit. Like dunnarts and ningauis, this species eats a wide range of invertebrates. However, unlike its smaller relatives, the Mulgara also preys upon lizards, birds and other small vertebrates that may serve to buffer it during adverse conditions when invertebrates are scarce. Mobility may also be directly disadvantageous for the Mulgara. As this species digs its own, often complex burrow systems, frequent movements to fresh sites would dramatically increase energy expended in digging activity.

ESTHER BEATON/TERRA AUSTRALIS

Carrying a small radio-tag, this Lesser Hairy-footed Dunnart was found sheltering 15 centimetres below the sand surface in the spiral burrow of a scorpion.

Vagrancy in small mammals in other world deserts may be inhibited similarly by its high costs and small benefits. Rain falls more predictably in other arid regions than in Australia; animals experiencing drought overseas may do better to stay put than to move, as their chances of getting local rain are greater than for their counterparts in Australia. It remains possible, of course, that small mammals in other world deserts are itinerant, but that long-range movements have not been detected because of the small scale of most overseas studies. Our results might serve to stimulate other desert ecologists to look more closely at their small mammals to determine if this is the case.

THE FINDING OF LONG-DISTANCE MOVEments in the small mammals of arid Australia has important implications, both for interpreting past patterns of faunal loss and for guiding management for effective conservation in the future. Since European settlement in 1788 mammals have fared poorly in Australia's arid interior, with many small and medium-sized species (in a critical weight range of 35–5,500 grams) having declined or become extinct. Although losses probably have been caused by combinations of factors, degradation of refuge sites by introduced herbivores is believed to have had particularly damaging effects. At disturbed refugia mammals weighing less than 35 grams may have been better

Animals experiencing drought overseas may do better to stay put than to move, as their chances of getting local rain are greater than for their counterparts in Australia.

KATHIE ATKINSON

Unlike other small mammals of the Simpson Desert, the Mulgara seldom makes long-distance excursions.

able to persist than larger species (in the critical weight range) because their meagre resource requirements could still be met. However, in view of the extraordinary mobility of small mammals, persistence may have been facilitated also by colonisation of distant, intact refugia scattered across the desert landscape. Such refugia could be permanent oases, or simply ephemeral patches of increased productivity that are generated after local rains.

For effective future conservation of small mammals, and other biota in arid Australia, it is clear that permanent refugia must be identified and protected. The importance of this action has been recognised recently with the publication of a major document that has listed key refugia throughout the arid inland. A further important conservation action is to ensure that large tracts of land are available, to permit small mammals to track transient oases that appear only after local rain. Across the inland, protected land has been set aside in some 77 reserves of 10,000 hectares or more. Collectively these cover 33.9 million hectares, or six per cent of the arid zone. The larger part of the inland, which is dominated by the pastoral industry, also remains traversable by small mammals. However, large areas continue to be degraded by ecologically unsustainable practices such as clearing of woodlands and dry-land grain cropping, or worse, rendered wholly sterile by new industries such as cotton growing. The introduced rabbit adds further to land degradation throughout the southern and central arid zone. Careful stewardship of this vast area must therefore be seen as an essential complement to the protection of small, permanent refugia that are sprinkled throughout it.■

BABS & BERT WELLS/NATURE FOCUS

The Hairy-footed Dunnart occurs patchily throughout much of the sandy country of arid Australia. The species made its first recorded appearance in Queensland in 1992, apparently having migrated eastward in response to unusually high rainfall there since early 1991.

Further Reading

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Dr Chris Dickman is a Senior Lecturer in the School of Biological Sciences at the University of Sydney, and Director of the University's Institute of Wildlife Research.

