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VELVET GECKOS
THE BIG CHILL
EARTHWORMS
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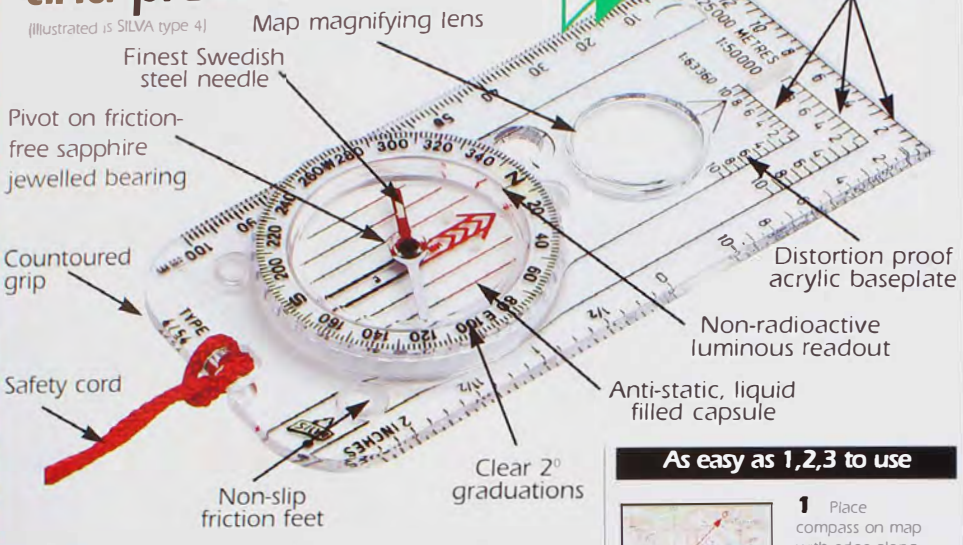

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Up Front

Know all about the Greenhouse Effect? Sick of hearing about El Niño? Well here's a global phenomenon you may not be as familiar with but one that can have just as much impact on the planet . . . and us. In fact it's responsible for Australia turning from the lush tropical forest of the past into the harsh desert we know today. It's called an ice age and it seems that our planet has been subjected to several of these cold events since they began millions of years ago. What started all this freezing and thawing is still unknown (although Geoff McNamara presents some interesting theories) but what continues to trigger them appears to be a complicated interplay of various planetary conditions. One thing is for sure, they have been responsible for some major events including mass extinctions and allowing humans to migrate from Siberia to Alaska. So when is the next one? Is it time to stock up on extra winter woollies? You may be surprised by the answer. Read "The Big chill" on page 54 and find out.

Lesueur's Velvet Gecko.

KATHIE ATKINSON

From the chill of an ice age to the tropical warmth of a coral cay in the Great Barrier Reef, we follow the trials and tribulations of booby chicks struggling to reach maturity. From the moment they hatch, these birds are harassed by siblings, neighbours and predators, and if that's not enough, their parents are often conned out of dinner before it gets to them.

Velvet geckos, on the other hand, face quite different dilemmas. Being nocturnal, they laze about in the warmth of their rock crevices during the day and then rush about at night until it's time to go home. Unfortunately for Lesueur's Velvet Gecko finding a home is a bit like playing Russian roulette as any potential abode could contain an angry rival male or even a gecko-eating snake. So how do the geckos tell which home is a safe house?

We also take a look at how giant squids have sex, and discover that the smartest marsupials are wearing long tails. Our regular features include tips on saving a species when there is only one individual left, instructions on the best way to serve earthworms to your friends, advice on how to beat the flim-flam virus, and The Last Word highlights what can happen when we all look the other way.

—Jennifer Saunders

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Front Cover
Masked Boobies (*Sula dactylatra*) live and breed in an impoverished blue-water environment—the Great Barrier Reef. Photo by Kathie Atkinson.

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LETTERS

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

Stilt ID

One of the satisfying aspects of *Nature Australia* is the wonderful photographs, accompanied by informative captions. As a committed waderologist (one who studies wading birds), and an amateur photographer, I feel it is my duty to point out a small lapse in caption accuracy in the Summer 1998–99 issue. The photograph labelled Banded Stilt (*Cladorhynchus leucocephalus*) is actually of a Black-winged Stilt (*Himantopus himantopus*).

The Banded Stilt is endemic to Australia, and very few records of its breeding have been made. Recently, it has emerged that the birds breed around inland salt lakes, when they are filled by the unpredictable rainfall of the interior. Black-winged Stilts are found in Australasia, Eurasia, India, Africa and the Americas. In Australia, they also seem to move inland with favourable rainfall conditions, but their breeding tends to occur at freshwater wetlands.

The easiest single clue to identifying stilts in Australia is the head plumage. The Banded Stilt has an all-white head, and the Black-winged Stilt has a black area stretching from the back of the head down the neck. There are many clues to identification, including other plumage patterns, and hints that derive from the bird's habitat choice or behaviour. For example, the nest habitat shown in the mislabelled photograph is typical of a Black-winged Stilt breeding around a freshwater wetland, but very different from the scorched sand of an island in a salt lake, where Banded Stilts breed.

—Michael A. Weston
University of Melbourne, Vic.

Chocolate Bilbies

I have in my possession a book *Billy the Aussie Easter Bilby* written by Rose-Marie Dusting and first published in Australia in 1979. This contradicts the claim by Robert Morrison (*Nature Aust.* Spring 1998) that the Easter Bilby owes its origins to the Anti-Rabbit Research Foundation of Australia (ARRFA) in 1991.

Quite independently of ARRFA, Melbas Chocolates made and sold an Easter Bilby before Haighs in 1993. They and other chocolate bilby makers have contributed proceeds to the saving of Bilbies and other wildlife ever since without reference to ARRFA. So, people can purchase chocolate bilbies at Easter as well as other times, and know that not only are they increasing community awareness of Bilbies but in many instances they are also helping wildlife financially.

This is particularly true for Melbas Wildlife Chocolates, which feature Brush-tailed Bettongs, quolls, Numbats, Short-beaked Echidnas, as well as Bilbies. A royalty goes to the South Australian National Parks and Wildlife and the Threatened Species Foundation of Australia.

—D. John Hunwick
Eden Hills, SA

TOM & PAM GARDENER/NATURE FOCUS

Banded Stilts—note the all-white head plumage, which is one of the easiest ways to differentiate them from Black-winged Stilts.

COURTESY BRIAN CHUDLEIGH

Copulating New Zealand Kakas. This pair seemed to continue for an unusually long time.

Fly Traps & Kaka Sex

A couple of articles in the Spring 1998 issue of *Nature Australia* really caught my interest. First was Tim Low's "Plants with Sensitivity". Common in cultivation in Australasia is the Venus Fly Trap (*Dionaea muscipula*). Any insect that enters the open leaf and touches any two of the trip hairs will be lucky to escape ensnarement as the trap is sprung and the leaf closes over the intruding insect. The rapidity of the closure is amazing to watch and, if an insect is caught, the leaf remains closed until most of the nourishment it contains is absorbed by the plant. Leaves can be triggered into closing by brushing the trigger hairs, but if no food provider is trapped, the leaf gradually reopens shortly afterwards.

The second article of particular interest to me was the one on "Why Kissing is for the Birds". Several months ago my wife and I were in the walk-through aviary at Auckland Zoo where we spotted a pair of courting New Zealand Kakas (*Nestor meridionalis*). In my years of bird watching and photography I have often seen birds copulate—a very brief and vigorous affair lasting just a few seconds. This pair of Kakas was on the ground, on a bank above the walking track, surrounded by considerable vegetation, and if was difficult for us to get an open view for photography. Initially there was a lot of sparring with beaks, flapping and bumbling around, and eventually copulation began . . . and went on and on and on, like I have never previously seen with birds. As there is supposedly no penis to connect the birds, I found it quite extraordinary how they remained in contact for so long. My wife missed the beginning but still got 75 seconds of it on video and I obtained eight photos, using a 300-millimetre lens with flash in very dark surroundings, which really soaked up battery power requiring many seconds for repowering between shots. I would say that copulation lasted two minutes. When the male finally baled out, he remained standing on the ground, beak open, panting for some time, before regaining enough energy to fly off. An amazing feat of endurance for a bird.

—Brian Chudleigh
Katikati, NZ

Peregrines Not People

In the article on Peregrine Falcons (*Nature Aust.* Spring 1998) by Penny Olsen, I found what seems to be commonplace when interpreting animal behaviour—anthropomorphism.

The female falcon was said to be able to "judge what sort of a provider the male is and scale her reproductive effort accordingly" based on the male bringing prey to her during courtship. I resent this statement. It implies the female Peregrine has the intelligence to examine her current situation and project it into the future to see what impacts may be had, then to make decisions concerning her future.

The male's courtship behaviour indirectly dictates the success of the breeding pair of birds. Since it is driven by instinct (not learned), it's grounded in genes, and so the stronger the instinct (the more prey captured), the better chance of breeding success. The male's ability to "provide" for the female is also governed by physical attributes that are grounded in genes. The female doesn't decide on which male to mate with by a conscious, deliberate examination (judgement); instead she mates with the male whose behaviour inspires the greatest instinctive reaction on her part.

Olsen also mentions the "female 'decided' to lay a certain number of eggs based on the male's provisioning abilities . . .". If the female lays fewer eggs with a male that is a poor provider, it's because there has been insufficient energy (from her diet) to produce a larger clutch, not because she determined he wasn't good enough to sire three or more eggs.

Putting a human perspective on animal issues is scientifically unsound and leads to false understanding of the psychology of animals. Unfortunately it is too common.

P.S. The magazine is excellent.

—Dean Portelli
Westmead, NSW

NATURE AUSTRALIA **welcomes letters for publication and requests that they be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in this issue will receive a copy of *The Graham Pizzey & Frank Knight field guide to the birds of Australia* from the Museum Shop. The winner this issue is Brian Chudleigh.**

Nature Strips

COMPILED BY
GEORGINA HICKEY

Paydirt for Parrots

Humans and other animals have eaten soil for generations. Descriptions of geophagy go back to Roman times, and the practice continues today. In Zambia and Zimbabwe, for example, 90 per cent of pregnant women eat soil, a nutrient-rich mix derived from giant termite mounds.

So what's so great about eating dirt? Theories on why abound, including to suppress appetite, provide grit for grinding food, buffer the stomach, add minerals such as salt to the diet, and adsorb toxins. Now new clues have emerged from two recent studies on soil-eating parrots. Jared Diamond and David Bishop (University of California at Los Angeles) studied parrots in New Guinea, while James Gilardi (University of California at Davis) looked at the soil-eating habits of Amazonian parrots.

Suspecting that dirt was eaten as a dietary supplement, the researchers investigated the mineral content. But in both areas, the soils were low in nutrients, and were also too fine to be of use in grinding food. They also had little value as a buffer against acidic foods.

One thing the researchers did notice was that both soils were rich in clay. Clays are known to bind to bacteria and toxins, effectively preventing them from being absorbed in the blood. In fact, Kaomagna, an over-the-counter medicine used to combat diarrhoea, is largely fine clay in solution. Diamond surmised that ingestion of the clay soils helped parrots cope with plant toxins in their diet.

Many seeds and unripe fruits contain toxins, such as quinine and strychnine, to deter predators. Parrots, it seems, have learnt that eating dirt protects them against plant toxins. So effective is this method that dirt-eating parrots have to ingest 50 times more quinidine (a poisonous alkaloid) than humans for it to be detectable in their blood stream.

—A.T.

Roman False Teeth

A trip to the dentist is bad enough these days, with the option of anaesthetics and modern technology. Pity then the Gallic man who 1,900 years ago had to have an iron replica implanted in his upper jaw.

This remarkable discovery of the oldest-known functional prosthetic tooth was made in a skeleton from a cemetery at Chantambre in France, and was the only one of the 500 or so skeletons with such dental work.

Particularly interesting, says Eric Crubézy (Université Paul Sabatier, France) and colleagues, is the iron tooth's precise fit in the socket, suggesting that whoever

JOHN CANCALOSI/AUSCAPE

Why do humans and other animals, like this Eclectus Parrot (*Eclectus roratus*), eat dirt?

The ears of bullfrogs, like this South African Giant Bullfrog (*Pyxicephalus adspersus*), are used not only for listening but for talking too.

ERWIN & PEGGY BAUER/AUSCAPE

modelled it carefully copied it from the original premolar, and gave the tooth its shape through a hot hammering and folding process. The prosthesis was then gently placed in the socket, where bone subsequently grew around it, cementing it in place.

It takes between three and six months for bone to grow around a tooth implant, although modern dentists opt not to insert false teeth directly into the bone because of uncertain success. Minor reactions between the iron tooth and the bone suggest that the 30-year-old man was able to enjoy his dental work for at least a year before he died.

The researchers say that, although chance played a part in the success of the implant, the technical choices made by the dentist were conducive to the bone-integration process. But how an Iron-Age healer acquired the skill for such an operation, or prevented infection, is unknown. Indeed, Marshall Becker from West Chester University believes it wasn't an iron implant at all, but a natural tooth stained with iron oxides. However no iron or metal objects were found associated with the burial, and even if they were, it is unlikely they would have affected just one tooth. One thing is certain: this early Roman tooth has definitely given archaeologists something to chew over.

—R.S.

Blame Big Ears

Bullfrogs can make one hell of a noise! During the breeding season their chorus can be deafening. Croaking has always been affiliated with the vocal sac that inflates like a balloon under the frog's chin. However, Alejandro Purgue, a biologist researching acoustics at the University of California in Los Angeles, has traced sound projection to a different part of the bullfrog's anatomy. It seems the frog is no loud-mouth—he just has big ears.

By placing a sound-generating device inside the mouth of a North American Bullfrog (*Rana catesbeiana*), Purgue measured how various parts of the body amplify pulses of sound. Although the vocal sac picked up some vibrations, the overwhelming response emanated from the ears. Most (70–80 per cent) of sound output was transmitted through the tympanic membrane—the external skin covering the middle ear.

The tympanic membrane has always been exclusively associated with sound reception, yet Purgue's results reveal bullfrogs not only hear, but also talk through their ears. By amplifying the sound from the vocal cords, the tympanic membranes function as loudspeakers for broadcasting the mating call. This also explains why males of the species have eardrums 50 per cent larger than females. The silent female's ears only have to listen, while the male's ears have to listen plus do all the 'talking'.

Strangely enough, those other incessant noisemakers—cicadas—also have eardrums that broadcast their calls. There is no escaping the cacophony of summer, as the shrill chirping of sweet nothings resonate from millions of tiny ears.

—K.H.

Oxpeckers and Elephants

Are oxpeckers pernickety when picking a tick to peck? It is often stated, for example, that elephant ticks

FERRERO-LABAT/AUSCAPE

Are oxpeckers, such as these Yellow-billed Oxpeckers (*Buphagus africanus*), choosy about their hosts?

are off the menu. Perhaps the common elephant ticks (*Amblyomma tholloni*) are too large for oxpeckers (*Buphagus* spp.) to comfortably eat. But perhaps it's the elephant that shuns the oxpeckers. Elephants are known to tolerate other birds crawling over them to find ticks. Do the sharp needle-like claws of oxpeckers irritate the elephant's skin?

Despite this general (and possibly mutual) aversion, there have been six sightings of oxpeckers on African Elephants (*Loxodonta africana*) in the Hwange National Park of Zimbabwe in the last 15 years. Most of these rare incidents occurred in the dry season of a drought year when many elephants were starving and in poor condition. Peter Mundy of Zimbabwe National Parks and Gary Haynes from the University of Nevada believe this may be because stressed elephants are likely to harbour more ticks, of several varieties, and so could be more suitable hosts to oxpeckers. Also, in their poor state, the elephants seemed indifferent to the birds, perhaps too weak to object. Rather than being selective, oxpeckers may just be opportunists.

—B.D.

Dinosaur's Supersonic Tail

What's 12.5 metres long and moves faster than the speed of sound? A dinosaur's tail, according to a recent investigation by Nathan Myhrvold (Microsoft Research) and Philip Currie (Royal Tyrrell Museum of Paleontology).

The purpose of the enormous, gracefully tapering tail of sauropod dinosaurs has always been a puzzle. Was it used as a thrashing weapon, or like a scare gun? Myhrvold and Currie believe the latter. Using computer simulation, the researchers created a virtual tail based on measurements from an *Apatosaurus* specimen. They were able to show that the wispy tip of the massive tail may have been capable of moving at supersonic speeds, creating a crack like a bullwhip.

A bullwhip cracks because the tip exceeds the speed of sound and creates a sonic boom. It relies on two physical properties to do this: flexibility and decreasing cross-sectional area from base to tip. When the researchers looked at the tail structure of *Apatosaurus* and other diplodocid dinosaurs, not only did they find these two features, but they noticed that, not far from the base of the tail, eight of the vertebrae were elongated, which may have provided increased stiffness and reinforcement at a point of stress between the base of the tail and the more flexible whip-like section. It is interesting to note that the equivalent section of a bullwhip is the first point of failure, ending the functional life of the whip.

To have had any impact as a weapon, the tail would have needed to travel at great speeds. Although this was shown to be possible, if it had hit anything at these speeds, it would have been damaged. It seems more likely that the tail was used as a noisemaker, perhaps to scare away predators, to establish dominance in intraspecific competition,

to enforce group discipline (herd), or even during courtship.

—R.S.

Penis Fencing

The 'genital handshake'—where the male copulatory organ enters the female reproductive tract—isn't the only way to achieve internal fertilisation. In bed bugs and fleas, for example, the male simply pierces any part of the female's body with his penis and ejaculates just under her skin. His sperm then works its way to her eggs.

This method of 'hypodermic insemination' is also favoured by leeches, flatworms and sea slugs—animals in which the male and female organs are found within the same individuals. For such hermaphrodites, however, is it better to stab or be stabbed?

Nico Michiels and Leslie Newman collaborated at the Heron Island Research Station (University of Queensland) to investigate this question and to determine whether or not it was a source of conflict. According to the rules of natural selection, it would presumably be better to stab than to waste time and energy healing wounds after being stabbed.

L. NEWMAN & A. FLOWERS

Hypodermic insemination by the flatworm *Pseudoceros bifurcus*. To stab or be stabbed? That is the question.

The researchers observed sexual behaviour in *Pseudoceros bifurcus*, a polyclad marine flatworm (see *Nature Aust.* Spring 1997). Although hermaphrodites, they act as males when mating. Sexually interactive animals rear up and, on contact, evert their penises. Mating then involves around 20 minutes of 'penis fencing', with individuals striking and parrying—behaviour that is clearly aimed at getting a stab in while avoiding the stab of others.

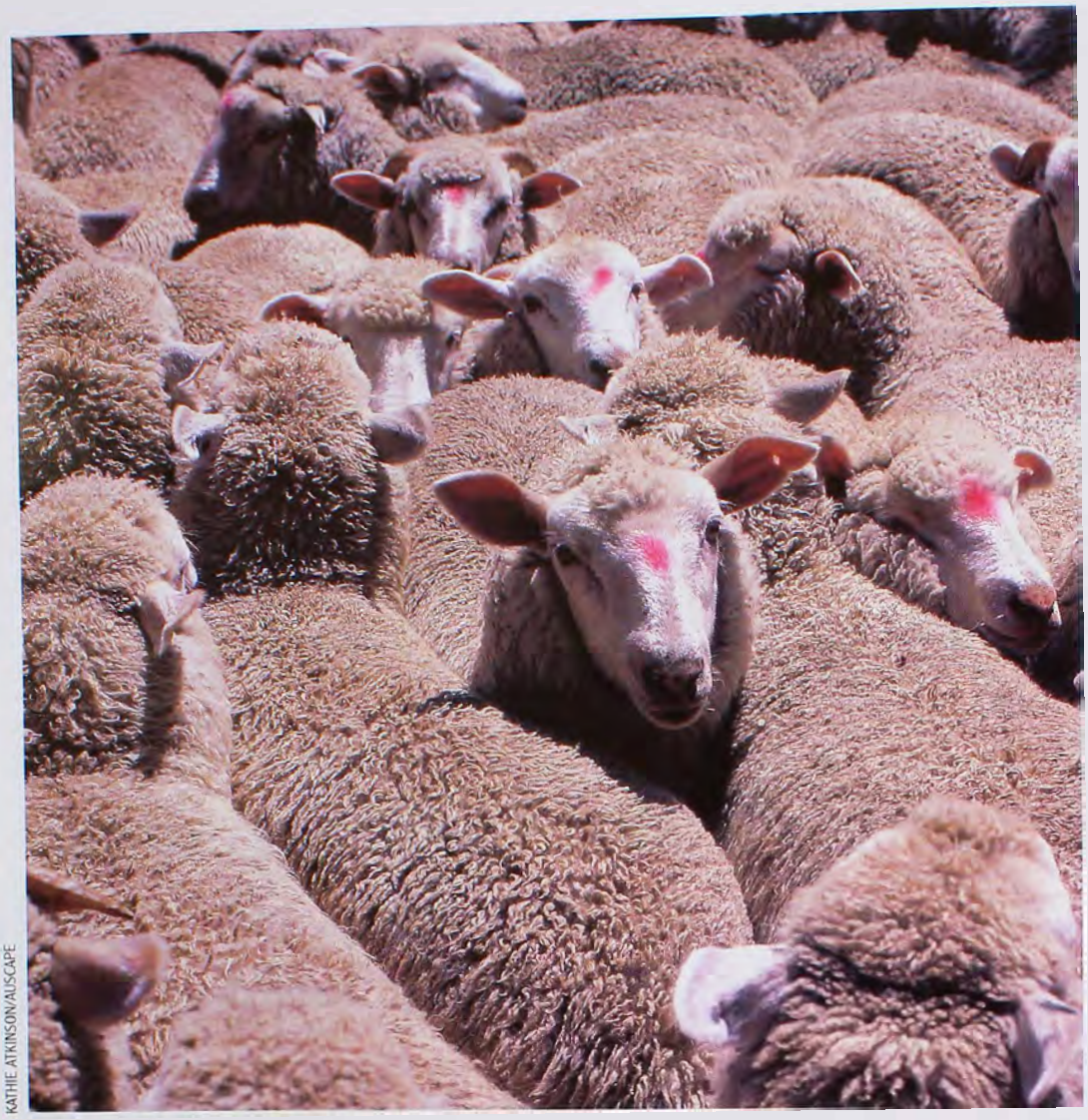
In most matings, only one partner is inseminated. However, in cases where both partners manage to stab one another, the animal that stabs first has a longer time to inject sperm, fertilises more eggs and endures fewer wounds.

