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Up Front

If you were asked to name some of Australia's most beautiful native animals, it's more than likely the Numbat would not be among them. Why not? This striking animal certainly fits the bill, as the photos in this issue will testify. Well, it's probably because, up until recently, almost nothing was known of these secretive and highly endangered native animals. The Numbat is with us today only because the introduced Red Fox is highly susceptible to the toxins of a certain genus of Australian plants. As a result, our only termite-eating marsupial was able to fend off extinction by surviving in two pockets of bushland in the south-west of Western Australia. And it took the near extinction of this animal before scientists were able to gain enough funding to carry out a detailed study of their day-to-day life. What they have discovered so far is quite extraordinary, but despite all the attention, the Numbat still has a few secrets left.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Two young Numbats at the entrance to their nursery burrow.

Antarctica in winter is full of secrets. Research at this time of year is restricted to the areas around the coastal bases and what goes on elsewhere on that frozen continent is largely unknown. So, it has long been an accepted fact that whales migrate away from these harsh conditions, primarily because nobody has been able to go and look to see if this was true. That was until the Australian National Antarctic Research Expeditions conducted its first mid-winter cruise into the sea ice and, as a result of the trip, scientists are having to take another look at these astonishing mammals. Take a look for yourself on page 24.

JOHN BRACKENBURY

See the world through a cicada's eyes!

It's a commonly pondered question: how do other living things perceive the world? What does the world look like to, say, an insect? Dr John Brackenbury wondered that exact thing and set about finding the answer. So, ponder no more, just turn to page 32 and see the world through the eyes of a cicada, or how about a dragonfly, maybe a moth...

—Jennifer Saunders

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Front Cover

A young Numbat (*Myrmecobius fasciatus*) emerges from its nursery burrow. Photo by Jiri Lochman/Lochman Transparencies.

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LETTERS

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

Flat Food

I would like to respond to the "Feeding on flattened food" Nature Strips article in the Winter 1996 issue of *Nature Australia*.

On the morning of 27 January 1991, while on a trip to Bat Cleft Cave on Mount Etna to see the Little Bentwing Bats (*Miniopterus australis*) returning to the cave at dawn, I witnessed a Children's Python (*Liasis childreni*) eat two dead bats.

At dusk the bats spiral up the 30-metre entrance shaft, going out to feed on insects during the night. It takes about three-quarters of an hour for all the bats to emerge. The flight out of the shaft is full of danger for the bats as there are many snakes waiting to eat them. At dawn the bats return to the cave and in less than half an hour they are all back. On most occasions the snakes have gone or are on their way out of the shaft.

On this particular morning, while standing at the entrance watching the bats disappear down the shaft, I witnessed a Children's Python coming up out of the cave. When it was on a ledge just below where I was standing it slithered over to where two dead bats lay. On reaching the first bat the snake circled its head over the bat several times as though smelling it. It repeated this with the second bat before picking it up in its mouth, slithering a short distance away and eating it. This bat had been regurgitated by another Children's Python three nights previously. After the snake had finished eating, it returned to the other dead bat, carried out the same circular motion with its head, and then ate it as well. This bat had been dead for five days. The whole incident took about an hour. The snake ate the first bat without any difficulty but had trouble getting the second bat's wing bones past its mouth.

On the evening of Saturday 29 January 1994, also at Bat Cleft, visitors witnessed a Children's Python consume a bat that had been dead for no more than 24 hours.

I hope the above will be of interest to your readers and those who are studying and documenting these lovable creatures. Thank you too for a wonderful publication.

—Dianne Vavryn
Rockhampton, Qld

MERRIDY CAIRN-DUFF

Healthy pandanus palms.

Pandanus Palms

I had always accepted reports on how many species humans eliminate from the Earth with some scepticism. In a recent interview with environmentalist David Suzuki he mentioned 50,000 species reach extinction each day. I don't think I could even name that many animals.

On a recent trip to Noosa National Park, alas, the reality sunk in and I was able to see for myself just how delicate nature is. The pandanus palms in the Noosa-to-Tewantin area in New South Wales are all dying—every single one of them. When visiting the area in 1994 I had explored the Noosa National Park and took roll after roll of scenic photographs, pandanus palms being the feature of many of them. There were so many of the palms they really were the feature of the coastline. On a recent visit in August I couldn't wait to get more photos. But I didn't take one! There were comparatively few pandanus and most had brown leaves or none at all, somewhat resembling cacti. A lucky dozen or so still had some green foliage, none of them bore fruit. I thought perhaps this was a seasonal variation but no, they were dying. The cause? Somebody living locally had brought in a diseased pandanus from somewhere tropical. Scientists don't yet know what the disease is or how it works. They are desperately trying to locate the diseased palm because identifying the disease is the only way they can stop it spreading up to Rainbow Beach and beyond. Pandanus take around 100 years to reach maturity. I find it difficult to comprehend that in my lifetime, and I am only at the quarter mark, I will never see Noosa looking as it did upon that first visit. That's quite a statement and, alas, it's true. Clearly our actions, no matter how seemingly innocent, still need careful consideration.

—Merridy Cairn-Duff
Carlingford, NSW

Viva Sleepy Lizard!

Viva the Sleepy Lizard! And it will because, according to Michael Bull's fascinating article in the Spring 1996 issue of *Nature Australia*, it lives for up to 30 years. Bull has vividly described a landmark in reptile research.

Until the appearance of this article, I had fruitlessly searched the literature for information about this fine animal. My interest was spurred last year by the presence in my garden of three lovely such lizards which, in response to my call, would come hurrying across the lawn for handouts.

So, viva all Sleepy Lizards...and viva Michael!

—Rick Radford
Camden Park, SA

Blinding Cherry

The Finger Cherry (*Rhodomyrtus macrocarpa*) can be included in the list of tropical Australian nasties. The Queensland Museum's monograph *Toxic plants and animals* (1987) indicates that the fruit should not be eaten. Further, it indicates that "Children who have eaten the fruit in quantity have suddenly become blind". It suggested that injury is caused by eating the fruit. However, during a visit to the Mossman Gorge, northern Queensland, an Aboriginal park

ranger told us that the Finger Cherry is food for eating but that it is imperative people wash their hands after eating the fruit. When he was a child, the ranger witnessed several people become permanently blind after they had eaten this fruit and then rubbed their eyes with their hands. Hence, the mechanism of injury appears to be contact between substances in the fruit and the eye. It is important, then, that visitors to the wet tropics are made aware of this botanical blinder. Whereas cautious tourists may decide not to eat the fruit, there is potential for injury simply by handling the fruit. The ranger described the fruit as being elongated in shape, and purple in colour; however, the fruit can be other colours. For me, the rule is never touch the fickled Finger Cherry of fate.

—Peter Gross
Mossman, Qld

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

A feral cat dines on a Galah (*Cacatua roseicapilla*).

Chinese Whisper

Michael Archer's article "Evolution after death" (*Nature Aust.* Spring 1996) was, as usual, good to read. However I think that the reference to 'Chinese Whispers' was probably hyperbole. In Ernistine Hill's book, *The territory*, she says that in 1867, on Port Darwin beach, Goyner and his surveyors were amazed when the Larrakia performed a corroboree for them. They sang "John Brown's body" and "The Old Virginia" word and pitch perfect. They had learned it from a neighbouring language group who had picked it up from Finniss' survey camp on the Adelaide River five years before. Such is the value of the spoken word, pre-print. But then again, maybe Ernistine Hill's story was already a 'Chinese Whisper'.

—Beryl Marnane
Chillagoe, Qld

Why Do Native Stingless Bees Fight?

I read Tim Heard's recent article on stingless bees (*Nature Aust.* Spring 1996) with interest. As a stingless bee enthusiast I also have been frustrated and puzzled by their occasional tendency to swarm and fight each other. The latest massacre for my *Trigona carbonaria* hives occurred in late May 1996 in my garden, a few days after the first cold snap of winter. A swarm of bees hovered outside one of the hives. A few pairs of death-locked bees could be found on the ground and the hive entrance looked like city centre at rush hour. Next day all three hives were at it—the ground looked black with their bodies for weeks.

But why do they fight to the death? Bees are all closely related to their queen and each other, and what's good for the hive is good for them. In fact the hive *is* the organism, and it has to compete not with other bees but other hives. This being the case, what happens when winter finally arrives? The workers suddenly find themselves unemployed as the hive winds down and they become a drain on the hive. The queen does her sums—20 per cent of current workers must go! They could fly off into the great blue yonder, jump in front of a passing truck or they could go and commit suicide by attacking and killing as many as possible of their nearest neighbours. This reduces the demands on their own hive but protects its future by reducing the strength of competing hives. On the themes of selfish genes and kin selection what are the alternatives? Assume the workers decided to go quietly, no fuss or fighting. They weaken their hive (even if only for a few days) and leave it open to further weakening if subsequently attacked. The optimal strategy would appear to be to attack all neighbours at once and for them to do the same.

—Henry Drew
Palmwoods, Qld

Caring for Wildlife

I am extremely concerned about the plight of Australia's native wildlife, particularly the large number killed or injured by both domestic and feral cats. I am also frustrated with my own inability to do anything, hence the reason for this letter.

I would like to be able to form an action group for the protection of native species, initially focusing on cats, although also branching into other areas. I understand that there are already some laws being passed in Victoria and New South Wales about cats, but I would like to see laws made and enforced on an Australian-wide basis. If all people concerned with cats can somehow unite, this will mean greater lobby power. I had thought of a name, "Group for Protecting Native Species", but would be extremely interested in other people's ideas for a name, logo and course of action. Alternatively, if there are already established organisations, I would be very interested in joining.

I would really appreciate any help or information that readers could give me. I have also joined the Internet, so I can readily access and distribute information. My address is 21B Brilliant St, Mt Isa 4825.

—Debbie Bennion
Mt Isa, Qld

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 Henry Drew.**

Nature Strips

COMPILED BY
GEORGINA HICKEY

Iguana Sex

Sex is a difficult business for small male Marine Iguanas (*Amblyrhynchus cristatus*). When they copulate, Marine Iguanas need around three minutes to achieve ejaculation. This constitutes no difficulty for large, territory-holding males who can generally mate at their leisure. Smaller lizards, on the other hand, are usually interrupted by one of their larger brethren before they're done. The intruders bite and head butt and sometimes even attempt to drag the copulating male off the female while simultaneously trying to copulate with her himself.

Martin Wikelski and Silke Bäurle of the Max Planck Institute in Germany studied Marine Iguanas on one of the Galapagos Islands. After observing the difficulties faced by small non-territorial males, they decided to investigate whether they were still able to fertilise females. Indeed, five females who had not previously mated that season, and who were disturbed before their partners had time to ejaculate, were found to have viable sperm in their cloacas and went on to produce fertilised eggs, despite abstaining from further copulation.

But how do the small males manage this miraculous feat? Male reptiles have a pair of penises known as hemipenes, inverted pouches that lie inside the tail on either side of the cloaca when not in use. During copulation they are everted, turned inside out like the fingers of a glove. Wikelski and Bäurle examined the hemipenes of males that had not copulated for at least 24 hours and found viable sperm in almost all of the non-territorial males but in less than half of the territorial males. Seven of eight males caught just before they initiated copulation also had old ejaculate inside their hemipenes.

The researchers concluded that, in the face of seemingly unbeatable competition from larger males, the smaller lizards had hit upon a rather novel strategy: premature ejaculation. So premature in fact that the lizards actually ejaculate before they've even come in contact with the female. Wikelski and Bäurle observed small non-territorial males exhibiting the characteristic copulatory posture of a bent body and tail as females passed by. When they captured these males they all had fresh sperm in their hemipenes.

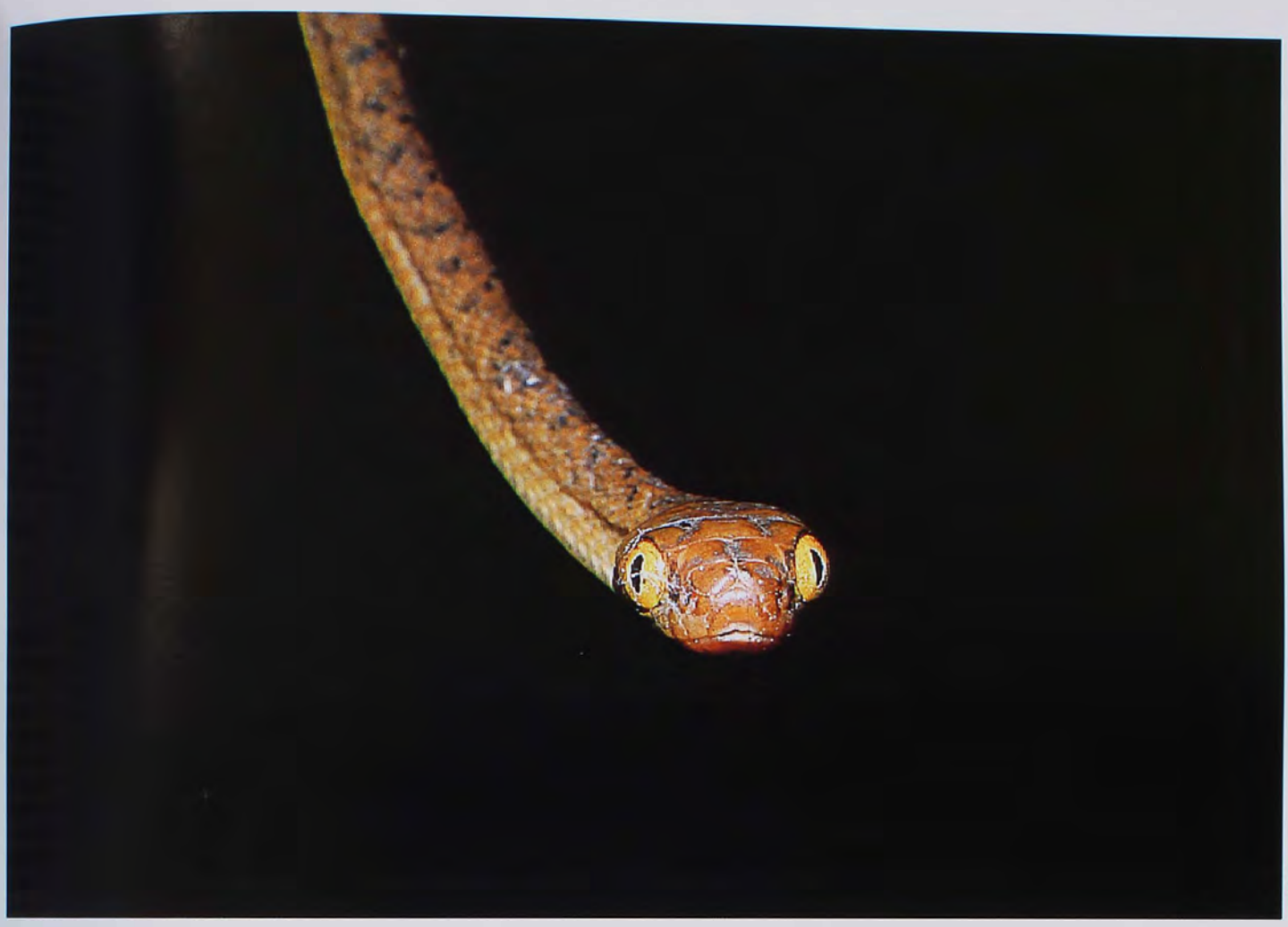
—G.T.

Oldest Coprolites

Just when you thought you'd heard it all, a team of British researchers has proudly announced a novel item for the record books: the world's earliest known terrestrial faeces. The 412-million-year-old coprolites were unearthed in Siluro-Devonian siltstones in Wales by Dianne Edwards (University of Wales) and colleagues. Initially thought to be individual spore-bearing organs,

TUI DE ROY/AUSCAPE INTERNATIONAL

How do small non-territorial male Marine Iguanas compete in the mating game?



S. WILSON

The Brown Tree Snake (*Boiga irregularis*) kills prey by constriction. Its oral secretions were never meant for quickly killing prey.

this view was revised when Edwards and her team discovered that, in addition to other plant debris, some of the deposits contained fossil spores from up to nine different plant species.

As to what produced the coprolites, which pre-date other examples by 90 million years, that riddle is not so easy to solve because the only known local fossil animals from the same period were carnivores.

One suggestion is that the coprolite producers may be early terrestrial herbivores, which fed on the nitrogen-rich spores. An alternative idea is that the animals were detritivores, working their way through leaf litter teeming with spores. There is no firm evidence for either, but whatever the case, the spores would have been hard to digest, and passed through the gut unscathed.

And where evidence of their feeding habits is tenuous, that for the animals themselves is virtually non-existent. The size of the coprolites (up to 3.3 x 1.3 millimetres) excludes most known animals from that time and leaves the likeliest contenders as millipedes.

—R.S.

Snake Toxins Aren't All Venom

If you were to inject your saliva into the skin of another person, they'd experience symptoms such as localised pain and swelling. In short, a toxic reaction.

The reason why is simply that human saliva contains poisonous compounds. Yet we don't and probably never have used our oral secretions to immobilise prey, and we've never considered ourselves to be a venomous species. The toxic qualities of our saliva are incidental to our biological success.

The same can be said for some snakes, argues Kenneth Kardong of Washington State University's Zoology Department. Even though the oral secretions of many snakes contain toxic compounds, they can't always be considered venomous. This distinction, says Kardong, is important when interpreting the behaviours, feeding strategy and evolution of snakes.

Consider, for example, colubrid snakes in which oral secretions are produced in what is known as the Duvernoy's gland. When most of these snakes hunt for food, the Duvernoy secretions and the way they are delivered into the mouth prove to be very inefficient in killing prey.

Nevertheless, it's been widely accepted that the Duvernoy system did evolve to kill prey and its inefficiency has led to it being known as the "poor-man's venom system". This, according to Kardong, is a gross misinterpretation. Duvernoy secretions, he believes, have not evolved as a venom intended for, but unsuccessful at, quickly killing prey. Instead it's more likely that they developed for other purposes such as swallowing prey and preparing it for digestion, in much the same way as human saliva.

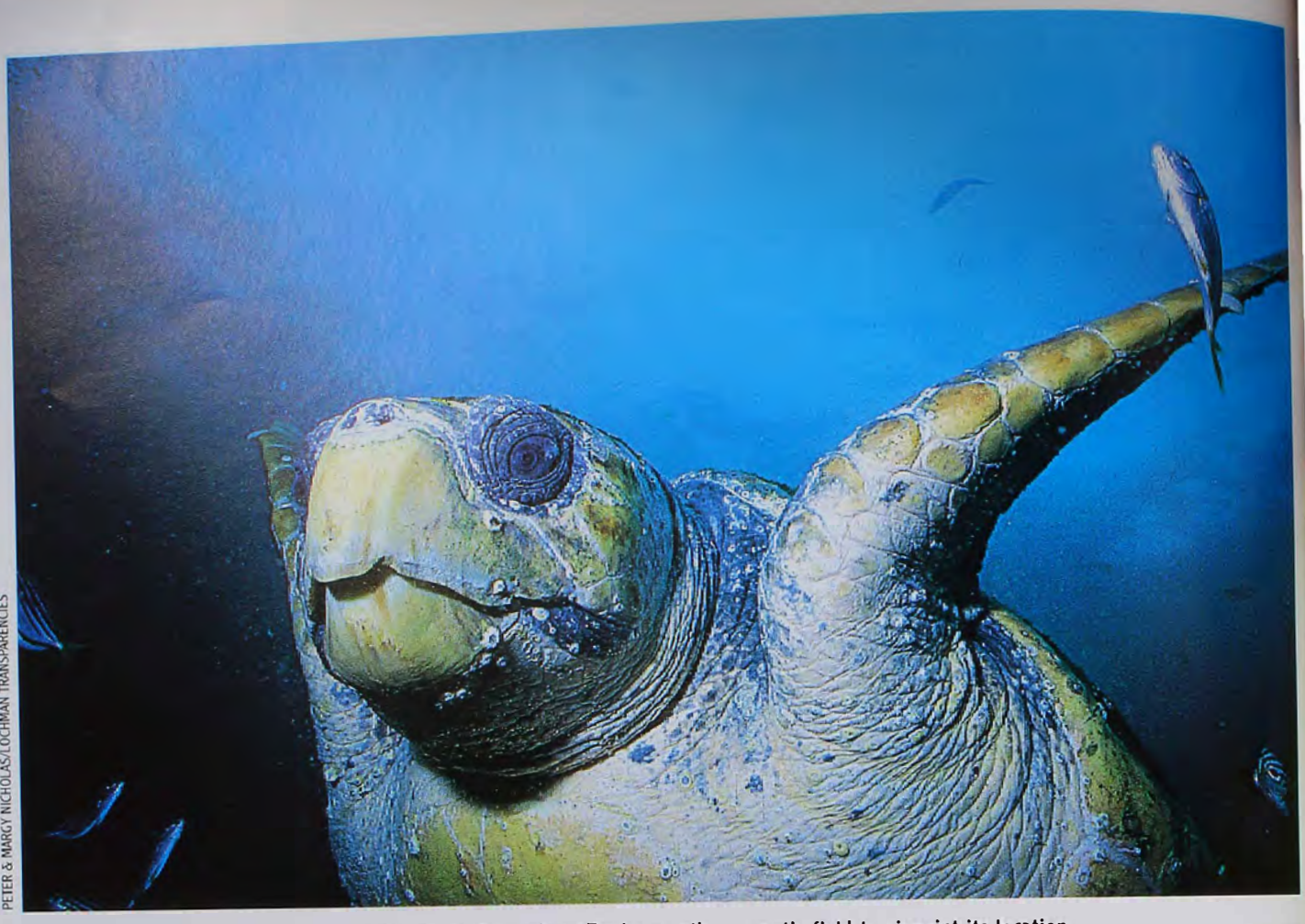
For this reason, says Kardong, it is important in evolutionary studies of snakes to clearly discern between the various biological roles of oral secretions and not simply their pharmacological qualities.

—K.McG.

Magnetic Map Readers

You may wonder how sea turtles manage to migrate across the thousands of kilometres of open ocean between their feeding grounds and the beaches on which they nest, without a map. Well, according to Kenneth and Catherine Lohmann of the University of North Carolina, not only do the turtles have a map, but they're pretty adept at reading it.

Scientists have long debated whether or not animals can pinpoint their location using the Earth's magnetic field. For an animal to possess such a 'magnetic map' it would need to be able to detect two different features of the magnetic field, both of



PETER & MARGY NICHOLAS/LOCHMAN TRANSPARENCIES

At last researchers have worked out exactly how the Loggerhead Turtle uses the magnetic field to pinpoint its location.

which varied in a different direction across the surface of the Earth. These features would then act in much the same way as our latitude and longitude, giving each place on Earth a unique 'address'. The two most suitable features are the strength of the magnetic field and its inclination angle (the angle at which magnetic field lines intersect the Earth's surface).

The Lohmanns studied the behaviour of hatchling Loggerhead Turtles (*Caretta caretta*) that migrate east from their Florida birthplace towards the North Atlantic gyre—the circular current system that surrounds the Sargasso Sea—where they feed and grow for several years. It is critical for the young turtles to stay within the confines of the gyre. If they go too far north they will enter cold water and freeze to death; if they go too far south they risk being swept into another current system that can carry them thousands of kilometres from their normal range.

The researchers placed the baby turtles in a circular fibreglass tank filled with water. Around the tank was a computerised coil system that controlled the magnetic field strength and its inclination angle. They found that when they subjected the turtles to a magnetic field whose inclination angle corresponded to that along the northern edge of the gyre, the turtles swam south, into the gyre. An inclination angle corresponding to that along the southern edge of the gyre caused them to swim north–northeast, again into the safety of the gyre.

So, the Lohmanns had demonstrated that, by using the inclination angle, the turtles could approximate their latitude. But what about longitude? For this study they placed the hatchlings in a tank, but kept the inclination angle constant while varying the magnetic field strength. Again the hatchlings swam in the direction that would keep them within the confines of the gyre: east when they were in a magnetic field with the same strength as that encountered on the western side of the gyre, and west when they were in a field equivalent to that east of the gyre.

Together these two experiments provided the researchers with strong evidence to support the notion that the turtles have the sensory abilities they need to qualify as magnetic map readers.

—G.T.

If they go too far north they will freeze to death; if they go too far south they risk being swept into another current system.

Pass the Parcel

Drinking from mud puddles may not seem to be a particularly effective way to prepare for a date, but that's exactly what males of one American moth species (*Gluphisia sepentrionis*) do. These 80-milligram moths have been observed drinking for several hours, pumping an incredible 10–50 millilitres of fluid through their gut and voiding it in jets that may be squirted distances of up to 40 centimetres. The total amount of fluid expelled from the moth in one sitting can exceed 600 times the moth's body mass. The function of this so-called 'puddling' behaviour has now been elucidated by two researchers at Cornell University in New York.

It has long been suggested that puddling, which is more commonly seen in butterflies, has something to do with the uptake of sodium. Indeed, when Scott Smedley and Thomas Eisner analysed the sodium levels of male moths they found that those that had puddled had higher sodium levels than non-puddlers.

But why do the males pud-

Wetland birds discovered in new habitat.

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dle when the females don't? Acting on a hunch that it had something to do with reproduction, the researchers released puddler and non-puddler males into a mating chamber with a virgin female. They found that the bodies of puddlers had lower sodium concentrations after mating and that females, after mating with puddlers, had higher sodium concentrations than those that had mated with non-puddlers. Furthermore the eggs of puddler-mated females were found to contain higher levels of sodium than eggs sired by non-puddlers.

These results suggest that sodium is passed from puddler males to the females during mating (presumably via the spermatophore), and from the females to the eggs. Smedley and Eisner suggest that this 'gift' helps the newborn caterpillars overcome the low level of sodium in the leaves of their food plant.