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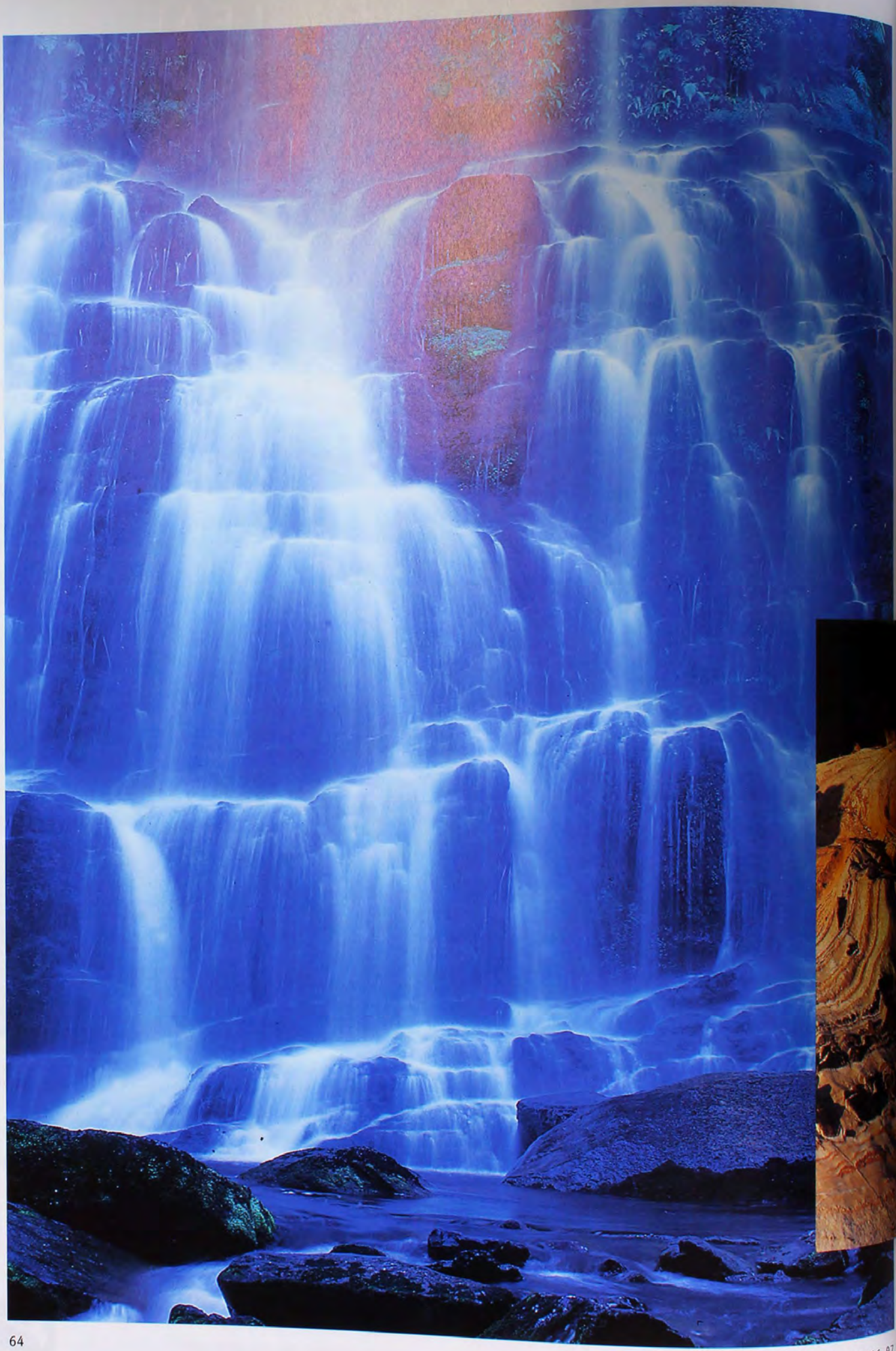
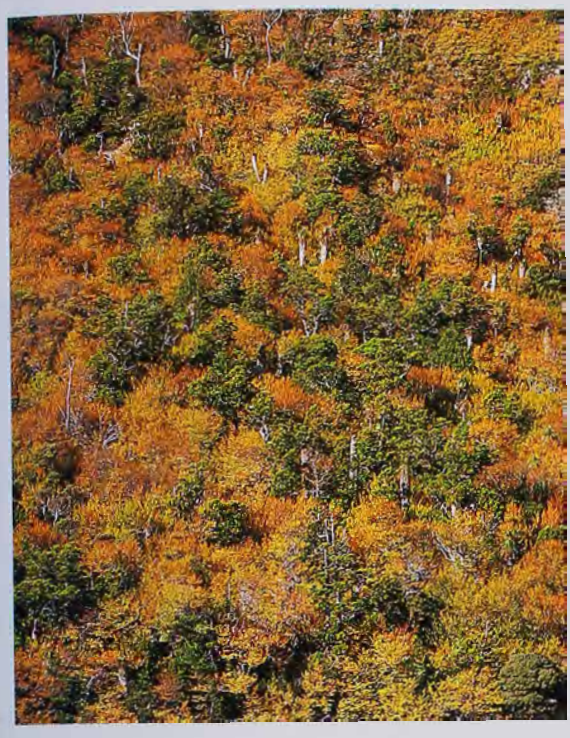
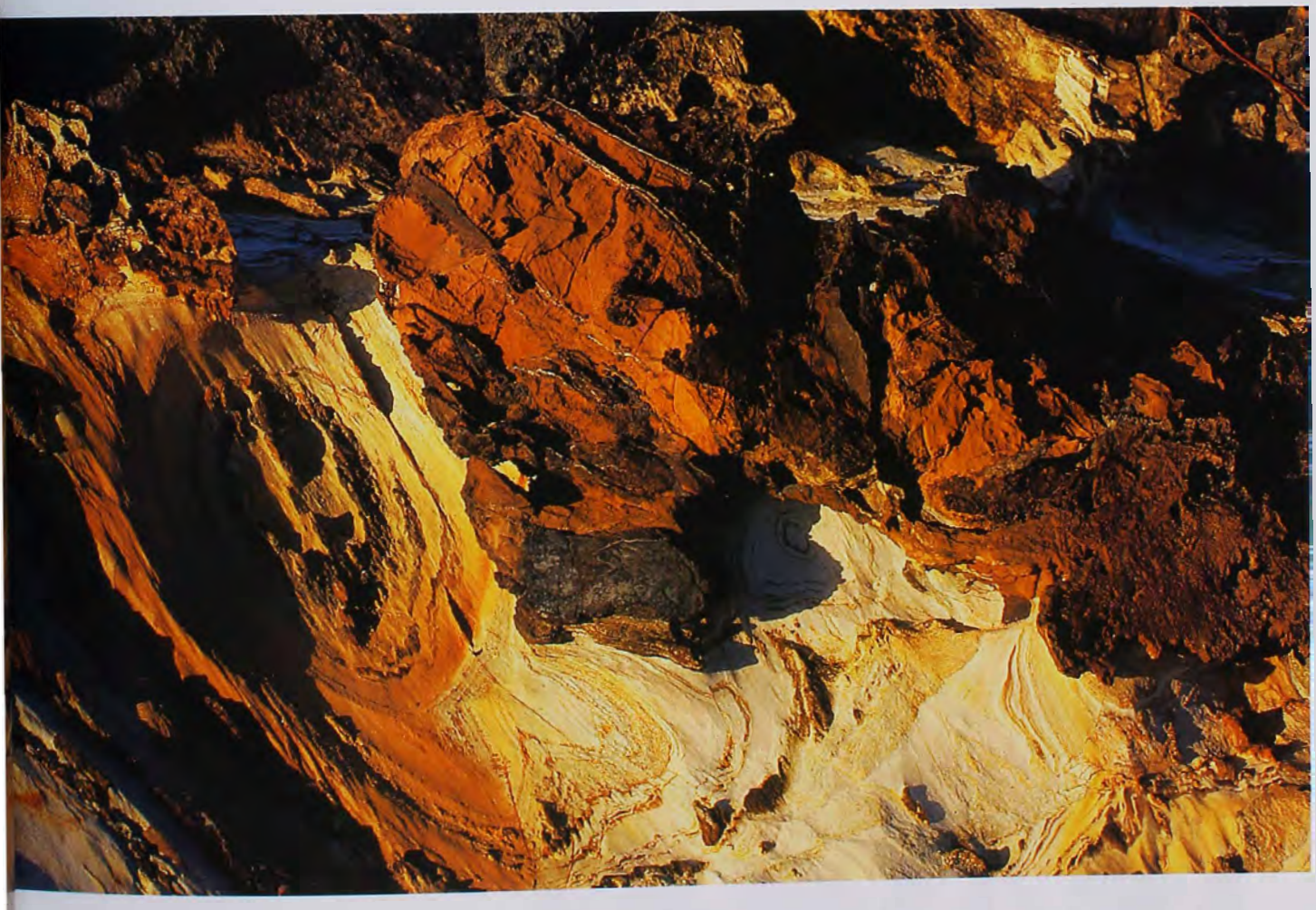