By trying to avoid insemination, these flatworms not only cut the immediate costs of wound repair, but may then have the opportunity of being inseminated by better 'stabbers', which presumably would lead to more successful offspring.

—K.McG.

Knowing Me, Knowing Ewe

A Scottish Sheep farmer I once knew claimed he could individually identify each of his Sheep by its face. Humans, it seems, are very good at recognising individuals, even among Sheep. The Sheep themselves, although



KATHIE ATKINSON/AUSCAPE

Sheep can recognise members of their own flock, but can they tell individual humans apart?

they can recognise other members from within their own flock (see *Nature Aust.** Autumn 1989), are generally thought to be quite poor at recognising individual humans. Some scientists conclude that Sheep cannot even discriminate between male and female humans, or between humans wearing different clothes. Recent research, however, suggests that, when food depends on it, Sheep are quite capable of distinguishing human differences.

Hank Davis and colleagues from the University of Guelph in Canada trained 15 young Arcott Sheep to press their nose into a person's left hand to receive food from the right. Two female handlers conducted the training. They were virtually identical in height and dress, although one was blond and the other brunette and they obviously differed in facial features. One trainer provided positive reinforcement, by feeding the Sheep after being nose-pressed. The other trainer offered no reward (even though she too held food in her hand). The Sheep rapidly learnt to distinguish between the two handlers, sniffing and vigorously pressing the hand of the positive reinforcer, while turning away from the other handler.

It seems that these Sheep used some kind of individual cue—whether visual or a subtle olfactory difference—to discriminate between the two individual handlers. While it is tempting to suggest that Sheep might just prefer blondes (or brunettes), this is not the case. Apart from the fact that Sheep don't see in colour, for half the Sheep the blonde was the positive reinforcer and the brunette gave no rewards, while for the other half the roles of the women were reversed. In each case the Sheep learnt to associate the positive reinforcer with food.

I doubt that my Scottish friend would have been much surprised by this evidence of ovine talent. As his Sheep bounded down the hill to greet him (while ignoring me), I'm sure he had no doubts that they knew who he was, just as clearly as he knew them.

—D.C.

*Previously *ANH*

Frog Bubble Nests

Sneezing on your offspring seems a rather strange way to ensure their survival. But two frog biologists working in the Atlantic Forest of south-eastern Brazil have discovered a small frog, *Chiasmocleis leucosticta*, doing precisely that.

Célio Haddad (University Estadual Paulista, Brazil) and Walter Hödl (University of Vienna, Austria) observed

COURTESY CÉLIO HADDAD

A novel approach to parenting: this small Brazilian frog, *Chiasmocleis leucosticta*, 'sneezes' life-saving bubbles of air onto its eggs.

frog eggs in floating 'bubble nests' made up of large air bubbles trapped inside a thick and sticky mucus. What intrigued Haddad and Hödl was that these floating nests were quite unlike the foam nests produced by other frog species. Frogs normally construct floating nests using their arms or legs to vigorously beat the mucus produced by females during egg-laying, literally whipping it into a froth of tiny bubbles. How did *C. leucosticta* produce the large air bubbles for their floating nests? To answer this question the researchers made careful observations of nest construction, both in the lab and in the field, and video-taped an entire nest-making sequence.

After the female finished laying eggs, the male and female pair took a breath and dived beneath the egg mass. With a distinct metallic sound, they then blasted air from their nostrils by compressing their throats. Large bubbles rose into the mucus of the egg clutch, keeping the eggs afloat. The frogs repeated the gulp, dive and 'sneeze' sequence about 50 times, and the male continued for a short while after the female left.

The construction of floating nests presumably evolved to anchor embryonic frogs at the more oxygenated levels of oxygen-poor ponds. By sneezing air bubbles onto the eggs and forming a floating raft, this species has opted for a novel way of ensuring its offspring do not sink to the bottom and die of oxygen starvation.

—S.R.

Frosty Warning

Anyone with a vegetable garden or orchard will be intimately aware of the damage frost can cause. Now new findings suggest that a plant's sensitivity to frost will increase with our increasing levels of atmospheric carbon dioxide.

In a paddock near Bungendore in southern New South Wales, Jason Lutze (Australian National University) and colleagues placed six-month-old seedlings of the frost-hardy Snow Gum (*Eucalyptus pauciflora*) in specially designed open-top chambers, which subjected the seedlings to the natural vagaries of the weather. Half the chambers were flushed with double ambient levels of carbon dioxide, the other half received normal levels.

After a chilly –5° C night, frost damaged 68 per cent of leaves grown under elevated carbon dioxide levels, while it damaged only 37 per cent of leaves under normal conditions. The researchers strongly suspect this increased sensitivity to frosts will apply to most plant species.

Given that atmospheric carbon dioxide levels are predicted to double by late next century, these findings may have serious implications in areas of vegetation dynamics, agriculture and forestry. Foresters, for example, aim for tall, single-stemmed trees, while frost-damaged seedlings tend to grow multiple stems. And even if increased carbon dioxide levels lead to global warming and fewer finger-numbing mornings, Jack Frost need only visit once to ruin an entire crop.

—J.M.

Cuckoo's Secret

Cuckoos are famous for their habit of duping other birds into raising their young. The Common Cuckoo (*Cuculus canorus*), for example, regularly parasitises the nests of Reed Warblers (*Acrocephalus scirpaceus*), laying a single egg into the warbler clutch. After hatching, the cuckoo ejects its hosts' young, yet still manages to get the host parents to deliver the same amount of food normally supplied to the whole brood. Until now it was assumed it was the cuckoo's large size (up to eight times greater than its hosts) that stimulates the warblers into action. But new research by Nick Davies and colleagues from Cambridge University has shown that the cuckoo's secret is in its call.

Blackbird (*Turdus merula*) and Song Thrush (*T. philomelos*) chicks, which are about the same size as the cuckoo, were temporarily placed in warbler nests. Initially the birds were given less food, but when the researchers installed speakers playing the

JAIME PLAZA VAN ROON/AUSCAPE

Snow Gum seedlings are more sensitive to frosts when carbon dioxide levels are up.

RAOUL SLATER/LOCHMAN TRANSPARENCIES

With the last of its hosts' eggs ousted from the nest, this newly hatched cuckoo chick will now sing for its supper.

cuckoo's hungry cry (a rapid si-si-si-si) the provisioning rate increased dramatically. And when the cuckoo's call was analysed on a sonagraph, it proved to be almost identical to the noise made by a nestful of hungry warbler chicks.

Given that the cuckoo is being raised alone, and does not face competition for food, it is unlikely that the vocal trickery is used to distract attention from its unusual appearance. Another possibility, suggest the researchers, is that it may compensate for the cuckoo's reduced begging postures, restricted because of its large size, and the fact that it produces the visual stimulus of only one gape.

—R.S.

Stoned Gannets

You may have been fooled by the life-like statue of a shopfront mannequin. Now New Zealand gannets are being given a chance to meet their own stony look-alikes.

Life-size concrete replicas of Australasian Gannets (*Morus serrator*) are being 'released' on the coast of Mana Island (near Wellington) in the hope of attracting the real thing to establish breeding colonies. Gannets are known to feed offshore, however the nearest major breeding colony is 160 kilometres away.

Colin Miskelly, from the New Zealand Department of Conservation, devised this unusual experiment as part of a program to restore Mana Island's ecology. After 150 years of pastoralism, the island is now a scientific reserve. Many bird species are being reintroduced or encouraged to the island, which is also being reforested.

The first stage of the gannet-luring program occurred in December 1997. Local schoolchildren painted 50 concrete birds, each weighing 15 kilograms, and arranged them on a coastal cliff. To their delight two curious gannets landed among the decoys within half an hour. One even picked up some nesting material and offered it to a stony replica.

Miskelly's experiment is similar to a program in Maine, USA, where decoy Atlantic Puffins (*Fratercula arctica*) have encouraged young birds to return to islands that the species once colonised (see *Nature Aust.** Summer 1991–92).

Miskelly hopes there will be more interest from the gannets after the full complement of 100 decoys have been put into place. So far at least, it appears that gannets have as much trouble picking an impersonator as we do.

—B.D.

Snails' Agony and Ecstasy

There is a particularly moving scene in the film "Microcosmos". To the sound of an Italian aria, two

DAVE HANSFORD/ORIGIN NATURAL HISTORY MEDIA

Concrete replicas of Australasian Gannets attract the real things on Mana Island, New Zealand.

snails meet, entwine eye stalks, and proceed to wrap themselves sinuously around each other. It is strangely romantic, and yet the snails' subtle, slimy dance hides a gruesome and puzzling act.

Just before copulation, Brown Garden Snails (*Helix aspersa*) drive mucus-covered, calcareous darts into each other's soft bodies. The darts, up to a centimetre long, mostly fall out, but one study showed about 20 per cent remain embedded. For more than a century, scientists have puzzled over the function of these so-called love darts. Once thought to be used for defence, Daniel Chung from the University of Michigan proposed that the dart serves to deliver a substance into the blood that prolongs penile eversion (see *Nature Aust.** Winter 1987).

The dart has also been proposed as a 'nuptial gift', in this case of calcium, to help the embryonic snails build better shells. However this idea has recently been disputed by Joris Koene and Ronald Chase, from McGill University in Canada, who found the dart contains only 1.5 per cent of the calcium needed to form just one clutch of eggs. Instead Koene and Chase suggest a substance in the dart mucus may help increase the chances of a particular shooter's sperm fertilising the recipient's eggs.

Only a tenth of one per cent of sperm ever escapes from the sperm packet (the rest is broken down by the sperm-digesting organ, the bursa copulatrix), and this is then stored in the spermatheca for up to two years before being used to fertilise eggs. Koene and Chase found that, in the Brown Garden Snail, the mucus causes a contraction in the copulatory canal, closing off the entrance to the sperm-digesting organ. At the same time, the mucus initiates peristalsis in the organ that receives the sperm packet (the bursa tract diverticulum). This increases the speed of sperm uptake and the chances that sperm will successfully escape its packaging (before the sperm-digesting organ opens up again) to reach the spermathecal 'holding pens'. All in all, Cupid's love darts give sperm a better chance of hitting their desired target.

—A.T.

DENSEY CLYNE

If they don't increase mating time, or provide mineral supplements, what function do the love darts of Brown Garden Snails serve?

*Previously *ANH*

MICHAEL CERMAK

An extra helping of legs for the Cane Toad (*Bufo marinus*).

Frogs' Legs in Hot Water

In news that would delight the French restaurant industry, a spate of reports of frogs with extra legs is flooding in from the United States. Dozens of multi-legged and misshapen Northern Leopard Frogs were first reported by Minnesota schoolchildren in a wetland in 1995, adding to the recent declining fortunes of the amphibians.

The appropriately named David Hoppe from the University of Minnesota in Morris also raised the alarm after collecting over 200 deformed frogs in the following year, compared to only two deformed frogs collected in the previous 20 years. And Stanley Sessions from Hartwick College in New York has reported an unusually high frequency of amphibian limb abnormalities among Pacific Tree Frogs and Long-toed Salamanders in northern California.

Why some frogs are getting an extra helping of legs, or in some cases no legs at all, is now being hotly debated. Sessions claims the deformities could be caused by parasites, which bury themselves in the hind legs. To test this, he placed plastic beads, meant to resemble parasitic cysts, in the limbs of developing frogs, and found the limbs would sometimes split into two.

Increased UVB light reaching the Earth through a thinning ozone layer could also be a culprit. UVB light can cook amphibian DNA, causing deformities during metamorphosis from tadpole to frog. Frog embryos exposed to only 30 per cent of natural UVB levels for 24 days can become deformed, as was found in an experiment conducted at the Environment Protection Authority's Mid-Continent Ecology Division in Minnesota.

A third possibility is a mystery chemical, such as an insecticide or even a natural plant steroid, that interferes with normal larval development. To test this, an exotic species of frog was grown in Minnesota pond water where deformed frogs had been found, and it too developed abnormally, although other workers have not been able to repeat the result.

But are we hopping to a hasty conclusion? Deformed frogs have been reported for at least 250 years, and some researchers suggest that it may just be that the more we look, the more we find.

—A.T.

Novel Way to Track a Python

Having something eat one of your painstakingly captured and radio-collared research animals is usually a cause for irritation, but for Roger Martin from Monash University, the untimely demise of a young tree-kangaroo provided a unique opportunity to study the movements of a little-understood python.

Martin's original investigation was into the dietary and habitat requirements of a population of Bennett's Tree-kangaroos (*Dendrolagus bennettianus*) in lowland vine forest near Cooktown, Queensland.

One morning, when checking the position of a juvenile female tree-kangaroo that had been fitted with a radio-

S. WILSON

One Amethystine Python swallowed and got more than it bargained for.

Canada Geese show that you are what you eat.

collar 12 days earlier, Martin noticed that, instead of coming from somewhere up in the canopy as it usually did, the radio signal was at ground level. He traced it to an engorged 3.3-metre-long Amethystine Python (*Morelia amethistina*), apparently sleeping off its meal under a fallen log, near the heavily scratched trunk of a favourite food tree of the local tree-kangaroos.

Because of the python's narrow pyloric sphincter, the radio-transmitter remained lodged in its stomach, enabling Martin to track the python's movements for 44 days. For more than a week the snake remained motionless, probably digesting its meal, but then moved regularly (up to 348 metres a day) between open and closed forest for a fortnight. It came to a halt in a large tree used as a daytime roost by another study animal and her young, which disappeared a short time later (presumably eaten).

The snake's sporadic movements make sense, says Martin, if, like its cousin the Diamond Python (*M. spilota spilota*), it is an ambush predator that catches prey by waiting beside frequently used trails and roosts. And, although the evidence is largely circumstantial, this serendipitous study suggests Amethystine Pythons probably have a significant effect on tree-kangaroo abundance in lowland rainforest areas.

—R.S.

RICHARD DAY/OSF/AUSCAPE

Goose Growth Island Style

Canada Geese (*Branta canadensis*) decrease in body size as latitude increases. However, on an island off the coast of Ontario, Canada Geese defy this trend by being unusually small. So small, in fact, that geese on Akimiski Island are the same size as those in the cold, harsh regions of Manitoba, 600 kilometres to the north.

So what makes the birds on Akimiski Island smaller than their mainland counterparts? Is there a genetic difference, or perhaps something about the island that's effecting goose growth?

James Leafloor (Ontario Ministry of Natural Resources) and colleagues set about collecting goose eggs from Akimiski Island and the neighbouring mainland. Forty eggs from each location were incubated to hatching, with all goslings raised in a common environment where food was freely available.

On reaching maturity the island captives had grown faster and larger than their wild relatives (17 per cent greater bill length, ten per cent greater skull length), but mainland geese grew to their 'normal' size. Consequently, all captive-raised geese, regardless of origin, grew up to be identical in size.

The researchers therefore deduced environmental factors must be limiting gosling growth on Akimiski Island. Interestingly, Lesser Snow Geese (*Chen caerulescens*) also nesting on the island have slower growth rates than in some other colonies. Both goose species nest in very high densities on Akimiski; the nesting density of Canada Geese is seven times higher than mainland populations. Such crowding has resulted in increased competition for food and habitat degradation. Furthermore, the persistent ice cover around Akimiski Island promotes colder temperatures than on the mainland, shortening the growing season and delaying the onset of breeding. In effect, Akimiski Island has an environment as extreme as the far north—where being small is the norm.

—K.H.

Plastic Perils for Platypus

Environmental organisations have raised public awareness of the threat posed to seabirds and marine life from carelessly discarded rubbish. But the problems are not limited to oceanic wildlife, as Melody Serena and Geoff Williams found out. The Platypus (*Ornithorhynchus anatinus*) is a victim too.

During the course of nine years observations, the researchers from the Australian Platypus Conservancy in Victoria found that 10.5 per cent of their study animals were entangled in some sort of plastic rubbish, including elastic bands, sealing rings from jars and even an engine gasket. While these obstructed movement, life-threatening injuries were caused by entanglement in fishing line, with several animals dying as a result.

The study, which took place in six suburban waterways around Melbourne, found that affected animals most commonly had litter looped around the neck (61 per cent) or wrapped diagonally from the shoulder to the opposite leg (33 per cent). All of it was presumably caught while foraging, during which the animals wag their bill from side to side. It is extremely difficult for the animals to remove the rubbish, because the front foot has a web of skin stretching between each toe, effectively turning the foot into a paddle.

Serena and Williams say reducing the problem is simple. Manufacturers could incorporate an easily broken weak link into the design of all small to medium plastic loops (where it doesn't affect the function of the product). But just as importantly, consumers should take the initiative and sever all loops or rings before disposing of them.

—R.S.

KATHIE ATKINSON

A lucky break for the Pilbara Dtella (*Gehyra pilbara*), but his social life is shot.

Tell-tail Lizards

Like many other lizard species, the Side-blotched Lizard (*Uta stansburiana*) can save its neck by losing its tail. When in the clutches of a predator, the tail can be safely cast off and left wriggling while the rest of the lizard scurries away.

Although the advantage of this tail 'autotomy' is obvious, it also has its down sides. For example, until a lizard can regenerate its tail, it is more susceptible to predators. And, because the tail also functions as a status symbol, a tail-less lizard falls in social standing, is unable to maintain as large a home range as a tailed lizard and, as a result, suffers a reduced reproductive rate.

Stanley Fox and colleagues from Oklahoma State University tested the force required to induce tail autotomy in the Side-blotched Lizard and found that males lose their tail less readily than females, especially after they have reached maturity. But when it comes to losing a tail the second time around, males are as quick to drop it as females, which surrender it with the same ease all the time.

This is the first demonstration of sexual dimorphism in the ease of tail autotomy. But why does it exist? The researchers believe that the fall in social status that comes with tail loss has less impact on the reproductive rates of females than it does on males. A female without a tail can adopt a subordinate role, secure a poorer-quality home range and still find opportunities to mate (although fewer than a tailed female). Males without tails, however, have very few chances to reproduce. And the reason males relinquish their tails much more easily the second time around is because they have already lost their social standing and so, in the literal and figurative sense, they have far less to lose.

—K.McG.

DAVID PARER & ELIZABETH PARER-COOK/AUSCAPE

Carelessly discarded rubbish entangles not only sea-going creatures, but the Platypus too.

Tongue Transfer

Plants have evolved some ingenious ways of getting pollen to their peers. The red-flowering milkweed *Microloma sagittatum* from South Africa produces packages of pollen with 'bulldog-clip' attachments. These, as Anton Pauw from the University of Cape Town has recently discovered, clamp onto the tongues of nectar-feeding sunbirds and get transferred safely inside the bird's mouth to the next plant it feeds from.

The tongue of the Lesser Double-collared Sunbird (*Nectarinia chalybea*) is rolled up lengthwise from each edge, forming twin siphons that draw up nectar. The tip of the tongue is forked and frayed. These frayed bits are what the pollen clips onto.

Pauw found that seven of eight captured sunbirds had pollinaria attached to their tongue. To confirm their role in pollen transfer, he exposed

South Africa's Lesser Double-collared Sunbird sipping nectar from a milkweed.