But why don't female *Gluphisia* puddle directly? First, females are not equipped with the greatly modified gut that appears necessary for the passage of huge amounts of fluid and the uptake of sodium. And second, for females whose cost of reproduction is already much higher than males, puddling is too energetically expensive and risky, as they must sit for hours at the edge of puddles, often containing hungry frogs!

—G.T.

COURTESY CHARLES CLARKE

Ant Garbos

Talk about consorting with the enemy. Charles Clarke and Roger Kitching of the University of New England have uncovered a case of an insect in collusion with a traditional foe—a carnivorous plant. As long ago as 1904 it was suggested that *Nepenthes bicalcarata*, a carnivorous pitcher plant found in Borneo, was 'tended' by ants. The ants make a nest in the hollow tendrils that connect the ends of the leaves to the pitchers. It was assumed that,

It's clear what the ants get out of this association, but what's in it for the pitcher plant?

in return for sleeping quarters, the ants ate the animals on and around the plant, thereby reducing the effects of herbivory. However, the full story has only recently come to light.

Clarke and Kitching studied the pitcher plants along an abandoned railway line in Brunei. The ants (*Camponotus schmitzi*) appeared to ignore any animals that visited the plant and instead foraged in the pitcher itself, swimming in the fluid and removing for consumption any large prey items they encountered.

When there weren't any large prey items available, the ants turned their attentions to mosquito larvae. Two worker ants would enter the fluid together and herd the larvae into a small group against the pitcher wall. One ant would then leave the fluid, remaining just above the surface, while the other would accelerate around the wall of the pitcher, slamming into the larvae and carting off any it managed to grab hold of.

It's clear what the ants get out of this association, but what's in it for the pitcher plant? The researchers noticed that when large prey items were caught in the pitcher they often went putrid, eventually killing the plant. Clarke and Kitching investigated this by placing dead members of a particularly large species of ant into colonised and uncolonised pitchers. They observed the pitchers for five days and found that, in the colonised pitchers, half of the large dead ants were removed and only one of 45 pitchers went putrid. On the other hand none of the prey items was removed from the uncolonised plants and a quarter of the pitchers went putrid. So, it seems, in return for food and lodgings, the ants provide the pitcher plant with a garbage removal service.

—G.T.

Curious bedfellows? The curly hollow tendril of this carnivorous pitcher plant (*Nepenthes bicalcarata*) is home to a species of ant.

See-through Nests?

Small birds often decorate their nests with lichen flakes and white spider cocoons. It is generally agreed that this is an attempt at concealment from predators.

Exactly how this works, however, has not been clear. The idea that the decorative additions camouflage nests by making them blend into the branches upon which they are built has been popular. But Mike Hansell, from the University of Glasgow, favours a different explanation.

Hansell examined 64 nests of the Blue-grey Gnatcatcher (*Polyoptila caerulea*), 42 nests of the Long-tailed Tit (*Aegithalos caudatus*) and single nests from 50 other species, all of which used lichen and spider cocoons.

He found little support for the suggestion that the nests were decorated to match the branches to which they were attached. In fact, in most cases the branches bore no lichens and, when they did, the lichens on the nests weren't even the same colour as those on the branches. Many of the nests were also

much wider than the branches they were on, making it unlikely they were being made to look like tree limbs.

Instead, Hansell found support for the theory that the lichens and cocoons worked as light reflectors to camouflage nests. When decorated with pale lichens or spider cocoons, the nests, instead of looking like dark shapes in the tree, dissolve into the background. Nests with a few pale patches create the illusion that light is passing through them, making the nests look, to a potential predator, like nothing at all.

—K.McG.

MIKE GRAY

When this juvenile male Redback Spider grows up, he will sacrifice himself to the female during sex. But male suicide in Redbacks is cheap.

Redback Suicide

The love lives of Redback Spiders (*Latrodectus hasselti*), in which males offer themselves as a coital snack, are legendary. Suicide seems a high price to pay for sex, but new research by Maydianne Andrade (now at Cornell University) provides the first empirical evidence that male suicide is both adaptive and sexually selected.

During copulation, males somersault over their mate, placing their abdomen above the female's jaws. Andrade observed that, while all males performed the somersault manoeuvre (often twice—first with one mating palp and then with the other), only two-thirds ended up being eaten. Their fate is related to the female's hunger level.

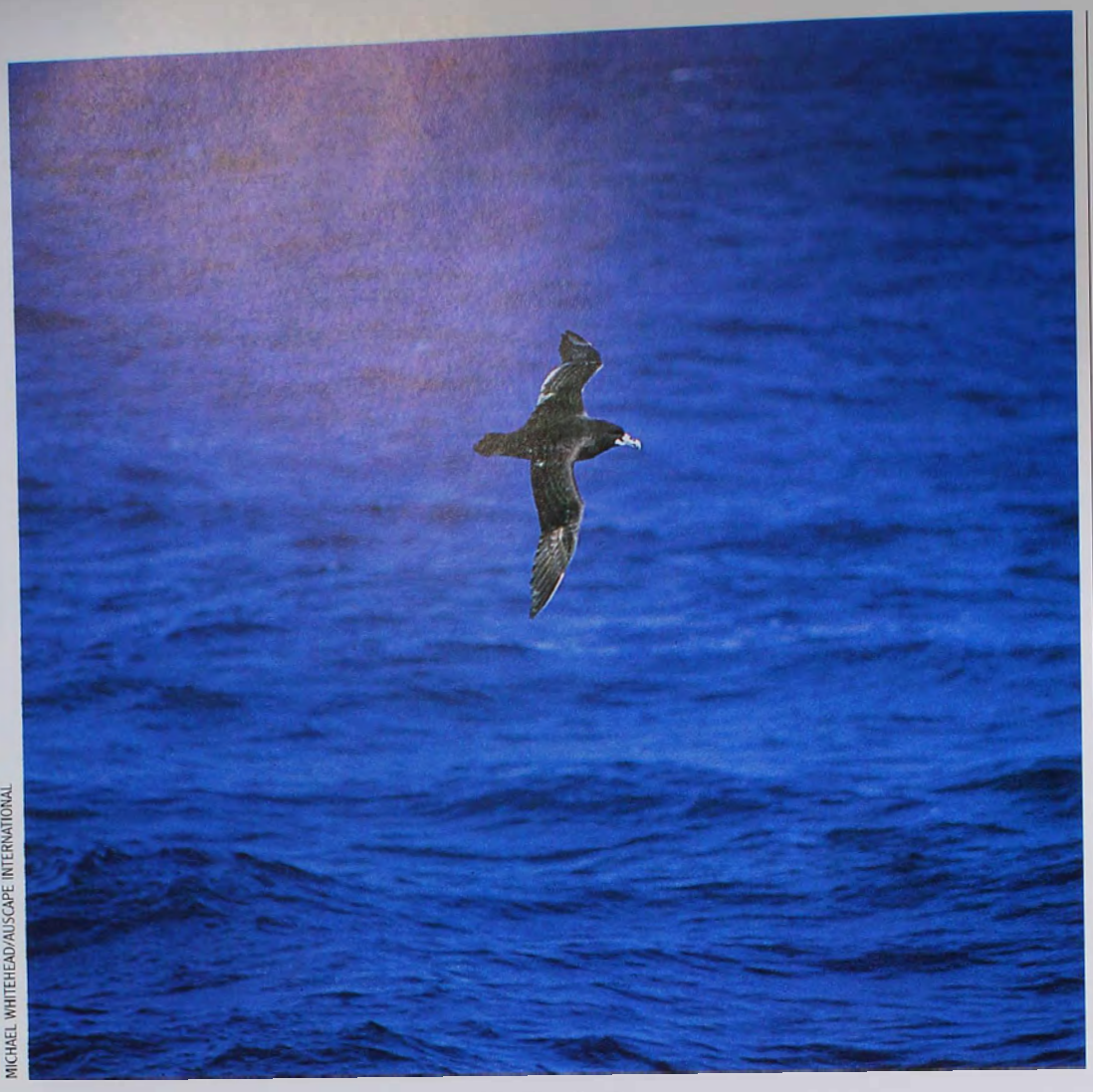
Andrade disregarded paternal effort as the reason for the male's willingness to be eaten, because separate laboratory tests showed consumption of a single male does not result in increased numbers of eggs or a greater egg mass for his partner.

She found, however, that longer copulation allowed the transfer of more sperm, and that females permit longer matings when they are engaged in eating their partners. Females were also found to be less likely to remate if they had eaten their first partner.

For males, whose life span is shorter than females' anyway, the cost of being cannibalised is low because they are unlikely to mate again even if they do survive. The tips of the male's mating palps always break off during copulation, rendering them useless for any further mating attempts.

Many male arthropods present 'nuptial gifts' to their mates, and Andrade concludes that the male Redback's willingness to be cannibalised probably evolved through sexual selection for the most extreme mating gift.

—R.S.



MICHAEL WHITEHEAD/AUSCAPE INTERNATIONAL

When looking for food, White-chinned Petrels follow their nose.

Seabirds Smell their Dinner

The smell of rotting seaweed may make most of us wrinkle our noses in disgust. But to a seabird searching for food in a vast featureless ocean, it's like a flashing neon sign.

Results of recent research by Gabrielle Nevitt (University of California) and colleagues support a long-held theory that seabirds forage by using their sense of smell.

In the waters around the sub-Antarctic island of South Georgia, the researchers created small slicks of vegetable oil to which a chemical called dimethyl sulphide (DMS) had been added. DMS is a naturally occurring compound given off by microscopic plants in the plankton when they are grazed on by small animals like krill. Krill are a favourite food of petrels and other pelagic seabirds, so it would make sense for them to be able to detect DMS.

The man-made slicks were very attractive to several seabirds such as Wilson's Storm Petrel (*Oceanites oceanicus*), the Black-bellied Storm Petrel (*Fregetta tropica*), White-chinned Petrel (*Procellaria aequinoctialis*) and prions. Albatrosses (*Diomedea* spp.), however, showed no interest in the slicks, which tallies with their suspected visual foraging behaviour (they often find food by joining mixed feeding groups of seals, whales and other seabirds).

But the ability to detect DMS may not only help hungry birds to find food. The researchers point out that DMS concentrations tend to be highest in sea water associated with upwellings and shelf waters, and they suggest these features could help the birds, known for their long-distance seasonal migrations, to navigate their way around an otherwise barren landscape.

—R.S.

When Size Doesn't Count

We all know how important female choice can be in deciding which males get to mate, leading to all manner of male showiness, such as long tail plumes and elaborate dances. But for the male Black Wheatear (a type of small thrush), mating is just the beginning. Even after she's mated with him, the female wheatear still wants her male to prove his worth.

Around two weeks before the start of egg laying, male Black Wheatears (*Oenanthe leucura*) fly off in search not of food, but of rocks: small flat stones that they pick up in their beak and carry back to the nest site. These 35–40-gram birds carry on average almost two kilograms of stones. Although these stones usually form the foundation of the nest, they have no obvious function in terms of support, insulation or protection from predators. Instead, it appears that the

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Faithful parents don't always share the work load: for Kirk's Dik-diks, the male doesn't lift a hoof.

females use the number of stones that their mates carry to determine his quality and hence to help them make certain decisions about their reproduction.

To test this idea, Manuel Soler (from the University of Granada in Spain) and colleagues manipulated the numbers of stones in Black Wheatear nests and then observed how the females reproduced.

Nest sites often contain stones from previous nests. When the researchers removed these old stones it had no effect on the number of new stones the males carried, nor on the reproductive behaviour of the females. However, when they removed new stones, halving the number of new stones every second day, the males worked harder to make up the deficit. The females rewarded this diligence by laying their eggs earlier and producing more young. Addition of new stones caused the males to reduce their effort and the females followed suit, laying later and producing fewer young, even though the rock pile was actually bigger.

So, for Black Wheatears at least, size doesn't matter. The females weren't interested in how big a male's pile of stones was but in how much effort he put into building it.

—G.T.

Useless Dik-dik

In most mammal species, the females look after their young on their own, freeing males from parental duties. As a result males normally compete to mate with as many females as possible. But some (five per cent) are monogamous, with males and females working together to raise their young. In the case of monogamous dik-diks (dwarf antelopes), however, males have recently been found to be completely useless to females and their offspring—the first conclusive demonstration of the absence of paternal care in a monogamous mammal.

Peter Brotherton and Anna Rhodes from the University of Cambridge studied 23 pairs of Kirk's Dik-diks (*Madoqua kirkii*) in Etosha National Park, Namibia. They looked for three separate behavioural traits in males that would indicate some measure of paternal care—defending food resources for their mates, guarding offspring against other infanticidal males, or sharing the burden of keeping watch for predators.

Unfortunately for the females, the only thing their partners were observed doing was chasing other males away, although they were tolerant of foreign females. Because this aggression is sex specific, males can't be considered to be defending resources.

There was no evidence of males attacking unrelated babies, nor were there any signs that males were more watchful for predators than their partners. In fact, when the researchers played a tape of an African Hawk Eagle (*Hieraaetus spilogaster*), a predator of young dik-diks, females stayed alert for up to 20 times longer than their mates.

Because the potential reproductive rate of males is higher than for females, it is hard to imagine why males would remain faithful unless it conveyed some advantage. Well, say Brotherton and Rhodes, there is intense competition among males, and to stand any chance of reproducing, now or in the future, a male has to defend his mate year-round against other potential suitors.

—R.S.

Insects and Elephants Follow the Same Scent

Pheromones are volatile compounds that are produced by many animals to entice a mate. In some cases, only a few molecules of the pheromone are all that is needed to attract a potential partner kilometres away.

Females of many insect species, especially butterflies and moths, release a pheromone with the active compound (Z)-7-dodecen-1-yl acetate (or 7-DDA for short).

And, in an amazing example of convergent evolution, researchers have now found that female Asian Elephants (*Elephas maximus*) attract their mates with exactly the same compound, released in the urine during oestrus.

Why should such different animals as moths and elephants hit on the same chemical to seduce mates?

Bets Rasmussen, from the Oregon Graduate Institute of Science and Technology, and colleagues presented male

elephants with a range of substances, including samples containing known concentrations of 7-DDA, and urine from oestrous, as well as non-oestrous, females. Male elephants were found to react positively to samples containing 7-DDA, but not to the non-oestrous urine, and other controls. Interestingly, 7-DDA in water was less effective than the same concentration in non-oestrous urine, suggesting that something else in the urine (possibly proteins) enhances the compound's effect.

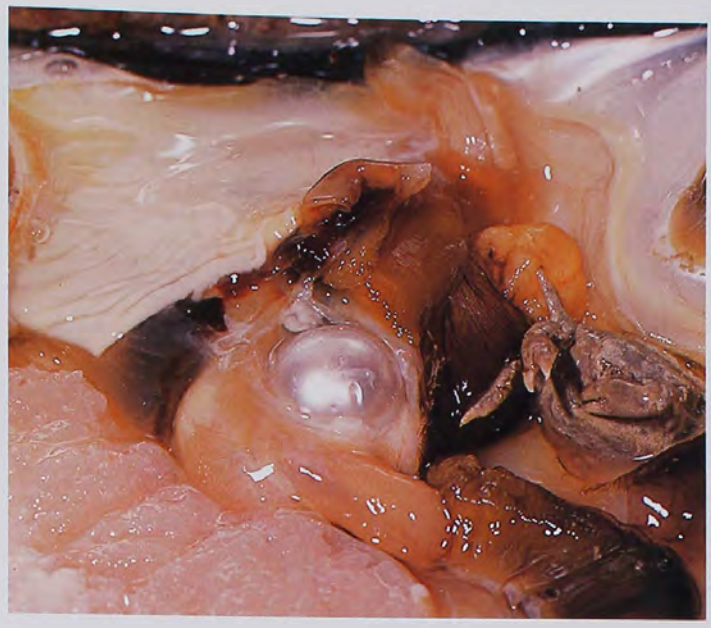
But why should such different animals as moths and elephants hit on the same chemical to seduce mates? The compound's volatility may be responsible, say the researchers. And what effect might elephant pheromones have on local insects that use the same pheromone? Presumably there is little confusion between species because of the different compounds and secretions in which the 'hot' compound is delivered. —C.B.

Pearls of Wisdom

It was the romantic but misplaced belief of Christopher Columbus that pearls originated from dew drops which fell from mangrove leaves into open shellfish where they 'crystallised' into a solid, lustrous form. Of course, we all now know that it is a grain of sand that stimulates the development of a pearl...or is it?

While it's true that both scientific and popular literature have definitely leaned in favour of the sand grain theory, Swiss gemmologist Eduard Gübelin argues that there is not a grain of evidence to support it.

According to the popular theory, the formation of a natural pearl is stimulated when a grain of sand penetrates certain bivalve molluscs between the shell and the outer shell-building layer of the mantle (epithelium), which lines the inside of the shell. A smooth pearl (which is essentially an inside-out shell) forms around the grain of sand to reduce its irritation to the animal. However, Gübelin argues that it would be extremely difficult for a sand grain to penetrate this region, unless forced. This is because, when shell is formed, the epithelium produces the first and outer shell layer (the periostracum) in the fold that runs right around the edge of the mantle, thereby forming a skin that seals off the space between it and the shell. Besides, of all the millions of pearls that have been drilled or X-rayed in the past, no-one has ever come across a grain of sand inside a pearl.



IRI LOCHMAN/LOCHMAN TRANSPARENCIES

The popular sand grain theory to explain the origin of a pearl has been seriously threatened.

After reviewing biological research carried out in Germany between the wars, Gübelin proposes an alternative theory. He believes that natural pearls begin as a result of abnormal growths, such as benign tumours, from the mantle. As with the sand grain theory, the epidermis gradually envelopes the tumour, continuing to secrete shell material, with nacre being secreted last, and in this way forming a pearl. The repeated development of such tumours is presumably inherited in certain species of bivalve molluscs.

Gübelin admits, however, that until it becomes possible to directly observe the process of pearl formation, exactly how and why it occurs will remain one of the great mysteries of nature.

—K.McG.

Beetles Shoulder the Burden

Rhinoceros beetles (family Scarabaeidae) are reputed to be the strongest of all animals, able to carry more than 850 times their own weight, according to some reports. To test this extraordinary claim, Rodger Kram, a physiologist from the University of California at Berkeley, measured how much weight the beetles could carry and the metabolic energy they needed to do it.

Kram built yokes for the beetles which he velcroed onto their backs. He loaded the yokes with lead weights and put the beetles on a treadmill in a special chamber. The beetles' oxygen use was estimated by measuring the difference in the amount of oxygen coming into and out of the chamber. These measurements were used to calculate the metabolic energy required by beetles under different loads.

Kram found that, in fact, rhinoceros beetles can't carry 850 times their own weight. When they carry 100 times their weight, they can hardly move. Loaded with 40 times their weight, they can plod for a while but soon get tired. But carrying 30 times their weight, they can maintain a steady pace. This is the equivalent of a man strolling along while carrying a large car.

Not only are rhinoceros beetles strong, they are cheap to run. For humans, carrying a given per cent of body weight increases metabolism by the same percentage. But rhinoceros beetles carrying 30 times their body weight only increased their metabolism by four times.

Why and how rhinoceros beetles should find large burdens so easy to shoulder is unknown. They don't carry any loads in the wild, but they do use their strength when burrowing through tough soil.

—C.B.

QUICK QUIZ

1. What do sanguinivorous animals eat?
2. Is Dutchman's Pipe animal, vegetable or mineral?
3. Which members of the Animal Kingdom have the largest eyes?
4. What are macropods more commonly known as?
5. Where on Earth was the two-kilogram meteorite known as ALH84001, and thought to contain evidence for life on Mars, found?
6. What do mycologists study?
7. Name the huge flightless birds that once lived in New Zealand.
8. How many legs does a cockroach have?
9. Who is the author of the 1995 book *The future eaters?*
10. What sort of plant is depicted on the new $5 note?

(Answers in Q&A)

MATHIE ATKINSON

Rhinoceros beetles are capable of carrying 30 times their own weight without slowing down.

Stay-at-home Salmon

When male Atlantic Salmon (*Salmo salar*) reach a certain age many leave the streams in which they hatched and head for the sea. There they feed intensively and grow rapidly before leaping up waterfalls and dodging hungry bears etc. to return to their birthplace to mate. But when they get there they find that they have tiny rivals—male fish that didn't make the oceanic pilgrimage but instead remained at home, growing little but maturing in comfort.

Matthew Gage and colleagues from the University of Liverpool in the UK wondered how this apparently lazy strategy could possibly pay off. The small fish, known as parr, weigh only a minute 0.15 per cent of the average body mass of the anadromous males (which have made the journey to sea and back) and must gain fertilisations by sneaking in and showering the eggs with their sperm while the big anadromous males are occupied with the same activity.

What the researchers found was that the tiny males pack a big reproductive punch. Although their smaller size means they have smaller testes and produce smaller numbers of sperm, as a proportion of body size their testes were actually twice as large and they produced more sperm and a greater volume of ejaculate. And, although the sperm sizes were the same, the parr produced a greater propor-

COURTESY MATTHEW GAGE

Large male Atlantic Salmon that return from sea to mate find themselves competing with diminutive home bodies.

tion of motile sperm and those sperm lived longer than those of their competitors.

So why don't all salmon take the stay-at-home option? Although they achieve a higher proportion of fertilisations than would be expected given their tiny size, the parr can still only fertilise around five per cent of the eggs during a spawning. They are attacked by the anadromous males and are not attractive to females as mates. So, although it involves a lot more effort and a fair degree of risk, a trip to the ocean is still the best strategy for a male salmon that wants to maximise his reproductive success and make lots of baby salmon.

—G.T.

Lizard's Green Beret

They say that a rolling stone gathers no moss and it seems that this piece of folk wisdom is true for the animal kingdom too. The occurrence of epizoic plants (plants growing on the bodies of living animals) is rare and appears to be restricted to long-living, slow-moving animals in the tropics. These include giant tortoises in the Galapagos that have lichens growing on their carapaces, sloths turned green by the algae living on their hair, and various sluggish beetles and weevils in the forests of Papua New Guinea that grow a veritable forest on their backs containing algae, fungi, lichens, mosses and liverworts.

Now the rather dubious honour of membership in this select club has been granted to a lizard. *Corythophanes cristatus* is a Central American rainforest lizard that does a very good imitation of a dry branch. It spends hours sitting motionless on the side of a tree, waiting for food to trundle past.

While in the rainforests of southern Mexico, Rob Gradstein (University of Göttingen, Germany) and Clementina Equihua (University of Mexico) found one of these lizards sporting a very tasteful green hat made up of four different species of algae and a liverwort, the latter being the first known example of a cormophytic plant (one that has stems and leaves) living on a vertebrate.

The cranial garden growing on this Mexican rainforest lizard (*Corythophanes cristatus*) makes the lizard even harder to see.

COURTESY S.R. GRADSTEIN

The back of these lizards' heads are slightly concave, creating an ideal spot for a cranial garden. Spores can easily lodge there and be watered by rain drops and moisture dripping from the trees, the lizards' immobility ensuring nothing is dislodged.

Unfortunately when the lizard sheds its skin its vegetative headgear will probably be lost and the plants may not be able to reach sexual maturity. However, because many rainforest lizards shed their skin quite infrequently and often do so incompletely, the plants may well remain, giving the lizard a little bit of added camouflage and keeping it at the top of the sartorial stakes.

—G.T.

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

It is undoubtedly the most successful and adaptable of all the animals introduced into Australia.

HOUSE MOUSE ROUSE

BY STEVE VAN DYCK

AT NINE YEARS OLD I became suspicious of my parentage on account of some pet House Mice. The mouse cage was a Hilton edifice, a '50s kitchen dresser more reluctantly relinquished by my father to me for a rodent house than it had been by my mother to him for a tool cupboard. It had sliding ripple-glass doors on the top floor, cutlery-drawer bedrooms in the middle, and a labyrinth of ramps and cardboard pipes in the lower compartment. It was very high on 3-D, but low on ventilation.

I bought two pairs of white mice from an old Sydney pet shop that reeked deliciously of ferrets and fouled bird seed. Once installed in the Hilton, it took them about three days to cloy the whole garage with that polluting, pasty mouse aroma (mostly male!) that reminds me of a pâté of garlic and boot mould. By the fourth day the two males had gouged great hunks from one another's rumps so I was forced to find other accommodation for the old scabby male the pet shop lady had off-loaded onto me and stuffed into the bayoneted shoe box before I could tell her he looked mean and unhealthy and I wanted to choose another.

By the end of the third week, both females were as fat and shiny as Packham pears, and the memorable morning they synchronised births was also the breakfast at which they tore their little newborn pinkies apart and devoured them like a couple of frenzied White Pointers.

The local chemist prescribed 'Wheat-Hearts' to cure their post-partum–post-pet-shop blues, and 19 days later the white Packham pair exceeded themselves in producing 18 pink, squirming jelly beans. The good ladies restrained their appetites and the birthday party was a great success.

I don't think I was being unreasonable in expecting 18 naked pups to sprout 18 white fur coats at about a week old, but when brownish-grey velvet began covering them, it all got a bit confusing.

My father was approached with the problem of explaining the genetic engineering going on in the tissue-stuffed cutlery drawers. He deftly explained it in terms of his black hair and my brown, but when I later opened the cage and got a glimpse of an unmistakably wild brown mouse slipping out a hole in the bottom, I put two and two together and started worrying whether our friendly baker with the curly brown hair confined his attentions to delivering just the bread.

Some Don Juan from the compost heap must have found the perfume of Snow White and her sister so besotting that he risked life and limb chiselling in from west of the wall to pledge his troth to the two ladies. Maybe he just liked Wheat-Hearts better than potato peel.