TASMANIA IN FOCUS

BY JOE SHEMESH

Whether photographing a rainforest scene in the tropics or an unusual rock formation on the south-western coast of Tasmania, I am constantly reminded of nature's intriguing beauty and serenity. Nature's ability to impress should not be underestimated as it provides us with a special insight into our environment.



TASMANIA IN FOCUS

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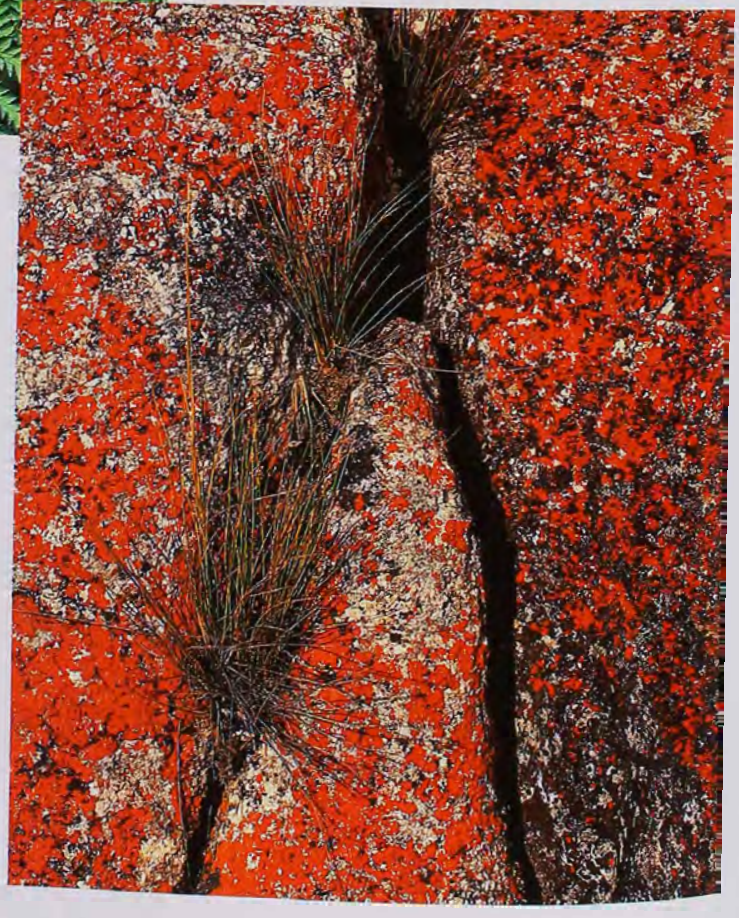


Like sugar-coating medicine, science served with humour can make a sometimes dreary topic more appealing.

TICKLING THE DULL OUT OF TAXONOMY

BY MICHAEL ARCHER

AN ESTEEMED COLLEAGUE of mine when first sighting a copy of *Vertebrate zoogeography and evolution in Australasia*, a student textbook we stuffed with silly but relevant cartoons, sternly remarked that humour had no place in the presentation of science. A reviewer of the same book summed up with "Naughty, naughty; never do it again!". And yet the first (and so far only) edition sold out within one year, several major overseas universities set it as a required textbook asking for far more copies than existed, and rare second-hand copies can now cost $300. So what is wrong with mixing humour and science if it makes the science more palatable? Apparently some scientists think mixing humour with science risks undermining the credibility of the science. If that's true, the credibility of systematics (the study of the diversity, relationships and classification of creatures) must be one of the highest because so many of its practitioners seem to work very hard to keep their writing free of wit; but fortunately not all!

Titles of papers indicate that some otherwise serious biologists at times can't resist being just a bit naughty. Consider the title of a scientific paper written by one of my colleagues who had discovered that penis shape in marsupials may provide useful information about relationships: "Phallic morphology of the Australian species of *Antechinus* (Dasyuridae, Marsupialia): a new taxonomic tool". One entomologist announced a new butterfly as "A spectacular new *Idea* from Celebes (Lepidoptera, Danaidae)", and another described a new insect as "*Ohno*, another new genus of sphecid wasps".