37 unpollinated or 'virgin' milkweed flowers to a captive sunbird for two minutes each. At the end of the experiment, a total of 39 pollinaria had been successfully delivered to the flowers.

This is the first known case of pollen transfer on the tongues of birds, but it may be more widespread. New World hummingbirds and Australian honeyeaters have similar frayed tongues. Anecdotal accounts record Australian honeyeaters sipping nectar from the introduced milkweed *Hoya macgillivrayi*, and Pauw believes they may also visit native milkweeds.

—J.M.

ANTON PAUW

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Danielle Clode, Beck Dawson, Karina Holden, Jason Major, Karen McGhee, Stephen Richards, Rachel Sullivan and Abbie Thomas are regular contributors to Nature Strips.

QUICK QUIZ

1. What is an octopus' hectocotylus used for?
2. Who is the new Director of the Australian Museum?
3. Where, in New South Wales, is Australia's largest known population of Green and Golden Bell Frogs?
4. What do the introduction of Rabbits to Australia and the publication of Darwin's *On the Origin of species* . . . have in common?
5. How are the toes arranged in zygodactylous bird feet?
6. What does a hippophage eat?
7. Where in an animal would you find the tapetum lucidum?
8. Name the process that uses the Sun's energy to combine water and carbon dioxide to make sugar and oxygen.
9. What are coleopterans more commonly known as?
10. Which has the smallest penis: a Chimpanzee, Gorilla or human?

(Answers in Q&A)

The earthworm throws its throat through its mouth, grabs a chunk of the tunnel face, slides the lump back in through the mouth, and swallows.

WORMS TO MAKE THE EARTH MOVE

BY STEVE VAN DYCK

THE GRASS LAWN WAS invented in England chiefly for royal families and Corgis to pose on for the *Women's Weekly*. In Australia, the lawn's most useful function is to cushion the fall of husbands having heart attacks from mowing it in mid-summer. Whatever we use them for, the fact remains that lawns absorb more resources (phosphates, poisons, labour) than just about any other agricultural industry in the world. One Australian permaculturalist likened the lawn-gardener to a cross between a schizoid serf and a feudal lord, slavishly following the mower for hours, then clipping and torturing the hedges and roses around the borders.

A few years ago, when a lawn-lover moved onto a property in our valley, out came the ride-on mower and in no time the five-acre bush block was sanitised and reduced to a clipped-grass wind tunnel with a horticultural biodiversity to challenge Death Valley. Our district then entered one of the driest periods on record, so this enterprising new neighbour bought a water-delivery business and proceeded to fill empty rainwater tanks at $40 a pop. Our turn came, and he pulled up outside and asked us where he could run the delivery hose to our tank. When we pointed to the shortest route through a five-metre-wide strip of ferns and a bit of lantana, he barked "We've got better things to do than force our way through that", and roared off leaving us covered with dust and nothing to wash it off with.

I must admit I did dream of slashing his tyres, but divine retribution came his way when the first really good rains arrived. Not only did everyone's tanks fill with free water, but a gross transformation took place over the entire show-off acre of his front lawn. To this day, after every period of heavy rain, his lawn turns itself inside-out overnight. The grass simply disappears under what looks like a Krakatoa blanket of erupted Nutri-grain that dries hard and gravely in the sun and makes his whole yard resemble a postcard from Chernobyl.

Although this persistent punishment looks like it could come only from above, the fantastic transformation is in fact achieved from the bowels below. Earthworm bowels. The knobbly organic lumps packed over the lawn are lozenges of night-soil, deftly deposited outside their burrows by hundreds of very clever periscopic bums.

The definition of a head end and a derrière in an earthworm is probably no more immediately up-front than it is on a string of dangling vermicelli. But a mouth there is, and an anus to boot. According to the species, the mouth might take in fresh leaves, dead plant roots, decomposing plant litter or animal manure. This in itself is not very exciting, unless you happen to be growing a crop of tasty young vegetable seedlings. The really crafty thing an earthworm can do with its mouth comes to the fore when it burrows. Normally it would force itself through minute cracks in the soil, using the little bristly tufts (setae) along its segmented body. But when the soil lacks cracks, it must excavate as it peregrinates. The earthworm throws its throat (inside-out) through its mouth, grabs a chunk of the tunnel face (much as a human fist might

EARTHWORMS

Classification
Phylum Annelida, class Oligochaeta, 12 earthworm families. Around 4,000 spp. worldwide, 350 named Aust. spp. and 60 introduced spp. (from Europe, Asia, North and South America, Africa, India and Indo-Pacific islands).

Identification
Body divided into small discrete segments, each with a set of muscles that contract and expand under the coordination of a 'brain' near the mouth. Small, short bristles (setae) associated with each segment assist locomotion through soil. Length a few mm to over 3 m (in Giant Gippsland Earthworm, *Megascolides australis*). Lack eyes, although photoreceptors present in skin. Adult earthworms identified by anatomical details such as features of reproductive organs, bristles, shape of mouth etc.

Distribution and Habitat
Terrestrial burrowing scavengers (mainly of plant material) found everywhere except in deserts (hot and cold). Some spp. occur in shallow soils and feed near surface; some live deep in soil and form semi-permanent vertical burrows; others live and feed in horizontal burrows and rarely come to surface.

Reproduction
Hermaphrodites. Sexual reproduction (not necessary in all spp.) by coupling and mutual exchange of sperm. After copulation, a ring of mucus, secreted by the conspicuous light-coloured collar (clitellum), slips forward over the head of the earthworm and, on its way, collects waiting eggs and sperm from the separate female and spermathecal pores. Once off the worm, the ring hardens, enclosing the fertilised eggs, which hatch in next moist season. Some adults die during dry months; other spp. may live longer than 2 years; and specimens in laboratory cultures have survived for over 10 years.

Regeneration
If cut in two (by predator, spade or through autotomy), many spp. will regrow missing part. Regeneration of back end takes place more readily than front end, with regrown tail often having paler and more narrow segments. Head regenerates are less commonly encountered as worm lies coiled and dormant in soil until mouth regrows. It is theoretically possible to get 2 worms when an individual is cut in half. They may also occasionally grow a head where the tail should be and *vice versa*. Survival of such freaks is unlikely.

KATHIE ATKINSON

Dragging leaves into burrows is just one strategy worms use when feeding.

when digging in sand), slides the lump back in through the mouth, and swallows.

As every toddler know, there's a limit to the amount of soil you can eat before you generate a nappy change. So too an earthworm reaches the point when enough is enough. What it then passes as waste is, to gardeners and agriculturists, slow-release gold. A concentrated pellet of soil and organic matter, brimming with iron, calcium, magnesium, potassium and phosphorus, laced with nitrogen from its urine and mucus, and loaded with beneficial gut bacteria. Some earthworms deposit this as 'casts' on the surface; others simply drop it as they go. In Britain, casting earthworms are busy for such long periods that, within the space of 100 years, an original surface might be 18 centimetres underground! In Australia, high temperatures and dry seasons reduce both worm activity and this figure to around 1.8 centimetres.

Not only do earthworms break up and mix organic matter into the soil, but their burrowing reduces surface run-off and erosion by increasing the water-holding capacity of the soil. More oxygen and nutrients are made available to plant roots, and microbial activity is accelerated. All this can lead to substantially higher (up to 100 per cent) crop yields.

Why then don't wonderful things happen when I collect a can of worms and throw them around the garden? For a start, many of the worms we associate with are accidental imports that came with potted plants from moist, cool, temperate climates. These worms are unsuitable for most parts of Australia, particularly the monsoonal north. Although there are more than 350 native Australian earthworms described (and probably three times as many undescribed), few are found in the pastoral conditions we have created. Of the 60 or so introduced earthworms, only about a dozen are found commonly. These don't like areas of low rainfall, they hate sand and heavy clay, they don't like soils that are regularly dug up and turned over, they don't appreciate being chopped up by forks and spades, and can't survive in temperatures over 25° C so they lay dormant deep in soil throughout the hot dry months. They also require a fairly rich, high-protein diet. Because my water-selling 'neighbour' lives on a rich creek flat, he gets earthworms, while I, on a drier hillside, just get white ants.

For those who can't keep the moisture and mulch up to the garden, or where the soil is not right, the environmental conditions inside the frying pan might be more suitable. Earthworms are high-protein, ironman breakfast material! You can grow them in a modest compost heap, put them in flour or cornmeal for 24 hours to purge their guts, rinse them, paper-towel-dry them, give them two or three separate ten-minute boilings in fresh water, then cook them immediately or freeze them for later.

One recipe for a heart-stopping omelette appeared 20 years ago in a CSIRO publication. Beat together 6 eggs, 1/3 cup milk, 1/4 cup parsley, 1/2 teaspoon seasoned salt, 1/2 teaspoon pepper, some garlic. Put the mixture in a medium-hot omelette pan. When almost done, add 3/4 to 1 cup earthworms (prepared as above, and unchopped for more impact), 1/4 cup chopped celery, 1/3 cup chopped capsicum, 1/4 small chopped onion, 1/3 cup grated cheese, 1/3 cup chopped mushrooms. Finish cooking. Add 1 drop Tabasco sauce, 1 dash Worcestershire sauce, serve and stand back.

If a certain enterprising water-carrier I know hears about this, residents from my area might soon find themselves lolling on a patchwork rug in the middle of his luxurious lawns, eating designer 'game' washed down with a dry red. The combination sounds seductive, but don't overdo it. If you lie on your back and close your eyes for too long . . . the earth might move. ■

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RARE & ENDANGERED

How do you save a population with only one individual remaining?

NORFOLK ISLAND BOOBOOK

BY PENNY OLSEN

THE RAREST OWL IN THE world was once found on tiny isolated Norfolk Island in the south-west Pacific. The last surviving bird disappeared, presumed dead, in 1996, but not before she had raised two hybrid broods, each of two chicks, and founded a new population of owls on the island.

I have been involved in the recovery effort of the Norfolk Island Boobook Owl since 1986 when, with a group of friends, I visited the island to recommend some action for the bird's conservation. Although no owls were found during a survey conducted in the previous year, locals still occasionally heard the distinctive 'boo-book' call and so we knew they were still there. We were elated, therefore, when we captured an owl on our first night. After we measured it, took a small blood sample and put two dots of iridescent nail polish on the tail as a temporary marker, we released it back into the night. I don't think any of us were prepared to accept there was only one bird left on the island, but each time we located an owl, two familiar white dots shone back in the torch light. It was the first of many bitter-sweet experiences working with the Norfolk Island Boobook.

How do you save a population with only one individual remaining? In fact, is it worth saving at all? Because of our desire to preserve some of the owl's genetic integrity and the islanders' wish for action, we opted for a low-key recovery program. This involved alleviating the reasons for the owl's decline, and importing an owl of the opposite sex from a closely related population. But there were problems: the owl was virtually unstudied and next to nothing was known of its taxonomic standing, its breeding habits, or even how to sex it.

J. HICKS/NATURE FOCUS

Superficially it resembled the other small boobook species that nest in tree cavities in Australia and New Zealand. Indeed, 75 per cent of Norfolk Island had been cleared and the remainder selectively logged, so the extreme scarcity of mature trees with suitable nesting hollows seemed the most likely cause of the owl's plight. Apparent vindication of this view came when we hung several nest boxes in the forest and the owl began roosting in some of them almost immediately.

But was the owl male or female? Several Norfolk Island owls had been collected for museums in the early 1900s and, by referring to them and the measurements of the remaining living individual, we decided it was a relatively large bird and therefore probably a female.

I don't think any of us were prepared to accept there was only one bird left on the island, but each time we located an owl, two familiar white dots shone back in the torch light.

Museum specimens also helped us identify the most closely related owl for breeding purposes. For years, there had been disagreement over whether the Norfolk Island population was a new species of boobook or whether it was a subspecies of those occurring in New Zealand or Australia. Several features of the plumage, and structural differences such as wing shape, indicated that the smaller-sized boobook from New Zealand was probably closest. We found two birds and had them surgically sexed to make sure they were both male (we decided against using this sexing technique on the Norfolk Island bird because of the small risks involved), and released them on the island in late 1987.

In October 1988 the Norfolk Island Boobook laid her first eggs and confirmed, to our relief, that she was indeed a female. However, the eggs failed to hatch and it wasn't until the following spring that she raised her first brood and eased our concerns about whether we had chosen a genetically compatible partner. My scientific objectivity was swept aside by the joy I felt knowing that this lonely bird had paired up and raised a family.

Since then we have reached several milestones, including 'grandchildren' in 1993. Molecular techniques, which would have been invaluable at the start of the program, have become more accessible in recent years and we can now use DNA from a tiny sample of blood to reliably sex the owls.

These laboratory techniques have also reassured us that we made the correct taxonomic assessment. A spot of the blood taken from the original female in 1986 showed her to belong to a distinctive subspecies of the New Zealand Boobook (*Ninox novaeseelandiae*)—*N. n. undulata*. DNA studies have also shown that both the Norfolk Island and New Zealand boobooks are significantly different from the boobooks on the Australian mainland, which are now regarded as a separate species, *Ninox boobook*. Thus, our guesstimates of a decade ago proved sound and the current owl population on Norfolk Island was confirmed to be made up of hybrids of subspecies (rather than of full species) and thus closer to the original population.

At last count there were about 20 owls on the island. This is an extraordinarily successful conservation effort, and can only encourage attempts to conserve other severely endangered animals. Nevertheless, for me, it must be tempered by the realisation that the owls will be dependent on nest boxes for the foreseeable future, and there will never be sufficient habitat for the population to return to its former, albeit low, numbers. ■

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In the 19th century Australians were enthusiastic about the prospects of making paper, cloth and rope from native plants.

DREAMING ABOUT FIBRES

BY TIM LOW

INDIAN HEMP (*CANNABIS SATIVA*) is attracting much interest these days as an alternative source of fibre, although I suspect this is mainly because of its reputation as a 'naughty' crop. Other fibre plants that may be better options for farmers, such as Kenaf (*Hibiscus cannabinus*) and Roselle (*H. sabdariffa*), aren't receiving much attention at all.

In the 19th century, before synthetic fibres were invented and before paper could be made from wood, Australians were enthusiastic about the prospects of making paper, cloth and rope from native plants. Britain was hungry for paper-making materials and Australia seemed an ideal source of fibre, judging by all the plants used by Aborigines to make nets, bags and fishing lines.

Aborigines used both the inner bark of certain shrubs and trees, and the linear leaves and stems of sedges and grasses and other monocotyledonous plants. These plants had long parallel fibres, made up of long, thick-walled cells, and could be torn into thin but strong strips. Some families abound in suitable plants, especially the hibiscus family (Malvaceae), to which Kenaf, Roselle and Cotton (*Gossypium hirsutum*) belong. Australia has more than 160 plants in this family, including Native Rosella (*Hibiscus heterophyllus*), an important fibre plant of the Aborigines, and Sturt's Desert Rose (*G. sturtianum*), a close relative of Cotton.

Colonial entrepreneurs experimented with many of the Aboriginal plant fibres, including rushes, bark of the Giant Stinging Tree (*Dendrocnide excelsa*), and roots of fig trees (*Ficus* species). In South Australia, coarse textiles were made by blending wool with Broad-leaved Tapeweed (*Posidonia australis*), a seagrass dredged from the sea, and there was even talk of making paper from freshwater algae drawn from drying swamps.

At colonial exhibitions of promising new products, native fibres and experimental papers often found a place. The Paris Universal Exhibition of 1867, for example, featured bark and fibres of Australian tea trees, palms, figs, kurrajongs, stinging trees, "native cotton", riceflowers (*Pimelea* species) and Settler's Twine (*Gymnostachys anceps*). Melbourne's Intercolonial Exhibition of 1866–67 presented paper made from 30 different plants, mostly eucalypts, sedges and tea trees. Messmate Stringybark (*Eucalyptus obliqua*) was considered especially promising for paper.

The enthusiasm of the times shows through in old articles, such as one that appeared in the *Queensland Agricultural Journal* in 1919: "From the bark of the eucalyptus trees, which cover millions of acres of Australia, can be produced a fibre which . . . will make the Commonwealth independent of Indian jute goods and New Zealand flax, save millions of pounds annually from being sent overseas, and create employment for thousands of Australian workmen . . .". The article announced that a factory at Footscray in Victoria had produced twine, rope and sacking from eucalypt bark.

Men dreamed of making fortunes from native fibres. Alexander Tolmer, a

PHOTOS: TIM LOW

The small flowers of Australian Hollyhock show this to be a member of the hibiscus family and, like many members of the family, its stems can be used as string and the roots eaten as a vegetable.

Coast Sword Sedge was both a food and fibre plant of Aborigines along the southern Australian coast. The white bases of young leaves were chewed.

colourful police commissioner in South Australia, was camped out on the Coorong one night when a long and leathery leaf, dancing in the wind, jabbed his ear. He grabbed it in annoyance but so sharp was the blade that his finger was sliced to the bone. Years later Tolmer lost his job and decided to make his fortune from this plant, Coast Sword Sedge (*Lepidosperma gladiatum*). He petitioned the South Australian Government for exclusive rights to harvest it for rope, sail-cloth and paper, but his private bill was rejected because local Aborigines already used the plant for baskets and fishing lines. He then patented the right to make paper from the leaves, after having paper samples prepared in England, but due to poor communication his patent lapsed, and in 1876

In the 1920s, after years of experimentation, Australians discovered that paper could be made from eucalypt wood, previously thought to be impossible.

Samuel Ramsden's paper mill in Melbourne began making wrapping paper from the leaves, to Tolmer's dismay.

Another plant that excited interest was Australian Hollyhock or Native Marshmallow (*Lavatera plebeia*), a small outback plant in the hibiscus family that Aborigines used for nets and bags. In 1860 F.A. Corbett suggested it might be an ideal fibre source because it grew luxuriantly alongside our greatest navigable rivers in country that was otherwise useless. Experimental paper was made from the stems and the fibre was exhibited in Paris.

Like the early attempts to exploit native plants for food and medicine, very little came of all this talk and experimentation. England's mills needed fibre for paper and sails, but freight costs made Australia uncompetitive. Fibre could be processed before export to reduce the freight, but Australian labour proved prohibitive. There was some local production of experimental paper, rope and cloth, but ultimately the supply of wild plants was inadequate. Corbett realised that suitable plants would have to be cultivated, noting that "articles of which the consumption is great, such as paper and rope, cannot be sufficiently and uniformly supplied by the spontaneous action of nature".

With development overseas of the kraft bleaching process, in which fibres were chemically separated, paper could be made from softwood, a vast, cheap and consistent resource, and interest in alternative fibre crops subsided. Interest fell even further when Cotton and synthetic fibres won dominance in the clothing trade. But in the 1920s, after years of experimentation, Australians discovered that paper could be made from eucalypt wood, previously thought to be impossible because of the short fibre length, and by the 1940s our native fibres had at last become a major economic resource. ■

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M. NORMAN

C.C. Lu holding one of the two long feeding tentacles of a ten-metre-long giant squid, the first of four caught off Tasmanian waters between 1996 and 1998. As with most previously reported specimens, the skin was lost during capture, exposing the underlying white muscle.

RIVETING SEX IN THE GIANT SQUIDS

BY MARK NORMAN

The largest was still covered in its maroon-coloured skin and it was in this skin that the first-ever evidence of the mating behaviour of giant squids was discovered.

LITTLE IS KNOWN OF THE ALMOST mythical giant squids, which belong in the genus *Architeuthis*. They occur in deep cold waters of all oceans of the world, to at least one-and-a-half kilometres depth, and have never been witnessed alive in their natural habitats. It is unknown how many species there are, how abundant they are, or how long they live. The only clear facts are that Sperm Whales (*Physeter catodon*) seem to be able to find them and feed on them (stomach contents frequently include the beaks of giant squids) and that giant squids feed on fish and smaller squids. The longest giant squid record is 18 metres and the heaviest over 250 kilograms.

In recent years, deep-sea trawlers poking around in the dark depths off the Tasmanian coast have brought up some unexpected finds. Three female giant squids, ranging from 10 to 15 metres in length, were captured in separate trawls more than half a kilometre down. The heavy Orange Roughy trawl nets in which they were captured must have struck these giant animals while they were still alive. Most reports of giant squids in the past have come from carcasses that have floated slowly to the surface, rotting and being consumed on the way up. The recently captured specimens differed in that they were fresh and largely intact. The largest (15 metres long and weighing 220 kilograms) was still covered in its maroon-coloured skin and it was in this skin that the first-ever evidence of the mating behaviour of giant squids was discovered.