As romantic as it sounds for us city slickers to refer to the small mice our cats bring in as 'Field Mice', there are no real Field Mice in Australia. They are all the same smelly old House Mouse (*Mus musculus* or *M. domesticus*, depending on the prevailing taxonomic wind) that arrived with the First Fleet in 1788, if not much earlier on other ships. That same animal is the black-and-white pet shop mouse, the white laboratory mouse, the

KATHIE ATKINSON

House Mouse populations often irrupt into plagues, during which they can number several thousand individuals per hectare.

KATHIE ATKINSON

The sight of a House Mouse loose in the kitchen sends most people rushing for the mouse trap!

brown grain-shed mouse, the one that dies in the bottom of the potato drawer, the one that shorts out the dishwasher, and the one that often comes into the Queensland Museum for identification inside hamburgers and packs of walnuts or dried fruit.

It is undoubtedly the most successful and adaptable of all the animals introduced into Australia, being just as fecund inside functioning refrigerators and cold rooms (at –10°C) as it is in 40° C heat inside sun-blasted metal shipping containers. Its numbers may irrupt to plagues in grossly disturbed habitats. It even occurs in Antarctic bases. It is definitely not, however, the only mouse found in Australia.

We have our own designer suite of around 30–35 species of small native mice, plus another 30 or so larger species that, following European convention, we call rats. Some mice are adapted to mud and mangroves, some to harsh waterless deserts, some to wet heathland. A few are virtually indistinguishable externally from the House Mouse. None, however, has a distribution that covers all mainland Australia (and most of its islands) as does the House Mouse. One island-bound population of the Lakeland Downs Mouse (*Leggadina lakedownensis*) may be threatened by irruptions in House Mouse numbers, but other species, like the New Holland Mouse (*Pseudomys novaehollandiae*), might push out and thereafter exclude House Mice from mined or burnt areas.

During plagues, which occur every four years or so in the grain belt, House Mice may number several thousand individuals per hectare. Life is predictably quick, cheap and nasty, ending in a bird of prey's claws or a ditch alongside other exhausted relatives. Females characteristically become infertile in high-density populations, the vagina permanently closes and the uterus becomes thin and non-functional. In 1907 Dudley Le Souef, while Director of Melbourne's Zoological Gardens, quoted the following newspaper report: "For three months or more, the country around Merriwa and probably far beyond, has been subjected to a plague of mice so numerous as to beggar description. Recently on the premises of a general store 10,000 mice were destroyed in four nights. Upwards of 500 were captured while a cricket net was being unrolled. Four bushels of oats in a bag were appropriated by the mice in a night. A local well ceased to yield water and on examination it was found to contain a solid mass several feet thick of dead vermin...".

While House Mice are smelly nuisances and a serious economic pest, the other side of the coin shows that for just about everything we eat, rub into our skin, drop into our eyes, inject into our muscles, or wash our hair with, it has all been tried out on the poor old House Mouse, *ad nauseam*, long before it hit the market.

But royal food-taster or not, the ones around our place still break their necks to get the lowly pumpkin seed from the trap every time we set it.■

HOUSE MOUSE

Mus musculus

Classification

Order Rodentia, family Muridae. Considered by some to be *Mus domesticus*.

Identification

Yellowy-brown to blackish with grey belly (more coastal populations), biscuit-brown to creamy-fawn with pure white belly (central desert areas); head–body length 60–100 mm; tail about 85 mm; 10–25 g. Distinguished from native species by a notch behind the cutting edge of the two upper incisors. This can be seen with a hand lens in living animals. Females have 5 pairs of teats compared with 2 pairs in native mice. Native mice lack characteristic *Mus* stink.

Distribution and Habitat

Originally from Europe and across the Asian steppes to Japan. In Australia occurs in most habitat types, but mostly in disturbed habitats and as a commensal of humans. The present domestic strains are derived from both European and Japanese 'fancy mice', which were bred as pets/curios, particularly in Japan, in the 19th century or even earlier.

Behaviour

Nocturnal except when populations dense, home range might be as small as 30 square metres. Becomes sexually mature at 8 weeks; 4–12 young per litter; gestation period 19–20 days; up to 11 litters per year. Average life span less than a year, max. 2 years. Hears sounds up to 40,000 Hz. Young pups, in particular, communicate with their mother by ultrasonic (>20,000 Hz) calls well above our hearing. Omnivorous but prefers grain and grain products.

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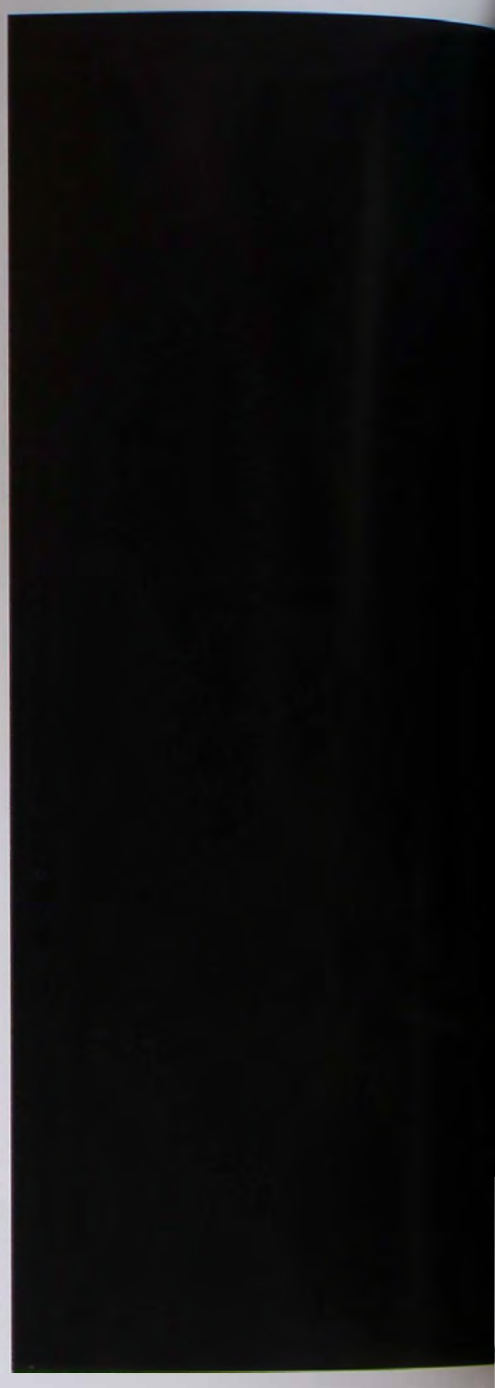
Steve Van Dyck is a Curator of Vertebrates at the Queensland Museum where he has worked since 1975.

The slightly pendulous, green and purple flowers are just under a centimetre long with a faint unpleasant odour.

TINGLE TAIL-FLOWER

BY GRANT WARDELL-JOHNSON



Its unusual habit, the potential for many members of the potato family to contain chemicals of major pharmaceutical significance, and the possibly relictual nature of the species, make it worthy of detailed study.

THE TINGLE TAILFLOWER (*Anthocercis sylvicola*), a rare new species from the potato family (Solanaceae), has recently been described from the high-rainfall tingle (*Eucalyptus jacksonii* and *E. guilfoylei*) and Karri (*E. diversicolor*) forests of Walpole, south-western Australia. It is the only member of the genus confined to tall open-forest. The species name *sylvicola* (dweller in forests) is from the Latin *sylva* (forest or wood), and *cola* (dweller), in reference to the habitat of the species.

The Tingle Tailflower was first collected in the 1960s but had not been relocated since that time, nor described. It was abundant in a small area of Karri/tingle forest near Walpole during a floristic survey of the area in 1989. Subsequently another small population was discovered 30 kilometres to the north, and another 6.5 kilometres to the west. Being known from just three populations within an area of less than ten hectares, the Tingle Tailflower is thought to be the most geographically restricted species, in a genus notable for restricted species, and is thus of considerable conservation interest.

Each of the known populations is situated at the base of a granite outcrop. Similar sites exist as islands in the tall Karri/tingle forest throughout the Walpole area. However, given that there has been considerable botanical survey work in the region, the species appears to be genuinely rare. While it is possible that further populations await discovery, particularly in the Soho Hills to the north-east and Sharp Forest Block to the north-west, the dense vegetation and poor access to these areas would make surveying difficult.

It is a spiny shrub up to 2.5 metres tall with stems up to 1.5 centimetres in diameter. Its growth habit is unusual, being sometimes erect but often fallen to an inclined or horizontal position with erect branches. Thus it resembles a small prickly version of Tasmania's Horizontal Scrub (*Anodopetalum biglandulosum*). Although no evidence has been found of rooting from trailing branches, there is nevertheless some difficulty in deciding what constitutes an individual plant.

The Tingle Tailflower has another unusual growth habit. It, like several other species of *Anthocercis*, is deciduous or at least semi-deciduous. Although there is no totally leafless period, the old leaves are shed just as the new leaves start to shoot. A few species such as *A. genistoides* and *A. gracilis* are totally deciduous, losing their leaves during the warmer, drier part of the year. Thus some *Anthocercis* species share growth characteristics with many plants from the tropical north of Australia.

Flowering occurs from September to February and up to five distinctive flowers sprout in short clusters near the ends of the branches. The slightly pendulous, green and purple flowers are just under a centimetre long with a faint unpleasant odour. Fertile fruits have not been seen, although insects have been observed visiting the flowers. Sterile fruits have been collected in December and February. The long flowering period and moderate abundance of flowers suggest that the pollinator has become rare or extinct. It is possible that the species seeds rarely in unusual conditions and that, like many other species in the

GRANT WARDELL-JOHNSON

genus, it has long-lived, soil-stored seed. If that were the case, the species may well become more abundant following fire. Although the damp substrate that forms around the base of granite outcrops of known populations naturally protects them from frequent fire, it is inevitable that they are burnt occasionally. Clearly the response of this species to fire is worthy of examination.

The discovery of a species of *Anthocercis* confined to tall open-forest of the High Rainfall Zone is significant. Its two closest relatives (*A. genistoides* and *A. anisantha*), also from the south-west, are species of the Transitional Rainfall Zone. Although *A. gracilis*, another local endemic, is also a forest species of the High Rainfall Zone, it occurs in the more seasonal environment of the Darling Scarp.

It is possible that the Tingle Tailflower represents an early lineage in the genus *Anthocercis* and that its populations are relicts from former wetter times. Its unusual habit, the potential for many members of the potato family to contain chemicals of major pharmaceutical significance, and the possibly relictual nature of the species, make it worthy of detailed taxonomic and ecological study. Once this work is done we will be in a better position to manage the species, ensuring that it holds its own in the Karri/tingle forests of the south-west.■

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Dr Grant Wardell-Johnson has extensive experience in south-western biogeography and ecology, and undertook the floristic survey of the Tingle Mosaic in the Walpole area. He is currently based at the University of Namibia where he is carrying out a biogeographic overview of the region.

How a South American weed came to be used in such like ways in such distant places is a puzzle to me.

STROLLS ON STRADBROKE

BY TIM LOW

IN 1823, THREE TICKET-OF-LEAVE convicts—Pamphlet, Finnegan and Parsons—were caught up in a storm and shipwrecked on Moreton Island. They borrowed a canoe and crossed to Stradbroke Island where, for 39 days, they enjoyed the hospitality of island Aborigines, who plied them with fish and sustaining starch of Bungwall Fern (*Blechnum indicum*). They were later rescued by explorer John Oxley, who was helped by Finnegan to discover the Brisbane River.

More than 170 years later, Stradbroke Island still supports a large Aboriginal community. There are older Aborigines who still know their wild foods, and they are still hospitable to visitors. On two recent trips to the island I was privileged to go bush with perhaps the most knowledgeable island resident, 'Auntie' Margaret Iselin. As a child in the 1930s she was one of five or six girls taken on bush walks by two elderly 'grannies' living at Myora Mission. Although she no longer gathers many plants, Margaret has remarkably clear recollections of how they were used.

Margaret showed me dozens of plants used for food, medicine, weaving and dyeing. If much of what she said was familiar, a surprising amount was new. I found it remarkable that I could be within view of Australia's third largest city, in the 1990s, recording significant new information about Aboriginal culture.

In a patch of heathland Margaret showed me "tittybottle", a heath shrub (*Leucopogon leptospermoides*) with tiny cream fruits, sweet to taste, and vaguely resembling teats, hence the name. Growing beside it was "citronella", a tea tree (*Leptospermum juniperinum*) with fragrant foliage that was placed under mats to repel fleas and other insects. Other plants nearby were a sawsedge (*Gahnia* sp.), once strung together to make brooms, and "honeysuckle" (Coast Banksia, *Banksia integrifolia*) with bark that was boiled in drums to tan cotton fishing nets to make them stronger. These plants were typical of many I was shown, in having a name or a use that wasn't completely traditional.

Yet some of the plants were less traditional than this; they were weeds. Margaret showed me White Passion-

PHOTOS: TIM LOW

Madagascar Periwinkle, according to Margaret, was a remedy for diabetes, diarrhoea and stomach problems. Leaves were boiled and the liquid drunk.

fruit (*Passiflora subpeltata*) and Guava (*Psidium guajava*) with their edible fruits, Inkweed (*Phytolacca octandra*) used for dyeing reeds, and Redhead Cotton Bush (*Asclepias curassavica*), Madagascar Periwinkle (*Catharanthus roseus*) and Blue Billygoat Weed (*Ageratum houstonianum*), which served as medicines.

Whenever I visit the less-remote Aboriginal communities I am usually shown a few edible and medicinal weeds (see *Nature Aust.** Spring 1993 on Tasmania's Aborigines). Even so, the extent of weed usage always surprises me. I was certainly wide-eyed when Margaret told me that in times past the "witchdoctor of the tribe" crushed the seed of the Castor Oil Plant (*Ricinis communis*) as a purgative. A witch doctor doling out castor oil—what an image!

I never expected to actually meet someone who would remember this food.

Another interesting remedy was Blue Billygoat Weed, which was crushed and applied to stings. This South American weed (or the closely related *A. conyzoides*) was used by Aborigines at Innisfail and along the Daintree River to treat scratches, wounds and sores; similar uses are recorded from India and Nigeria. How a South American weed came to be used in such like ways in such distant places is a puzzle to me.

Of the native remedies, I was curious when Margaret told me about "sarsaparilla" (False Sarsaparilla, *Hardenbergia violacea*), a vine with leaves that were boiled to make a blood tonic. I strongly suspect this remedy originated in Sydney, among white colonists, who are known to have substituted False Sarsaparilla for Sweet Sarsaparilla (*Smilax glycophylla*), a scurvy treatment of First Fleet convicts. Aborigines traditionally did not boil medicines, nor did they talk of tonics or treating blood.

The use of Sida Retusa (*Sida rhombifolia*) to treat diarrhoea, Pennyweed (*Centella asiatica*) for arthritis, Madagascar Periwinkle for stomach problems, diarrhoea and diabetes, Castor Oil seed as a purgative and Common Sowthistle (*Sonchus oleraceus*) as a vegetable are also, I believe, uses borrowed from white Australians. They were probably introduced to the Aboriginal community by mission staff or white residents of Stradbroke.

*Previously ANH

Margaret's amazing bush lore is thus a potpourri of old-time white and black usage.

Of the native foods Margaret showed me, I was especially delighted to be shown Climbing Maidenhair Fern (*Lygodium microphyllum*). Only one doubtful record exists of Aborigines eating the starchy underground stems on Moreton Island over 160 years ago. I never expected to actually meet someone who would remember this food.

My second trip to Stradbroke Island was sponsored by Redlands Tourism, which is promoting tourism on the island. The company has employed a young Aborigine, Matthew Burns, to run wild foods tours, and I was asked to help train him. The real teacher, of course, was Margaret.

That was a few months ago. I can now report that the 'Goompi Trail' is up and running. It is pleasing to know that Margaret's expertise will not be forgotten; that it has passed to a new generation. Now white Australians visiting the island, like Pamphlet, Finnegan and Parsons long ago, will have the chance to experience Aboriginal culture, Stradbroke Island style.■

Succulent stems of Blue Billygoat Weed were crushed and applied to stings on Stradbroke Island.

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Tim Low is a Brisbane-based environmental writer and consultant. He has written four books about wild foods and medicines.

One can only marvel at the blow of a whale issuing from an apparently unbroken field of heavy ice extending to the horizon.

WHALES IN THE FREEZER

TEXT & PHOTOGRAPHY BY PETER GILL

ANTARCTICA IS THE MOST seasonally influenced of all the continents. Summer sunlight and warmth stimulate biological activity on a massive scale in its surrounding seas, as the covering of sea ice shrinks to its minimum. Baleen whales return from their winter breeding haunts, drawn by the promise of Antarctic Krill (*Euphausia superba*), and bull Sperm Whales (*Physeter macrocephalus*) and beaked whales dive to astonishing depths for abundant squid. Seals, most penguins and other seabirds rush to complete their breeding cycle during the brief summer months. By early April breeding is finished, and migratory species are moving north. This seasonal activity is not just limited to Antarctica's animal life. Most Antarctic research also takes place during summer, and there is now a broad understanding of the timing and dynamics of summer's biological processes.

At summer's end, however, a curtain comes down on the lives of the fauna that remains in the far south. Winter biological research is usually limited to animals that are easily accessed from coastal bases, such as Weddell Seals (*Leptonychotes weddellii*) or Emperor Penguins (*Aptenodytes forsteri*). What happens out at sea, where sea-ice* cover nearly quadruples in the winter darkness and cold, is largely unknown. We know that krill, the staple food of much Antarctic wildlife, winter here, as do species such as Adelie Penguins (*Pygoscelis adeliae*) and Crabeater Seals (*Lobodon carcinophagus*). But the handful of mid-winter voyages into the sea ice have been confined to the region of the Weddell Sea, below the tip of South America.

In 1995, however, Australian National Antarctic Research Expeditions (ANARE) conducted its first mid-winter marine science cruise into the sea ice to the south of Australia, principally to conduct glaciological and oceanographic research. As biologists involved with an ANARE program to survey whales in Antarctic waters, Deborah Thiele and I were able to obtain berths aboard *Aurora Australis*, ANARE's 5,000-tonne research icebreaker. Our brief was to record whale and seal sightings.

While it was long assumed that all whales migrate away from Antarctic waters by late autumn, in recent years Minke Whales (*Balaenoptera acutorostrata*) have been seen in ice near the Weddell Sea during winter. We were curious to see if they wintered in 'our' part of Antarctica, and whether any other species were present. Research

'Sea ice' is a general term encompassing 'pack ice' (drifting frozen sea water), 'fast ice' (frozen sea water attached to the shore), and floating, freshwater ice of land origin, such as icebergs.

Two young Killer Whales spyhopping, apparently inspecting the group of Emperor Penguins seen resting on the nearby ice floe. In the background are stranded icebergs, and the open water formed as pack ice flows past them with wind and current.

has also shown that many female Humpback Whales (*Megaptera novaeangliae*) do not migrate to winter breeding grounds in the Southern Hemisphere. Do they stay in the Southern Ocean to feed, taking a rest from their breeding cycle? Do Orcas, or Killer Whales (*Orcinus orca*), migrate north, or stay to feed on abundant fish, seals and penguins? No-one knew.

THE AURORA LEFT HOBART IN MID JULY 1995, and began an oceanographic program, stopping every few hours to collect water samples at varying depths from the bottom up. The major cruise objective was to relate the dynamics and heat balance of Southern Ocean water masses to global warming, and particularly to determine the role of sea-ice formation in heat transfer between the ocean and the atmosphere. The water sampling made for a very slow crossing of the Southern Ocean, yet in five summer voyages south I had never seen the sea so calm. Soon after leaving Tasmania we encountered a large group of Sperm Whales, but the only other marine mammals seen on the way south were two exuberant pods of Hourglass Dolphins (*Lagenorhynchus cruciger*) in the high fifties of latitude.

We left the open sea at 61° 45' S, slipping into fields of open pack ice. A Leopard Seal (*Hydrurga leptonyx*) was our first marine mammal to be spotted in the ice, soon followed by Crabeater (really

krill-eating) Seals. Then, 185 kilometres into the ice, a Minke Whale raced alongside.

The first week in the ice was surprisingly warm for an Antarctic winter (air temperatures were just below freezing). However, the bemused glaciologists cheered up when a cold south-east wind caused temperatures to plummet. Once we were well into the sea ice with the influence of ocean swells far behind, the seascape changed from the smallish floes of the outer sea ice into the increasingly larger floes of the inner sea ice. Finally it resembled a vast wind-sculpted snowy plain, with the *Aurora* creeping across it like a giant orange tractor. Then a seal or a small group of penguins would remind us that we really were at sea, above 2,000–3,000 metres of water. From the pink colour of their scats on the ice it was apparent that many were feeding on krill.

It was now August and we were deep into winter, with only six hours of light each day and air temperatures consistently below –20° C. Strong winds blew large areas of ice together, so seals and penguins not only had to leave the water while it was still possible, but had to remain exposed on the ice, in very low temperatures and high winds, sometimes for days until leads opened again. Unable to leave the water, whales face even more dire problems. They either have to avoid areas where the ice packs up tightly during strong winds, or somehow find small leads in the packed ice. Minkes continued to appear in the thickest of ice as far as 370 kilometres south of the ice edge. It is now clear that at least a proportion of their population is quite at home deep in the winter sea ice, probably right around the continent. One Minke in the Weddell Sea was sighted 1,300 kilometres south of the ice edge.

A group of Adelie Penguins toboggan towards an open lead, under a winter moon. Penguins and seals must remain fasting on the ice when leads are closed by winds and currents.

The *Aurora Australis* carves a path through the sea ice towards the southern end of the study area. In calm conditions the ice has spread to allow the formation of many leads. Antarctic sea ice is generally less than a year old, and easy for icebreakers to penetrate.

How do whales find their way under ice? Cetacean orientation and navigation is a mysterious area of their biology, but nowhere can this skill be more useful than in heavy ice. Bowheads (*Balaena mysticetus*), the most ice-adapted whales of the Northern Hemisphere, are suspected of using reverberation of their calls to 'read' the underwater surface of the ice. Minkes may do likewise, or they may use shafts of light entering leads, or other cues. However they do it, it is a truly phenomenal ability. One can only marvel at the blow of a whale issuing from an apparently unbroken field of heavy ice extending to the horizon.

August 10 was our big day. While on an ice reconnaissance trip, the helicopter pilots spotted something astonishing to the south of the ship: a large pod of Killer Whales. Killer Whales were first recorded in the Antarctic winter in 1955, when a large group was seen in relatively small open pools in coastal ice, near the tip of the Antarctic Peninsula. It was assumed at the time that those whales had been trapped. In the scientific literature the view has been firmly adopted that Killer Whales migrate to warmer waters at the onset of winter. No-one has really challenged this, because no-one has been able to look.

It resembled a vast wind-sculpted snowy plain, with the *Aurora* creeping across it like a giant orange tractor. Then a seal or a small group of penguins would remind us that we really were at sea, above 2,000–3,000 metres of water.

The pilots returned to the ship to pick up Deb and me, and we flew back to the area of the sighting. Many icebergs were aground here on a shallow bank, each one creating an open lead where pack ice flowed around it with wind and current. This formed a mosaic of icebergs, open water, newly formed ice and drifting pack ice, 30 kilometres long. Nearby was a large coastal polynya, or pool of permanently open water.

A group of Killer Whales was clustered around an ice floe. They were spyhopping—bobbing their heads vertically out of the water—eyeing off some Emperor Penguins standing on the floe. We landed on a large nearby ice floe and walked to its edge. About 20 metres away the whales continued to spyhop, now also casting their eyes on us.

Adult males, conspicuous by their tall dorsal fins, remained several hundred metres distant. Most whales nearby seemed to be youngsters of various sizes, accompanied by two or three adult females, one with a small calf. This calf was exciting news indeed, as it had long been accepted that no whale species breeds in Antarctic waters. Yet here was a calf in mid winter, with nearly 450 kilometres of ice between it and the open sea. If newborn Killer Whales can survive in Antarctic sea water, whose temperature remains at

IMAGE COURTESY ROGER LURZ & STEVE PENDLEBURY, AUSTRALIAN METEOROLOGICAL BUREAU; AND GLENN HYLAND & NEAL YOUNG, ANTARCTIC CRC

Infrared satellite image of the Antarctic sea ice, taken in August 1995. The coast, including the Dibble Iceberg Tongue, is shown by the fine black line near the bottom. Extensive lead systems are seen throughout the sea ice, which is obscured by cloud north of about 64° S. The dark band along the edge of the fast ice is a large polyna or pool of permanently open water. The Killer Whales were sighted at the spot marked ✪. Minke Whale sightings are shown by black crosses.

around –1.8°C throughout the year, there is no need for a winter migration, as their prey remains present during winter.

We had little time to spend with these beautiful predators, so after taking off we flew around the area, and could see at least 40 whales. It was easy to see where they had been—their breathing holes dotted the skin of young grey ice that formed in the leads. Research in McMurdo Sound has shown that Killer Whales can surface through newly formed ice up to 15 centimetres thick. Flying back to the *Aurora* allowed us to see the number and extent of leads in the main body of sea ice, which were not apparent from the ship. Satellite imagery showed extensive leads occurring on a much larger scale as well. The picture emerging from the glaciological research was extremely dynamic, with ice constantly forming, thickening, breaking up and drifting with wind and current. It is this constant opening and closing up of leads in the sea ice that make it possible for whales to remain in Antarctic waters during winter.

It was now the end of August and, although conditions remained comfortable inside the ship, temperatures outside dropped as low as –30°C, often with strong winds and icy fog, further fuelling my admiration for Antarctic wildlife. With the winter solstice now well past, there were between seven and eight hours of light each day and, although the nights were actually get-

A young Killer Whale spyhops through newly formed ice, studying the author and a group of Emperor Penguins nearby.