The International Code of Zoological Nomenclature states that no zoologist should give an animal a name with bizarre or comical meaning. Fortunately, not all zoologists have heeded this warning! Australia's giant extinct horned turtles include one recently named *Ninjamys* by a palaeontologist who was a fan of the infamous Mutant Ninja Turtles. Even among plant systematists, wit has worked its wicked ways such as happened when the parasol-shaped alga was named *Hummbrella*.

The names of several new creatures from the fossil deposits of Riversleigh have similarly dared tickle the funny bone. When the first large Riversleigh snake was discovered by colleagues, it was named *Montypythonoides* in honour of the BBC's infamous circus of comedy. Sadly, this name bit the dust after a reviser concluded that the new species was better placed in *Morelia*, a less imaginative but earlier-named genus. When two kinds of strange, crescent-shaped teeth dropped out of our acid vats from Riversleigh, the name 'Thingodonta' seemed inescapable. When we submitted our paper to the international journal *Science*, we proposed that they be placed in the new genus 'Thingodonta' and these in the new mammalian order '*Thingodontia*'. The basic substance of the paper was accepted by *Science* but the editor was clearly worried about the name. Each of the referees' reports began with some version of "No, I do not think this is a hoax...", suggesting they had all been asked to consider whether the whole thing might be a joke! At his urging, we caved in (I wish we hadn't) and called the genus *Yalkaparidon*, a far less memorable name meaning 'moon-shaped tooth', and the order Yalkaparidontia.

Other Riversleigh names for radically distinct beasts survive as popular handles. For example, while we wanted to name another strange mammal '*Bizzarodonta*', we chickened out and gave it the far less memorable name *Yingabalanara* which, to those intimate

ILLUSTRATION BY PETER SCHOUTEN

Riversleigh's extinct 'Thingodonta', so-named because its teeth are wildly different from those of any other Australian animal—live or dead.

ly familiar with the Waanyi Aboriginal language, means 'another moon' in reference to its double-crescent-shaped teeth. But there is still hope. A stunningly different kind of Riversleigh kangaroo with huge wolf-like canines may yet hit the scientific arena as '*Fangaroo*'! At the very least, 'Fangaroo' will be a star character in the Australia-on-CD-ROM title "Tales from the Kangaroo's Crypt: 4 Billion Years of Extraordinary Australia" now nearing completion.

A similar case involved one of the weirdest monotremes ever found (*Nature Aust.* Winter 1995). When Tim Flannery described to me over the phone the jaw of this Cretaceous creature from Lightning Ridge, he said it had teeth like a hot cross bun and we were soon informally calling it 'Hotcrossbunodon'. When the time came to submit the technical paper to the international journal *Nature*, we considered '*Hotcrossbunodon*' for the beast's generic name. But again scientific conservatism prevailed! Abandoning what would have been a very memorable and descriptive name, we eventually named the beast *Kollikodon*, which means 'bun tooth'. I suppose that's a kind of compromise—at least for readers fluent in Greek. Finally, along these same lines, Glen Ingram (Queensland Museum) tells me that he and a colleague considered naming a new frog species from the frog genus *Kyarranus*, *Kyarranus aurusrex* (say it quickly). The species name would have meant 'gold king' in reference to the frog's distinctive colour, but was dropped for the more conservative *K. kundagungan*, which means 'mountain frog'.

Far more provocative names have been the stock and trade of other systematists such as Richard Wells and Ross Wellington. For example, in their revision of Australian reptile systematics, they named one skink *Eroticoscincus* (the mind boggles why) and another *Vaderscincus*, said to be in honour of the "Star Wars" villain Darth Vader.

The International Code of Zoological Nomenclature also states that no zoologist should create a name that "gives offence on any grounds". One reason for this curious warning may have been the naming by John Gray (former Keeper of Zoology at the British Museum) of a new zebra after its discoverer, the explorer William Burchell. Disliking Burchell, Gray named it *Asinus burchelli*, saying that it, like its discoverer, was an ass. Burchell promptly challenged Gray to a duel! There was also a colonial ichthyologist in the Museum of Victoria who was so infuriated at his treatment by the Board that he submitted a manuscript naming a range of ugly pickled fish from the Murray River after each of the Board Members. Unfortunately, someone who read the paper before it was published informed the Board and the manuscript (which still exists) was unceremoniously rejected.

Some scientific names that have achieved notoriety were parts of hoaxes. For example, *Brunus edwardii* turned out to be a scientific name for a teddy bear, *Tyrannonasus* was a mammalian predator that walked on elongated, muscular flaps of its nose, and *Homo marsupialis* (whose authors incidentally were Have, A.P. & Flush, A. John) was supposed to be a pouched primate found in a remote region of central Australia.

And what of common names and their often curious origins? In the 1995 edition of Ron Strahan's *The mammals of Australia*, the common name for *Petrogale burbidgei*, a rock-wallaby from the Kimberley region of Western Australia, had been changed without explanation from its original 'Warabi' to 'Monjon'. Why? Rumour has it that the original describers realised that, when they first asked the Aborigines of the region "What is the name of this animal?", the quick response "A warabi" may not have been quite as specific as they presumed ("Of course it's a warabi, mate; we got lots of kinds of warabies here!").