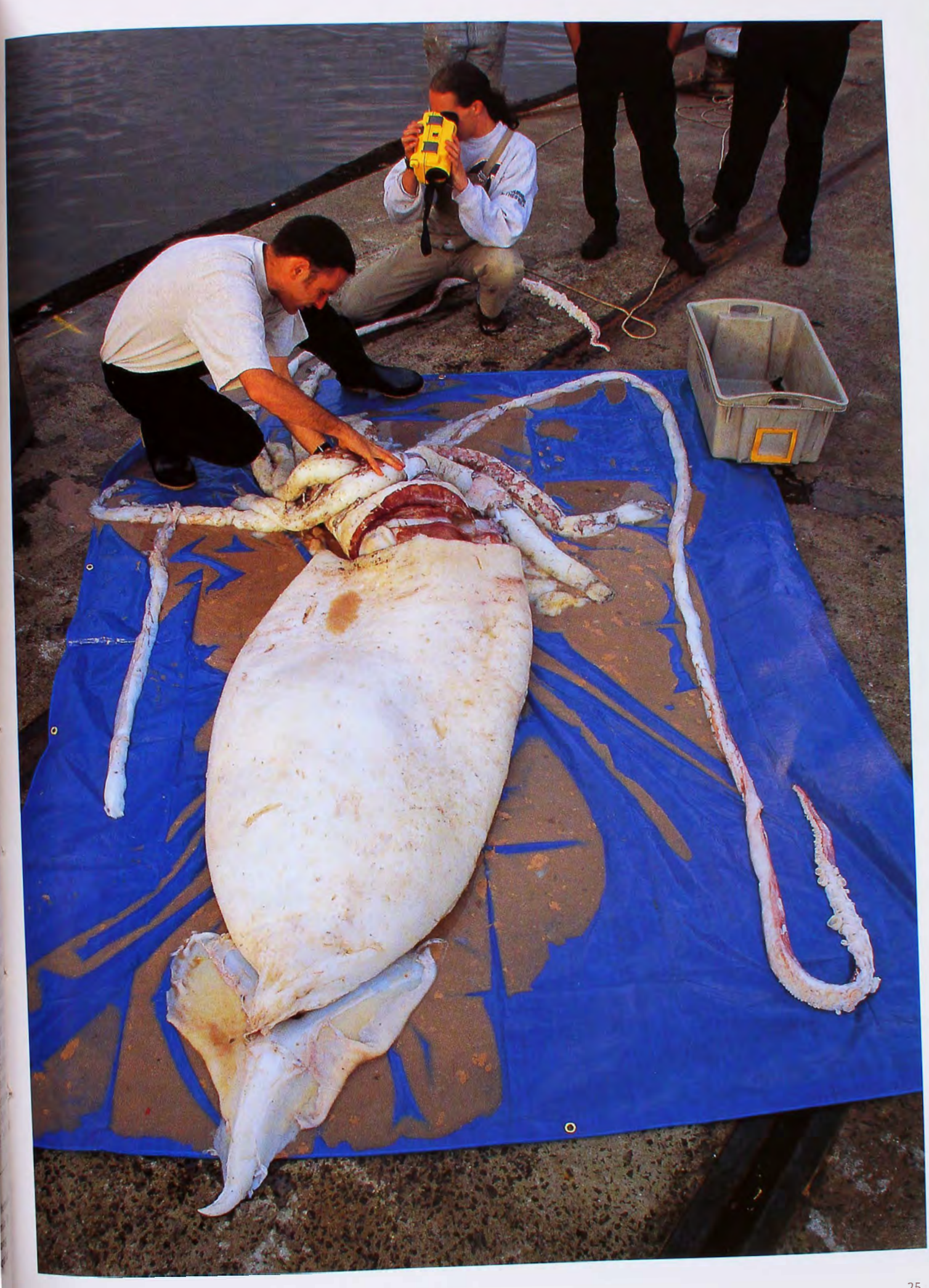
ALL THREE SQUIDS WERE TRANSPORTED to the collections of the Museum of Victoria where C.C. Lu, his staff and myself proceeded to dissect and describe the animals. In measuring and examining the largest female, a one-to-two-millimetre-thick white 'string' (which looked like a parasitic worm) was found in an area of torn skin on one of the arms below the mouth. Further searching found the tip of another 'string' sticking out of a small hole on the other arm below the mouth. When we excavated around the hole, many more 'strings' were found radiating from the apparent point of entry. Microscopic examination of the tissue revealed that these 'strings' were actually cords of sperm, stored in the skin.

All cephalopods (squids, octopuses and their relatives) package sperm in elongate waterproof structures known as spermatophores. Males usually have a specially modified arm or arms used during mating to pass spermatophores to the female. In octopuses, the male uses his special arm (the hectocotylus) to place sperm packages in the oviducts of the female (see *Nature Aust*. Summer 1997–98). In some squids and cuttlefishes, the sperm packages are placed in special pouches under the mouth of the female. To understand how the spermatophores became embedded in the skin of our giant squid specimen, we need to understand the reproductive system of male giant squids.

Little is known of male giant squids. The males that have been collected possess long thin spermatophores (3–5 millimetres thick and 11–20 centimetres long) and a greatly elongated and muscular penis (up to a metre long), which can protrude up to 50 centimetres outside their body cavity. They lack the modified mating arms of other squids. Giant squids are also the only cephalopods reported to have a gelatinous coating on the outside of the spermatophores. The find of numerous spermatophores embedded in the skin of the female's arms, radiating around a single small entry hole, combined with the males' attributes, suggest that the spermatophores are injected directly by the penis into the skin under pressure, much like a rivet gun or pneumatic nail gun. The gelatinous coatings on the spermatophores may aid the penetration of these sperm stores.

So, for giant squids, mating events may consist of short encounters where a male shoots a round of sperm packages into the female's skin. One male giant squid caught off Norway in the 1950s is particularly unusual in that spermatophores were found embedded in the skin of several of its arms and the mantle. Another male may have accidentally injected these spermatophores while attempting to impregnate a female, effectively 'riveting' the co-suitor. Alternatively, the male may have literally 'shot himself in the foot'.

Mark Norman (left) and Julian Finn (University of Melbourne) examining a female giant squid captured off eastern Tasmania in 1996. The skin was missing and both long feeding tentacles were damaged. The squid was estimated as being 12 metres long when alive.



D. PAUL

M. NORMAN

Tim Stranks (left) and C.C. Lu of the Museum of Victoria dissecting a 15-metre-long female giant squid, the first mated female of these deep-sea squids ever reported. This specimen differed from most other giant squids collected in the past in that the blood-red skin was largely intact.

GIANT SQUIDS

Classification
Family Architeuthidae, genus *Architeuthis*. At this stage there is little consensus on the number of species or the appropriate names to use.

Identification
Same shape as other smaller common squids found in Australian waters, with a tube-like body, small heart-shaped fin on rear of body, head with 2 large eyes, 8 arms about same length as body, plus 2 feeding tentacles. Compared to other squids, giant squids are much larger (longest recorded female was 18 m and weighed 250 kg; males smaller than females), and have extra-long feeding tentacles, which have numerous matching suckers and lugs along the long shafts. These 'press studs' are used to lock the tentacle shafts together so that the clubs on the end of the tentacles act as a large snapping claw.

Distribution and Habitat
Mostly collected from deep waters in cool and cold latitudes of all oceans. Probably associated with the sea floor and sea mounts in depths of 500 to 1,500 m.

Reproduction
Males appear to inject spermatophores directly into the female's skin. Females release millions of small eggs, probably in a jelly-like matrix. Egg masses have never been found. One tiny juvenile was caught in only 125 m of water off Tasmania. Otherwise nothing is known of young giant squids.

Diet
Fishes and smaller squids, seized by the 2 long feeding tentacles, probably shot into the midst of schools.

The female squid in which the spermatophores were found was immature. At 220 kilograms, she had a small, poorly developed ovary of only three kilograms (the ovary of one giant squid caught off South Africa weighed over 14 kilograms). The females of many squids, octopuses and their relatives can store viable sperm for considerable periods of time, with records of up to ten months in some species. This strategy may relate to their solitary lifestyles: if you only occasionally come across potential mates, you are best to secure sperm supplies when you can and pull them out of storage when eggs are ready for fertilisation. In the case of the giant squids, a solitary life in deep dark waters may well lead to only a few encounters with the opposite sex. It would therefore be worthwhile squirreling a supply of sperm away for when it's needed.

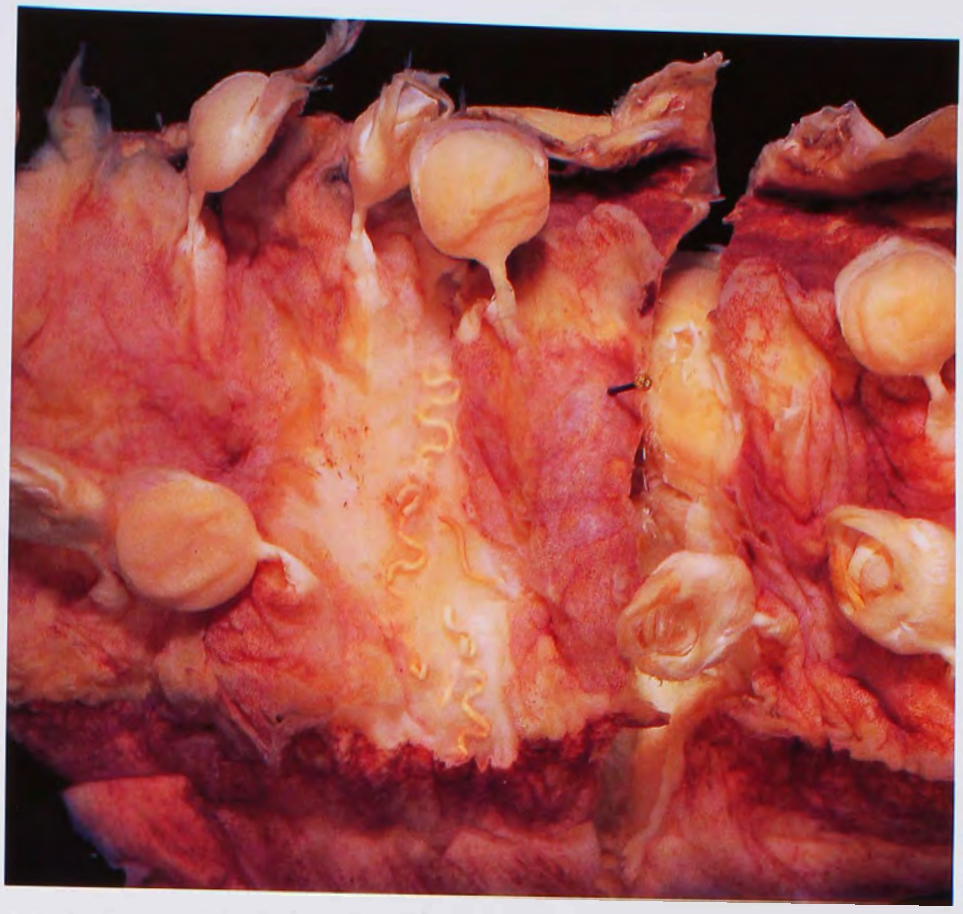
Giant squids are not the only squids that store sperm in their skin. Some smaller species use a different strategy, storing the sperm supplies in healed elongate wounds on the arms or mantle. Males in these species may use their beak or sharp scythe-like hooks on the tentacles and/or arms to produce these wounds in which small spermatophores are planted. The wounds then heal over, the scar tissue enclosing and protecting the sperm-embedded packets.

As spawning events have never been witnessed for 'skin-storing' squids (including giant squids), we do not know how the female accesses the sperm when it's time to fertilise her eggs. She may use her suckers or beak to peel open the skin covering the spermatophores, or hormonal or chemical cues may cause the sperm to migrate to the skin surface. Alternatively, the female's skin might degrade on spawning, exposing and activating the embedded sperm stores.

THE RECENT DISCOVERIES OF FRESH female carcasses have provided some exciting insights into the lives and biology of these 'krakens' or monsters of the deep. At the same time, these latest catches are disturbing in that they demonstrate the expanding nature of human impacts. As shallow-water fisheries reach or exceed maximum exploitation, more attention is being diverted to deep-sea trawling. Recent interest in deep-water fisheries off South Africa have resulted in the capture of 13 giant squids in two years.

Although it is premature to suggest that giant squids may be threatened by

Close-up section of one lower arm of the mated female giant squid. The skin has been removed from between the stalked suckers to show the embedded cords of sperm placed there by a courting male.



DAVID PAUL

such trawling activities, there is clear evidence that fisheries based on long-lived deep-sea species are not sustainable. Fishes such as Orange Roughy (marketed as 'deep-sea perch') and Ox-eyed Dories (marketed as 'trevally' or 'dory') live for more than 100 years and their harvests are already showing signs of collapse. Such short-term and short-sighted harvests need to be questioned. Quick profits cannot justify the scouring and decimation of deep-sea habitats, such as the sponge and coral forests of deep-water sea mounts. What wonders of the deep, including giant squids, are being lost to this strip-mining or wood-chipping mentality? With recent interest in Patagonian Toothfish in deep waters off sub-Antarctic and Antarctic islands, are there no limits to our reach? ■

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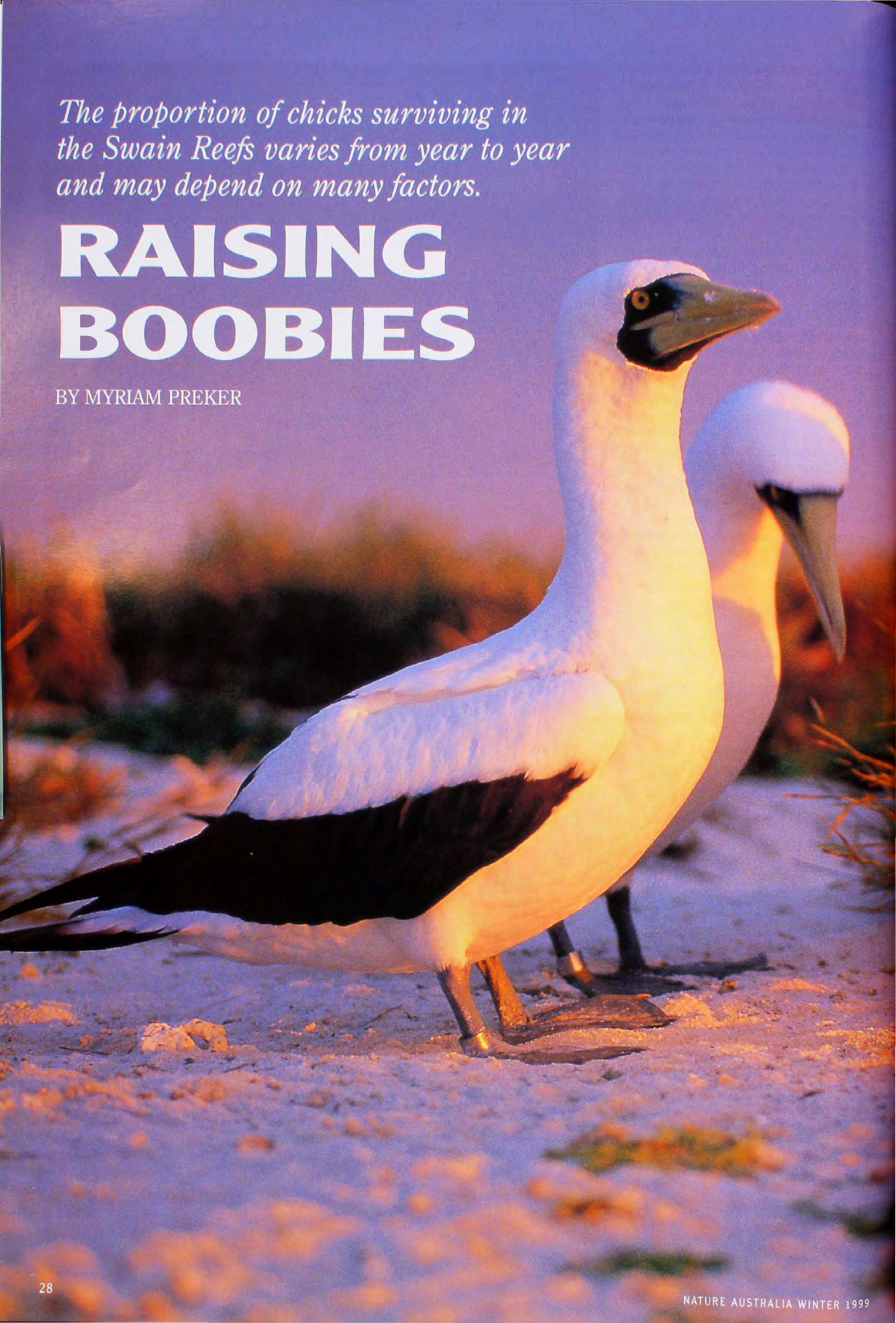
The proportion of chicks surviving in the Swain Reefs varies from year to year and may depend on many factors.

RAISING BOOBIES

BY MYRIAM PREKER



They may live in a tropical paradise but life for Masked Boobies, and the four other Australian booby species, is a challenge from the moment they hatch.

KATHIE ATKINSON

WHAT IS LIFE REALLY LIKE for a young booby chick being raised on one of the remote cays of Australia's Great Barrier Reef? At first glance, it seems idyllic: crystal-clear, turquoise-blue waters; gleaming-white coral cays; rich reefs teeming with fish; and plenty of other boobies to satisfy the need for social interaction. Over the past ten years, I have taken every opportunity to study the nesting behaviour of these large seabirds. The result is a fascinating insight into the daily lives of the booby chicks of the Swain cays.

Boobies (and gannets) belong to the family Sulidae, a group of large, exclusively marine birds found throughout the warm waters of the world. The boobies' long slender wings, wedge-shaped tail and conical beak give them a rakish profile in flight and make them one of the most spectacular seabirds encountered on the reef, especially when diving for food. Boobies are consummate fishers and can often be seen soaring, planing and banking backwards and forwards with bold, sweeping curves over the feeding areas. In an instant, wheeling around and with their wings half closed, they plunge, arrow-like, often from heights of 20 to 30 metres, into shoals of fish. A system of air sacs beneath the skin, and closed external nostrils, offer their only protection against the impact as they disappear into a spray of white water. Brown Boobies, and probably the others too, pursue their prey by swimming beneath the surface using their wings and webbed feet.

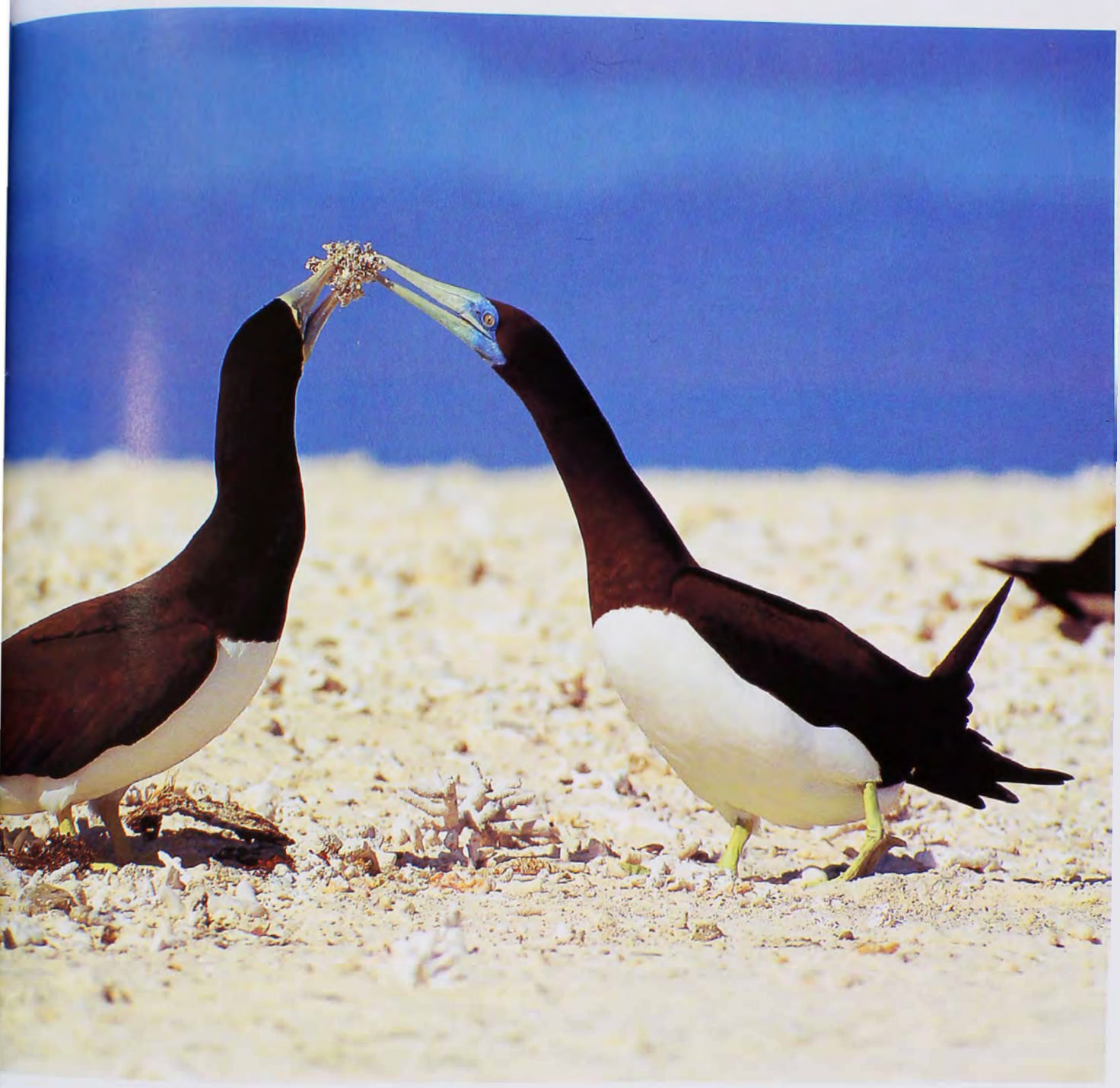
In an instant, wheeling around and with their wings half closed, they plunge, arrow-like, into shoals of fish.