Earth or Mars? Glaciologists and biologists conducting research on the inner sea ice resemble astronauts on some icy planet. One night Minke Whales surfaced in a narrow lead in such heavy ice, beside the workers.

The least-studied and most rarely seen Antarctic pinniped, a squid-eating Ross Seal (*Ommatophoca rossi*) raises its head in a characteristic gesture when disturbed. A few Ross Seals were seen among the outer ice, where ocean swells break the ice into smaller floes.

ting shorter, they appeared to be lengthening. It's called cabin fever, and it signalled it was time to turn north. Within an initially rough but otherwise uneventful week we were back in Hobart.

The voyage had given us an opportunity available to few: to penetrate the isolation of the Antarctic sea ice during the bitter southern winter, and to gain insights into the lives of those animals that inhabit it, particularly the whales. Although we didn't see any Humpbacks, Minke and Killer Whales are clearly at home in the Antarctic winter, and everything we learned about them increased our wonder and respect for these animals, whose existence is intricately bound to one of the harshest and most unforgiving environments on Earth.■

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Peter Gill is a biologist, writer and photographer who has been involved in cetacean research and conservation since 1983.

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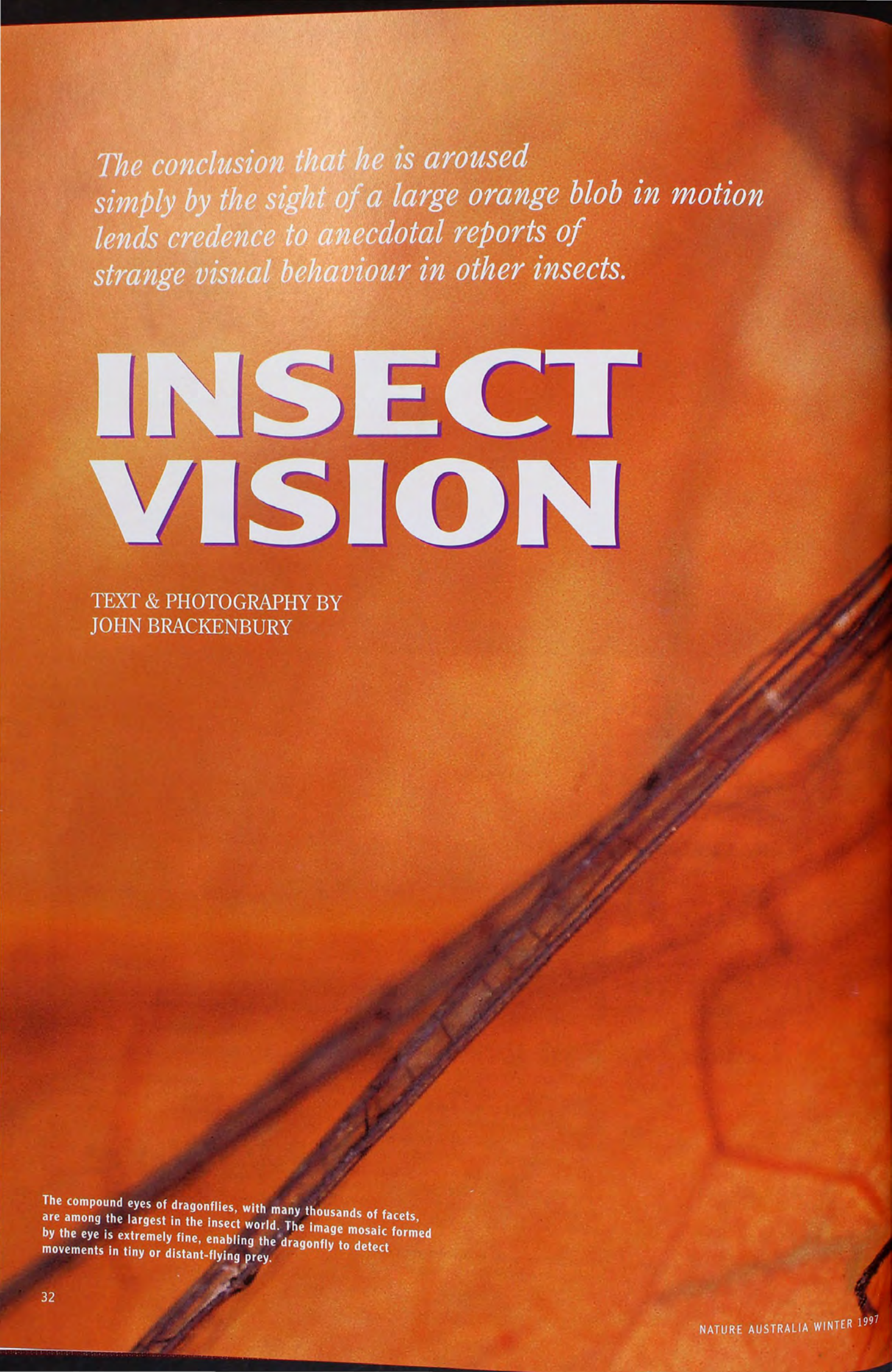
The conclusion that he is aroused simply by the sight of a large orange blob in motion lends credence to anecdotal reports of strange visual behaviour in other insects.

INSECT VISION

TEXT & PHOTOGRAPHY BY
JOHN BRACKENBURY



The compound eyes of dragonflies, with many thousands of facets, are among the largest in the insect world. The image mosaic formed by the eye is extremely fine, enabling the dragonfly to detect movements in tiny or distant-flying prey.

A MIDDAY BREAK FROM A LONG, hot car journey through central Spain provided a happy diversion for two heat-worn travellers. My wife Zena and I pulled off the road onto a rough track bordering a huge, gleaming stubble field. Stretching our legs, our attention was drawn to large numbers of Darter Dragonflies (*Sympetrum striolatum*) clinging to the dried grass stems with their abdomens pointing up towards the Sun. From their perches these creatures then proceeded to lend themselves to a neat demonstration of the qualities of insect vision. Choosing an individual at random, it was easy to show how a small pebble dropped from an outstretched hand instantly produced a flick of the insect's highly mobile head. The behaviour was so repeatable that we hastily improvised an experiment. Zena stationed herself directly above a subject, ready to monitor every swivel of its head, while I gathered up a handful of bone-dry sheep pellets, a perfect set of near-identical missiles for use in a systematic drop-test.

Starting from a point about half a metre from the dragonfly, I retreated in small steps, dropping a pellet each time to test the reflex. Finally, at a distance of about 2.5 metres the drop failed to trigger a response. For humans this would be equivalent to a tennis player losing sight of a tennis ball 20 metres away. Although not brilliant by human standards, it is five to ten times better than most other insects.

Our impromtu experiment highlighted one of the main characteristics of insect vision: sensitivity to movement. Motion sensitivity is particularly well developed in predatory insects such as dragonflies, praying mantids and tiger-beetles. A flexible neck, as in the dragonflies and mantids, is a great asset, because any object suddenly appearing at the edge of the visual field can be centred onto the most sensitive part of the eye (the fovea) with a flick of the head. This allows the image to be examined in greater detail and tracked against the background. Any kind of movement will trigger the reflex, as in our drop experiment, but only genuine prey will release a strike.

THROUGHOUT EVOLUTION, ONLY TWO kinds of 'smart' eyes have ever been invented. One is the vertebrate eye, which works like a single-lens camera; the other is the compound eye of insects and crustaceans which has numerous lenses and, as it were, wears its retina on the outside. Despite the differences in retinal architecture and the electrical wiring of the brain, insect and human

The head of the caterpillar of the Spurge Hawk Moth (*Hyles euphorbiae*) is made of two bulging domes resembling large compound eyes. In fact caterpillars have extremely poor vision, and the true eyes are tiny single-lens structures lying at each side of the jaws.

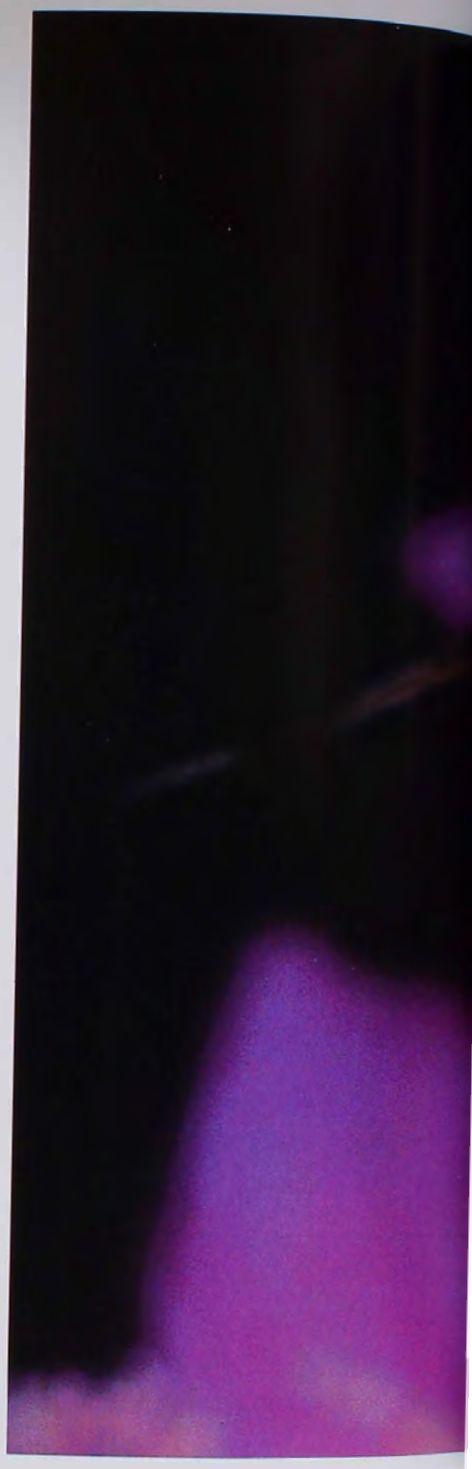
The surface of the compound eye is fretted with numerous individual corneal lenses, each supplying a single dot of light to the image mosaic. The larger the eye, and the greater the number of lenses, the finer the grain of the image produced.

eyes use similar ground rules. For example, both are designed to keep a stable image on the retina: as with dragonflies, our eyes will automatically fixate and track any object that suddenly appears at the edge of the visual field. Also, both eyes have a dual tracking system. If the background is plain, like an open sky, the object is tracked with a smooth motion. If the background is textured, the tracking is performed in a series of quick step-like movements or saccades because this minimises the time during which the retina, and therefore the brain, needs to be exposed to a messy, blurred image.

How do insects and people compare in their perceptions of the visual world? The truth is, we do not yet know enough about the computer behind the eye, the brain, to be able to visualise exactly what an insect sees. Many insects, particularly bees, butterflies and flies, are known to have good colour vision, and we can make reasonable guesses about the perception of shape and movement. Even the simplest eye, such as the tiny ocellus that guides the wanderings of a caterpillar, can take rudimentary clues from its visual environment, such as bright = day, dark = night, bright-up = sky, dark-down = ground. So, although a simple eye cannot form an image, it can provide its owner with enough information on contrasts of light and dark to be able to navigate.

The compound eye is a huge leap from this, because it generates a detailed image from which information can be drawn about shape and movement. Insect compound eyes are not as sharp

Male butterflies have been known to attempt to mate with fallen leaves, male ladybirds with small rounded pebbles and, most curious of all, male jewel beetles with discarded beer bottles.

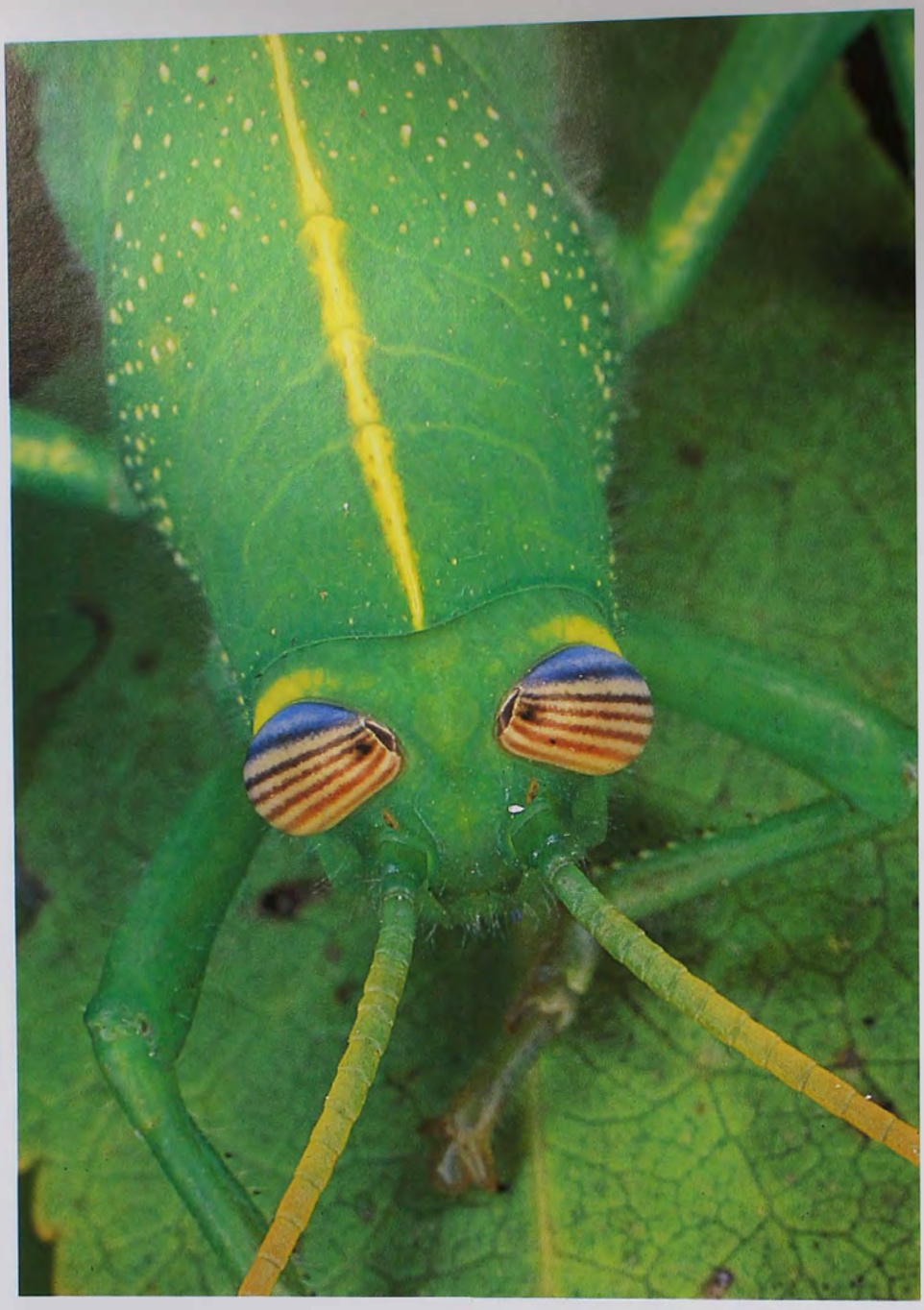


An insect's-eye view of a praying mantid, *Mantis religiosa*, gives an impression of the enormous field of view of the compound eyes. Mantids are hunting insects, with best vision in the region directly in front of the head where the most sensitive spot of the two eyes, the fovea, converge.

In life, the eyes of horse flies are often brightly iridescent with either plain, mottled or striped colouration. The source of the iridescence lies well below the light-collecting elements of the eye and does not interfere with normal vision. The function of the eye ornamentation is not known, although it may be a secondary sexual characteristic.

as their vertebrate counterparts because they have only a few thousand photoreceptors, each of which contributes only a single dot to the image mosaic. In contrast, the retina of our eyes contains approximately two million photoreceptors, producing a much finer-grained picture. Because the raw image formed in an insect's eye is so poor, its ability to recognise details of shape must be severely limited. There is good evidence on this point from the various models that tropical entomologists have developed for use as decoys against blood-sucking flies. The Manitoba horse fly trap, named after the Canadian province in which it was developed, consists of nothing more than a black sphere suspended from a tripod, and its design was inspired by the simple observation that the flies were attracted to dark-coloured weather balloons. A species of tsetse fly associated with domestic cows responded to crude cut-outs of their hosts, showing at least an inkling of shape recognition; but a second species specialising in wart-hogs could easily be duped by the sight of a four-litre drum, draped in coarse sacking to represent hide, and towed along on a wheeled chassis.

Inability to recognise shape can perhaps be understood in insects that rely heavily on smell and touch to identify their hosts, but one might have expected better from butterflies. After all, the varied colours and complex markings on their bodies must surely reflect a heightened sense of pictorial awareness. Apparently not, to judge from experiments carried out on the European Silver-washed Fritillary (*Argynnis paphia*). The male butterfly can easily be lured into pursuing cut-out models of the female spun round on a carousel. Repeated trials made it possible to reduce the female to her bare bones, as it were. The ideal paramour turned out to be four times normal size, of indeterminate shape, and plain orange in colour. The grey streaks on the upper wing, which to our eyes seem to stand out so prominently from the background orange, are evidently of no interest to the male. The conclusion that he is



aroused simply by the sight of a large orange blob in motion lends credence to anecdotal reports of strange visual behaviour in other insects. Male butterflies have been known to attempt to mate with fallen leaves, male ladybirds with small rounded pebbles and, most curious of all, male jewel beetles with discarded beer bottles (see *Nature Aust.** Summer 1988–89). Early German work, using small rotating striped drums as lures, showed that male butterflies were also attracted to objects that flicker at the same rate as the wingbeat of the female.

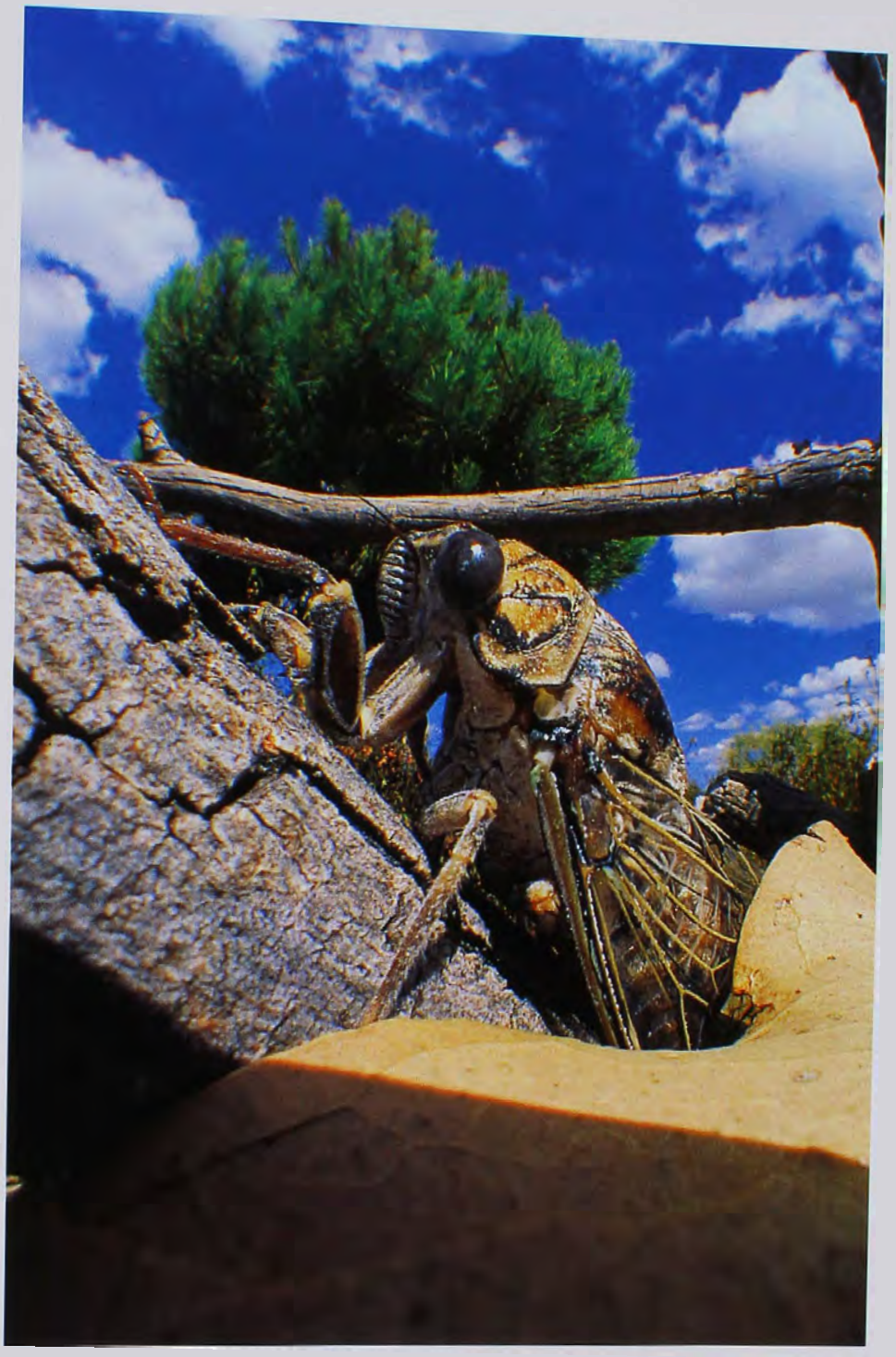
A slightly rosier picture emerges when we look at Honey Bees (*Apis mellifera*), perhaps not unexpectedly since it is well known that they recognise flowers mainly by visual cues such as colour and shape. Mandyam Srinivasan and colleagues at the Centre for Visual Sciences at the Australian National University in Canberra attempted to quantify shape recognition in Honey Bees by training them to associate vertical, horizontal or oblique striped patterns with a reward of sugar. Even a rudimentary awareness of shape, or at least orientation, could help a Honey Bee to recognise the arrangement of petals on a flower. It could also explain how Honey Bees build up a short-term memory map of their foraging territory by taking a 'snapshot' of lines of trees, footpaths or woodland edges.

Even in Honey Bees however, it is still the motion of images, not their shape, that dominates visual behaviour. Naturalists have known for many decades that bumble bees (*Bombus* spp.) and Honey Bees prefer wind-blown flowers to stationary ones. This happens despite the fact that bees, like most insects, normally perceive rapidly moving objects as threatening and therefore

* *Previously ANH*

Above: The rainbow-striped eye of the immature stages of the Egyptian Grasshopper (*Anacridium aegypticum*) is an enigma. The bright colouration of the body provides perfect camouflage against the *Inula* plants in which the younger stages are normally found, but this cannot be said of the gorgeous eye.

Right: Silver-washed Fritillaries recognise one another from the bright orange colouration of their wings and bodies. The fine etching of darker colour on the upper wing surface is not important in intraspecific recognition. This is not surprising since, even at close quarters, the compound eye is unlikely to be able to discriminate this level of detail.



The large, hemispherical eyes of cicadas give 'wrap-around' vision, alerting the insect to approach by predators from any direction, including directly behind.

tend to avoid them. On a windy day, bees visiting flowers need to override their natural inhibition in the same way that predatory insects have to make the distinction between an object that moves and is potentially dangerous, and an object that moves but is a potential source of food.

WHY SHOULD THE MOVEMENTS OF objects be so much more important to an insect than being able to recognise them? Image movement enables the insect to reconstruct its three-dimensional world. By noting the speeds at which images move within the visual field, the insect knows which objects are near to it, and therefore need to be given immediate attention, and which are more distant and can be ignored. For a flying insect it is vital to know whether objects lie in the foreground, middle ground or the far distance in order to avoid collisions. So how does the brain of the insect translate the speed of movement of an object into an estimate of its distance?

We can answer this question by reminding ourselves of the subconscious logic that we use every time we cross a busy shopping mall or struggle through the rush-hour traffic on the underground. As we walk forward our own motion makes the images of the people that are nearest to us sweep past our eyes more quickly than those that are farther away. The horizon itself hardly seems to move. You get the same impression by looking through the window of a moving train at the objects flowing past outside. Everything is moving past at the same speed but the things that are closest seem to be moving fastest. Like us, insects avoid colliding with objects in the foreground by noting how fast their images flow across the background.

This notion of parallax was used by Srinivasan and colleagues in Canberra to explain how Honey Bees manage to fly exactly through the middle of a gap, balancing distances to either boundary. Bees were trained to fly back and forth along a corridor made of perspex walls linking the feeding site with the hive. Two moveable panels of vertical stripes were mounted behind the transparent walls. When the panels were stationary the bees flew exactly down the middle of the corridor. If one of the panels was set in motion towards the hive, bees moving in the same direction flew closer to the moving panel, but those moving in the opposite direction flew closer to the stationary panel. The Canberra team correctly concluded that the bees were trying to maintain equidistance between the two walls by balancing the apparent speeds of the two sets of stripes.