There are also curious names immortalising professional colleagues for perhaps dubious reasons. Harold Cogger (John Evans Memorial Fellow at the Australian Museum) told me about *Apogonichthys coggeri*, a Great Barrier Reef fish evidently named in honour of his love of food when he was one of the members of the expedition on which it was caught—the fish belongs to a group popularly known as 'gobbleguts'. Unfortunately the species turned out not to be new and the name has now been sunk in favour of *Neamia octospina*. In my own case, I can cite Archerite, a new mineral named after me by Perth mineralogist Peter Bridge. Knowing of Peter's interest in phosphate minerals, I sent him a strange piece of crystalline material I had found on the floor of a Nullarbor cave. I was indeed honoured at having a mineral named after me until Peter explained that it was almost certainly mutated bat poop.

I guess my point in all this is that surely very little is lost in lightening up the professional as well as public face of science. If we filter the fun out of science to preserve its dignity, we may even endanger its appeal to the scientists of tomorrow. Like sugar-coating medicine, science served with humour can make a sometimes dreary topic more appealing and its key messages more interesting to learn. In most cases, the only price paid may be a wee bit of damage to personal dignity, a loss most of us could well afford.■

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

Australian Birds of Prey

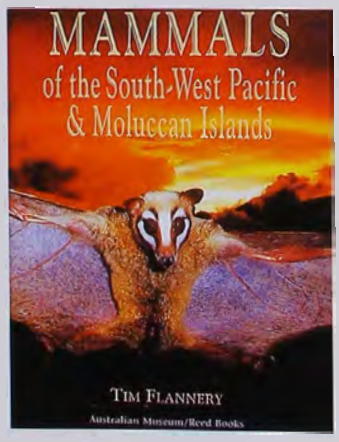
By Penny Olsen. University of New South Wales Press, Sydney, 1995, 256pp. $59.95rrp.

This compact collection of years of research and field work, from one of Australia's leading raptor experts, is a necessary addition to the library of any person who has even the slightest interest in Australia's birds of prey. The text is generally well written and, apart from a few editorial mistakes, presents a mass of both basic and technical material in a format that is easy to digest. There are many photographs throughout the book, a few of which are of poor quality (including the Brown Goshawk on the front dust cover), but the majority are great shots that are used to good effect, often depicting the subject in everyday activities that are extremely awkward to capture on stills. Other illustrations include several wonderful pencil sketch-drawings by Humphrey Price-Jones, and a range of tables and graphs.

The book is divided into nine sections that take the reader from the basic evolution, identification and classification of the Australian birds of prey (and some brief information on "Raptors of the world"), through the general diet, hunting, mating, studying and monitoring techniques, tips on handling sick and injured raptors, and concludes with some worthwhile considerations for the conservation of these wonderful birds.

In summary, this is an extremely worthwhile and informative publication.

—Peter Rowland
Australian Museum



Mammals of the South-west Pacific and Moluccan Islands

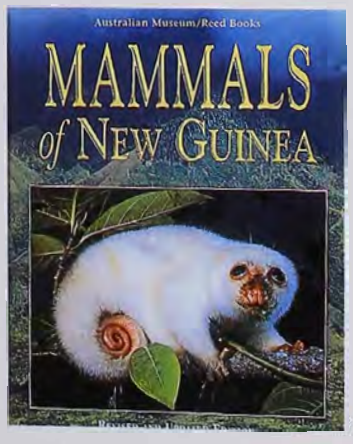
By T.F. Flannery. Reed Books, NSW, 1995, 464pp. $80.00rrp.

Taxonomy and status of the many and diversified mammal species of the south-west Pacific and Moluccan Islands has long been neglected. Flannery's latest publication does a great deal to breach the gap. What impresses me about Flannery's work is the manner in which he analyses the present status of mammals in this region. Meticulous thought and thorough research is the essence of its success.

Flannery's work is extensive in its coverage. It deals with current species, introduced species and extinct species. Not only does it cover the taxonomy and status of an extraordinarily diverse zoographical region, but also includes detailed accounts of geology, vegetation, human colonisation, palaeontology and zoogeography. This background data allows for a better understanding of the present status of the mammalian fauna. In addition his reference section is very comprehensive but unfortunately there are many spelling mistakes in the German, Dutch and French languages.

This book is well documented, based on five years of field study and two study tours to various museums around the world. It reviews 230 indigenous species, including some of the Earth's least known. Each species description contains taxonomic data, as well as details on status and ecology. All illustrations are in colour and most are excellent.

—Antoon de Voos



Mammals of New Guinea

By T.F. Flannery. 2nd ed. Reed Books, NSW, 1995, 568pp. $75.00rrp.

Publication of the first edition of *Mammals of New Guinea* in 1990 was a benchmark in the history of Australasian mammalogy. Up to that time, most practising mammalogists in Australia and abroad could probably recall that New Guinea, like Australia, was inhabited by monotremes, marsupials, rats and bats, however very few would have been able to name any of its endemic species or even genera of mammals.

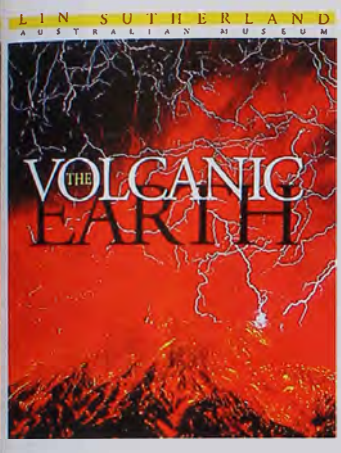
Flannery's book gave to the world its first comprehensive look at the spectacularly rich mammal fauna of New Guinea. Through a combination of good colour photographs of animals, indigenous people and places, and a clearly written text that drew extensively on both published and unpublished sources for both taxonomic and natural history information, Flannery took us step by step through the mammal fauna, treating each species with equal respect and enthusiasm. Along the way, he presented a number of novel taxonomic rearrangements, especially among the rodents, some of which await detailed justification.