There are six species of boobies worldwide: four of these—the Masked (*Sula dactylatra*), Brown (*S. leucogaster*), Red-footed (*S. sula*) and Abbot's Boobies (*Papasula abbotti*)—occur in tropical and subtropical Australasian waters. At my study sites on the small, treeless cays of the Swain Reefs, the Masked and Brown Boobies nest alongside one another. In this location, both species breed more-or-less continuously; the distinct breeding seasons observed in other locations, such as the Herald Cays in the Coral Sea, are absent. The lack of synchronised breeding means that, throughout the year, there are individuals at different stages of the reproductive cycle.

Banding and census studies have shown that the number of Brown Boobies nesting in the Swain Reefs has declined significantly. We do not completely understand the reasons for this, but reproductive success (a breeding pair's ability to raise a chick to maturity) is a major factor in maintaining any healthy population. I have therefore been looking at the types of things that influence a chick's chances of survival. The trials of life begin even before the chick has hatched. Some eggs fail to

Silver Gulls are major predators of booby chicks and eggs. This gull is taking advantage of an unattended nest and stealing an egg.

PHOTOS: KATHIE ATKINSON



A pair of courting Brown Boobies. Here the male booby (with the blue face) presents the female with a gift of dried seaweed.

hatch because they are not fertilised; others because of parental inadequacy, accidents, bad weather and predators. Even the ever-increasing numbers of people visiting the reefs takes its toll.

APART FROM HUMANS, AND A FEW introduced species, the effect of predation on boobies is considered to be insignificant in most parts of the world. In the Swain Reefs, however, a percentage of eggs and very young chicks falls victim to a small population of Silver Gulls (*Larus novaehollandiae*). The gulls patrol the nest areas continually and have learnt to steal from these powerful birds. They employ two different techniques to rob nests. One method is strictly opportunistic and takes advantage of any disturbance to the colony. A small boat circling the cay, or a group of people landing on the beach, may cause the birds to panic and leave nests unprotected. The gulls, forever watchful, are quick to take advantage of such events. On one occasion I saw two gulls stealing a total of four eggs from a group of ten nests. When there are no major external disturbances to the colony, the Silver Gulls can also steal eggs and chicks by working in pairs. One gull, careful to stay safely outside the range of the booby's powerful bill, faces the adult sitting on the nest and keeps making faked assaults. In response to this, the booby will sometimes make a jab at the assailant and, in doing so, momentarily exposes the nest from behind. The second gull then moves in quickly from the rear and robs the nest.

Brown and Masked Boobies are the only sulids that regularly lay two eggs

PHOTOS: KATHIE ATKINSON

A male Brown Booby attempts to feed its chick while being surrounded by harassing Silver Gulls intent on stealing the food.

MASKED BOOBY

Sula dactylatra

Identification

Robust white booby with black flight feathers and tail. Bill yellow in male, dull green–yellow in female; eye yellow; facial skin black; feet grey. Sexes of similar size; adult weight about 1.5–2 kg. Very noisy, especially in breeding areas: females honk and males whistle.

Habitat and Distribution

Marine, pelagic and aerial in tropical and subtropical waters around the world. Distribution may be determined by distribution of flyingfishes.

Feeding

Feeds mainly on flyingfishes and squids in deep water far out to sea. Can plunge-dive from 12–100 m.

Breeding

Breeds on offshore tropical islands, atolls and cays. Highly variable breeding season depending on region. Breeds in all months on Swain Reefs. Nest site on open, unvegetated ground but does not build nests. Both adults share in incubation and care of young.

(as opposed to one), but they never seem to raise more than one chick. This reduction of the brood, however, is not the work of the parent but that of the older sibling (see *Nature Aust.** Autumn 1990). The second egg serves as a valuable insurance for the long incubation period should the first egg (or chick) fail to survive. The eggs usually hatch four to five days apart and the older chick actively attacks and ejects the younger one from the nest. The younger chick usually survives for only two to five days, even though the parents are able to provide both chicks with sufficient food, at least at this stage.

Chicks of Brown Boobies are not quite as obsessed with killing their siblings as

**Previously ANH*

Masked Boobies at their nest. Both the male and female incubate the eggs and care for the young when hatched.

are those of Masked Boobies. I once observed a younger Brown Booby chick on Gannet Cay that, judging from its plumage, had managed to survive for four to five weeks. Although badly battered by its larger sibling (with bleeding head wounds, dirty down and numerous bare patches), it survived on the food it received from its parents when the older chick slept. I never saw the parents molest this chick; in fact, they always fed it and even made attempts to brood it. The older chick, when awake, was relentless in its attacks and never allowed the sibling access to the adults. More than once, I saw the larger chick pecking at the head of the smaller one while it was standing on its prone body. The younger chick, when temporarily evicted from its territory by its older sibling, was also subject to attacks of the neighbouring birds, as are all booby chicks in such situations. I'm not sure what finally killed it. It may have been starvation, the head wounds or, perhaps, heat loss, because it was after a particularly cold and rainy night that I found the young chick lying dead some distance from the nest. Although I have become used to the harsh realities of such interactions in nature, I must admit to a feeling of sadness when I discovered that this little battler, in particular, had lost its struggle for existence.

In order to catch enough food for their young, Masked Boobies must spend long periods of time away. During its parents' absence the fluffy chick can do nothing but wait.

The chicks are naked and helpless when they first hatch, and they require constant brooding, not only for protection against gulls, but also against the fierce heat of the sun and coolness of the nights. The small, naked chicks cannot thermoregulate and they may die after only 20 minutes exposure to the tropical sun. Older chicks can regulate their temperature by heat-dissipating behaviours, such as panting, gular fluttering and wing hanging. They are, however, at even greater risk than the small chicks under certain weather conditions. On one of my trips to the Swain Reefs, a cyclone in the Coral Sea was causing strong winds and continual, heavy rains. Not to be discouraged by the bad weather, I took advantage of the rare opportunity to gather data on what happens to boobies during a storm. The small chicks were totally protected because the parents sheltered them under their bodies; in contrast, the large downy chicks became wet and cold as they could only shelter in the lee of their parents. At the end of three days in

PHOTOS: KATHIE ATKINSON

Although boobies lay two eggs, they only ever seem to raise one chick. This is because the older chick attacks its younger sibling and removes it from the nest, thereby sentencing it to certain death. Here a Brown Booby chick is busy committing siblicide.

A male Brown Booby defends his nesting territory from an intruding male. On Swain Reefs, boobies will breed all year round.

these conditions, many of the older chicks lay dead. During this period, few adults were able to fish and, consequently, many of their chicks went hungry. The lack of food would probably not have affected them greatly, as research has shown that booby chicks have an extraordinary ability to survive conditions of near-starvation.

Despite the fact that coral reefs are extremely productive, the tropical seas that surround them are relatively impoverished and food can be difficult to come by. The booby chicks need to be resistant to starvation, particularly the Masked Booby whose principal food is squid and flyingfishes. In order to catch enough food to feed a growing chick, the parents need to forage far from the cays, and this may entail long absences from the nest. Inexperienced parents may not be able to deliver an adequate food supply and their chicks may die of starvation because the timing of their meals is too irregular. In contrast, Brown Booby chicks raised in the Swain Reefs receive fairly regular meals. Flyingfishes, often caught by aerial pursuit, still make up an important component of their diet but, because of their different diving tech-

BROWN BOOBY

Sula leucogaster

Identification
Small, dark brown booby with sharp dividing line across breast separating brown upper parts from white belly and underwings. Sexual dimorphism: adult males smaller and lighter (average 1 kg), bill bluish grey with deep blue base and facial skin, feet pale to bluish green; adult females larger and heavier (average 1.2 kg), bill greenish, yellowish or greyish, facial skin and feet greenish yellow. Less vocal than Masked Booby in the colony: harsh quack for females, thin sibilant whistle for males.

Habitat and Distribution
Marine, widespread in (but not restricted to) all tropical oceans. Mainly sedentary and often encountered in small groups near land. Often seen perching on channel markers, boats etc.

Feeding
Feeds mainly on flyingfishes and squids and a wide range of other items, depending on geographic location and seasonal variability. May capture high percentage of fish by aerial pursuit and will take flyingfishes in flight. Plunge-dives from variable heights but commonly 10–15 m. Smallness of male may facilitate fishing near the shore in shallow waters (mere cms).

Breeding
Breeds on offshore and inshore tropical and subtropical islands, atolls and cays. Highly variable breeding season depending on region. Breeds in all months on the Swain Reefs, but seasonal in the Capricorn–Bunker group. Ground-nesting, with nests ranging from shallow scrapes to substantial structures. Both adults share in incubation and care of young.

PHOTOS: KATHIE ATKINSON

A male Masked Booby sky-pointing in order to attract a female.

nique, Brown Boobies can also catch other fish species closer to shore. The small, light male is able to make successive slant dives into the water just outside the breakers of the reef, and can catch many fish in a short space of time.

The chicks beg for food by uttering 'chucking' sounds, thrashing their wings wildly and lunging at their parents' bills. If food is in short supply, the begging of the older chicks becomes increasingly more vigorous, to the point of discomforting their parents (not to mention the observer!). As with humans, boobies exhibit some individual approaches to parenting. While some adults respond immediately to the begging of the chicks, and feed them as soon as they return to the nest, others consistently ignore their offspring for up to an hour and will not feed them until they have preened, rested and even oiled their feathers.

Not only do boobies have the difficult task of finding adequate quantities of food, they also run the risk of it being stolen. Some birds practise kleptoparasitism—the deliberate stealing of food that has been caught by others. Least Frigatebirds (*Fregata ariel*) may rob boobies of their food as they return to the cay after fishing. The frigatebirds can fly at greater speeds, accelerate faster and are more agile in the air than the boobies. Their pursuit is relentless, and the victim is often outmanoeuvred and harassed until it disgorges its food. In the Swain Reefs, however, only a small proportion of the boobies lose their catch in this way.

The Silver Gulls also practise a form of kleptoparasitism not previously described between these birds. A small number of gulls have learnt to steal fish from the gullet of both the Masked and Brown Boobies. The gull, attracted by the frenzied begging of a chick about to be fed, positions itself so that it can move in and quickly snatch the fish from the adult's throat before the gangly chick can reach in. The gulls are so successful at this that the adult often leaves again before the chick has received any food. In contrast to the documented low impact that specialist kleptoparasites, such as frigatebirds, have on the boobies, these gulls act as opportunistic kleptoparasites and are much more likely to cause real stress to the population, especially when food is in short supply.

As with humans, boobies exhibit some individual approaches to parenting.

A chick's chances of survival can also depend on the location of its nest. On several occasions, dead chicks were found on nests that had been washed over by ocean swells. Others were found buried by collapsed sand banks. Even the wrong neighbours can have serious consequences. I have witnessed a five-week-old Brown Booby chick die as a result of being severely mauled by neighbouring Masked Boobies trying to establish a territory. This type of attack is uncommon for Brown Booby chicks as they are usually guarded by one of their parents. Masked Booby chicks, on the other hand, are often left unguarded for long periods of time while both parents are out fishing. Perhaps because of this, they have developed a response called 'bill-hiding'. If approached by a strange adult, a Masked Booby chick will tuck its bill right underneath its breast and lie prone. This fear-motivated behaviour greatly reduces the severity of the attacks.

THE PROPORTION OF CHICKS SURVIVING to fledging in the Swain Reefs varies from year to year and, as discussed, may depend on many factors. The lack of synchronised egg-laying has numerous benefits, especially for the Masked Booby, a tropical seabird that fishes in an impoverished, blue-water environment and whose small-island nesting grounds are periodically battered by cyclonic weather. Food shortages are unpredictable in timing and duration, and at no time of year can there be a guarantee that there will be enough for large numbers of growing chicks. Unfortunately, year-

When the parents are away, the chick will play. Here a Brown Booby chick entertains itself by tossing a feather in the air and catching it. This game helps the bird to develop the important fish-handling skills it will need as an adult.

round breeding does increase their vulnerability to predators and to disturbance by humans. If the boobies were occupying the islands for only part of the year, as would happen if egg-laying were synchronised, it would not be worthwhile for the Silver Gulls to develop the specialised skills of nest robbing and food stealing. A synchronised breeding population would also be easier to manage, as it could be adequately protected by rigorous, seasonal closures during the critical period of the breeding cycle.

The breeding activities of the boobies are characterised by considerable variability in natural mortality, particularly of the chicks. Bad weather and lack of food are the two greatest natural causes of breeding failure, and both can lead to very large losses. Typically, these losses are episodic events that allow populations to recover their numbers. Human disturbances, on the other hand, tend to be less severe but occur more frequently and over a longer time period. Such chronic disturbances can have a major impact on the population's ability to recover. The continued survival of the boobies in the Swain Reefs, therefore, may well depend upon stringent management practices that will allow these magnificent seabirds to rear their young successfully. ■

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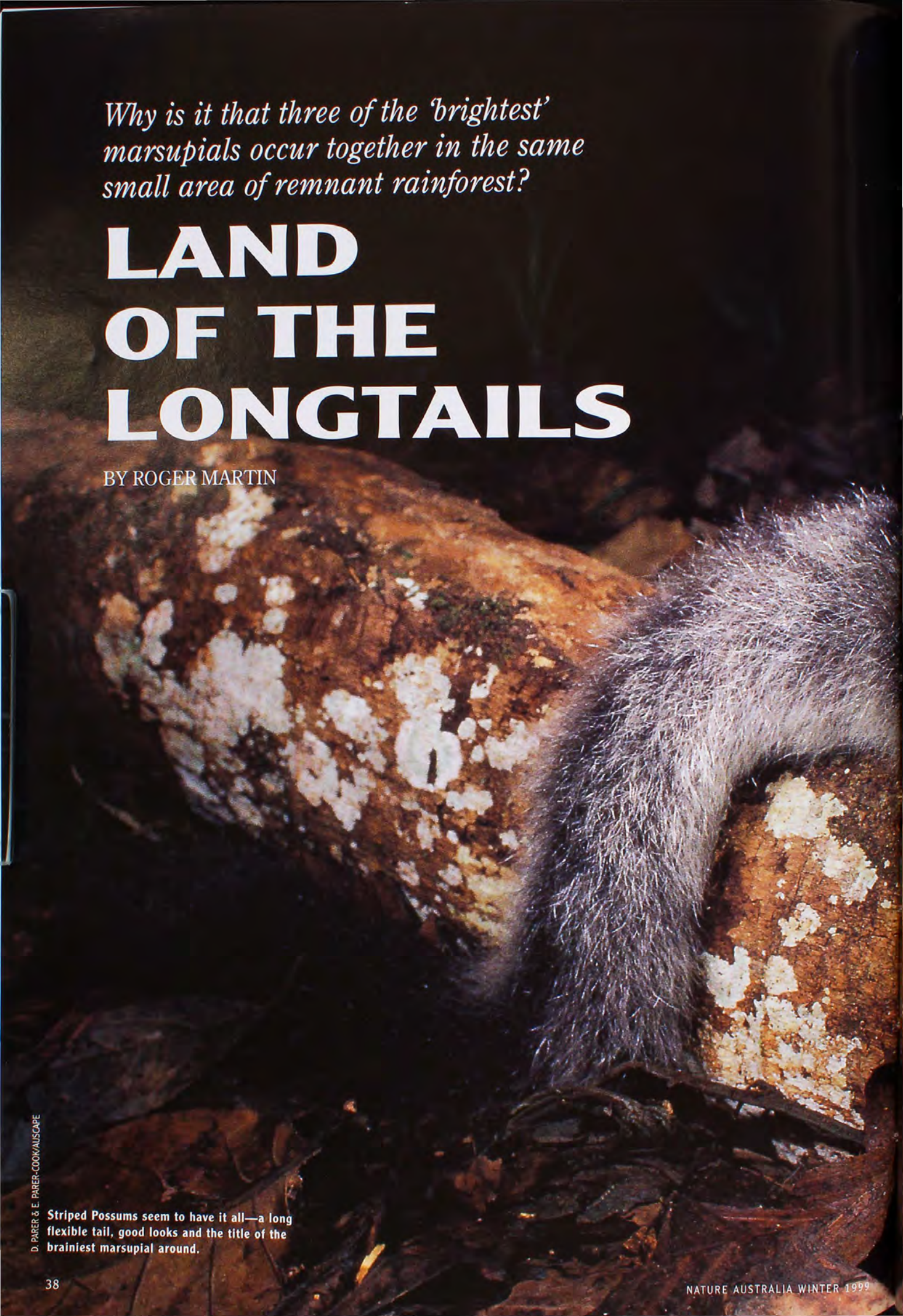
A Masked Booby chick displays the strange behaviour of bill-hiding. This behaviour seems to greatly reduce the attacks from other boobies during the long hours when its parents are away catching food.

Why is it that three of the 'brightest' marsupials occur together in the same small area of remnant rainforest?

LAND OF THE LONGTAILS

BY ROGER MARTIN



D. PARER & E. PARER-COOK/AUSCAPE

Striped Possums seem to have it all—a long flexible tail, good looks and the title of the brainiest marsupial around.

IN THE MINDS OF MOST PEOPLE, RAINforest epitomises biodiversity and the rainforests of northern Queensland certainly contain a diverse array of the group of animals I am most interested in—the arboreal marsupials. In the richest areas, such as the misty upland forests of the Atherton Tablelands, up to ten species occur together. These include a tree-kangaroo, a brushtail possum, a pygmy-possum, a striped possum, and several species of ringtail and gliding possums. As you proceed north of here, however, this diversity diminishes. At the northern end of the wet tropics, a mere 250 kilometres away, the fauna of arboreal marsupials is impoverished. In the drier rainforest scrubs surrounding Mount Finnigan, for example, ringtails and brushtails are absent and only five of the ten species of arboreal marsupials found farther south still occur there.

The reason I came to the foothills of Mount Finnigan had little to do with questions of biodiversity. Rather it was because one member of the local fauna, a tree-climbing kangaroo, fascinated me. Bennett's Tree-kangaroo (*Dendrolagus bennettianus*) was a rare species and, apart from a few individuals collected in 1894, it was largely unknown to science. Found only in the 3,000-odd square kilometres of rainforest lying between the Daintree and Annan Rivers, it has one of the smallest distributions of any Australian mammal. At the time I first went there its conservation status was doubtful. It was by no means common and was seldom seen, even by the locals. Only in one limited area, in the scrubs surrounding Mount Finnigan, did it appear to be reasonably abundant.

JEAN-PAUL FERRERO/AUSCAPE

Right: Tree-dwelling marsupials, like this Long-tailed Pygmy-possum seem to share more than just long tails—they all achieve high scores in the marsupial intelligence test. Why?

On arriving in the area, one of the first things I tried to establish was the local distribution of the species. Where were tree-kangaroos to be found? The mountaintops, the river valleys, all over? I was eager to talk to any locals who had seen them or had stories to tell. One day I struck up a conversation with an old man who had spent many years in the area, originally mining for tin. I was in the middle of telling him how I had been searching the nearby scrub for evidence of tree-kangaroos when he interrupted and asked whether I'd seen any tigers.

I was in the middle of telling him how I had been searching the nearby scrub for evidence of tree-kangaroos when he interrupted and asked whether I'd seen any tigers.

"Oh, you mean tiger cats (Spotted-tailed Quolls)?"

"No, not cats, son. Tigers! The big fellas!"