There could be no more graphic illustration of the insect eye in action than the robot recently designed by Nicola Franceschini and co-workers from the National Centre for Scientific Research in Marseilles, France. Roughly the size of an electric kettle, the robot was essentially a horizontal ring of photosensitive elements mounted on top of a trolley, permitting vision in every direction of the horizontal plane. The task given to the robot was to negotiate a route through a forest of poles. The only logic built into the machine was an extension of the law of parallax: if an object is near, it will appear to move fast, so avoid it. The robot was blind to everything around it except the movement of edges yet it triumphantly slalomed through the forest at seven kilometres per hour! As they say, seeing is believing! ■

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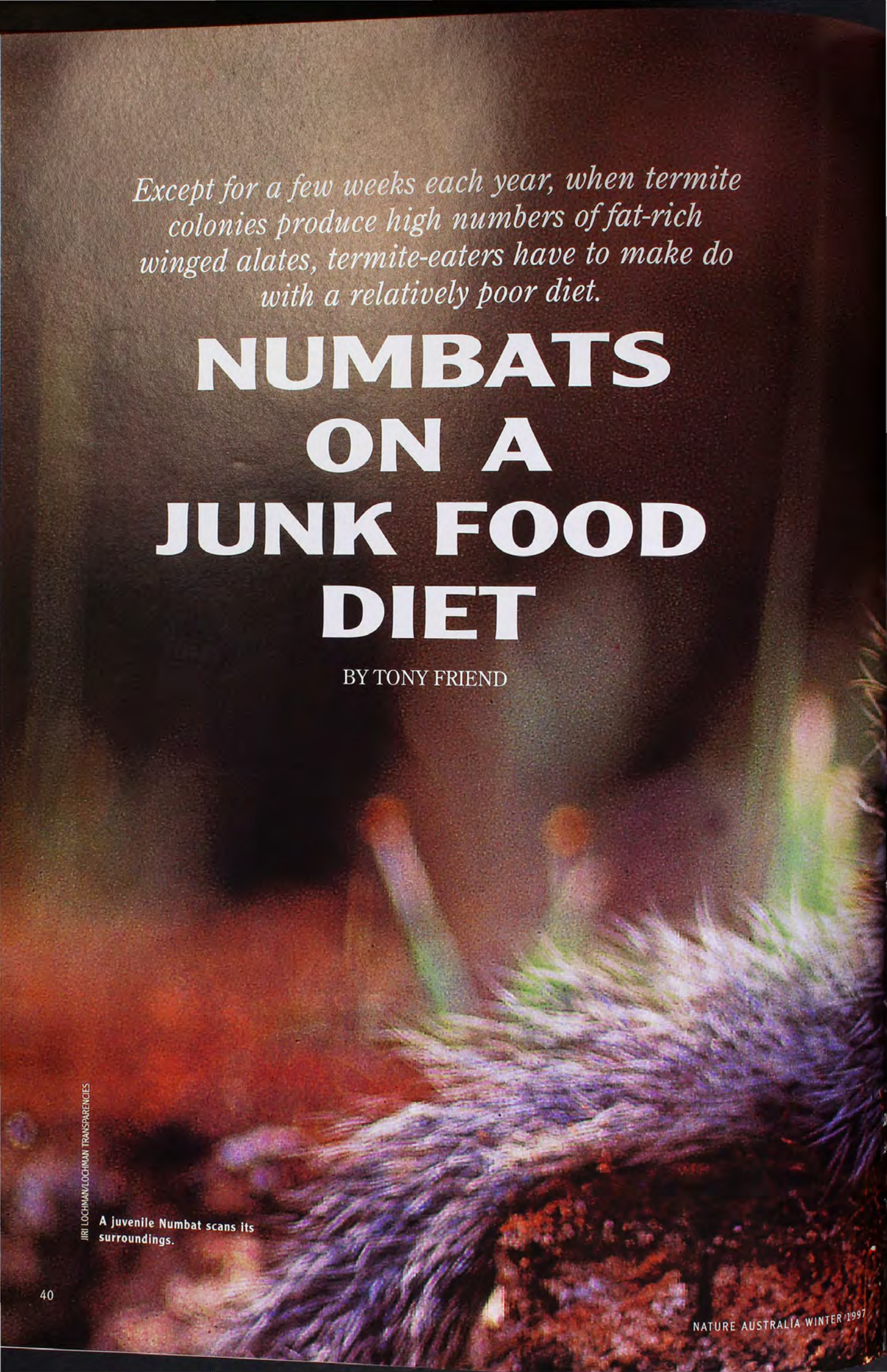
Except for a few weeks each year, when termite colonies produce high numbers of fat-rich winged alates, termite-eaters have to make do with a relatively poor diet.

NUMBATS ON A JUNK FOOD DIET

BY TONY FRIEND



JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

A juvenile Numbat scans its surroundings.

SURVIVING IN JUST A FEW SMALL areas of south-western Australia, the only termite-eating marsupial was an enigmatic creature with an unknown life history. Beautiful to look at but hard to catch, Numbats hid their private lives from scientists until it was almost too late. Research carried out during a concerted campaign to save the species from extinction has revealed how these animals have adapted to life on a very poor diet.

Once encompassing much of southern Australia, the distribution of the Numbat (*Myrmecobius fasciatus*) contracted at an alarming rate after European settlement. It now appears that the spread of the Red Fox (*Vulpes vulpes*) following its introduction to Victoria played a large part in the disappearance of this beautiful little marsupial. Having vanished from its entire range in arid and semi-arid Australia, the Numbat hung on in just two pockets of bushland in south-western Australia where high densities of poisonous plants kept its extinction at bay. Native animals in south-western Australia have evolved a tolerance to fluoroacetate, the toxin found in plants belonging to the genus *Gastrolobium*, but introduced species such as rabbits and foxes are highly susceptible to it. Foxes have remained at low numbers in these areas, apparently suffering secondary poisoning after eating the stomach contents of either their native prey or poisoned rabbits. Even so, the surviving Numbat populations continued to decline. Recently, however, this trend has been dramatically reversed by an intensive campaign against the fox by the Department of Conservation and Land Management (CALM).

While many aspects of the Numbat's biology were discovered through the meticulous work of John Calaby between 1954 and 1956, it took near extinction in the late 1970s to generate the urgency and the funding to carry out further detailed research on this fascinating animal. Besides showing that fox control is the key action needed to prevent imminent extinction, our studies have revealed many glimpses of the Numbat's private life.

Numbats are active and feed from about two hours after dawn until noon, then retire for a siesta until the late afternoon.

A remnant population of Numbats in Dryandra Woodland, 170 kilometres south-east of Perth, provided the subjects for our research. This was the area in which Calaby had shown, by observation and by identifying insect remains in their scats, that Numbats feed almost exclusively on termites, and that they eat the 25 or so species of termite found there in roughly the same proportion that they occur. Many details of the Numbat's reproduction remained unknown. However, by following radio-collared individuals over periods of months and sometimes years, we have been able to build up a comprehensive picture of the production, growth and dispersal of young Numbats. This information has been supplemented by observations of Numbats breeding in captivity.

IRI LOCHMAN/LOCHMAN TRANSPARENCIES

The author radio-tracks a Numbat in Dryandra woodland. By following the activities of individual radio-collared Numbats over long periods, researchers have been able to gain detailed knowledge of the biology of the species.

MUCH OF THE NUMBAT'S BIOLOGY IS dictated by its diet. Surprisingly to many people, Numbats are small animals, adults weighing only 550 grams (females) to 700 grams (males). Unlike Short-beaked Echidnas (*Tachyglossus*

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Numbat habitat in Dryandra is typically Wandoo (*Eucalyptus wandoo*) woodland, where there is an abundance of hollow logs and termites. The open shrub understorey provides cover from birds of prey but is interspersed with open feeding areas.

aculeatus), they are not strong enough to break into termite mounds to feed. Numbats can only obtain termites from shallow feeding galleries that radiate out in the soil from the mound or underground nest. During a feeding session, a Numbat moves around an open area, nose to the ground, every now and then stopping to investigate a spot, then often digging rapidly with both forefeet while sitting on its haunches. After making a small excavation to breach a shallow termite gallery, the Numbat puts its snout into the hole and extracts the insects by pushing its long tongue rapidly and repeatedly into the gallery. Termites within reach stick to the Numbat's tongue, and are pulled into the slightly open mouth. The jaws are then closed and the insects are held in the mouth by the ridged palate, as the tongue is protruded again. The extraction of termites from a gallery, from the first excavation to the end of feeding, can take only two seconds.

The availability of termites in the top few centimetres of the woodland floor varies with time of day and with season. Numbats are active only by day because that is when the highest numbers of termites are present in their shallow feeding galleries. The daily activity periods of Numbats change during the year to coincide with the greatest availability of food at that particular time. The presence of termites in the upper soil layers, where they are available to Numbats, is highly dependent on temperature. In summer, the soil surface heats up in the middle of the day and termites retreat downwards. Numbats are active and feed from about two hours after dawn until noon, then retire for a siesta until the late afternoon, when they emerge for another feeding bout until dark. In winter, they are not active until mid morning, when soil temperature rises and termite activity increases; the females feed continuously from then until dark. Males are less active in winter, but more about that later. In spring, termites reach their greatest abundance in places where Numbats can reach them. Consequently, the timing of reproduction in Numbats ensures that weaning occurs at the time of peak food availability.

The few species of mammal that can detect the presence of termites and penetrate their defences are rewarded with an abundant and dependable food supply. However, the down side is that most of the termites in a colony are either workers or soldiers, both of which are low in fat and high in non-digestible matter. Except for a few weeks each year, when termite colonies produce high numbers of fat-rich winged alates ('flying

Hollow logs are important for Numbats as daytime refuges from predators, but nests of grass and shredded bark are also built in carefully selected logs and used as sleeping quarters. This male Numbat displays the red stain that signifies an active chest gland.

ants'), termite-eaters have to make do with a relatively poor diet. Although many termites are eaten (a lactating Numbat will eat up to 20,000 termites in a day), it is still not enough to maintain high levels of efficiency in certain physiological functions. For example, studies of ant- and termite-eaters have shown them to be poor temperature regulators. The Giant Anteater (*Myrmecophaga tridactyla*) and some of the pangolins (*Manis* spp.), cope with this by living in the tropics where temperature stress is low; others have developed behavioural adaptations. Numbats, for example, put a lot of effort into building elaborate nests in their logs and burrows to prevent loss of body temperature on cold nights. But perhaps the most significant consequence of the Numbat's poor diet is the extremely low growth rate of their young. Whereas the young of most omnivorous bandicoot species are weaned less than three months after birth, and carnivorous marsupials like the quolls wean their young at four to six months, young Numbats are not weaned until they are nine months old. To ensure that weaning occurs in spring, Numbats give birth in January.

The apparently limited supply of termites in the upper soil layers is reflected in the fact that Numbats guard their feeding grounds jealously. Throughout the year, female Numbats occupy home ranges that are exclusive of other females. Over winter, males occupy very small home ranges (about 25 hectares), slotted in between the larger home ranges (30–70 hectares) of females, all of which are suckling young. From September, the males begin to move beyond their winter home ranges. At this stage, a large scent gland on the male's throat becomes active, exuding an oily liquid that leaves a long red-brown stain down the animal's chest and stomach. This liquid is smeared on sticks, rocks and logs

Right: Young Numbats will spend time together near the nursery den during the weeks leading up to their dispersal, when each one moves away to establish a new home range.

PHOTOS: JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Once the Numbat has breached a termite gallery, its tongue is pushed in and follows the tortuously winding tunnels to extract the insects. This Numbat is feeding on part of a broken termite mound.

TONY FRIEND/LOCHMAN TRANSPARENCIES

Photographed in the middle of July, these young Numbats are almost six months old and still remain attached to their mother's teats as she forages for termites during the day. They will not be weaned until October, when they will be nine months old.

as the male travels around, presumably to signal his presence in his enlarged range. As the height of the mating season approaches, the male's testes enlarge, reaching maximum size in late December. The male cloacal region swells noticeably with the associated glandular enlargement. By January, male Numbats are ranging widely and traversing the home ranges of a number of females.

Females come into oestrus during early January. In captive animals, microscopic examination of urine samples has been used to detect the onset of oestrus, when there is a sudden increase in the number of skin cells shed from the uterine wall. If mating does not occur in the 48 hours following this event, young are not produced. Female Numbats do not possess pouches; they do not even develop a rim of skin surrounding the young as found in many carnivorous marsupials. During the second week following oestrus, however, swellings develop on the abdomen just in front of the mammary area and behind it on the inner surfaces of the thighs, so that the four tiny pink teats are temporarily enclosed within a depression. The gestation period is about 14 days, after which the young are born—pink, hairless and measuring about ten millimetres long—and attach themselves to the teats.

Birth in Numbats has never been observed, so we don't know whether

NUMBAT

Myrmecobius fasciatus

Classification
Family Myrmecobiidae. The Numbat is the only member of this family.

Identification
Red-brown above, paler below, with darker rump and prominent, white, transverse bars. Narrow head with sharp snout and dark horizontal eye-stripe. Tail with long hairs often erected to look like a bottle-brush. Head–body length 230–270 mm, tail length 170–210 mm. Females weigh up to 550 g, males up to 700 g.

Habitat and Distribution
Open forest and woodland usually with open shrub understorey. Previously occurred across southern Australia from western NSW to the west coast and to the southern end of the NT. Now found only in several isolated populations in the south-west of WA.

Reproduction
Mating occurs in January. Up to four 10-mm-long young born 2 weeks later. Young weaned in October, disperse in November–December. Females breed in their first year, males in their second. Longevity in the wild is about five years.

Diet
Primarily termites, and some ants.

Status
Listed as 'Endangered' due to large historic range contraction and continuing loss of remnant populations. This situation is being reversed due to conservation action, and relisting as 'Vulnerable' may soon be warranted.

Each morning during October, the young Numbats emerge from the nursery burrow with their mother and remain near the entrance after she moves off. Their daily forays from the burrow cover greater distance as the month progresses.

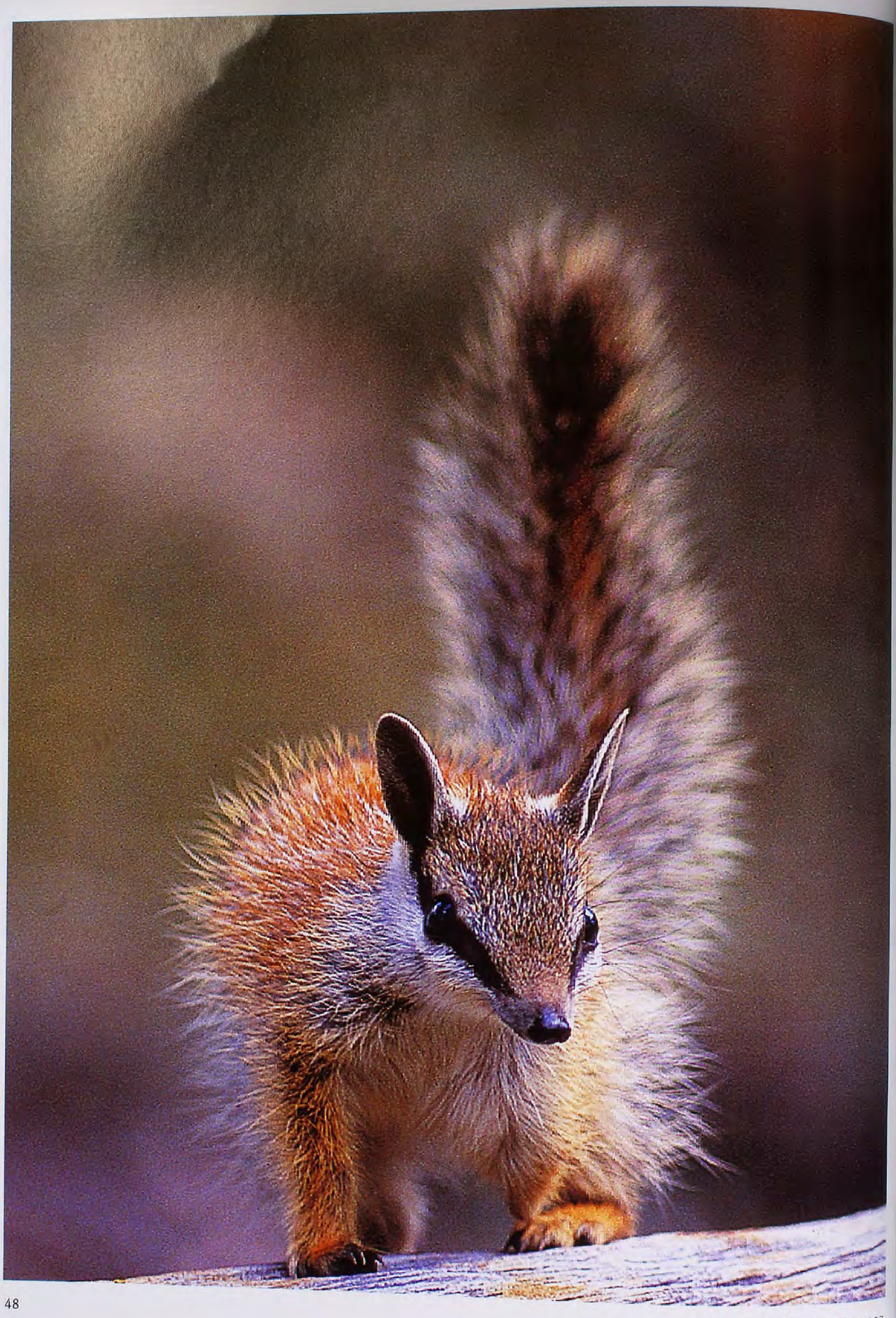
JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

more than four young are ever born. In many carnivorous marsupials, the Numbat's closest relatives, the number of young born is often greater than the number of teats present. However, as over 80 per cent of attached litters consist of four young, it is likely that more than four young are produced, and only the strongest four attach successfully.

At Dryandra, all young are born in the second half of January. After the mating season, the males drop out of the picture. Their testes shrink, their chest glands become inactive, and their range of movement once again becomes very small. During winter, males may emerge from their nests for only four hours each day, apparently just long enough to feed and maintain themselves. There is no interaction between males and females, or males and young, until the time leading up to the next breeding season. This seems to be an alternative and far less extreme strategy to the male die-off seen in some carnivorous marsupials. Both strategies serve to remove males from food competition with lactating females.

Birth in Numbats has never been observed, so we don't know whether more than four young are ever born.

Meanwhile, the young Numbats are carried on the female's teats until July, by which time they are lightly furred and about 45 millimetres long. The female deposits her young in a nest (usually in a burrow) in late July or early August and continues to suckle them each night. In early September, the young begin to emerge from the entrance of the burrow each morning and remain outside after their mother has departed for the day. During the first week or so, they do not



PHOTOS: JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

A radio-collared female Numbat emerges from her nursery burrow.

move more than a few centimetres from the burrow mouth, but as time goes on they venture further afield, learning, by trial and error, to dig for termites on the way. By mid October, the young Numbats are supplementing their mother's milk with termites from their own foraging efforts, moving up to 100 metres from the nest but within their mother's home range. The female often moves her litter, carrying them on her back, to a succession of nests in logs, trees or other burrows, particularly after the loss of any young to predators.

In November, some young start to nest away from the mother and their siblings, within the maternal home range. Later that month or in early December, all young leave their maternal home range and disperse. It is clear that the food resources in an occupied area cannot support the young as well as the established adults. At Dryandra, where the largest block of woodland is 20 kilometres long, the longest dispersal movement so far recorded is 11.5 kilometres. The dispersal movement is quite rapid, rarely taking more than a week from departure to establishment in the area where the Numbat will spend the rest of its life. By Christmas, most juveniles are settled in their new home ranges. The first-year females breed during the next month, but males are not sexually mature until their second year.

When active, young Numbats appear very fluffy, as the guard hairs in their coat stand erect. This makes the small animals appear larger and may possibly help to deter predators.

DURING THE COURSE OF RECOVERY OF the Dryandra Numbat population, the tenuous nature of the termite resource became clear. In 1993, after growing steadily under the protection of an intensive fox-baiting program, the Numbat population in the largest block of Dryandra Woodland reached approximately 900 animals. This is about twice the number calculated to be supportable if each female occupies 50 hectares, as predicted by radio-tracking studies. Within a year, the population had dropped back to half that value and has since remained at that level.

Numbats have evolved the means to successfully exploit the junk food niche. We have shown that, if their habitat is intact and introduced predators are controlled, these beautiful animals can make it. Now the global Numbat population is increasing, through a program of reintroduction to the growing number of areas in Western Australia under fox control. There has been one reintroduction to a fenced and baited area in South Australia, and we hope that the preparation of further suitable sites will allow more interstate transfers, to begin the return of the species to its former wide range. Through all this, however, an understanding of the Numbat's finely tuned relationship with its food resources will be vital to the orchestration of a successful recovery.■

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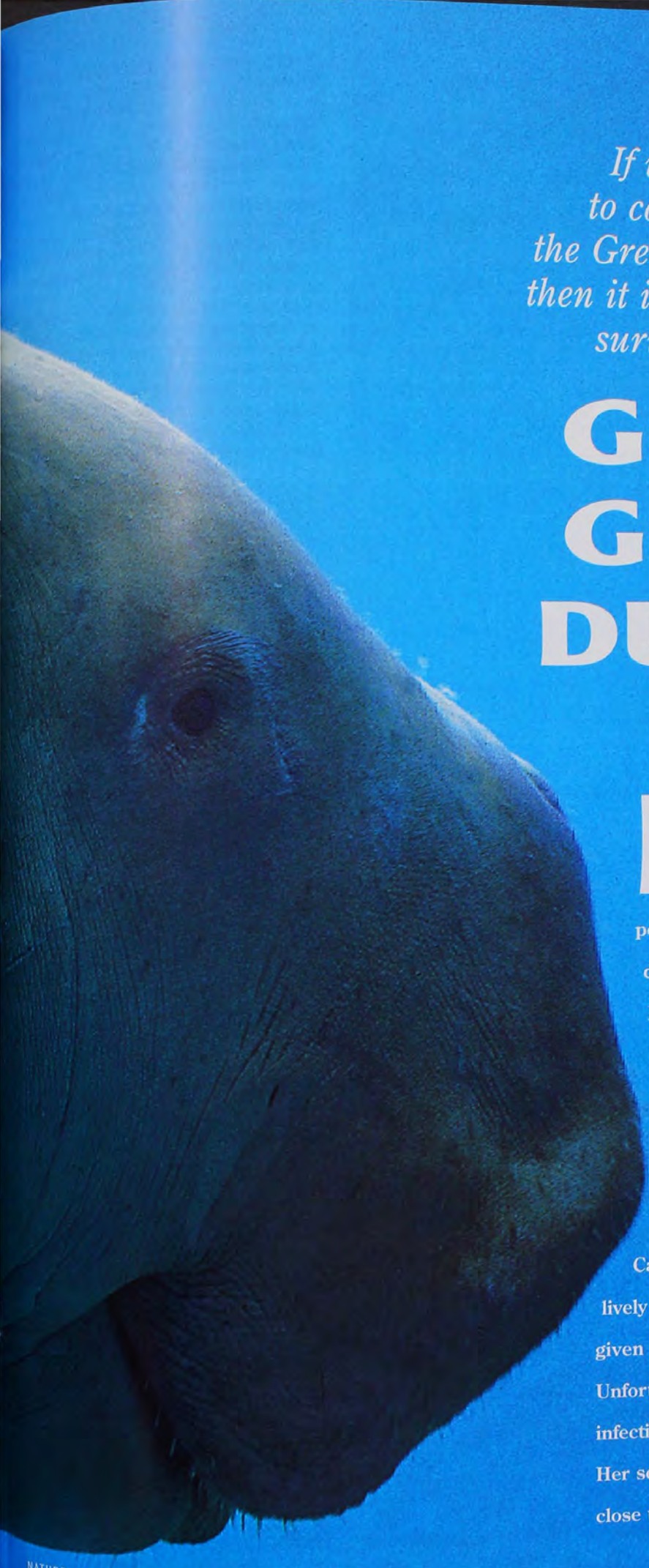
Dr Tony Friend is a Principal Research Scientist in the Western Australian Department of Conservation and Land Management at Woodvale. He has been working since 1980 on the conservation of threatened marsupials in Western Australia and currently heads the Numbat recovery program.

HENNETTE SCHLUPMANN

Parallel scars are seen on a high proportion of Dugongs. They are believed to be inflicted by the tusks of male Dugongs in mating herds.



If we cannot manage to conserve Dugongs in the Great Barrier Reef region, then it is unlikely that they will survive anywhere else.

GOING, GOING, DUGONG

BY HELENE MARSH

MY FIRST ENCOUNTER with a Dugong (*Dugong dugon*) was portentous. The Dugong was dead, drowned in a mesh net off Magnetic Island near Townsville. I waited four years to handle a live Dugong, a young calf that had also been accidentally caught in a mesh net by a fisherman who had taken it to an aquarium in Cairns. The calf was an affectionate, lively animal that thrived once she was given milk as well as seagrass. Unfortunately she died of a salmonella infection after several months in captivity. Her seagrass food had been collected too close to the Cairns sewage outlet!

The growth layers in the tusks, which are like the growth rings in a tree, show that Dugongs have a life span similar to our own and can live for 70 years or more.

Even though it has recently been discovered that Dugongs supplement their seagrass diet with invertebrate animals such as polychaete worms, sea squirts and shellfish at the subtropical limits of their range, they are essentially seagrass specialists, which is why they are also known as sea cows. In the Great Barrier Reef region there are eight genera and 14 species of these marine flowering plants and their distribution is dependent on the availability of light. Thus in areas of high turbidity, seagrasses may be limited to the intertidal region; in other areas they occur in deeper waters. Research by my former PhD students Tony Preen, Janet Lanyon and Lem Aragones indicates that Dugongs prefer feeding on pioneer seagrass species, especially *Halophila* and *Halodule* species, which are lowest in fibre and highest in nitrogen and digestibility. Their dependence on seagrasses means that Dugongs have an obligatory association with coastal habitats, which are vulnerable to the impacts of extreme weather events and to human activities such as hunting, fishing, coastal development and unsustainable agricultural practices.

In the 1970s and 1980s, a team of scientists at James Cook University led by George Heinsohn and myself salvaged and dissected more than 150 Dugongs. Most had been killed in mesh nets set by commercial fishers or in shark nets set for bather protection. Other Dugong parts were donated by indigenous

DUANE YATES

hunters from remote communities in northern Australia. Examination of all this material demonstrated that Dugongs are vulnerable to extinction not only because they are dependent on seagrasses but because they are slow breeders.