The revised and updated edition has involved a major rewrite and includes a large number of new photographs. In part this has been to accommodate a further 25 species, some of which are completely new discoveries (not least, two new tree-kangaroos), while others relate to taxonomic revisions. These latter changes are most prevalent among the rodents, with Flannery deferring to the authority of Musser and Carleton ("Family Muridae" in *Mammal species of the world*, second edition, 1992) for this group. In my view this was an unfortunate decision, as their arrangement of New Guinean species for the most part is based on cursory examination rather than careful revision, and is unlikely to be stable in the long term. However, such matters do not detract from the worthiness of this revised edition, which is not only more attractive but in many ways also more scholarly than the original.

In giving us *Mammals of New Guinea* Flannery has performed a great service to Australasian mammalogy. Added to his primary contribution as discoverer of many

new species of New Guinean mammals, this work clearly establishes him in the same league as the three explorers and scientists—Luigi Maria D'Albertis, Michael Oldfield Thomas and George Tate—whom he so obviously admires. We are in his debt.

—Ken Aplin



The Volcanic Earth

By Lin Sutherland. New South Wales University Press, NSW, 1995, 248pp. $49.95rrp.

We tend to think of Australia as being devoid of volcanoes and poor in examples of volcanic phenomena; far from it! Did you know that there is a projected volcanic 'hotspot' now lying under the Newcastle–Blue Mountains–Wollongong area? Such a hotspot could result in a volcanic eruption of basaltic lava (but probably not in the next thousand years or so).

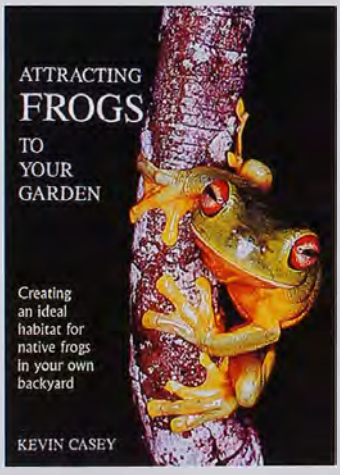
He even predicts likely areas for future eruptions and their possible effect upon our major cities.

This book could effectively be subtitlted *The life and times of volcanoes*. It vividly outlines modern-day plate tectonic explanations of volcanic distribution, describes the volcanoes themselves, the dating of volcanic events and the significance of volcanoes to the Earth's environment. The emphasis throughout is on our own region—the south-west Pacific.

We are then taken on a guided tour of the volcanic landscapes around Australia, and the volcanic minerals and rocks that occur within them. The author reveals that this interval of quiescence in Australia's volcanic history is just that, an interval, and that there are many indications of future volcanic activity, especially in the east. He even predicts likely areas for future eruptions and their possible effect upon our major cities. The book includes a unique trans-Tasman volcano spotter's guide complete with maps and including the spectacular, currently active, areas of New Zealand.

The book is beautifully illustrated in colour throughout, and the style and enthusiasm of the writing reflect the author's love of the subject. Much more than a 'coffee-table' book, it is a must for those people interested in volcanoes and the part they have played in shaping the landscape of our continent.

—Brenda Franklin
University of Technology, Sydney



Attracting Frogs to your Garden

By Kevin Casey. Kimberley Publications, Qld, 1996, 136pp. $14.95rrp.

It is surprising that a book like this has not been written sooner. The need and interest was there, and frogs are certainly an animal group with a strong cult following. Thankfully with this book the need explained in its title has been met. The book has tried to make itself applicable to anywhere in Australia and has succeeded very well. As a result, it is not specific to any species or group of species, with the exception of the Cane Toad and its control. The basic principles apply to most species of frogs likely to be found in a garden.

The book has 13 chapters with titles such as "Where Have all the Frogs Gone", "Identifying your Frogs", "Life as Predator & Prey", "The Backyard Pond" and "Frogscaping". In addition it covers some related but potentially useful areas too, like "Attracting Other Wildlife" and "Frog Photography". It has two appendices—one with "Additional Information Sources and Useful Addresses" (like the various frog societies) and the other "Suggested Further Reading". The book is 136 pages long and easily read. It could have had more colour photographs but that would have increased its reasonable $14.95 price tag. As it is, there are 41 black-and-white photos of good quality and three line drawings to help explain aspects of the text.

The book tries to list any pitfalls that may occur; for example, it covers the legal aspects regarding the keeping or transport of frogs and tadpoles, and gives the addresses of relevant State authorities so people can check (or indeed lobby if they think the laws need changing). I don't know whether I agree with the author's opinions on frogs in captivity but frogs in the garden are a better option for most people. It might also have been useful to include a paragraph on what to do if a frog turns up in your green groceries. This is more common than you might think. Recently while in the Eyre Peninsula, South Australia, I saw several specimens of the Dainty Green Tree Frog (*Litoria gracilenta*), also known as the Banana Frog, that had arrived on the fruit of their choice from Queensland!

All in all a recommended and useful book providing a variety of detail and aspects. A good companion to the book from the RANA group, *Raising native frogs* by Alistair Bax. Ideal for the basis of a family project!