I politely steered the conversation off in another direction. By this time I'd heard that, even by north Queensland standards, 'tin scratchers' had been a terrible bunch of drunks and I concluded

DICK WHITFORD/NATURE FOCUS

Left: A radio-collared Bennett's Tree-kangaroo. This tree-climbing kangaroo with its spectacular tail and curious lifestyle introduced the author to the mysterious world of longtails and their superior intelligence.

ed that the old man was probably hallucinating when he saw his tigers.

Eventually I saw many tree-kangaroos but it was almost a decade later that I caught my first glimpse of a tiger. It was in the middle of the day in a narrow strip of gallery forest beside the Annan. The animal was on the ground, just inside the forest, and I came on it suddenly after clambering up from the river. It startled and ran flat out, directly away from me. When it had covered about 50 metres, it started to wheel in a broad arc to my right. I followed it with my binoculars, catching glimpses as it dashed between the wide buttresses of the rainforest trees, its long, black-tasselled tail streaming out behind. Ah yes, undoubtedly a 'tiger'!

TREE-KANGAROOS ARE SECRETIVE AND largely nocturnal beasts and you don't often see them on the ground, particularly during the day. When you do, you notice that they move with short rapid hops and appear to lope rather than bounce along like normal kangaroos. Long tasselled tails, speed and manoeuvrability are traits usually associated with big cats and I realised I'd seen the genesis of the tin scratcher's tiger story. Perhaps I'd missed a twinkle in his eye at the time, but Bennett's Tree-kangaroo does have an extraordinarily long tail and it's the tail that everyone remembers. On average it's about 15 per cent longer than the animal's combined head–body (HB) length—even longer if you include the tassel. The tails of terrestrial kangaroos, the presumed ancestors of tree-kangaroos, are typically less than their HB length. For example the Agile Wallaby (*Macropus agilis*), a terrestrial macropod and tropical neighbour of Bennett's Tree-kangaroo, has a tail about 95 per cent of its HB length. The tail of the largest terrestrial kangaroo, the Red Kangaroo (*Macropus rufus*), is only about 80 per cent of its HB length.

Bennett's Tree-kangaroo does have an extraordinarily long tail and it's the tail that everyone remembers.

While hardly a relationship of profound biological significance, it caused me to speculate on why natural selection has favoured long tails in tree-kangaroos. The most obvious explanation is as an adaptation for arboreal life. While the long tail of Bennett's Tree-kangaroo is neither prehensile nor directly useful to it when climbing, once in the canopy it is undoubtedly a great aid to balance and mobility. While carefully traversing thin branches and vines, the tree-kangaroo holds its long tail out stiffly beneath it, counterbalancing the weight of its upper body.

During the tree-kangaroo work it soon became apparent that not only are these scrubs depauperate, but the few species of arboreal mammals that live there are thinly distributed. Sightings were few, even after the most diligent efforts. When I eventually became familiar with all of the resident species, it struck me that the other two non-gliding marsupials also possess extraordinarily long tails. The most spectacular member of the community, the black-and-white Striped Possum (*Dactylopsila trivirgata*), has a tail that is around 25 per cent longer than its HB length. The exquisite Long-tailed Pygmy-possum (*Cercartetus caudatus*) has an even longer tail, a full 27 per cent more than its HB. Even arboreal rats had picked up the trend. The rare Prehensile-tailed Rat (*Pogonomys mollipilosus*) is usually glimpsed fleetingly as it races along small branches high in the canopy, but in the hand its tail measures out at a whopping 35 per cent longer than its HB length.

The abiding theme of long-tailedness in this fauna of tree-dwelling marsupials intrigued me. Enhanced arboreal ability is the obvious explanation and, consis-

RELATIVE 'BRAININESS' OF MARSUPIALS

Species	Number of species	Encephalisation Index (EI)	Neocortical Index (NI)
Longtail group			
Striped Possum (*Dactylopsila trivirgata*)	1	320	1120
Bennett's Tree-kangaroo (*Dendrolagus bennettianus*)	1	246*	-
Long-tailed Pygmy-possum (*Cercartetus caudatus*)	1	266*	-
Other marsupial groups			
Family Pseudocheiridae (ringtail possums)	5	139	391
Family Phalangeridae (brushtail possums)	6	192	533
Genus *Macropus* (kangaroos and wallabies)	4	193	628
Subclass Marsupialia (marsupials)	151	194	512

*The EIs presented for Bennett's Tree-kangaroo and the Long-tailed Pygmy-possum have been estimated from the cranial volume of the skull. Fresh brain material has never been collected from either species. Simple definitions of EI and NI appear in the text.

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DAVE WATTS/NATURE FOCUS

The tail of the terrestrial Agile Wallaby may be an impressive sight, but it is nothing compared to the relative lengths of those possessed by the arboreal marsupials living in the dry rainforest scrubs.

tent with this, the tails of all of these smaller animals are also highly prehensile. An extra hand would be a great advantage, particularly when undertaking the longer jumps necessary when moving between trees. And these monsoon forests are very sparse compared to the upland rainforests. They contain many deciduous species and, after the heavy leaf fall of the late dry season, the canopy can be very thin. Many of the eucalypts in the surrounding woodland are also deciduous and this forest is skeletal in the late dry.

It was difficult to gain insights into the arboreal ability of the Long-tailed Pygmy-possum as sightings of this tiny animal were infrequent and its activities cryptic. However, I was often able to observe the larger, black-and-white beauty on its nightly forays. I was fortunate enough to participate in a detailed study of the Striped Possum's ecology (led by Kath Handasyde from the University of Melbourne), and this involved keeping track of a number of individuals by fitting them with small radio-collars. Often I followed them as they journeyed out into the surrounding eucalypt woodlands and their arboreal ability in this sparse forest proved to be remarkable. They are extremely athletic and traverse quickly through the canopy, leaping from tree to tree. In this, their long tail appears to be a great asset, acting as a counterbalance when they run along small branches, and also as an additional hand, the prehensile end clasping onto the foliage at the completion of the longer jumps.

I also saw Striped Possums use their tail for another, entirely unsuspected, purpose. At first I thought, like the tin scratchers of old, I'd been spending too much time in the scrub. But after seeing the performance a number of times from several individuals, I believe it to be consistent with their broader behavioural repertoire. Occasionally, when an animal was first illuminated in the spotlight, it would stare intently back at the light before turning away and stalking off up the branch, its long tail held high and lashing back and forth in the manner of a 'pissed-off' pussycat. It was most unpossum-like behaviour but its meaning was acutely obvious.

Striped Possums do a number of remarkable things but I will leave these for another article. Even before the fieldwork began we expected 'Stripeys' to be exceptional for, relative to their body weight (about half a kilogram), they are the 'brainiest' marsupials of them all! This had been established in long-term comparative studies of the neural anatomy of marsupials, carried out by John Nelson (Monash University), Heinz Stephan (Max Planck Institute for Brain Research) and Georg Baron (University of Montreal). The rationale underlying this work is that each species can be assigned a relative measure of 'braininess'. This is called an encephalisation index (EI) and it is the ratio of the actual brain size of the animal compared to the brain size expected if it was a member of that most primitive mammalian group, the eutherian insectivores (shrews, moles, hedgehogs and the like, which have the smallest brain to body ratio of all the mammals). Put simply, the EI of the Striped Possum is the ratio of its actual brain weight to the brain weight projected for a eutherian insectivore with the same body weight as a Striped Possum. Nelson and his colleagues don't claim that this is an exact measure of relative intelligence but they do believe that animals with relatively high EIs have greater potential for the integration of complex sensory information. These researchers use another similarly derived index, the neocortical index (NI), to indicate the relative size of the neocortex, the area of the brain that controls higher mental functions (see table).

What these indices suggest is that the Striped Possum is by far the brainiest of all the marsupials and that the other two longtails are well above average. This raises the obvious question: why is it that three of the 'brightest' marsupials occur together in the same small area of remnant rainforest?

I don't believe this is a coincidence. Braininess, or memory or intelligence if you like, is, like tail length, subject to

HANS & JUDY BESTE/LOCHMAN TRANSPARENCIES

The tree-dwelling Prehensile-tailed Rat has a tail that is 35 per cent longer than the length of its body.

natural selection, but investigating the conditions under which natural selection favours the brainy is a difficult area in which to do research. Those who have circumnavigated the question consider the relevant ecological forces impinging on intelligence to be the distribution of critical resources (food, shelter etc.) and the intensity of predation. Although the members of the marsupial longtail group utilise different resources, in the northern scrubs all their food resources appear to be sparsely distributed and temporally unreliable. In order to survive, all three species need to master a range of food-finding skills, to remember locations and recognise seasonal cues. One would expect the larger-brained individuals to be better at these tasks. As for intense predation, one needs to go no further than the Amethystine or Scrub Python (*Morelia amethistina*). This arboreal predator ambushes its prey and can strike in total darkness, relying on infra-red sensors clustered in pits surrounding the mouth to guide its strike (see *Nature Aust.** Spring 1994). Once again, attributes of the brain, such as alertness, memory and ability to learn, would be useful for prey animals trying to counter such a potent foe.

IN THE LIGHT OF SOME RECENT WORK IT IS interesting to speculate further on the evolutionary history and the origin of this long-tailed fauna. The major radiation of both tree-kangaroos (ten living species) and striped possums (four species) occurred in the rainforests of New Guinea and it has long been assumed that they evolved there. Their occurrence in northern Queensland (two species of tree-kangaroo, one species of striped possum) had been attributed to limited immigration across land bridges formed during the lowered sea levels of past ice ages. For tree-kangaroos, however, the weight of both fossil evidence and serological evidence (the latter suggesting a close relationship to rock-wallabies) now favours an Australian origin. With the recent discovery of a 20-million-year-old fossilised jaw and teeth of a striped possum at Riversleigh in Queensland, an Australian origin for this group has also been postulated.

If these species did evolve in Australia, is it likely that they came from deep rainforest or from dry scrubs on the rainforest edge? The close relationship between tree-kangaroos and rock-wallabies implies the latter. And striped possums? Is it fortuitous that they are so well adapted to the sparser forests on the rainforest edge, or is it possible that they also evolved there? Some recent work by Thomas Smith from San Francisco State University suggests that we should give serious consideration to a rainforest-edge origin. Smith and his colleagues worked in the African Cameroon on a species of small forest bird that occupies the ecotone (transition zone) between rainforest and savanna. From their data on gene flow and on the morphological divergence between the various populations of birds, they postulated that it was this rainforest edge that was the cradle where new species arose rather than in the rainforests themselves. They believe that ecotones are the likely source of any new diversity and that rainforests are more a sink for new species rather than an area where they are likely to be generated.

Is my 'land of the longtails' merely a whimsical place, or does Smith's radical concept have some practical significance for Australia's wet tropics? I think it does. The northern Queensland rainforests have enjoyed a very high profile over the last decade or so, and a great deal of effort, both administrative and scientific, has gone into their preservation and study. With a few notable exceptions the dry edges have been largely ignored or dismissed as 'depauperate' and 'not real rainforest'. Much of this area is presently unprotected and in the near future far-reaching decisions about its ownership and management will be made. In advocating a reappraisal of the biological significance of this less biodiverse forest I can think of no more cogent an argument than the one put by Thomas Smith: "If we are to protect biodiversity, we must also protect the processes that generate it." ■

*Previously *ANH*

ROBERT VALENTIC/NATURE FOCUS

Amethystine Pythons are highly efficient predators of tree-dwelling marsupials, able to hunt and strike their prey in total darkness. Could the existence of such potent foes have led to the development of high intelligence in their intended victims?

Alertness, memory and ability to learn, would be useful for prey animals trying to counter such a potent foe.

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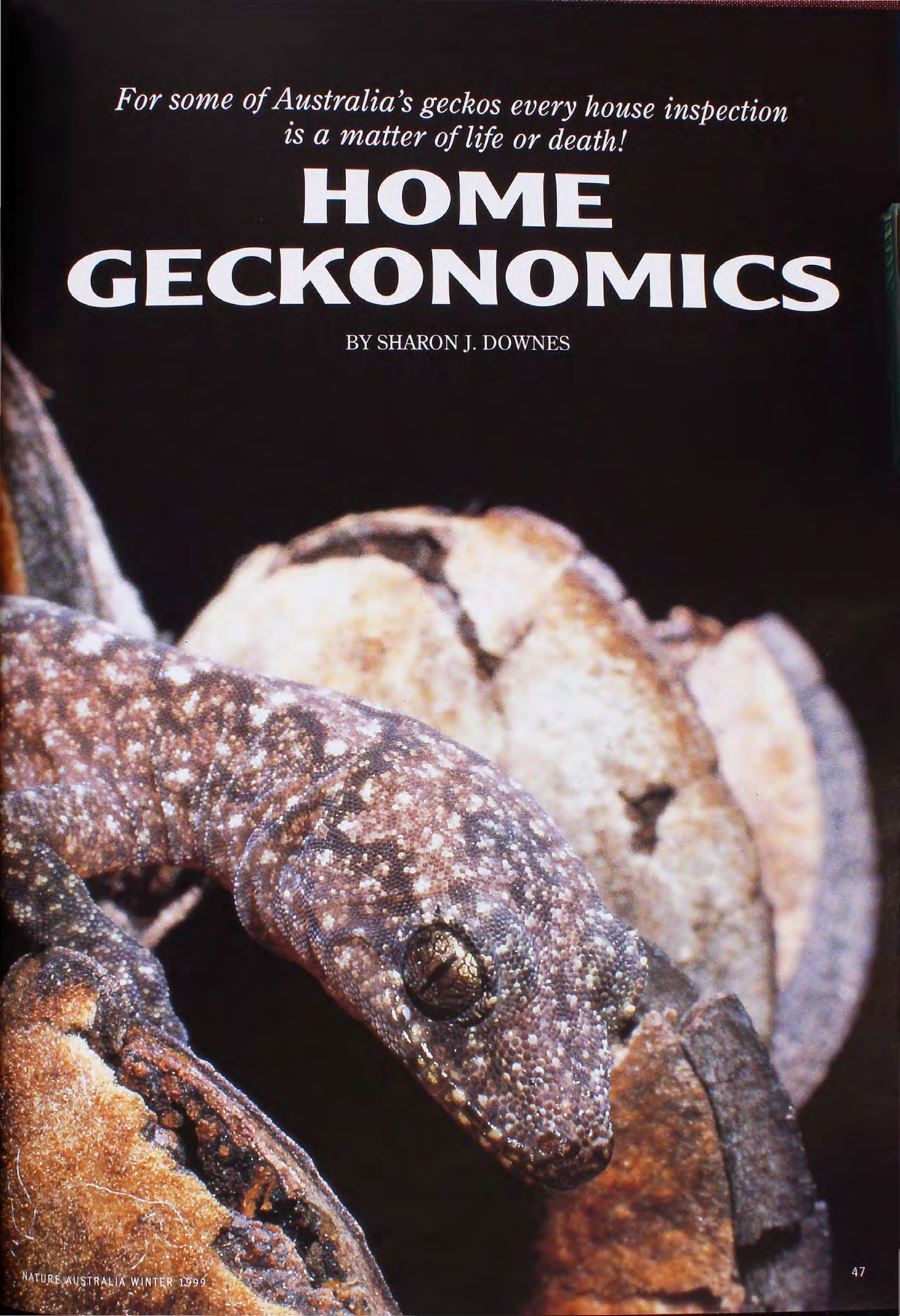
KATHIE ATKINSON

Night time is the right time for Lesueur's Velvet Gecko. It's when it tries to go home in the morning that the trouble starts.

For some of Australia's geckos every house inspection is a matter of life or death!

HOME GECKONOMICS

BY SHARON J. DOWNES



HOUSE HUNTING CAN BE A TIRESOME and frustrating experience. First you search the newspapers, notice boards and windows of real estate agencies for a description that vaguely resembles what you want. Then you spend days, weeks or even months inspecting these potential homes, often to find that the only accurate detail in the advert is the street name and number. Finally, you pinpoint the house of your dreams . . . to discover that it has just been sold. So you think house hunting is pretty tough? Well, spare a thought for some of Australia's geckos, because for these animals, every house inspection is a matter of life or death!

Dressed in dusty shades of red, grey, green and brown, and adorned with lined, spotted and tessellated patterns, geckos have the good fortune of being perhaps the most charismatic of Australia's lizards. Unique in both appearance and personality, geckos are flat lengthy creatures with silken bodies, endearing spectacles, and often bizarre hands and tails. Modified toes, equipped with fine hair-like setae, enable many of these small agile animals to safely ascend almost any surface. Their often flamboyant tails, taking the form of leaves or knobs, some with protruding spines, are a pantry for fat, and an ingenious strategy for escaping certain death. By vigorously waving this appendage, they can fool a potential predator into tackling a disposable part of their body; more often than not, the tail breaks, and the gecko escapes to live another day. The loss of a tail is a small price to pay for your life, and anyhow, it rapidly grows back to somewhat resemble its original form.

The lifestyle of most Australian geckos is frighteningly similar to that of your average 20-year-old university student.

The lifestyle of most Australian geckos is frighteningly similar to that of your average 20-year-old university student. To put it bluntly, geckos are party animals! They spend most of their days sleeping and lazing about within the comfort of their own abode (under rocks, bark, logs or debris, within ground litter or inside burrows), but around sunset they begin to get restless and enter a period of frenetic activity that usually lasts well into the night. They eat (mostly small arthropods, but some larger species eat smaller lizards), drink (water), socialise, and sometimes engage in sexual activities (but only in spring and summer). Then, during the wee hours of the morning, they quietly slip home to spend the next day sleeping off the festivities of the previous night.

Before the intricacies of 'home gecko-nomics' are explained, it seems appropriate to introduce the main star of this show: Lesueur's Velvet Gecko (*Oedura lesueurii*). Although a rather drab-looking beast (compared to some of its spectacular cousins), these lizards are probably the most common gecko residing along the coast of New South Wales. During the day, they usually laze about under slabs of rock on large outcrops and ridges. At night, they mostly frequent one of two venues: ground litter at the edge of rock faces or on the open rock face itself. For reasons that are not entirely clear, these geckos don't always return to their own abode after a night on the town. Perhaps they wander too far from their residence to make it back in one night, or maybe they return to find that another gecko has set up camp? They could have exhausted their local

LESUEUR'S VELVET GECKO

Oedura lesueurii

Classification
Family Gekkonidae (geckos).

Identification
Pale grey to brown above, with a broad, dark-edged vertebral stripe. Whitish below. The tail is moderately long and markedly depressed. Adults average 80 mm snout–vent length.

Distribution
Widespread along the coast and ranges of NSW and south-eastern Qld.

Habits
Nocturnal. Usually found living in caves or crevices, or under rock slabs on large slopes and ridges. Forages on open rock faces, but more usually among ground litter at the edge of rock faces.

Breeding
One clutch per year of 2 parchment-shelled eggs laid during Nov.–Dec. Up to 20 females aggregate under the same nesting rock several weeks before they deposit their eggs to form a communal nest. Eggs hatch around Feb.

Status
Common. Wholly protected. Perhaps threatened in some places by bush rock removal.

KEN GRIFFITHS

A Lesueur's Velvet Gecko sheds its skin. These geckos shed several times during the summer period of feeding and growth.

food supply, or it might be time to venture more widely to find that perfect match. Also, during late spring, females lay their eggs in a communal nest that can be located several hundred metres from their home site, and they probably need to find temporary daytime accommodation on the way. For whatever reason, Lesueur's Velvet Geckos almost certainly experience the frustrations of house hunting many times throughout their lives.

WHAT DOES LESUEUR'S VELVET Gecko look for in a potential house? Because reptiles are 'cold-blooded' or ectothermic (that is, they don't generate much heat from their own metabolic processes), they simply must have access to heat if they want to be active. Diurnal reptiles, like skinks and dragon lizards, bask in the morning sunshine, warm up, and then go about their daily business. But nocturnal reptiles are faced with a thermal dilemma: how can they become warm enough to be active when there is no sunlight at night? The answer is in their choice of rock retreat-site. Residing within a shelter that is well insulated and exposed to the afternoon sun means that a gecko can warm up in time for the night's activities. Thicker rocks take longer to heat up, but they hold the heat better and so remain warm later into the night. Thicker rocks are also less likely to overheat during the day. By selecting a shelter that varies in thickness, a rock-dwelling gecko can choose from a range of temperatures within the comfort of its own home.

For Lesueur's Velvet Geckos, life can

Geckos come in a variety of shapes and sizes. The large tail of this Southern Leaf-tailed Gecko (*Phyllurus platurus*) serves as both a pantry for fat as well as a disposable tool for predator evasion.

PHOTOS: KATHIE ATKINSON

Wood Geckos (*Diplodactylus vittatus*) like to sleep the day away in or under fallen timber, rocks or leaf litter.

be downright unpleasant when mature males attempt to share the same retreat-site, to the point where this situation rarely, if ever, occurs. Adult males can't stand each other, and they resolve issues of house ownership in a fairly predictable way: by fighting! Two geckos battling for the same retreat will firmly grip the tail of their opponent, and lock into a lengthy head-to-tail wrestle. Depending on their competitive abilities, these battles are usually sustained for at least several gruelling minutes. Eventually, the loser releases his grip on the tail of the winning male and retreats to find an inferior shelter.