I developed a method of estimating the age of Dugongs by counting the growth layers in their tusks. All male and female Dugongs have tusks, although these are often not obvious as they do not erupt until after puberty in males, and only in a small proportion of older females. The growth layers, which are like the growth rings in a tree, show that Dugongs have a life span similar to our own and can live for 70 years or more. Females do not have their first calf until they are at least ten years and sometimes up to 17 years old. They bear only one calf at a time, after a pregnancy lasting about a year, and suckle the calf for 18 months or so. On average, females produce calves only once every three to five years.

D. PARER & E. PARER-COOK/AUSCAPE INTERNATIONAL

A scattered group of Dugongs over seagrass in Shark Bay, Western Australia, as viewed from an aircraft. Shark Bay supports an estimated 10,000 Dugongs.

Computer simulations show that, if Dugong numbers are to be maintained, more than about 95 per cent of the adult females alive at the beginning of each year must still be alive at the end of that year. The maximum sustainable mortality from all human impacts is only about one to two per cent of adult females per year. If Dugongs do not get enough to eat because of deterioration in their habitat, they will calve later and less often, and the sustainable mortality will be even less.

Since the first international Dugong workshop held in Townsville in 1979, it has been recognised that Dugong conservation is largely dependent on Australian initiatives. Although Dugongs occur in the waters of over 40 countries, all except for Australia are developing countries with limited capacity to contain impacts on Dugongs within sustainable levels. In contrast, Australia is a developed country with a relatively small human population, particularly in the north where Dugongs occur. Our capacity to conserve Dugongs should be greatest in the Great Barrier Reef region. The Great Barrier Reef Marine Park is the largest multiple-use marine protected area in the world and a World Heritage Site. The importance of this region as a Dugong habitat was one of the reasons it was inscribed on the World Heritage List in 1981. If we cannot manage to conserve Dugongs in the Great Barrier Reef region, then it is unlikely that they will survive anywhere else.

When Dugongs feed on small delicate seagrasses, they dig up whole plants and create feeding plumes from the clouds of disturbed sediment. They prefer low-density, delicate seagrasses as opposed to dense strands.

MY COLLEAGUES AND I HAVE BEEN conducting aerial surveys in the Great Barrier Reef region since the 1970s as part of our studies of the distribution and abundance of Dugongs in Australian waters. The early surveys essentially consisted of counting Dugongs during flights parallel to the coast. We made no effort to estimate the size of the population, merely presenting our sightings as uncorrected counts of the Dugongs that were seen during the surveys.

There were several problems with this method, however. It did not take into account Dugongs that were invisible due to the turbid water, nor those that were missed because the aircraft was moving much faster than the Dugongs. By flying parallel to and close to the coast we also missed Dugongs in offshore waters. This simple technique was good for identifying important coastal Dugong habitats, but unsuitable for monitoring trends in abundance.

In consultation with a mathematician, I developed a more elaborate aerial survey technique in the mid 1980s. We now count Dugongs in 200-metre-wide strips of sea on either side of the aircraft as we fly at a height of 137 metres and a speed of 185 kilometres per hour along predetermined transects that are aligned perpendicular to the coast. The Dugong counts are converted to population estimates using sampling statistics and mathematical corrections for perception bias (the proportion of animals visible in the transect but missed by observers)

GEOFF TAYLOR/LOCHMAN TRANSPARENCIES

Young Dugong calves never venture far from their mothers and often ride on their mothers' backs.

and availability bias (the proportion of animals below the surface that are invisible due to water turbidity). Because the availability correction factors are conservative, the population estimates obtained from these surveys are probably underestimates. Nonetheless, they should still be a reliable index of changes in Dugong numbers between surveys.

We have now conducted three sets of surveys of Dugong habitats in the Great Barrier Reef region using this technique. For logistical reasons, the surveys have been conducted in two series: one covering the remote Cape York coast, the other the more urbanised coast south of Cooktown. We have also carried out a third series of surveys in Hervey Bay immediately to the south of the Great Barrier Reef region.

The northern region was surveyed in 1985, 1990 and 1995, and it was shown to contain the most important Dugong habitat within the Great Barrier Reef and one of the most important in Australia. It supports an estimated 10,000 Dugongs and 4,440 square kilometres of seagrass. The surveys indicated that the Dugong population is stable when the northern region as a whole is considered. However, the survey technique was designed to detect only macro-scale trends and cannot accurately detect small changes on a local scale. It would be inappropriate, for example, to use these surveys to evaluate the sustainability of Dugong hunting by members of Cape York communities whose activities occur at a local rather than a regional scale. Nonetheless, the surveys suggested that the prospects of the Dugong surviving in this northern region are good. This is because traditional hunting in a few localised areas is the only major impact. The mesh-netting effort is low relative to the more urbanised coast and there is little coastal development. The marine-park zoning ensures that most of

DUANE YATES

A male Dugong rubs its back on the substrate, perhaps to rid itself of external parasites such as barnacles. The dolphin-like tail of a Dugong is distinctive. Manatees, by contrast, have paddle-shaped tails like a Platypus.

the coastal seagrass beds are given a high level of protection.

Our surveys in 1986/87, 1992 and 1994 demonstrated that the situation south of Cooktown is very different. The numbers of Dugongs sighted between Cooktown and Dunk Island were insufficient to estimate the population size in either 1986/87 or 1992 and was not attempted in 1994. Our estimates of the Dugong population between Dunk Island and Bundaberg declined by more than 50 per cent from 3,500 Dugongs in 1986/87 to 1,700 animals in 1994. The decline was spread throughout much of the region, but was most serious between Townsville and Rockhampton.

Dugongs were generally sparsely dispersed throughout this region. This is not surprising as the known area of inshore seagrass (about 550 square kilometres) is small in comparison with the northern region, and individual beds are also relatively small. The largest numbers of Dugongs were found between Hinchinbrook Island and Townsville, and in the Shoalwater Bay Military Training Area, the latter being the most important Dugong habitat in the southern Great Barrier Reef region.

The status of the Dugong is also serious in Hervey Bay. In 1992, more than 1,000 square kilometres of seagrass were lost from this bay, one of the most important Dugong areas on the east coast of Queensland. The most plausible explanation for this loss of seagrass is that it died because of lack of light resulting from a prolonged increase in turbidity after two floods and a cyclone occurred within a three-week period. Although the cyclone and floods were natural events, their impact was increased by soil erosion from poor farming practices in the catchments draining into the bay.

Aerial survey estimates indicated that the Dugong population of the Hervey Bay region plummeted from about 2,200 in 1988 to 1,100 at the end of 1992 and 800 in 1994. The proportion of calves declined from 22 per cent in 1988 to two per cent in 1993 and 1.5 per cent in 1994, presumably because the Dugongs that remained in the region were not getting enough to eat. A total of 99 Dugong carcasses were recovered. Most Dugongs died between six and eight months after the floods and most were emaciated as a result of starvation. Some Dugongs travelled up to 900 kilometres before dying; four Dugong carcasses were found south of Sydney. Tony Preen conducted an aerial survey of Moreton Bay near Brisbane in April 1993. He counted 664 Dugongs during this survey—substan-

DUGONG
Dugong dugon

Classification
Order Sirenia (sea cows), family Dugongidae. Only four living species of sea cow: 3 manatee spp. (family Trichechidae) and the Dugong. The other modern dugongid, the 7-m long Steller's Sea Cow, was exterminated by sealers in the late 18th century.

Identification
Externally distinguishable from manatees by their whale-like tails and more streamlined appearance. Adult Dugongs between 2.4 m and 3 m long and up to 400 kg. Newborns about 1.2 m long and up to 30 kg. Eyes and ears at sides of head. Ears lack pinnae. Vision apparently equivalent to diver with face mask. Hearing acute. Nostrils on top of head and equipped with valve-like devices that prevent water entering during diving.

Distribution
Shallow coastal and island waters of Indo-Pacific from east Africa to Vanuatu, between about 27° N and 27° S. Historical distribution broadly coincident with the distribution of seagrasses. In many area, only relict populations remain.

Biology
Life span 70 years or more. Pre-reproductive period min. of 10 yrs for both sexes. One calf every 3–5 yrs after gestation of 12–13 mths. Lactation approx. 18 mths. Feed primarily on seagrasses but may deliberately forage on invertebrates at subtropical limits of range.

Status
Listed as vulnerable to extinction by IUCN.

DUANE YATES

Supported by its flippers, a Dugong digs up its seagrass food. Dugong flippers are callused and stained on the inside where they support the body during bottom feeding.

tially more than the maximum count of 569 recorded during his 28 previous surveys. This result suggested that some Dugongs successfully relocated to Moreton Bay from Hervey Bay. Experience from other areas suggests that the seagrasses in Hervey Bay will take a decade to recover. Dugongs, being slow breeders, will take much longer.

This massive decline in Dugong numbers means that the Dugong qualifies for classification as 'critically endangered' between Dunk Island and Hervey Bay. Anecdotal evidence from scientists and traditional hunters suggests that this decline has been occurring since the 1960s or even earlier.

Statistics collected by the Queensland Shark Protection Program reinforce this conclusion. Since shark nets were introduced in the 1960s, 541 Dugongs have been caught in the Great Barrier Reef region, most in the early years of the program. A total of 241 Dugongs were caught near Townsville and 161 off Cairns, an area where there are now so few Dugongs that the population cannot be estimated.

THE DECLINE IN DUGONG NUMBERS along the east coast of Queensland is embarrassing for Australia, which has a responsibility for conserving Dugongs under several international conventions. We also have a national responsibility to conserve Dugongs for future generations of Australians, especially indigenous Australians for whom the Dugong has special cultural significance.

It is widely recognised that Dugong meat and oil are among the most valuable traditional foods of coastal Aborigines and Torres Strait Islanders in northern Australia. Most people assume that traditional hunting is the most serious human impact on Dugongs in Australia. But the situation is clearly much more complicated than this in the Great Barrier Reef region. Dugongs are vulnerable to two broad classes of impacts: those that kill animals directly, for example netting, traditional hunting or large-scale losses of seagrass; and those that decrease the calving rate by reducing feeding opportunities, for example smaller-scale habitat loss or boat traffic.

Since they became aware of the

HOWARD HUGHES/NATURE FOCUS

Hunters at Mornington Island in the Gulf of Carpentaria prepare to butcher their catch. Aboriginal peoples regard Dugong hunting as an important extension of their Aboriginality.

DUANE YATES

Dugongs have flippers (and tail flukes) that resemble those of dolphins but, unlike most dolphins, they lack a dorsal fin.

decline of the Dugong in the southern Great Barrier Reef region, most of the Indigenous Councils of Elders that control traditional hunting in this area have decided to suspend Dugong harvesting and there is currently no permitted hunting south of Cooktown. The Darumbal-Noolar Murree Aboriginal Corporation for Land and Culture of Rockhampton also recently signed an historic agreement with the Great Barrier Reef Marine Park Authority stating that it would be inappropriate for indigenous hunting to occur within the Shoalwater Bay Military Training Area.

It is now up to other stakeholder groups on the Great Barrier Reef to respond to the challenge of reducing their impacts on Dugongs. In October 1996, the Federal Minister of Environment asked all parties to identify and implement emergency measures to prevent the decline of Dugongs in the southern Great Barrier Reef. These measures are being developed. The Queensland Commercial Fishermen's Organisation has acknowledged that the incidental capture and drowning of Dugongs in mesh nets is a problem. This organisation has supported the development of a code of practice and an education program to inform commercial fishers on aspects of Dugong conservation biology and management, and on methods to minimise Dugong take. It is hoped that attendance at this program will become part of the Trainee Master Fisherman's course and compulsory for Master Fishermen who wish to use mesh nets. Progress with this initiative is important as many fishers do not yet appreciate the seriousness of the 'Dugong problem', nor the way it threatens the future of mesh netting as a commercial fishing method in the Great Barrier Reef region.

The Queensland Shark Protection Program is also being reviewed to address by-catch issues. Baited lines, which do not catch marine mammals, have replaced nets at many beaches in the Great Barrier Reef region in recent years, but nets are still used at five locations near Cairns, two near Townsville and three near Mackay. A decision to replace all nets with baited lines would be controversial as some scientists believe that nets as well as lines are needed if inshore shark numbers are to be maintained at a level where their risk of attacking people is acceptably low. Other stakeholders consider that any by-catch of marine mammals in shark nets is unacceptable in a World Heritage Area, given the extremely low risk of a bather being attacked by a shark.

The greatest challenge ahead will be to ensure the conservation of inshore seagrass beds in the region. Experience has shown that it is hard to convince a prospective developer that a resort may have adverse impacts on Dugongs and their habitats. It will be even harder to convince a farmer that erosion from his property may threaten the survival of sea cows grazing on submarine pastures many kilometres downstream! ■

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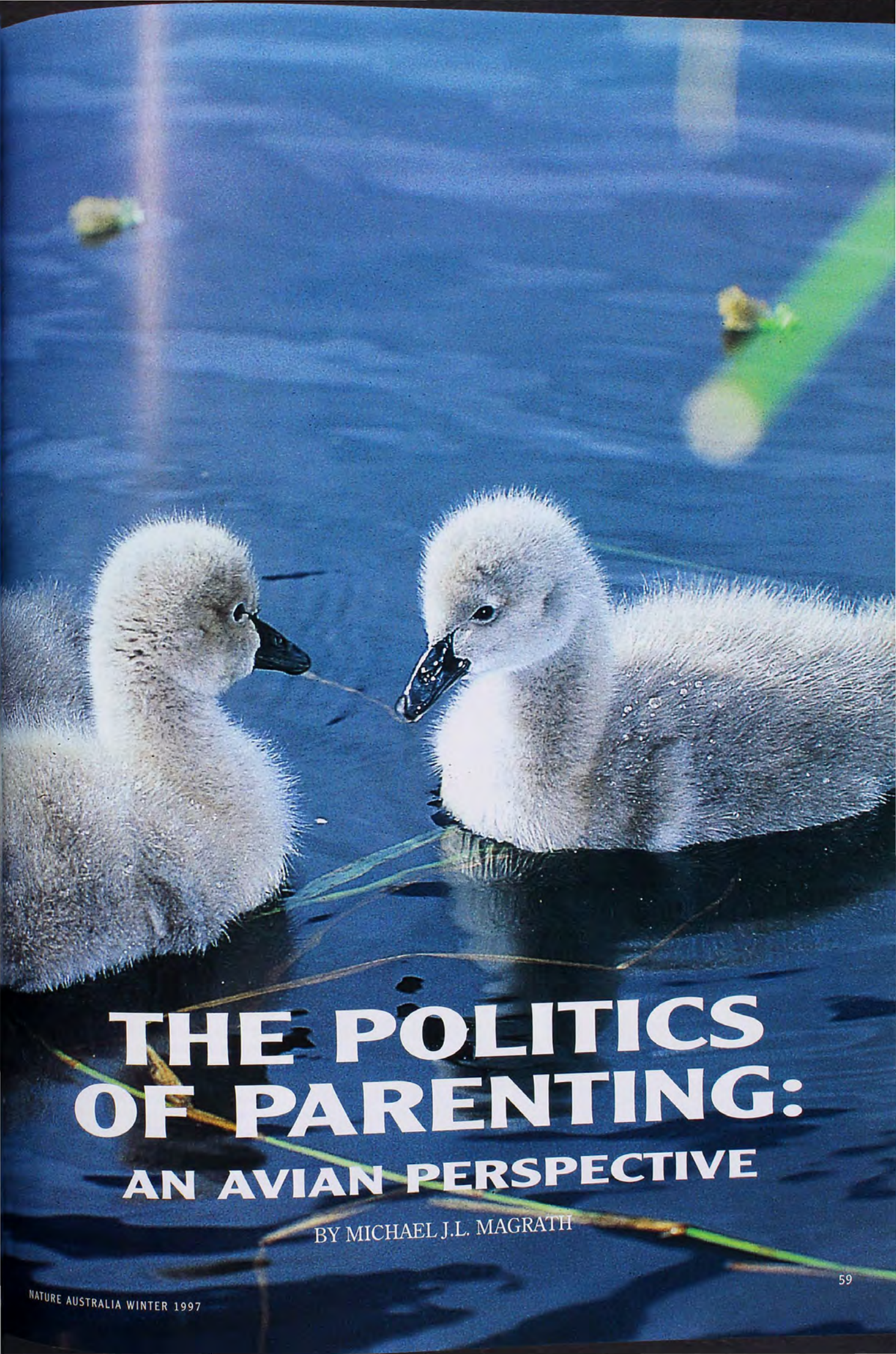
Helene Marsh is Professor of Environmental Science at James Cook University in Townsville and a program leader in the Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef. She has been studying the ecology and conservation of Dugongs since 1974.

The young of many Australian birds not only have the services of two dedicated parents, but will often benefit from the attentions of additional helpers.

BRIAN CHUDLEIGH

Although Black Swan cygnets are able to feed themselves immediately upon hatching, they are still attended by one or both parents.



THE POLITICS OF PARENTING:

AN AVIAN PERSPECTIVE

BY MICHAEL J.L. MAGRATH

WHEN IT COMES TO PARENTAL care, the male Emu (*Dromaius novaehollandiae*) is made of sterling stuff. Left by the female with a clutch of up to 15 eggs, he will incubate, almost continuously, for a period of eight weeks. Only rarely, if ever, will he venture from the nest to forage, and during this period he may lose as much as eight kilograms. And his diligence doesn't end there. When the chicks hatch, the male broods them beneath his feathers at night and escorts them for a further six months in the inhospitable semi-arid regions of inland Australia.

Such displays of lone male care are uncommon among birds, and indeed occur in only about 2.5 per cent of Australia's 740 or so native species (including vagrants). In by far the majority of our birds, parental care is a more collaborative effort between the female and male of a breeding pair and, in some species, may be aided by additional helpers. So why do male Emus, and the males of other species with single fathers including the Southern Cassowary (*Casuarius casuarius*) and most button-quail (*Turnix* spp.), take on the responsibilities of a lone parent?

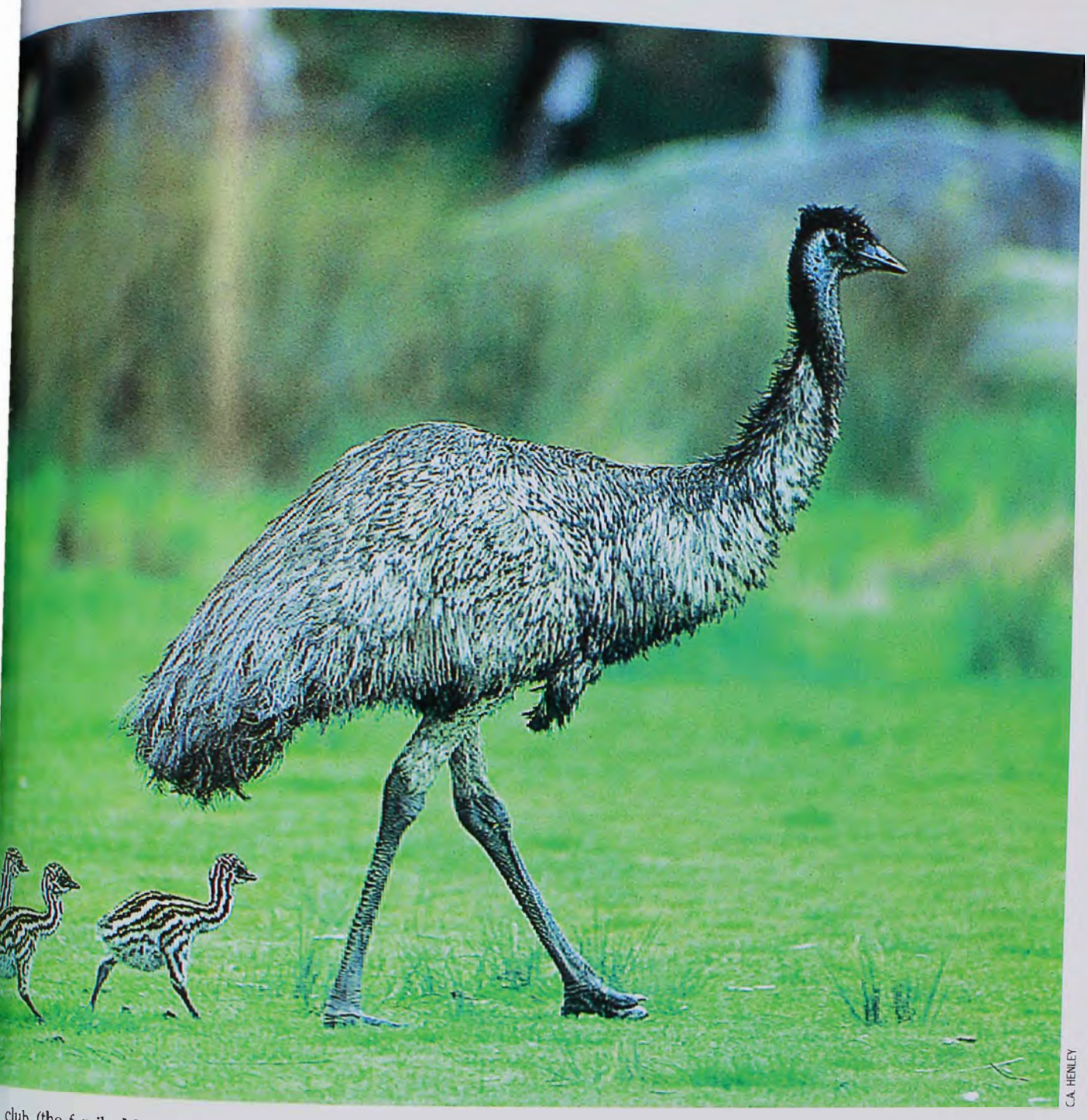
In part, the answer lies in the developmental mode of their young. While the Emu chicks require their father as an escort, they are capable of foraging for themselves almost as soon as they hatch. Young that are mobile and can, in species like the Emu, even forage independently after hatching are referred to as 'precocial'. All ducks, geese, shorebirds, rails and quail produce precocial young, along with other notables like the Brolga (*Grus rubicunda*) and Black Swan (*Cygnus atratus*). In contrast, the hatchlings of most birds, including all songbirds (passerines), parrots, birds of prey and most seabirds, are completely helpless and totally dependent on their parents for survival. Most of these 'altricial' young are naked (and rather ugly) on hatching, and remain in the nest where they are provisioned entirely by their parents until they can fly. This 'nestling period' may vary from as little as a week in some pigeons, up to an extraordinary nine months in the Wandering Albatross (*Diomedea exulans*).

Generally, escorting precocial young is a far less demanding task than feeding altricial nestlings, so it is not surprising to discover that all species with lone fathers produce highly precocial young. Indeed, male Malleefowl (*Leipoa ocellata*) and Australian Brush-turkeys (*Alectura lathami*) are not even required to supervise their young after hatching. These birds belong to a very exclusive

These females actually compete among one another for devoted dads, and have consequently become larger and more colourful than the males.

M.R. WILLIS/NATURE FOCUS

Australia has the highest percentage of 'helpful' birds in the world. These fledgling Noisy Miners are reared by both parents, with as many as 20 male helpers, most of which are related to the young.



C.A. HENLEY

The male Emu escorts the chicks and broods them under his feathers at night for up to six months.

club (the family Megapodiidae), whose members incubate their eggs inside an earthen and/or leaf-litter mound that is maintained at an appropriate temperature by the male. After hatching, the chicks are left completely to their own devices, and many will perish in the first few weeks through predation or starvation.

The highly developed state of precocial young results partly from the relatively large and nutritious eggs from which they hatch. And because less care is required after hatching, the clutch sizes of precocial species are usually also larger than their altricial counterparts. Producing a lot of large eggs, however, can be quite energetically demanding on the female, and this probably explains why only the male provides care in some of these species. But such 'role reversal' has gone a step further in a number of other species, such as the Comb-crested Jacana (*Irediparra gallinacea;* see *Nature Aust.* Spring 1995) and Painted Snipe (*Rostratula benghalensis*), where the female may lay a separate clutch for each of several males. These females actually compete among one another for devoted dads, and have consequently become larger and more colourful than the males. In these species where egg production may not be a problem, the opportunity to pass on parental duties to a series of willing males is too good to pass up.

Even among the majority of Australian birds in which the feeding of young is a collaborative effort, other aspects of parental care are not always shared. For example, while females incubate in all 'biparental' birds (with the single exception of the Emperor Penguin, *Aptenodytes forsteri*), the male contributes to this task in only about half these species. However, the male compensates in a range of birds, including most birds of prey and many parrots, by provisioning the incubating female with food, reducing her need to leave the nest to forage. This practice is taken to the extreme in some hornbills of South-East Asia in which the female is actually sealed into a nest hollow before incubation, remaining there until the young are ready to fly. She receives all her food from her attentive partner through a narrow opening. This tactic reduces the chances of clutch or brood predation by tree-climbing

HANS & JUDY BESTE/NATURE FOCUS

A male Malleefowl rakes his mound. He will incubate and care for the eggs until they hatch.

mammals. The males of some species also adopt a greater role in nest building and territorial defence, so overall participation in parental duties may be more equal than appears at first glance.

THE YOUNG OF MANY AUSTRALIAN BIRDS not only have the services of two dedicated parents, but will often benefit from the attentions of additional helpers. Species that commonly have helpers include the fairy-wrens (*Malurus* spp.), babblers (*Pomatostomus* spp.), many honeyeaters, the Laughing Kookaburra (*Dacelo novaeguineae*) and the White-winged Chough (*Corcorax melanorhamphos*; see *Nature Aust.* Autumn 1997). In fact, Australia has a higher percentage of 'helpful' birds than anywhere else in the world. This high incidence of cooperative breeding is thought to result from the low degree of seasonality in Australia's eucalypt woodland compared with forests of the Northern Hemisphere. Without the peak in food availability associated with spring in the Northern Hemisphere, it is argued, pairs will often find it difficult to fledge young successfully without additional help, especially if they are inexperienced at breeding. More recently, however, Eleanor Russell of the CSIRO's Division of Wildlife and Ecology showed that many of our cooperative breeders belong to a large group of passerines, known as the Corvida, which radiated in Australia some 30–50 million years ago. Since their origin a disposition to cooperative behaviour has persisted among these birds in a diversity of habitats, so the particular factors leading to the high incidence of cooperative breeding remain unclear.