—Martyn Robinson
Australian Museum

SOCIETY PAGE

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

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Contact: Mrs Sue Newman

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NSW Field Ornithologists Club
PO Box Q277,
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Ph: (02) 807 6828
Contact: Sheila Witt,
Hon. Secretary

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Ph: (008) 032 501
Contact: Colin Jackson,
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Executive Director

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CSIRO's Double Helix Science Club
PO Box 225, Dickson,
ACT 2602.
Ph: (06) 276 6643
Contact: Lynn Pulford,
Membership Secretary

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PO Box 56,
Modbury North, SA 5092.
Ph: (08) 277 2851
Contact: Mr Arthur M. Pratt,
Treasurer

Membership Fee: $25.00

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Canberra, ACT 2601.
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Fax: (06) 248 5343
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Director

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SA 5001.
Ph: (08) 231 0016
Contact: Helen Jaensch,
Secretary of Council

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Contact: Joyce Weeks, Secretary

Membership Fee: $20.00 (single/family); $12.00 (concession)

Field Naturalists Society of SA Inc.
GPO Box 1594,
Adelaide, SA 5001.
Ph: (08) 272 9015
Contact: Mr D. Kraehenbuehl,
President

Membership Fee: $20.00 p.a.

Field Naturalists Club of Vic.
Locked Bag 3,
Blackburn, Vic. 3130.
1 Gardenia St, Blackburn,
Vic. 3130.
Ph:(03) 9877 9860
Contact: Geoffrey Paterson,
Secretary

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TAMS, The Australian Museum Society
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VICTORIAN HIGH COUNTRY

Q&A

Leaf-curling Spiders, it seems, are not too particular about what they use to build their homes. This one has chosen to use a moist towelette that was accidentally dropped in a Sydney garden.

Tissue-curling Spider

Q: *What is this spider and just what is it doing with this tissue?*

—Edith M. Adler
Mona Vale, NSW

A: This is a Leaf-curling Spider (*Phonognatha graeffei*). These spiders are harmless to humans and like most spiders are beneficial insectivores. They are common in the gardens, open forests and woodlands of eastern Australia, including Tasmania (a closely related species is also found in south-western Western Australia). Normally the spider hauls a leaf up into its web and uses silk to draw it into a curled shape. This curled leaf is then lined with silk and used by the spider as its retreat. The spider builds an orb-shaped web around this retreat as an insect snare. The spider normally stays motionless inside its retreat but quickly darts out to attack any insects that become trapped in the snare.

As they grow, Leaf-curling Spiders renew their retreats to suit their increasing size. Adult spiders almost always use a dead leaf, whereas younger spiders often 'experiment' with green leaves still attached to plants. However, as you have discovered, Leaf-curling Spiders do not restrict their activities to leaves. They will opportunistically use whatever comes to hand. There are records of them using tram tickets, cigarette cards and scraps of newspaper. Even snail shells have been used as a pre-curled, if somewhat heavy, spider home. Tissues are no exception and this spider has curled this tissue into a suitable retreat in the same manner as it would a leaf.

—Michael Harvey
Australian Museum

When Wasps Meet

Q: *I enjoyed Steve Van Dyck's article on mud-dauber wasps in the Spring 1995 issue of* Nature Australia. *Whilst the mud-dauber larvae feed on spiders, I wonder whether the larvae of other wasps may feed upon the 'resident' (mud-dauber) larvae and/or their spider pantry.*

Enclosed is a photograph that I believe shows modifications to a mud-dauber's nest by another much smaller wasp. I am not sure whether it was a nest only recently constructed or from the previous year, but the small black-and-gold wasp spent much of its time going in and out of the nest, whilst a larger black-and-white wasp scoured the outside.

Just what are these wasps up to?

COURTESY ROBERT McNAUGHT

At no point did I see either species of wasp remove anything from the nest. Just what was going on?

—Robert H. McNaught
Bugaldie, NSW

A: The smaller wasp with extensive red markings is a potter wasp, *Paralastor alexandriae*. Females of this species construct a tubular mud nest inside the abandoned cells of an old mud-dauber nest. The tube protrudes a little way and expands into the delicate mud funnel seen in the photo. The females provision their cells with paralysed caterpillars. The female potter wasp is guarding the entrance to her nest, which she probably imagines to be under threat from the larger, black wasp, *Pison alexandriae*. *Pison alexandriae* is another widespread and fairly common wasp, known from northern Western Australia, the top end of the Northern Territory, Queensland and New South Wales south to about Sydney.

The black *Pison* wasp preys on spiders, so the potter wasp's provisions are not at risk. However, the black *Pison* would be constructing a mud nest in a cavity nearby and may be looking for building material. It is quite possible that it would like to bite a few chunks off the exterior of the nest occupied by the little potter wasp.

—Ian Naumann
Australian National
Insect Collection

Frog Food for Thought

Q: *In my garden I have a number of containers in which frogs lay their eggs when it rains. The tadpoles do not appear to survive, perhaps due to starvation. What is their natural food?*

—R.M. Bellamy
Jannali, NSW

A: I'm going to have to assume that the "number of containers" in which the frogs are laying their eggs are small and free of debris as most places frogs lay their eggs are generally suitable for the survival of the tadpoles that follow. Most frog tadpoles are raspers of algae and small organisms that encrust rocks, sticks etc. that are found in their ponds. Most will also supplement this diet with drowned insects, dead leaves and fallen fruit that may wash in. As they grow older, some species become a little more predatory and can catch mosquito larvae, water fleas, worms and even the eggs and tadpoles of other frogs. A few like Fletcher's Frog (*Lechriodus fletcheri*) are decidedly cannibalistic and will turn on and devour their sibling puddlemates. This extra protein results in larger froglets sooner and at metamorphosis they have a better chance of survival. If you want to increase the chances of survival of your tadpoles, the easiest diet is small pieces of crushed or boiled lettuce supplemented with a small amount of fish food or even grated dog biscuit. But beware of overfeeding! Remember to put in a few ramps and islands of sticks and/or rocks for the tadpoles when they develop legs, otherwise they may drown. You might also consider putting in a larger frog 'pond' somewhere in your garden as a more self-maintaining alternative for the frogs to breed in.