There's at least one more thing that any gecko (not just Lesueur's Velvet Geckos) ought to consider carefully before it selects a home. Several species of snake dine exclusively on lizards, late at night, and inhabit similar retreat-sites to many types of gecko. This means that geckos might encounter potential snake predators while assessing a likely retreat, or, worse still, return home to discover they are sleeping with the enemy! The good news is that many

A Bynoe's Gecko (*Heteronotia binoei*) emerges from its rock retreat. Nocturnal geckos absorb the heat they need for their night-time activities from their daytime rock retreat.

KATHIE ATKINSON

When is a snake not a threat to Lesueur's Velvet Gecko? When it's an Eastern Small-eyed Snake. But how does the gecko tell just which snake is in that rock retreat?

snake species simply refuse to eat gecko. However, it's difficult to distinguish between those that do and those that don't when the snakes are curled up and hidden within a crevice. A brave gecko might attempt to catch a glimpse of the snake by briefly entering the retreat-site. But if the retreat contains a gecko-eating species, even a fleeting inspection would almost certainly spell death for the gecko!

Unfortunately, Lesueur's Velvet Geckos are one of the unlucky species that share their habitat with a ravaging gecko predator, the Broad-headed Snake (*Hoplocephalus bungaroides*). Not only do these strategic hunters prefer the same kinds of retreat-sites, they often stay under a rock for up to four weeks at a time just waiting for a gecko to come along for an inspection. So, as well as considering thermal benefits and social factors, assessing a potential retreat-site for the presence of a Broad-headed Snake is likely to be an important part of the gecko's selection-making process.

Luckily, most geckos have come up with a safe, reliable way of determining whether a potential retreat-site contains a snake. By flicking out their tongue, they can detect airborne smells of potential predators and prey. Known as chemoreception, this remarkable sensory system is mediated largely by Jacobson's organ, a receptor in the roof of the mouth operating in association with the tongue. But can geckos use chemoreception to distinguish between different species of snake? And what should a gecko do if there are only two potential retreat-sites to choose from: one is shaded, and the other receives sun but is also occupied by a snake? Will a dominant male gecko open his home to another male if the only alternative is a shelter containing a snake? Let's find out.

Unfortunately, Lesueur's Velvet Geckos are one of the unlucky species that share their habitat with a ravaging gecko predator, the Broad-headed Snake.

By creating a small horizontal crevice between two slabs of rock, and placing a heating wire underneath the bottom slab, I was able to construct a display home for a gecko that closely mimics the temperatures of natural retreat-sites exposed to full sunlight. Not surprisingly, when I gave Lesueur's Velvet Geckos the choice between a heated and a cool retreat-site, they went for the hot one almost all the time. And this makes sense, because being warm will undoubtedly enhance a gecko's ability to eat, drink and be merry during the night. But a gecko would have to carefully consider the benefits of a warm retreat-site if it is covered with the scent of snake. Indeed, in my experiments, most of the geckos shunned the warm retreat-site if it had been in contact with a Broad-headed Snake, and went for the cooler, unscented one. Understandably, it seems that velvet geckos would much rather be cold than dead!

The plot thickened substantially when I added social conflict into the arena. I offered pairs of male velvet geckos the choice between a warm and cold house. As expected, in each case, both geckos bid on the warm option, paying little attention to the alternative. But, when they came face to face, fights erupted and the largest geckos would invariably win, forcing the subordinates to use the

inferior retreat. It seems that small males also get the rough end of the deal when the rocks making up the warm house are covered with the scent of Broad-headed Snake. In each of these cases, the dominant geckos settled for the cold but safe option, and the subordinates were forced to use the warm but potentially snakey retreat. Sometimes this option was so daunting that the smaller gecko didn't choose a retreat-site at all! Forcing smaller males to occupy a cooler or more dangerous retreat-site probably increases a dominant male's chances of surviving and mating.

There's still one more player to mention in this story: the Eastern Small-eyed Snake (*Rhinoplocephalus nigrescens*). Just like Lesueur's Velvet Gecko and the Broad-headed Snake, this small black elapid spends its days under slabs of rock on sandstone outcrops and cliffs, and its nights out on the town. But this snake is a fussy eater: it dines exclusively on diurnal skinks and flatly refuses to eat gecko. Because skinks are usually asleep at night, the Small-eyed Snake is forced to actively seek them from underneath the logs and rocks and between the cracks and crevices in which they live. As a consequence, it spreads its scent widely, providing yet another dilemma for the Lesueur's Velvet Gecko: what should the gecko do when faced with a retreat-site that contains the scent of this harmless snake?

One option is to avoid all potential or current retreat-sites that are labelled with the scent of any snake. This seems a safe strategy, but if the scent is from a harmless Small-eyed Snake, a gecko could be avoiding the house of its dreams for no good reason. Perhaps this is why Lesueur's Velvet Geckos are able to distinguish between the scents of Broad-headed Snakes and Small-eyed Snakes. When I placed adult geckos on rocks that had been covered with the scent of a Broad-headed Snake, they flicked their tongues at very high rates and performed an impressive tail display composed of controlled undulations and lateral waves. By waving their tails, the geckos were redirecting the aim of their potential predator away from the main body to the tail. But when the rock was covered with the scent of a Small-eyed Snake, the same geckos showed a comparable tongue flick rate but failed to act out the accompanying anti-predator tail manoeuvres. Also, geckos strongly avoided retreat-sites that contained the odour of Broad-headed Snakes, but frequently entered those covered with the scent of Small-eyed Snakes.

It's difficult to say whether the ability to distinguish between the scents of a dangerous and harmless snake has evolved over time or is learned by the geckos during their lifetime. Many wild-caught geckos have regrown tails, suggesting that Broad-headed Snakes may have been slightly off target during their attempts to obtain a meal. If this is true, geckos may be born with the ability to detect various scents using chemoreception, and learn to avoid the odours of Broad-headed Snakes after escaping an attack. On the other hand, the entire repertoire involved in detecting Broad-headed Snake smell may be inherited from their parents. Regardless of the mechanism, it's clear that life can be tough for a house-hunting gecko. So the next time you're in the market for a new home, consider the perils of these daring reptiles, and feel grateful that you're not a gecko! ■

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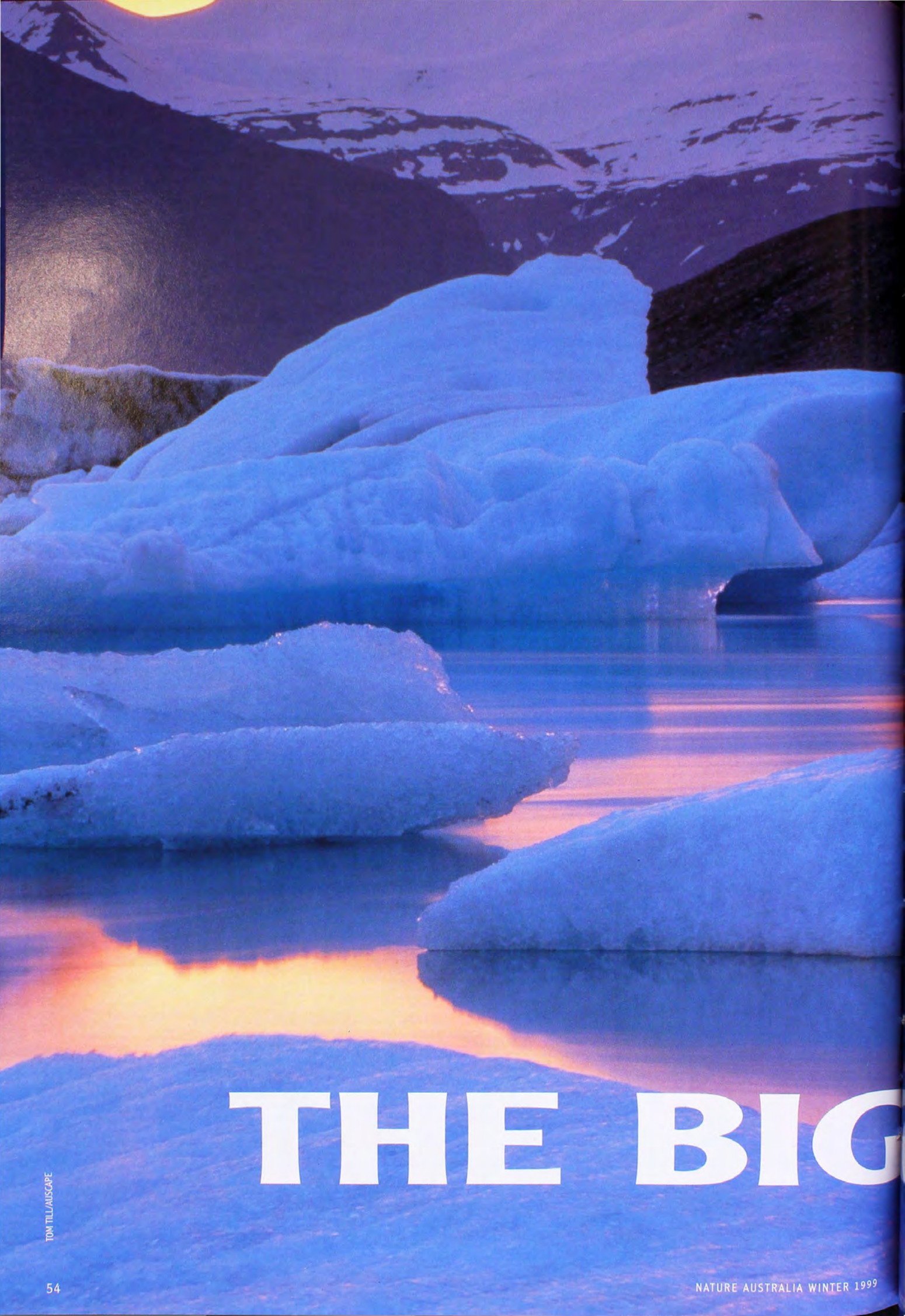
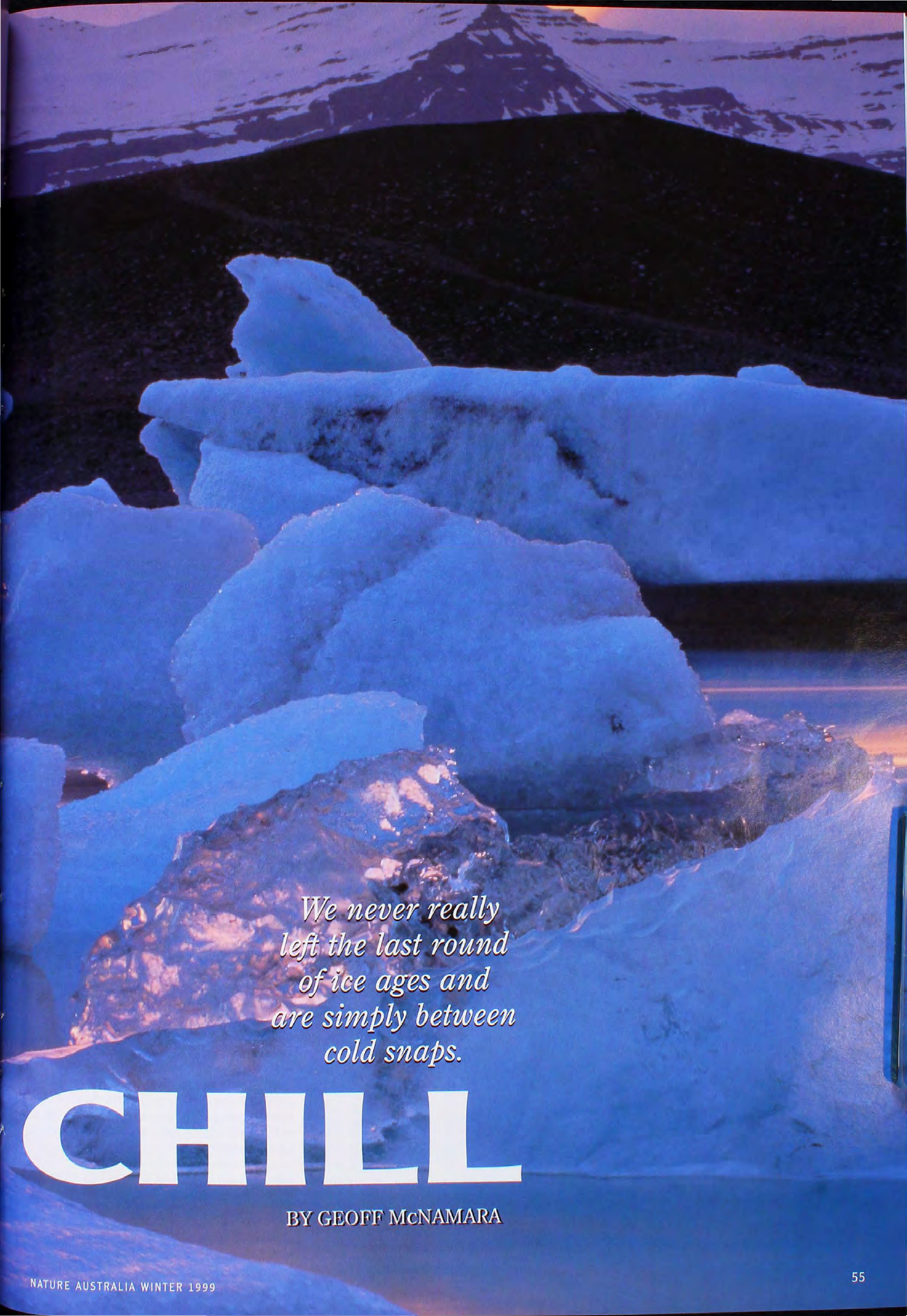
PAVEL GERMAN/NATURE FOCUS

A Broad-headed Snake dines on its favourite food—Lesueur's Velvet Gecko. The possible presence of this snake in rock retreats makes choosing a home a life-and-death decision for geckos.



THE BIG

TOM TILL/AUSCAPE



We never really left the last round of ice ages and are simply between cold snaps.

CHILL

BY GEOFF McNAMARA

IMAGINE IT'S 18,000 YEARS AGO AND you're approaching the Earth from space. From a distance, our home world is a blue-white disk bathed in the light of the Sun. As you fly closer the globe seems familiar: the supercontinent Pangaea has long since broken up, the continental fragments having drifted across the globe. From space, the Earth is easily recognisable . . . in all respects except one: a third of the dry land is frozen solid, submerged beneath giant sheets of ice.

Flying in from the north you can make out the ice-covered north pole, bloated but otherwise familiar. As the world turns beneath, however, you look down in amazement as one after another ice-covered continent rolls into view. With so much of the Earth's water now accumulated in frozen masses, the sea level has fallen, and bridges between previously isolated lands allow the migration of many species, including humans.

As you cruise silently southward you notice that the lower, warmer latitudes have resisted the cold. But the higher mountain ranges—the Andes and the Himalayas—are encased in ice. Glaciers have ploughed their way through New Zealand, Tasmania and Africa. Although cut off from other major landmasses, Antarctica has also grown as more and more of the sea that once lapped its coast froze against the shore.

The Earth has plunged into another ice age. And it isn't over yet.

THE STORY BEHIND ICE AGES* BEGINS IN the past. But not too far back; just to the last century, in fact. In 1837, Swiss zoologist and palaeontologist Louis Agassiz published a paper that suggested an explanation for huge deposits of boulders, gravel and sand left in strange places over northern Europe and North America. This geological debris, called 'till' or 'erratics', included granite boulders apparently transported over enormous distances. One explanation, popular well into the 18th century, was that the till had been moved by water during a worldwide catastrophic flood, an idea that fitted neatly into the biblical history of the world in vogue at the time. Those who believed in this 'Neptunist' theory were locked in dispute with the 'Plutonists' who preferred a volcanic origin for the till.

But both schools of thought were entirely wrong. Agassiz proposed that ice was the only reasonable way of transporting such huge masses of rock over large distances, and therefore the very existence of till was evidence that long ago the Earth had entered a period of intense cold. This 'ice age' had given birth to massive glaciers that gouged the land, ploughing rock and soil before them. The till was left where the glaciers stopped, in the mid-latitudes of Europe and North America. The reception of his paper was as cold as its subject, however. His one-time benefactor and colleague, Alexander Friedrich von Humboldt, was among the most vocal, telling Agassiz to "return to his fossil fishes" (a subject on which he had gained a reputation as an expert throughout Europe). Fortunately Agassiz endured this attack and went on to complete extensive fieldwork in the Alps, Scotland, northern England and Ireland, gathering evidence that supported his ice-age theory. In the end, the evidence was undeniable: the Earth had been subjected to periods of extensive glaciation, and that meant a global cold climate.

Strictly speaking, ice ages are called 'glacial episodes', while the times between them are called 'interglacials'. However, I have used the term ice age in this story for clarity, since during any given 'ice age' there are well documented glacial/interglacial episodes.

REG MORRISON

Once thought to have been moved by water or volcanoes, erratics, such as this boulder in western Tasmania, are actually transported by ice. Their existence indicates that, at certain times in its history, the Earth was a much colder place.

KATHIE ATKINSON

Did the evolution of cyanobacteria and other photosynthetic microorganisms, similar to those that make up these stromatolites in Western Australia, trigger the Earth's first ice age?

IT'S NOW KNOWN THAT THE EARTH HAS endured a number of ice ages, with the most recent and best studied having begun in the Quaternary some 1.6 to 1.8 million years ago. But so far no-one knows exactly why ice ages occur. Over the years there has been a bizarre array of explanations, including volcanoes that erupt ice, stars that radiate cold, and the Earth passing through alternately hot and cold regions of space. As it turns out, there seems to be more than one way to trigger an ice age. Jon Luly from James Cook University explains that the cause varies according to where you are in the geological time scale. According to Luly, some of the most intense ice ages—those that led to mass extinctions—may well have been triggered by the evolution of life itself.

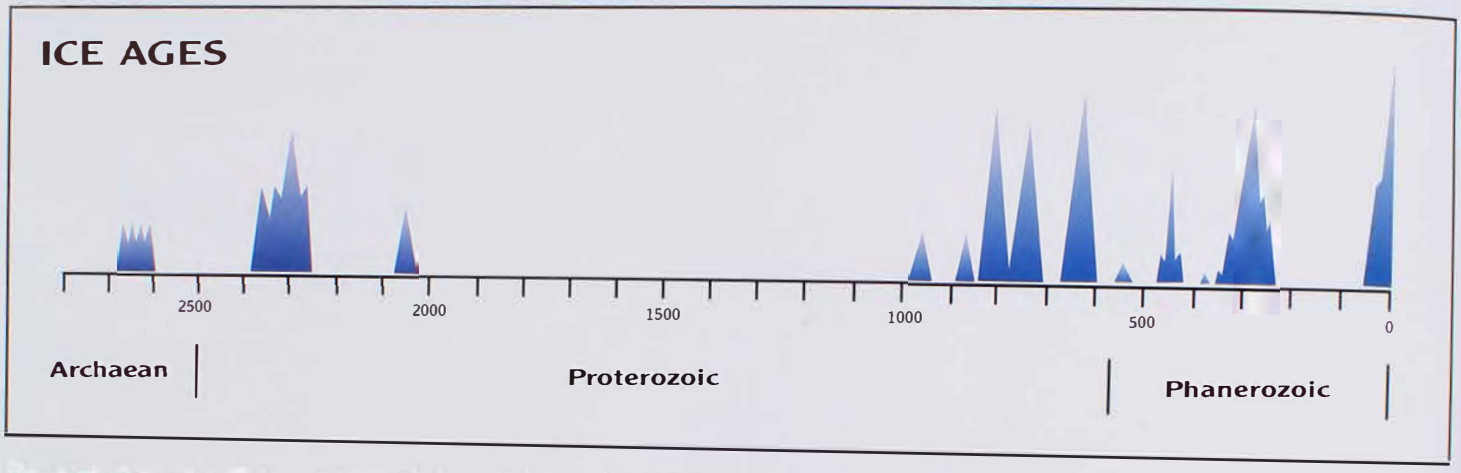
The Earth's climate is the result of many factors: the level of incoming solar radiation; atmospheric composition and circulation; chemical reactions involving the air, land and sea; and the life cycles of plants and animals. A major factor in the regulation of the Earth's surface temperature is the composition of the atmosphere. The Earth absorbs heat from the Sun during the day and cools at night by emitting infra-red radiation (heat) back into space. The so-called greenhouse gases, including carbon dioxide, limit the amount of infra-red radiation that can escape into space. Like a quilt for the sleeping hemisphere, these gases keep us warm at night. But it's a delicate balance: too much carbon dioxide and the Earth heats up intolerably; too little and the Earth chills. Humans may be guilty of upsetting the balance by adding excess carbon dioxide to the atmosphere and destroying the forests that absorb it, but the truth is Nature is capable of wreaking environmental havoc on Earth all by itself.