Assistance is all well-and-good for the breeding pair, but what's in it for the birds that help?

Assistance is all well-and-good for the breeding pair, but what's in it for the birds that help? In most cooperatively breeding species it seems that helpers are in fact close genetic relatives (siblings or previous offspring) of the breeding male and female. By participating in the care of relatives, these helpers are indirectly enhancing their own (inclusive) reproductive success, because relatives share a high proportion of the same genes. Noisy Miners (*Manorina melanocephala*), for example, live in groups where up to 20 males will assist in providing food to the young of a single nest. Genetic studies indicate that usually only one male will sire all offspring. However, most of the other males assisting turn out to be either sons or brothers of the genetic father.

The Superb Fairy-wren (*Malurus cyaneus*) is another cooperatively breeding species in which additional males help feed nestlings. The motivation for these helpers, however, appears to be somewhat different. While all appears harmonious in the wren troop, it has been found that most young are not fathered by the primary male, or in fact by any male in the group. Indeed, typically the young are sired by a neighbouring male. Consequently, because there is a high turnover of breeding females, helpers are commonly unrelat-

JIM FRAZIER

A Pacific Baza or Crested Hawk (*Aviceda subcristata*) with its nestlings. These chicks will be cared for and shown hunting techniques by both parents for several months.

BRIAN CHUDLEIGH

ed to the young they feed and defend, and hence stand to gain no genetic benefit. In this species, experiments indicate that helpers may contribute primarily as a form of rent payment to the primary pair for being permitted to remain on the territory. Good territories are at a premium and, by remaining on the home or 'natal' territory, helpers are in the box seat to inherit the plot upon the demise of the dominant male.

The social arrangements are somewhat different in another group of cooperative breeders that includes the Purple Swamphen (*Porphyrio porphyrio*) and Tasmanian Native-hen (*Gallinula mortierii*). Rather than a breeding pair with helpers, these groups comprise several, often unrelated, males that all mate with the one or two group females. Consequently, the males will often share paternity of the group's communal brood. Ideally males should only care for young of which they are the genetic father, but there is no evidence that birds can distinguish between related and unrelated young in the one nest. Instead, males may assess their likelihood of some paternity in the brood, possibly by how frequently they mated with the group female, and adjust their participation in incubation and feeding accordingly. Reduced care in response to low paternity has been reported for some Northern Hemisphere species but is not apparent in the Purple Swamphen, where male contribution is fairly equal and unrelated to paternity. Perhaps this species has a more egalitarian nature.

A similar dilemma also confronts the males of monogamous species, such as the Superb Fairy-wren, that are often unrelated to most young in their nest. While an association between reduced male care and low paternity has been reported for some species, the importance of paternity on parenting still remains contentious.

A male's dedication to care may also be compromised by his opportunity to mate with females other than his social partner (extra-pair mating). Because female birds are capable of storing sperm in their reproductive tract for an extended period, the duration for which a female will be sexually receptive is usually over a week, and may be up to months in some species (see *Nature Aust.* Winter 1996). Within a population or colony of breeding birds, the opportunity for males to mate with additional females will depend on the number of females that are sexually receptive at the

Purple Swamphens on a nest with the chicks.

time. One species in which males skimp on care when mating opportunities are at their greatest is the Fairy Martin (*Hirundo ariel*). These birds nest in colonies of up to several hundred pairs and, during the course of the four-month breeding season, there are times when many of the females are simultaneously receptive. Males contribute less to incubation when more females are fertile, suggesting a trade-off between providing care and soliciting additional matings.

OTHER BIRDS AVOID THESE DOMESTIC complications altogether by dumping their parental responsibilities onto others. The most well known of these birds are the cuckoos, in which the

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

A male Black-breasted Button-quail (*Turnix melanogaster*) on his nest. Although both sexes share in nest building, it is the male that incubates the eggs.

female distributes her eggs into the nests of other 'host' species. Australia has a large contingent of 11 parasitic cuckoos, including the world's largest, the Channel-billed Cuckoo (*Scythrops novaehollandiae*) of northern and eastern Australia. This species appears to specialise on parasitising crows, ravens and currawongs, although there are even records of chicks being reared by birds of prey (not the sort of host you'd want to discover your secret). Unlike most other Australian cuckoos, in which the cuckoo chicks evict their host nest mates, the host eggs or young are often thrown out or even eaten by the adult Channel-bill.

Less well documented is the practice of laying eggs in the nests of same-species neighbours, often referred to as egg dumping or, more formally, 'conspecific brood parasitism'. As with cuckoo parasitism, this strategy places the burden of parental care onto the unsuspecting (or at least unwilling). Unlike the cuckoo however, these conspecific parasites will usually also lay a clutch of their own. This behaviour occurs in a wide range of birds including some swallows, finches, and waterfowl.

Several coot species (*Fulica* spp.) engage in such brood parasitism, often laying some eggs in neighbouring nests before initiating their own clutch. As the number of chicks that a pair can raise to independence is limited, this tactic allows the female to increase her total reproductive output. However, for the same reason, it also confers a disadvantage on the host because parasite chicks may be reared at the expense of the host's own young. To counter this problem, a rather clever detection mechanism has evolved. Coot eggs are strikingly variable in shape, spot pattern, and background colour between females. However, they vary little within an individual's own clutch. It seems that females are able to employ these markings, almost like a personal signature, to identify eggs that are not their own. Once detected the host female will either toss the 'bad egg' out or, more commonly, bury it down in the nest lining never again to see the light of day. Cruel, perhaps, but indisputably fair.■

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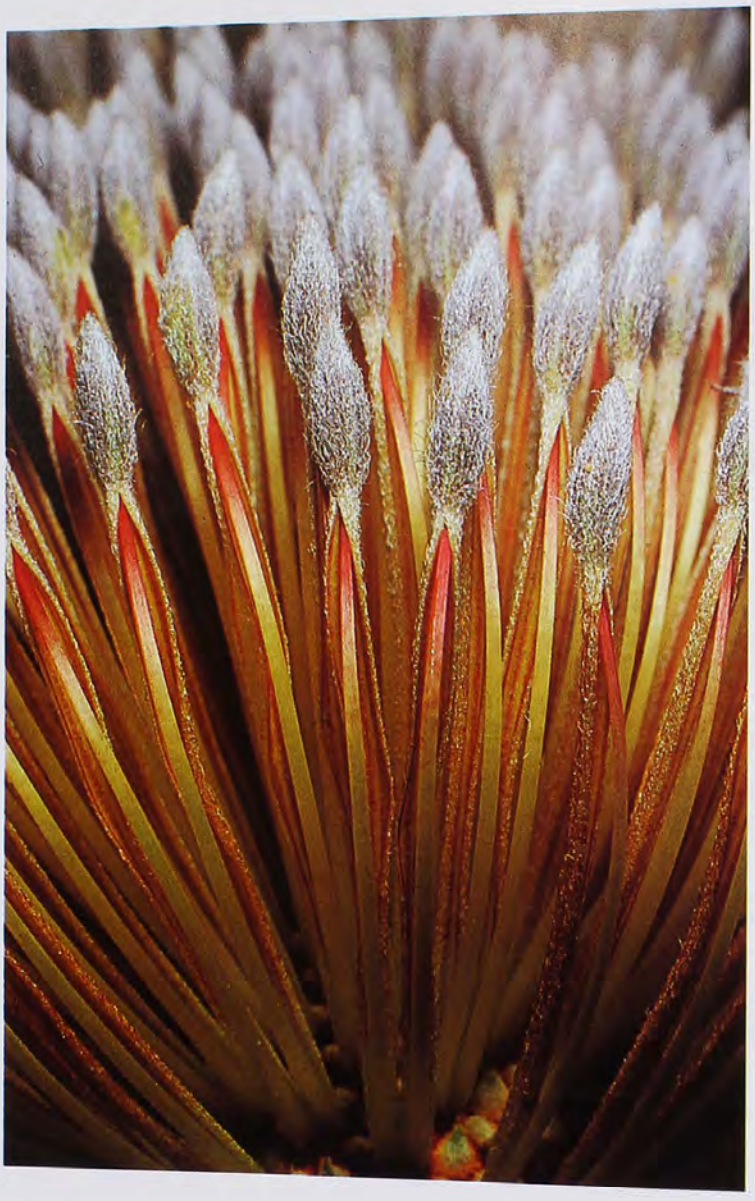
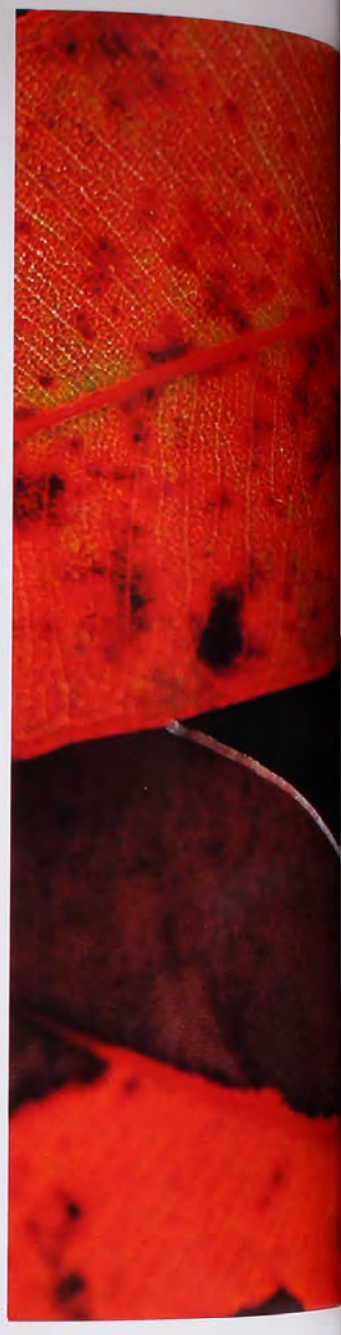
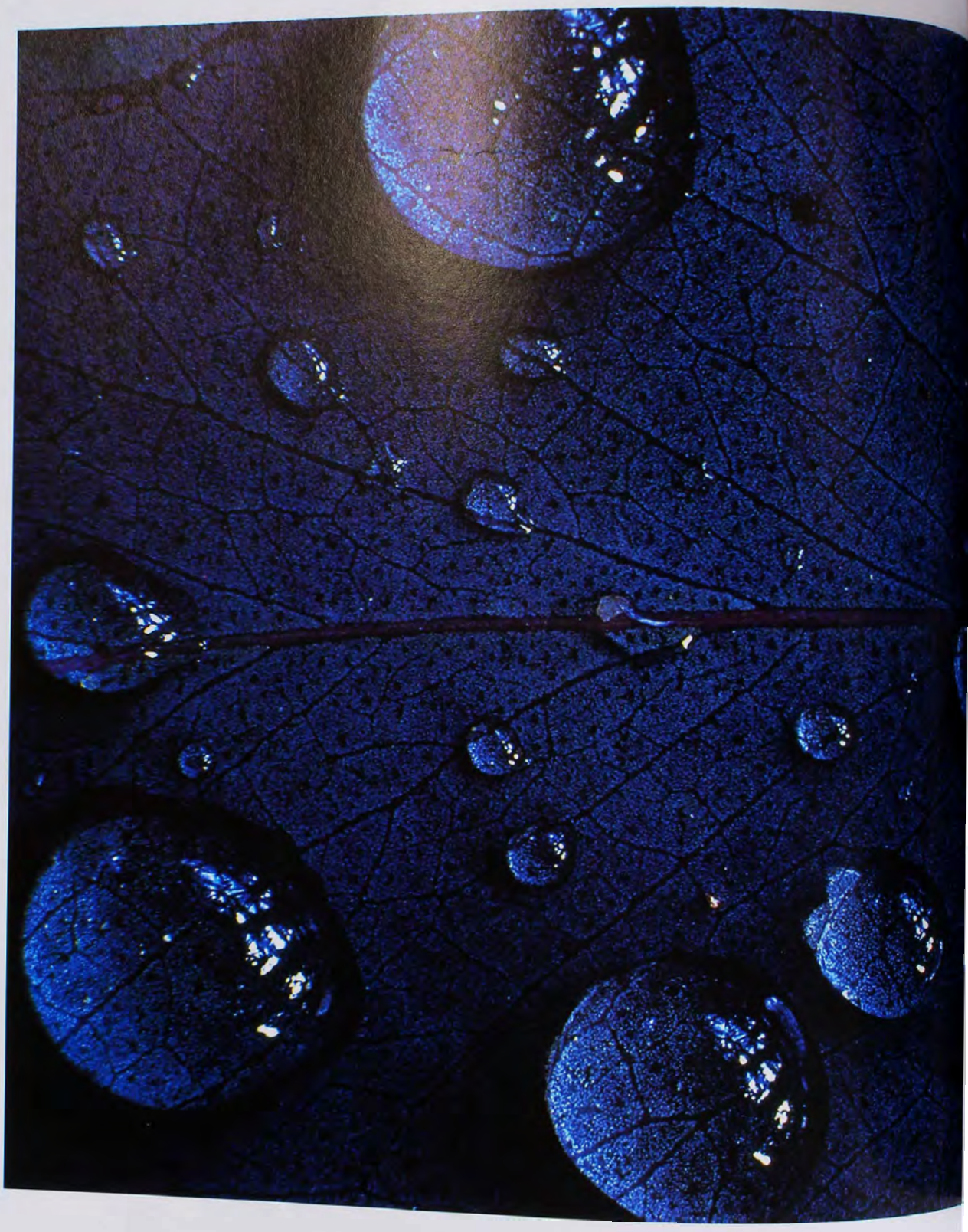
PHOTOART





DESIGN BY NATURE

BY WESLEY TOLHURST



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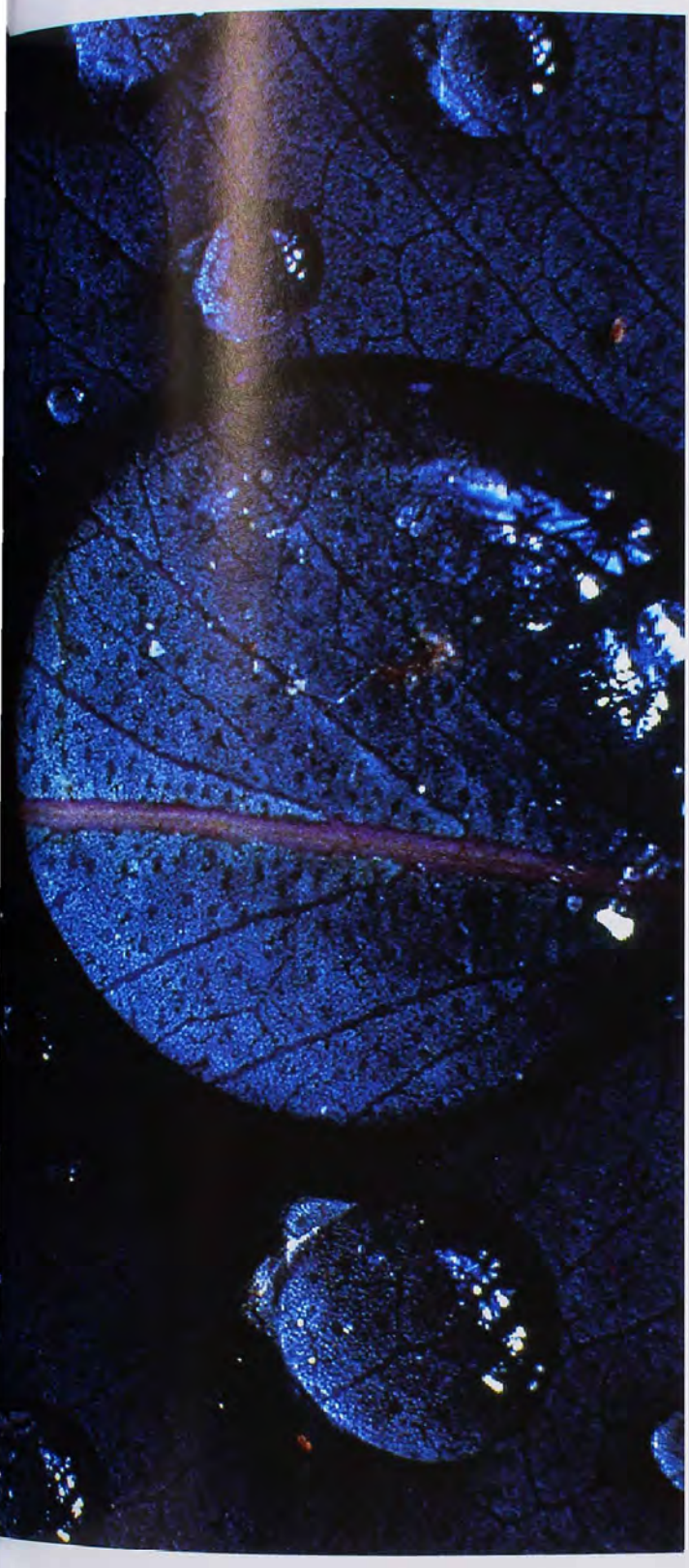

PHOTOART

The search for a 'fountain of youth' may soon find an end in the complex machinery of the cell.

THE LENGTHENING LIMITS OF LIFE

BY MICHAEL ARCHER

For Creation 'Scientists', the chain of descent recounted in the Bible from one Old Testament patriarch to another, provides all the 'science' they need to draw the conclusion that the Earth is less than 10,000 years old. Compared with the calculation of about 4.5 billion (x 10^9) years provided by geologists and physicists, the estimates of Creation 'Scientists' seem just a tad on the improbably young side. But conversely, the Bible tells us that these same Biblical patriarchs whose lives measure the short Biblical history of Earth, lived improbably long lives. Enoch, the father of Methuselah, is said to have been 'taken to Heaven by God' (without having died!) at the age of 365. Methuselah reportedly lived 969 years. Lamech, son of Methuselah and father of Noah chalked up 777 years, and Noah didn't give the game away until he was 950. The rest of us mortals would count ourselves lucky if we racked up a tenth of these times.

Life spans are a curiously little-understood part of life. For bacteria it can be hours; for many insects it's a matter of weeks; for small mammals it is commonly no more than a year; and for bigger beasts such as elephants it is rarely over 50 years. In general, for animals, there appears to be a correlation between absolute body size and longevity—the larger you are, the longer you live. A few striking exceptions to the rule stand out, such as some small insect-eating bats that live for more than 30 years, humans who not uncommonly reach 80 years and beyond, the tiny crustacean known as *Diaptomus sanguineus* whose chiton-covered eggs have been found to be able to survive at least 350 years buried in pond mud, and deep-sea colonial sea anemones (*Gerardia* sp.) that have been estimated to live at least 2,000 years.

But all animal life spans are trivially short compared with the life spans of several, far less agile organisms. Recent discovery of the frozen body of 'Ötzi', a hunter that died in the Alps 5,300 years ago, provided more than a shrivelled human to contemplate. Hay taken from inside Ötzi's boots was found to contain spores of two species of modern fungi. Despite thousands of years in the alpine 'fridge', they grew without hesitation when placed in trays of nutrient agar.

Considering greener things, some lichens (blends of fungi and algae) have life spans several thousands of years long. Tree-ring data and radiocarbon dating have demonstrated that Bristlecone Pine trees (*Pinus aristata*) in North America can live for at least 5,000 years. Even better, the North American Creosote Bush (*Larrea divaricata*) can live for more than 12,000 years.

And on the topic of long-lived plants, what is the natural life span of the rose? If all of the last few centuries of beautiful roses have been grown from cuttings taken from a few ancestral plants, without the genetic renewal of seeds, will there come a moment at the natural end of the rose plant's life when every cultivated rose in every garden in the world suddenly turns black and drops dead? Or (equally intriguing) are the cells of the rose plant cuttings immortal?

Equally surprising are what biologists

AUSTRALIAN MUSEUM

Insect DNA recovered from amber is challenging our definition of life.

are finding out about the life spans of plant seeds. Because one of the purposes of seeds is to enable the young individual to survive periods of hostile conditions before germinating, perhaps it should come as no surprise that some seeds can do this for extremely long periods. A magnolia seed was found among 2,000-year-old rice grains. When watered, to everyone's amazement the 'fossil' seed promptly germinated to produce a beautiful eight-petalled form of magnolia that differs from the six-petalled form that survives today—possibly an extinct species come back to life. Wheat seeds 4,500 years old found in the pyramids of Egypt have been successfully germinated, as has a 30,000-year-old lotus seed.

However, even these colossal life spans pale in the face of results of more recent and controversial research. Microbiologists Raul Cano and Monica Borucki (California Polytechnic State University) have successfully kick-started bacteria back to life after being preserved as spores in amber for 25–40 million years. They are now attempting to do the same for bacteria found in amber up to 135 million years old. Already a company called Ambergene has purchased 16 'revived' bacterial cultures and secured the rights to any commercial benefits that might arise. Although the research warrants cautious scepticism, it has already sparked concern in some quarters about whether or not reviving ancient beasts like bacteria is a wise thing to do. What if, they questioned tongue in cheek, a revived late Cretaceous bacterium turned out to be a mean microbe that in its day took out the dinosaurs? Similar unease followed the exciting announcement by microbiologist Gerald Goldstein (Ohio Wesleyan University) that he successfully cultured bacteria retrieved from the gut contents of a 12,000-year-old mastodon (see *Nature Aust.* * Winter 1994).

George Poinar (University of California at Berkeley), who with colleagues has been recovering intact sequences of insect DNA from 25-million-year-old amber, has used these discoveries to challenge our simple concepts of life. Everyone would agree, he points out, that an organ successfully transplanted from a dead person to a recipient is alive—if it functions in the new body as it once did in the now-dead donor. What then of fossil DNA? If it can be successfully transplanted into a living genome and churns out proteins in the way it formerly did in the prehistoric creature, isn't this DNA alive in the same sense as a transplanted organ? He suggests that the definition of life should be expanded to include "any entity that can grow and/or reproduce when placed in an optimum environment, or any entity that can direct protein synthesis pathways by itself or in another organism".

At the extreme end of life spans, however, is still the four-dimensional, time-travelling, shape-changing Bioblob that I described in an early article in this series (*Nature Aust.* * Summer 1988–89). At last count, it is already at least 3.5 billion (x 10^9) years old. In this view, all of the longest life spans noted above shrivel into mere twigs on the immense tree of life. All branches are eternally connected and biological death becomes no more than an illusion of limited vision—the result of our incapacity to see the Bioblob, as it really exists, in four dimensions.

The growing number of anti-ageing pills and rejuvenating creams is expensive testimony to the fact that we humans are obsessed with the signs of ageing and want to reject our natural lot in the lottery of life spans.

Despite this biological reality, the growing number of anti-ageing pills and rejuvenating creams is expensive testimony to the fact that we humans are obsessed with the signs of ageing and want to reject our natural lot in the lottery of life spans. The search for a 'fountain of youth' may soon find an end in the complex chemical machinery of the cell. Thomas Johnson (University of Colorado) has found—and slowed down—'clock' genes that control ageing in a nematode worm such that, instead of its usual life's run of ten days, it now lives six times that long. Perhaps the Biblical patriarchs will soon have to watch their wrinkled rears.■

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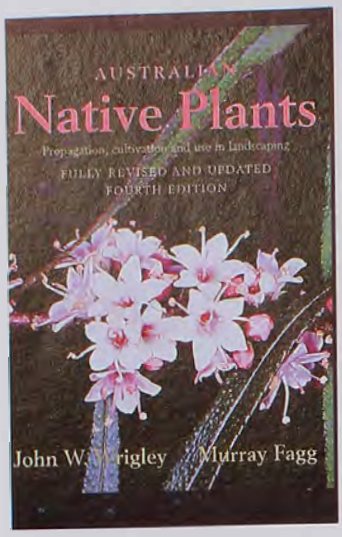
* *Previously ANH*

REVIEWS



Australian Native Plants: Propagation, Cultivation and Use in Landscaping (4th ed.)

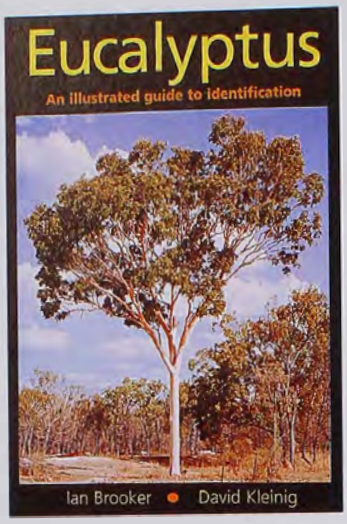
By John Wrigley and Murray Fagg. Reed Books, Vic., 1996, 696pp, $85.00rrp.

Eucalyptus: An Illustrated Guide to Identification

By Ian Brooker and David Kleinig. Reed Books, Vic., 1996, $24.95rrp.

These recent publications from Reed Books will be used and enjoyed by thousands of Australians who are interested in this country's unique flora. Both books contain excellent photographs and information and clear line drawings.

The first edition of *Australian native plants* was published in 1979 and each subsequent edition just keeps getting better and better. Apart from updating names, I am not sure how subsequent editions could be further improved! Essentially a practical book on growing Australian plants, the horticultural information is the result of John Wrigley's own experience with most of the species treated. For those readers who already have earlier editions, I would recommend this 4th edition; there is so much more in it, including over 360 species and cultivars, over 170 line drawings, and the names have been updated to the time of printing.