—Martyn Robinson
Australian Museum

Answers to Quiz in Nature Strips (page 16)

1. An extinct giant bird
2. 1,000
3. The moon comes between the Earth and the Sun, momentarily blocking out the Sun's light.
4. Chimpanzee
5. Ants and/or termites
6. Tasman Sea
7. Alcohol
8. Douglas Mawson
9. Amphibian
10. *Brontosaurus*

PIC TEASER

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a $20 gift voucher for the Museum Shop Book Catalogue. Spring's Pic Teaser was a scanning electron micrograph of a spider's spinnerets.

DENSEY CLYNE/MANTIS WILDLIFE FILMS

Censorship by others is bad enough; but self-censorship is even more dangerous and threatens to undermine the whole scientific process.

CENSORING SCIENCE

BY IAN LOWE

THE RESULTS OF RESEARCH ARE usually published in scientific journals. This has two benefits: the work is subject to peer review, so it is more likely to meet accepted standards; and the findings then become available to other scientists, science journalists and the general public. However, this procedure is now under threat.

The increasing reluctance of governments to fund university research is driving scientists to seek support elsewhere. There is a steady rise in the number of applied research projects and consultancies, feeding on the scientific base built by public money. This yields economic benefits to particular companies, and sometimes to the nation, but it affects the integrity of universities. As former UK minister Shirley Williams said, "Those who want to harness the universities to commercial objectives may destroy the very qualities they observe in them—intellectual excellence, free inquiry, scientific imagination."

Government policy in recent years has undermined the independence of CSIRO and its capacity to do research in the public interest. Only about 70 per cent of CSIRO's budget now comes from its government allocation. Many community groups see a cosy relationship between areas of CSIRO and their industrial sponsors, with the direction of research being driven by the projects that sponsors are prepared to fund.

Private funding also brings with it reduced freedom to pass on new knowledge. A commercial sponsor, for example, will often want publication of important results to be either suppressed or delayed for long enough to give a head-start in exploitation.

So, many areas will not be studied, and some of the findings will not be made public. This reduces the ability of scientists to serve the overall interests of the community. Those whose research is supported by industry are reluctant to bite the corporate hand that feeds them. Others hesitate to risk future funding by public criticism of large companies. When a Tasmanian honours student recently documented unacceptable pollution of the King River by mining operations, university officials tried to keep the findings under wraps.

Those whose research is supported by industry are reluctant to bite the corporate hand that feeds them. Others hesitate to risk future funding by public criticism of large companies.

Another disturbing practice is the suppression of research carried out by government bodies. Much of the data collected by State government agencies are not open to public scrutiny, nor to peer review. Instead, this 'grey literature' is only reviewed internally and then locked away in filing cabinets. This is part of a long tradition of government secrecy. I recall being in the UK when there was a controversy about lead emissions from the Avonmouth smelter. The inspectors had known about the problem for years. Instead of releasing the data to the public, they had negotiated behind closed doors for moderate improvements to an unacceptable situation.

Three years ago, a conservation group released successive drafts of papers prepared by scientists working for the Western Australian Department of Conservation and Land Management (CALM). The process of 'internal peer review' had removed findings that exposed deficiencies in CALM's forest management. By suppressing this information, CALM was guilty of misleading the public. Governments are often tempted to put short-term economic expediency before the long-term good; an informed public can restrain this tendency.

The issue came to a head when the US ecologist Paul Ehrlich (from Standford University) was in Australia recently. At a forum held at the University of Technology Sydney, in a series intended to raise public awareness of scientific issues, he claimed that research on environmental problems was systematically suppressed by government agencies. As if to prove his point, the forum organisers, after an unofficial discussion with a junior officer in the Commonwealth Government's Environment Department, decided not to release Ehrlich's paper to the media! Of course, Ehrlich couldn't resist telling the media of this attempt to suppress his findings about research findings being suppressed!

The real worry is that the present research climate has caused collective self-censorship by scientists in public agencies. Censorship by others is bad enough; but self-censorship, where the scientists themselves are made to feel they must bite their tongue or produce results that fit the departmental ideology, is even more dangerous and threatens to undermine the whole scientific process.

Public funding of science is not serving the public interest in the way it should. If research *funding* comes from the public, the research *findings*—all of them—should go to the public. That is a fundamental principle. Those who pay the piper should at least *hear* the tune! ■

Professor Ian Lowe is in the School of Science at Griffith University, Queensland. His research interests are in the broad area of policy issues affecting science and technology.

BACK ISSUES AND SUPPLEMENTS

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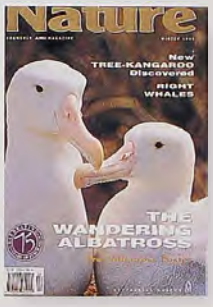

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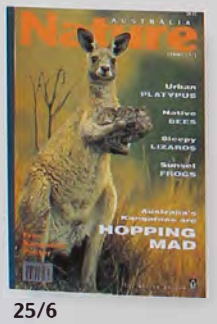

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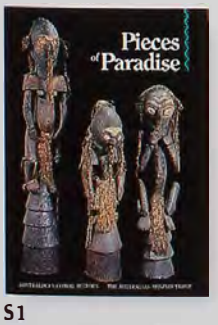

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