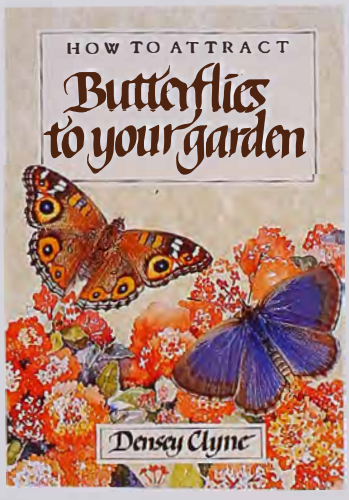
Eucalyptus: an illustrated guide to identification is a very different book as it contains no horticultural information. It is simply a guide to the identification of 200 of the 800 species of *Eucalyptus*.

The simple and well-illustrated 'key' to groups of species covered in the book, using visible characters such as bark type, fruit and bud shape, leaf colour, number and position of buds on the twigs and the plant's habit, allows the reader to get down to a 'short list' of species with a particular combination of features. This book will be most useful in the field. The distribution maps show the approximate natural occurrence of each species, but trying to identify plants in cultivation will be most frustrating and probably futile. This is not a criticism of the book, as it was not intended for this purpose, just a warning to users. One major disadvantage of the book will be when users are trying to identify one of the other 600 or so species that are not included. Many of these species are closely related to one or more included in the book and could 'key out' the same way. Reference should then be made to the three volumes, also by Brooker and Kleinig, entitled *Field guide to eucalypts*, which cover all species (at least at the time of printing).

The book is of a manageable size to carry around the bush, but one disappointment is that there is so much blank space on most of the pages. With one species per page, there is room to have had another photo of some other feature. For example, the feature from which *Eucalyptus urnigera* gets its name (the shape of the fruit) is not illustrated, only the buds, and yet there is space available!

Although sizes of buds, fruits etc. are in the descriptive text, the illustrations of these features do not have a scale, nor are all the photos of the same magnification. Some species have photos of fruits and no buds, or buds and no fruits, and no habitat picture. The next, but ambitious, edition could hopefully cover all 800 species, with photos of all the features of each that are used in the 'key'. However, despite the limitations referred to, I consider this to be a very useful little book that can only assist users in the bush.

—Don Blaxell
Royal Botanic Gardens



How to Attract Butterflies to Your Garden

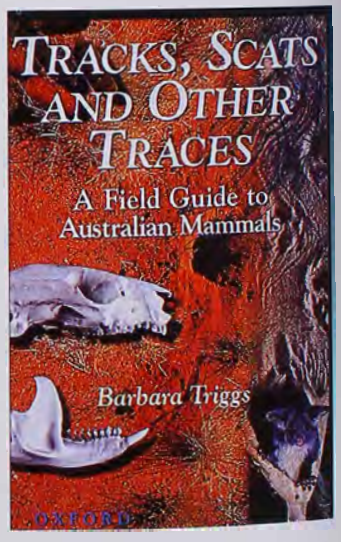
By Densey Clyne. Kangaroo Press, NSW, 1996, 88pp, $16.95rrp.

This beautifully illustrated guide introduces the reader to the pleasures of attracting butterflies to gardens. With Densey's characteristically lyrical style we are reminded that there are "two mouths to feed"—the "sexless caterpillar with a one track mouth" and the adult butterfly that fuels up at flowers to sustain the hunt for mates and food plants.

This is a book ideally suited to the suburban naturalist, the school teacher, or the junior or senior amateur. The photographs are exquisite. A number of eggs, larvae and pupae are pictured, and instructions on how to rear them and their food plants are included. These are tried and tested examples, as Densey has limited her discussion to those species with which she has had some experience.

Attracting butterflies to a garden is a simple process once the appropriate lures and attractants are known, and this book is full of clues and tips. It is worth emphasising Densey's message: that is, animals need appropriate habitats in which to breed. Sometimes these can be created in your backyard, but there are thousands more species out there that need a whole undisturbed forest before they feel well enough at home to breed.

—Shane F. McEvey
Australian Museum



Tracks, Scats and Other Traces: A Field Guide to Australian Mammals

By Barbara Triggs. Oxford University Press, Vic., 1996, 340pp, $29.95rrp.

Anyone fortunate enough to have had the tracks and signs of Australian mammals interpreted for them by

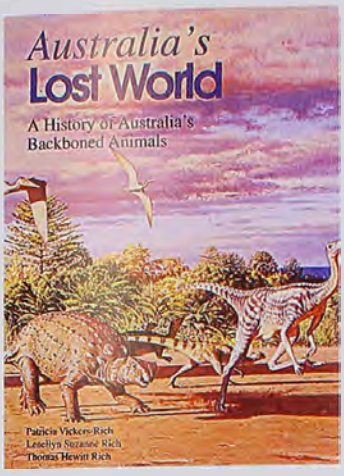
experts, particularly Aboriginal elders, will appreciate how much can be learned about our generally secretive mammal fauna from the traces they leave behind. This revised version of an earlier award-winning book titled *Mammal tracks and signs: a field guide for south eastern Australia* is an essential companion for anyone curious about animal tracks, scats (droppings) or other signs in the bush.

This edition has been extended to include mammals from all over Australia. It is divided into four sections: tracks, scats, other signs (shelters, feeding signs and other traces) and bones (skulls, lower jaws, humeri and femurs). Each section includes a general introduction, a key to assist in identification, and introduced mammal species. Descriptions and plates of signs that may be confused with those of mammals (like those left by some reptiles, birds, amphibians or invertebrates) are also provided.

The new format of the guide and the addition of colour photographs make it easy to use. Photos of scats from 128 mammal species are interspersed with their distribution maps. There are 73 colour plates of mammal shelters, feeding signs and other traces, as well as 40 black-and-white plates showing skulls, lower jaws, humeri and femurs of 38 commonly occurring species. Mammal tracks are depicted in the form of line drawings and photographs of footprints in sand. The photos are particularly helpful as few tracks found in the wild are perfectly clear and they vary considerably in form depending on the substrate, age, climatic conditions etc.

Surprisingly there is no acknowledgment of the tremendous tracking skills to be found in Aboriginal communities throughout Australia. Inclusion of such material would have greatly added to the value of this guide and introduced a new level of detail to the interpretation of mammal signs. However, this is only a minor criticism and I strongly recommend this field guide for anyone interested in enhancing their understanding of Australian mammals and their appreciation of the Australian bush.

—Sandy Ingleby
Australian Museum



Australia's Lost World: A History of Australia's Backboned Animals

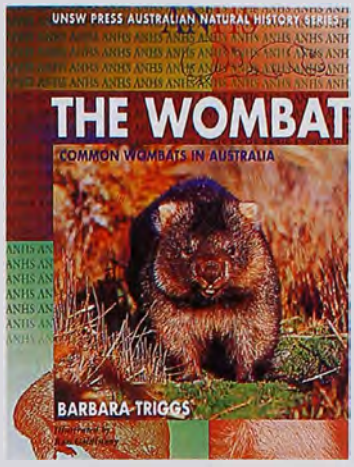
By Patricia Vickers-Rich, Leaellyn Suzanne Rich & Thomas Hewitt Rich. Kangaroo Press, NSW, 1996, 128pp, $19.95rrp.

Two of the authors, Patricia Vickers-Rich and Thomas Hewitt Rich, will be familiar to many people through their previous publications on Australia's dinosaurs and extinct mammals and birds. In this publication they team up with their daughter, Leaellyn Suzanne Rich, to produce an inexpensive volume aimed at the interested high-school student or other non-specialist readers.

A number of steps have been taken to reduce the cost of the publication, including a soft-back cover and mostly black-and-white photographs and illustrations. Unfortunately these detract from the book's visual appeal, and the lack of an index is infuriating.

The text contains a wealth of detail presented in a clear narrative style. The coverage of the history of Australian vertebrates is, however, somewhat idiosyncratic, featuring sites and specimens that the Rich family has had extensive experience with (for example, Riversleigh and Murgon). Overall the book contains many useful facts and some excellent presentations, but should be read in conjunction with other books (such as Pat and Tom Rich's *Wildlife of Gondwana*) to give a balanced and more rounded treatment of the subject.

—Paul Willis
Quinkana Pty Ltd



The Wombat: Common Wombats in Australia (2nd ed.)

By Barbara Triggs. UNSW Press, NSW, 1996, 156pp. $27.95rrp.

Wombats! Muddle-headed? Far from it. This book will dispel most of those myths you have heard about the Common Wombat because what Barbara Triggs doesn't know about this marsupial probably hasn't been discovered yet. This book is the second edition in the very useful Australian Natural History Series. Each book in the series deals with a single species or group. In this case there are three species of wombats in Australia, however most of the book is devoted to the Common or Forest Wombat (*Vombatus ursinus*). Greater use has been made of photographs in this edition; new ones have been added and those from the first edition enlarged. A very useful section of the book is the appendix, which deals with the rearing of young wombats in captivity. These days, as wildlife rehabilitation is taken up by an increasing number of people, it is important that the job is attempted with the full facts at hand. Having seen for myself what damage a wombat can do in a suburban backyard, I would advise everyone to think carefully, and to read this book, before taking on these furry bulldozers.

—L. Gibson
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.

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7 Ormsby Avenue,
Modbury North, SA 5092
Ph: (08) 8264 4958
Contact: Mrs Sheila Burbidge

Membership Fee: $30.00 (Family); $20.00 (Single); $10.00 (Pensioner/Student)

Wildlife Information & Rescue Service (WIRES)
PO Box 1457,
Dubbo, NSW 2830
Ph: (068) 844 995;
mobile: 015 459 008
Contact: Helen Taylor, Secretary; Robin Taylor, Publicity Officer

Membership Fee: $37.00

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University of WA,
Crawley, WA 6009
Ph: (09) 380 2853
Contact: Jane Mulcock, Secretary

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Ph: (03) 9877 5342
Contact: Mrs E McCulloch

Membership Fee: $48.00 and various conc.

Victorian Ornithological Research Group
PO Box 1000,
Blind Bight, Vic. 3980
Ph: (059) 987 996
Contact: Mr Arnis Dzedins

Membership Fee: $15.00 (single); $20.00 (family)

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PO Box 41,
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Ph: (065) 856 470;
fax: (065) 856 528
Contact: Meredith Ryan

Membership fee: $20.00 (single); $25.00 (double); $30.00 (family); $5.00 (junior under 18)

Tasmanian Conservation Trust
102 Bathurst St,
Hobart, Tas. 7000
Ph: (002) 34 3552
Contact: Suzi Manigian

Membership Fee: $25.00 p.a.

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PO Box 528,
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Ph: (02) 9299 6366
Contact: Angela Peteren, Thanya Scott

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CSIRO's Double Helix Science Club
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Contact: Lynn Pulford

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Ph: (02) 9621 3437
Contact: The Secretary

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Queensland Conservation Council
PO Box 12046,
Elizabeth Sth, Qld 4002
Ph: (07) 3221 0188;
fax: (07) 3229 7992
Contact: Danielle Nelson. Phone for details regarding meetings.

Membership Fee: $20.00 (single); $25.00 (family); $15.00 (non-wage earner); $300 (life); $22.00 (group<50); $36.00 (group<150); $50.00 (group>150)

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Contact: Lorrie Davison

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Contact: Ms Kath Berg

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Ph: (02) 9399 7921
Contact: Mr B.L. Brunet.

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c/- Australian Museum, Division of Invertebrate Zoology,
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Ph: (02) 9320 6275
Contact: Ms Alison Miller

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Ph: (07) 3840 7632
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Contact: Dr David Walter

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PO Box 174,
Albert Park, Vic. 3206
Ph: (03) 9866 8699
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Australian Society of Zoo Keeping (ASZK)
PO Box 248,
Healesville, Vic. 3777
Ph: (059) 62 4022
Contact: Michael Taylor

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Q&A

Frog or Toad?

Q: *This photograph was taken in our garden in Seaforth in 1953. What sort of frog is it, or could it be a Cane Toad?*

—John Street
Middle Cove, NSW

A: Although it may have a toad-like appearance, with a rotund body and warty-looking skin, this animal is definitely a frog. It is a Giant Burrowing Frog (*Heleioporus australiacus*). The major differences between Cane Toads (*Bufo marinus*) and native frogs are that toads have distinct bony ridges over each eye, and enlarged venom glands on their shoulders. A warty skin and short legs are not necessarily signs of a toad as many native frogs have similar features. If you look closely at the frog's hands you can make out a series of black spines along some of its fingers. This indicates that the individual in the photo is an adult male. Breeding males also develop powerful, muscular forelimbs, as you can see from this photo. This combination of an Arnold Schwarzenegger physique and spiky hands is probably used for fighting off other males during the breeding season. Male Giant Burrowing Frogs produce an owl-like call to attract female frogs. Around Sydney, the Giant Burrowing Frog is usually found in sandy creek banks in Hawkesbury Sandstone areas. Their complete range stretches from the central coast of New South Wales to the east coast of Victoria. The species has declined greatly since this photo was taken in 1953, and Sydney-siders would now be very lucky to see one in their gardens. The species is now regarded as vulnerable and rare.

As you can see from the photograph, the frog is responding to the threat presented by the inquisitive cat by stiffening its legs and puffing up its body to make itself appear larger. Cane Toads will do a similar thing when threatened, but may also tilt their body side-on towards their attacker to present their venom glands. Like that of the Cane Toad, the skin of a Giant Burrowing Frog also contains toxic chemicals, so perhaps this cat is being wisely cautious.

—Michael Harvey
Australian Museum

JOHN A. STREET

A male Giant Burrowing Frog responds to its feline threat.

© NHPA/NATURE FOCUS

A Southern Leaf-tailed Gecko, with its tail still attached.

A Mysterious Tail

Q: *Please identify this animal, which I found in my Sydney garden. It looks like a miniature stingray, with a broad body, and a small pointed tail. It was about 45 millimetres long, and pale grey in colour. Its surface was smooth on one side and rough on the other, and was not slimy or worm-like. When I found it, it was writhing about, obviously in some distress.*

—S. Hunt
Oatley, NSW

A: It is the broken tail of a Southern Leaf-tailed Gecko (*Phyllurus platurus*). These lizards are common in suburban gardens around Sydney. Leaf-tailed Geckos are mainly nocturnal, and feed on insects such as cockroaches and moths. They have a broad tail that tapers to a thin point. Like many lizards, including skinks and legless lizards, geckos can drop their tails if attacked by a predator such as a cat, bird or snake. The broken tail writhes around for a short time in a very life-like manner. This distracts the attention of the predator while the lizard's head and body make good their escape. It appears that you came across a very recently jettisoned tail that was still capable of movement.

—Michael Harvey
Australian Museum

It's A Rat!

Q: *I think I have a native mammal visiting my garden. Perhaps it is a baby Ringtail*

Answers to Quiz in Nature Strips (page 16)

1. Blood
2. Vegetable
3. Giant Squid
4. Kangaroos
5. Antarctica
6. Fungi
7. Moas
8. Six
9. Tim Flannery
10. A eucalypt

Possum? It is about eight centimetres long, brown with a white belly, big round ears, quite a round face and the tail is long with a white tip. I have seen it hopping and scampering about the yard and climbing trees. It comes out in the daytime to eat the bird seed and the cat's supper, and it isn't afraid of me. I live in Bellevue Hill. I know it isn't a rat because it looks so cute and it's very clean—I have seen it grooming itself. Could you tell me what animal it is?

—E. Noti
Bellevue Hill, NSW

A: This animal is a young Black Rat (*Rattus rattus*), sometimes called a Roof Rat. A Ringtail Possum of the size you mention would still be in its mother's pouch or on her back, and would not be fully furred. A rat's tail is scaly with sparse hairs all around it, while a possum's tail has a strip of naked skin on the underside but is quite thickly furred along the upper side. The tail of the Black Rat is very long—longer than the head and body combined, whereas the tails of native rats are shorter.

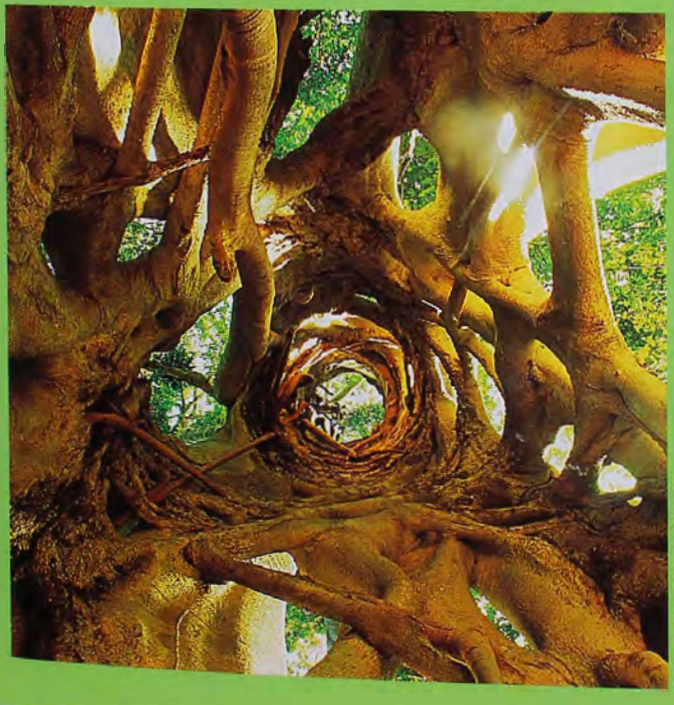
It may be cute, furry and clean, but don't be fooled, it's a feral Black Rat.

Black Rats can climb well and may appear quite tame. If their home (nest of grasses, rags or shredded paper) is destroyed, displaced rats may be seen in the open during the day. Native rats such as the Bush Rat (*Rattus fuscipes*) have not been recorded in the inner city for many years.

—Liz Cameron
Australian Museum

PIC TEASER

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a $20 gift voucher for the Museum Shop Catalogue. Autumn's Pic Teaser was a protozoan (*Spirostomum* sp.) feeding on algae.



DENSEY CLYNE/MANTIS WILDLIFE

One day the farmer found a strange and beautiful flower in a patch of scrub on his property. The farmer had never seen anything like it before.

THE FARMER AND THE FLOWER: A FABLE

BY BOB MESIBOV

ONCE UPON A TIME, in a faraway kingdom, there lived a simple farmer who loved birds and butterflies and blossoms and all things natural.

One day the farmer found a strange and beautiful flower in a patch of scrub on his property. The farmer had never seen anything like it before. He took a photograph of the flower and sent it to the Professor of Botany at the University.

The Professor became excited when he saw the photograph. He wrote to the farmer and said that the flower was so rare, everybody had thought it was extinct. He asked the farmer to take very good care of the rare flower.

The Professor also wrote to the Government's Department of Nature Conservation. Officials in the Department were very happy about the farmer's discovery, because it gave them a chance to implement nature conservation policies and to target strategic conservation objectives.

The first thing the Department did was to direct one of its Flora Conservation Officers to visit the farmer's property and write a report. Unfortunately, there was no scope for such a visit in what remained of the financial year and, owing to cutbacks in travel allowances and the need for a reassessment of travel priorities, no visit was possible for another two years. In the third year, an Officer visited the farmer and confirmed the existence of the rare flower.

With the Officer's report in hand, the Department proceeded along its sequence of conservation management duties. It listed the rare flower on the Government's Official List of Threatened Plants, and it entered the name and location of the flower on the database of rare flora. A number of sophisticated studies were begun in the Department's Environmental Resources Section, which sought to relate the flower's location to rainfall, day length, soil type and other environmental parameters.

The Department also raised the issue of the rare flower at a meeting of the Interdepartmental Working Group on Threatened Species. The flower rose higher and higher on the agenda at successive Working Group meetings, but after a few years it was displaced by higher-priority species, and the Working Group never actually discussed the flower or what to do about it.

Earlier, however, the Department had applied to the Royal Court for money to conserve the flower under the King's Threatened Plants Rescue Program. Because the Program received many such applications, and because each one had to be carefully evaluated by a panel of experts, it was some time before the Department's application was processed. The result was favourable. The application was short-listed for funding, and after several more years the Department received a Royal grant. A Consultant was then hired to determine precisely what additional information was needed in order for the rare flower to be effectively conserved.

The Consultant worked quickly and prepared a detailed report, which spelled out exactly how much money would need to be spent on additional fieldwork and management studies. The Department referred the report to the Interdepartmental Working Group on Threatened Species and to the Royal Treasury Liaison Unit, which advised the King on how government resources could best be allocated given the various constraints on expenditure.

Ten years had passed since the farmer had made his discovery. In the meantime, the farmer had put a stock-proof fence around the rare flower, and a little colony of the plants had grown up and prospered. The farmer got a great deal of pleasure each spring when he saw the blossoms and smelled their perfume. The farmer believed he had done the whole kingdom a service when he put up the protective fence, so he wrote to the Department of Nature Conservation asking for $100, which was the cost of the fencing materials.

The Department replied with a long and polite letter. The officials explained that, while they would like to help the farmer cover his fencing costs, there were still some small, mainly administrative obstacles to spending Royal money on private land. Besides, nearly $100,000 had already been spent on the rare flower in Department Officers' time, data-processing, publicity, interdepartmental meetings, consultant fees etc. and there was nothing left in the budget for that particular item. The officials were sorry, but there was nothing the Department could do at the present time. However, the matter would certainly be raised at the appropriate meetings in the next financial year.

The letter concluded, "The Department greatly appreciates your efforts in helping the Government to conserve this priceless feature of our natural heritage." ■

Ten years had passed since the farmer had made his discovery. In the meantime, the farmer had put a stock-proof fence around the rare flower, and a little colony of the plants had grown up and prospered.

Dr Bob Mesibov is a Research Associate at the Queen Victoria Museum and Art Gallery, Launceston, Tasmania. This fable was born out of frustrating experiences the author has had with the conservation of rare species. He believes that successful conservation requires much less bureaucracy and much more community goodwill.

BACK ISSUES AND SUPPLEMENTS

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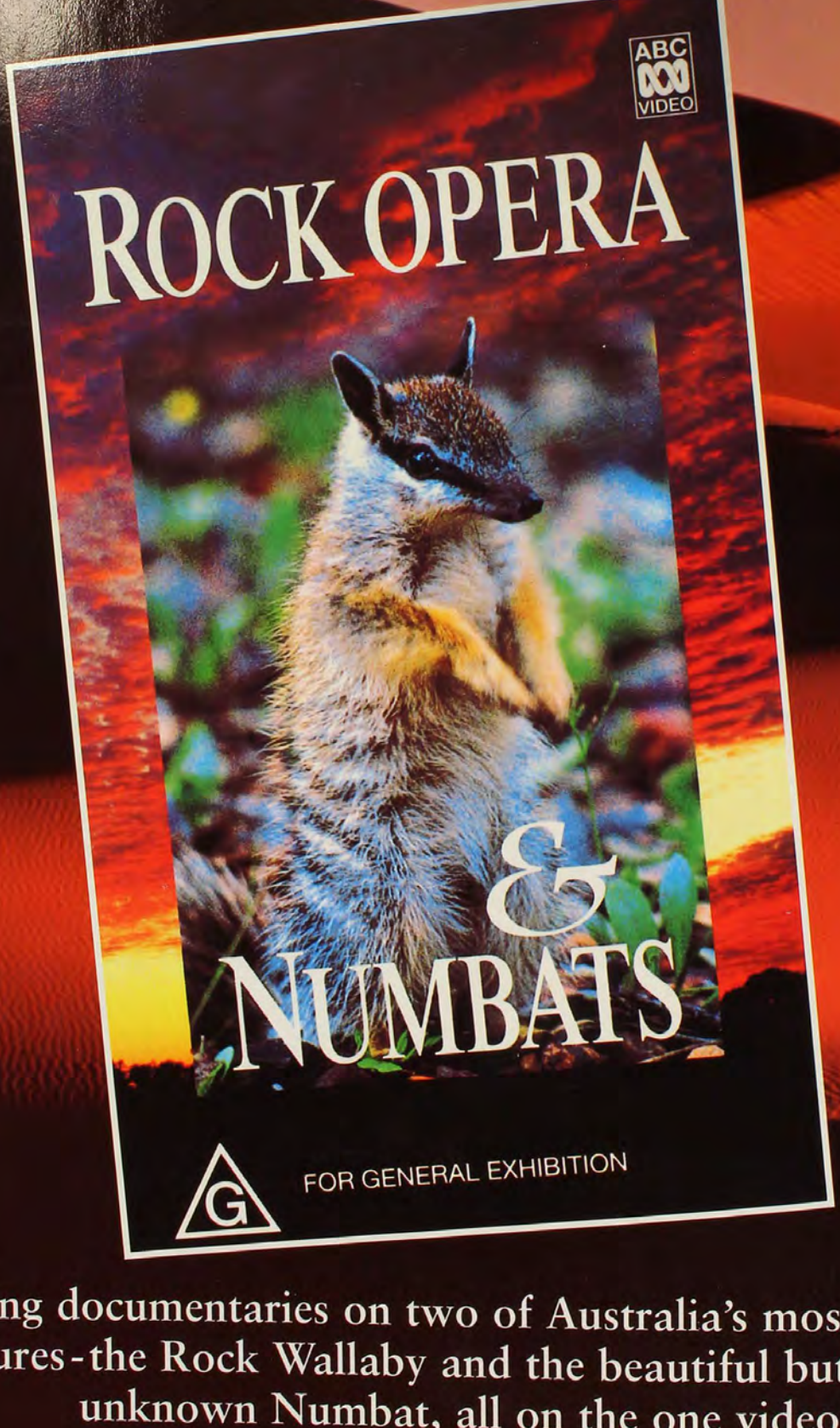

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