The Earth has a natural recycling system for carbon dioxide. The primitive, carbon dioxide-rich atmosphere was, and continues to be, released through volcanoes. The carbon dioxide reacts with rain to form carbonic acid, which in turn reacts with silicates on the ground to form carbonate rocks. When continental plates grind each other below the surface, these rocks are buried deep below the crust. The carbon dioxide is absorbed into the Earth from where, millions of years later, it is released back into the atmosphere through volcanoes and erosion. This carbon cycle has been operating non-stop for thousands of millions of years.

But when the cyanobacteria and other photosynthetic microorganisms came along some two-and-a-half thousand million years ago—first in the oceans and then later on land—they extracted the carbon out of the carbon dioxide to produce carbohydrates. What they returned, of course, was oxygen, which is transparent to infra-red radiation. It's just possible that the cyanobacteria sucked so much of the carbon dioxide out of the primitive atmosphere that it took the climate by surprise. The decrease in atmospheric carbon dioxide allowed the Earth to chill in the cold emptiness of space, and the first ice age began.

The theory is far from confirmed, however. Larry Frakes, from the Department of Geology and Geophysics at the University of Adelaide, says that ice ages don't always coincide with low carbon dioxide levels. Frakes points to geological and ice-core records of atmospheric composition during distant ice ages. These indicate that, while the carbon dioxide-depletion explanation is confirmed for most ice ages, it does not seem to work for others.

Another factor affecting both the start and progress of an ice age is continental drift. In 1990, John Veevers from Macquarie University pointed out that the formation and break-up of supercontinents like Gondwana—the massive proto-continent from which Australia, Africa, Antarctica and South America were born—is a cyclic activity. As the continents drift, the sea floor between them literally tears apart; the resulting undersea volcanic activity releases huge volumes of carbon dioxide replenishing that taken out of the atmosphere by the plants and rain. There are few places a continent can go on Earth, however, and eventually they all bunch up in a sort of continental traffic jam. When they're amalgamated as one supercontinent, lit-



This graph shows, in millions of years, periods of glaciation. The relative height of the peaks represents the extent of the Earth's surface that was affected.

tle sea-floor spreading takes place, and the carbon cycle becomes a one-way activity: carbon dioxide levels go down . . . followed by the surface temperature.

The distribution of land plays another important role in ice ages: oceans are generally too warm and deep to freeze solid, so large areas of ice only form over land or the shallow water over submerged continental shelves. Further, since ice ages start with large ice deposits at the poles, a polar continent is required for an ice age to begin. During the Carboniferous and Permian Periods (320 to 270 million years ago), that meant Gondwana sitting over the south pole.

The break-up of Gondwana in particular may have helped trigger yet another round of ice ages. Continental drift and associated mountain building alter the flow of oceans and atmosphere around the globe. Luly gives as a possible example the Pleistocene Epoch, which began about 1.6 million years ago and lasted until 10,000 years ago. Throughout this time, glaciers alternately advanced and retreated across the land in response to global temperature changes at roughly 100,000-year intervals. The Last Glacial Maximum, commonly referred to as *the* Ice Age, peaked at about 18,000 years ago. Luly explains that the Pleistocene ice ages may have been presaged by the separation of the southern continents from Antarctica. As the break-up of Gondwana took place, the ocean and atmospheric circulation gradually altered until the separation of Drake Passage (between the tip of South America and Antarctica) allowed the West Wind Drift to develop. This ocean current effectively isolated Antarctica from the rest of the global climate, or at least the oceans, changing the flow of heat around the world. This added to the refrigeration effect in Antarctica, which in turn helped intensify global cooling.

A completely different (and admittedly less popular) explanation for the origin of ice ages has to do with the fact that from time to time the Earth's magnetic field, or magnetosphere, reverses polarity—north becomes south and *vice versa*. The Earth is continually bathed in many types of radiation (not just light) from the Sun. The magnetic field that surrounds the Earth filters out much of this radiation before it reaches the atmosphere. It has been suggested that, if the magnetic field weakens during a reversal, solar radiation could reach the atmosphere, perhaps triggering the formation of more clouds. Since clouds reflect sunlight, any increase in cloud cover helps cool the Earth.

WHICHEVER WAY THEY BEGIN, IT'S known that during the most recent ice ages the extent of the ice is not constant, but advances and retreats over periods of roughly 100,000 years. Times of advancing ice are called glacials, while the warmer periods between are called interglacials. It's now widely accepted that the advance and retreat of the glaciers is the result of a complex interaction of planetary cycles described in 1920 by a Serbian scientist, Milutin Milankovitch.

To understand Milankovitch's cycles we need to step back from the Earth again and consider it as a planet hurtling through space. First, the Earth is a spinning globe orbiting the Sun once a year. Its axis of rotation is tilted with respect to its orbit so that sometimes the southern hemisphere is inclined towards the Sun, and sometimes the reverse. It's this tilt that gives us the seasons: seen from any given place on the ground in either hemisphere, the Sun appears higher or lower in the sky at different times of the year. When the Sun is high in the sky at midday, as in summer, sunlight strikes the Earth's surface at a steeper angle and so warms the air and the ground more efficiently; when the Sun is lower at midday, as in winter, cooling results. The tilt of the Earth's axis is not con-

Eighteen thousand years ago, almost a third of the Earth was covered with a blanket of ice. Explaining how, why and when ice ages occur is proving to be a challenge for scientists.

ROBYN STEWART/AUSCAPE

REG MORRISON/AUSCAPE

When the last ice age peaked, and the continents at higher latitudes were frozen under a blanket of ice, Australia turned from a green continent into the giant desert we know today.

stant, however, but fluctuates between 21.8° and 23.46° over a 41,000-year period. The greater the angle, the more extreme the seasons in either hemisphere will be.

Second, like all the planets, the Earth moves around the Sun along an elliptical or oval-shaped orbit that carries it sometimes nearer the Sun, sometimes farther away. As you'd expect, the greater the difference in distance from the Sun during the year, the greater the change in heat received. But the orbit alternates between an elliptical and (almost) circular shape over a 100,000-year cycle. This varies the difference in distance from the Earth to the Sun.

Finally, the Earth is currently closest to the Sun during southern summers and northern winters, but this arrangement won't last forever: over a 21,700-year period the Earth's spin axis wobbles like that of a spinning top. In about 10,000 years, the northern hemisphere will be experiencing winter at the time the Earth is farthest from the Sun. These changes in the Earth's orientation with respect to the Sun are cyclic, and so can be calculated and plotted on a graph. And this is just what Milankovitch did in 1920, and he suggested that the Earth's planetary rhythms match the periods between glacials and interglacials. There are problems with the Milankovitch cycle theory, however. For a start, it cannot explain the initiation of major glacial changes. Also the changes in insolation—the amount of sunlight the Earth receives due to the cycles—are small and yet are used to explain significant climate changes within the ice ages. Further, there's a lag time of up to 9,000 years between the predicted changes in insolation and climate cooling or warming. As a result, some people question whether they are truly related.

While much of the northern continents was buried under ice, Australia and the other middle-latitude lands, including Africa, Asia and South America, dried out.

Even if the Milankovitch cycles don't alone explain the ebb and flow of glaciers during an ice age, there are many other subtle factors that amplify their effects. One is the Sun's variability: not only was the Sun 30 per cent dimmer at the time the Earth formed, but its output varies over an 11-year cycle and perhaps longer cycles as well. Long-term solar variations have been tied with cooler climates, such as the 'Maunder Minimum', a period of low solar activity that lasted from 1645 to 1715 and coincided with unusually low temperatures recorded in Europe.

Ice itself plays a major role in keeping the planet cool once an ice age has begun. All the planets absorb some sunlight and reflect the rest back into space. The Earth currently reflects about a third of the light it receives from the Sun and absorbs the rest. But as anyone who's been to the snow will testify, ice is very good at reflecting sunlight so, as the global ice cover increases during an ice age, so does the amount of sunlight reflected. In this way, the highly reflective snow helps keep the planet cool in the same way a white car left in the sun all day will be much cooler than a black car.

It now seems likely that, by themselves, none of these factors is enough to trigger an ice age; working in unison, however, they seem to be capable of global climate change. For example, the combination of the presence of land and the reflective nature of ice may have highlighted the 100,000-year Milankovitch cycles during the Pleistocene Epoch: the existence of land at high northern latitudes allows snow and ice to accumulate, and more ice means less absorption of sunlight, leading to lower temperatures . . . and more ice. Given the extent of geological time, there is ample opportunity for these cyclical phenomena to line up like the hands of a clock at midnight. And when they do, the Earth shivers.

BUT WHAT DO ICE AGES MEAN FOR LIFE on Earth? Were they simply geophysical anomalies that life muddled through, or did they have a greater impact? The best studied and most recent ice age occurred during the Pleistocene Epoch. The glacial episodes that occurred during this time period resulted in almost a third of the planet being submerged beneath a thick blanket of ice. The latest Pleistocene glacial episode peaked around 18,000 years ago. It may not have been the most severe, but it led to two extraordinary events. One was that it literally paved the way for humans to migrate in large numbers from Siberia to Alaska, and from there into North America. The second was a sudden and global mass extinction, nowhere more pronounced than in North America where 32 genera of mammals died out in just 2,000 years.

Was it mere coincidence? No-one knows for sure, but it seems reasonable that large mammals living in North America at the time that humans made their appearance would have been totally unprepared for this new—and to them, no doubt, puny—intruder. But the new arrivals were skilled and well-equipped predators. And to survive they had to slaughter the existing animals.

That was up north, but what about down south? The Australian ice-age experience was startlingly different from continents at high latitudes. While the northern continents were smothered in ice, the once-green Australian continent turned into a giant desert. How? Girdling the Earth like a giant inner tube is an atmospheric current called the Hadley cell. This current rises at low latitudes (resulting in low air pressure) and descends at mid-latitudes (resulting in high air pressure). As a general rule, high pressure means little rain. It has been suggested that, when the Pleistocene ice ages began, the Hadley cells intensified, resulting in much more descending air influencing a lot of the middle-latitude areas, including Australia. The high-pressure belts that determine the presence of today's deserts became more intense, resulting in extremely dry conditions over most of the Australian continent. While much of the northern continents was buried under ice, Australia and the other middle-latitude lands, including Africa, Asia and South America, dried out.

So what of the future? When will the next ice age occur? If you'll pardon the pun, ice ages are a matter of degree. Luly points out that, compared with the Tertiary, we are already in an ice age. Frakes agrees, adding that, despite the name change from Pleistocene to Holocene (10,000 years ago to the present), we never really left the last round of Pleistocene ice ages and are simply between cold snaps. And so we're in for another ice age any millennium, but now there's a new, unknown factor affecting global climate change—industry. Just how the Earth responds to this new phenomenon, to what degree, and on what time scale, is difficult to know. Whatever happens, one thing seems likely: the Earth will some day enter a new glacial period. If our species is unprepared when it arrives, the artefacts of our brief day in the Sun may become frozen in time. ■

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Geoff McNamara is a freelance science writer based in Sydney and a frequent contributor to Nature Australia. *His first book,* Ripples on a cosmic sea, *co-authored with David Blair, was published in 1997 by Allen & Unwin. He extends sincere thanks to Larry Frakes and Jon Luly for their help in preparing this article.*

REG MORRISON

Sunrise over the Simpson Desert in South Australia. The Earth has a complicated relationship with this hot star and the interplay between the two has led to many theories as to what triggers an ice age.


Seabird Nesting Area
Please stay clear.
These birds are easily alarmed by human approach and will leave the nest. Unprotected eggs and chicks are rapidly killed by heat, cold or seagulls. Chicks may also become lost or exhausted if disturbed.
This sign will be removed when nesting is complete.
Thank you for your co-operation.
QUEENSLAND NATIONAL PARKS AND WILDLIFE SERVICE

A courting pair of Masked Boobies (*Sula dactylatra*).

P H O T O A R T

BOOBIES

BY KATHIE ATKINSON

Left: A male and female Brown Booby (*Sula leucogaster*) perched on a sign.

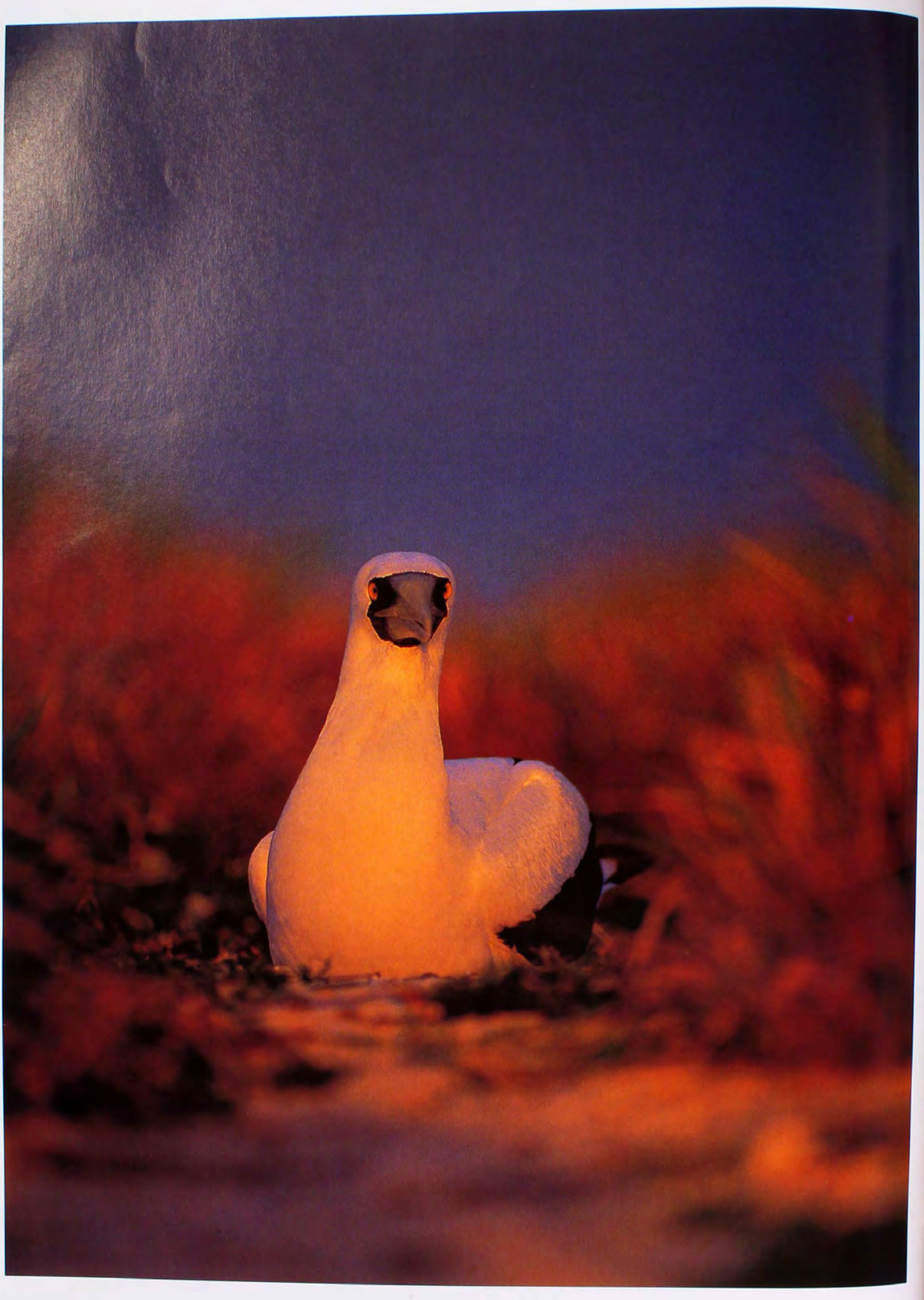
A Red-footed Booby (*Sula sula*) calling for a mate.

Brown Booby parents with their chick.

P H O T O A R T

An adult Red-footed Booby.

Masked Boobies.



A Masked Booby sits on its eggs.

Masked Boobies courting.

P H O T O A R T

Belief in anything is a powerful addiction; once it takes hold, most of us are unwilling to objectively examine these beliefs again.

IMMUNISING AGAINST FLIM-FLAM VIRUS

BY MICHAEL ARCHER

FAIRIES ARE REAL. ALIENS ARE abducting and sexually experimenting on humans. In a former life, Shirley MacLaine lived in Atlantis and today 'channels' the thoughts of a now thoroughly decomposed Atlantean. Near-death experiences prove there is life after death. Holding the terminals of a galvanometer can 'clear' your mind, enabling you to travel through space. Telekinesis is real and minds can bend forks. Tarot cards accurately predict the future. Levitation is real. Crystals heal. Big Foot stalks. Elvis lives!

Many people believe these and much stranger things to be true. Belief in anything, from astrology to gods, is a powerful addiction; once it takes hold, most of us are unwilling to objectively examine these beliefs again. If we do, it is normally to pay attention only to evidence that supports our preconceived beliefs. Psychologists tell us that we think with a mind-set that begins to harden by the time we are five, an age when we were comfortable believing in the reality of a staggering amount of mental fluff from the Easter Bunny to Santa Claus, ideas often encouraged at this formative age by well-meaning parents.

Why is it important to be able to distinguish gobbledegook or flim-flam from reality? Does it matter if we believe in aliens or Santa Claus? In most cases, perhaps not. But some beliefs can lead to decidedly unpleasant consequences. Consider the Heaven's Gate cult. Its members believed every word of charismatic leader Marshall Applewhite. He advised them that an alien spaceship, hidden in the tail of Comet Hale-Bopp which arrived in our inner solar system in 1997, had come to take them to a better life. All they had to do was shed their mortal bodies. Fired with faith, 39 true believers committed suicide after packing their suitcases for the expected interstellar journey. Only slightly less suicidal, cigarette advertisements encourage us

A postcard from Heaven's Gate leader Marshall Applewhite after his departure from Earth?

to believe it's OK to join the three million per year who already die from smoking-related causes.

At the very least, most beliefs turn out to be expensive (pass the plate or pay the dowser) and some damage our capacity for critical thinking. Rhondda Jones (James Cook University) found that students who had been taught Creationist beliefs in high-school science classes exhibited a remarkable tendency for 'Orwellian double-think'—in which they simultaneously embraced completely contradictory aspects of Creationism and science.

Presuming we care, how *does* one distinguish flim-flam from reality? The novelist Philip K. Dick suggested that reality is that which, when you stop believing in it, doesn't go away! If that doesn't work for you, try the checklist proposed by James Lett (Indian River Community College, Florida), summarised by the capital letters of the word FiLCHeRS: Falsifiability, Logic, Comprehensiveness, Honesty, Replicability and Sufficiency.

Scientifically sound ideas should be testable or *falsifiable*. They should also be *logical*, with valid conclusions drawn from sound premises, and *comprehensively* consider all available evidence, not just the bits that support the conclusion. They should involve rigorous *honesty*, free of self-deception. Supporters of ESP (extrasensory perception) claim that it exists despite repeated failure to demonstrate it in controlled experiments. Ideas derived from research should also, where possible, be based on *replicated* experiments or observations to minimise the situation of chance producing misleading results. *Sufficiency* refers to the nature of the evidence required to provide adequate support. For example, I would need far less evidence to convince someone I had seen a live kangaroo than I would need to convince them that I had seen a werewolf.

How could we apply the FiLCHeRS test? Try the widespread belief that Thylacines still exist. Recall the currently understood wisdom of science. Thylacines on mainland Australia were gone by 4,000 years ago, about the same time that Dingoes were introduced. They survived in Tasmania because rising sea levels isolated Tasmania about 10,000 years ago. Then along came Europeans with Sheep, and the last undoubted Thylacine died in the Hobart Zoo in 1936. Despite this, many still believe, on the basis of frequent and long-term sightings, that Thylacines survive in Tasmania, as well as on mainland Australia.

Would this belief stand up to *falsification*? Unfortunately not. Although we can't falsify the possibility that they *do* exist, neither can we test personal sightings as evidence for this belief. Is the belief *logical*? Not if the logic of the argument is: people have reported seeing Thylacines; therefore Thylacines exist. The test of *comprehensiveness* also fails because embracing the belief means ignoring evidence that they do not survive (see *Nature Aust.* Autumn 1997), including their absence from formerly preferred habitats and complete absence of even a single hair of material evidence. Is it an *honest* claim, free of self-deception? This would be hard to defend, considering the number of methodical yet always unsuccessful searches since the 1930s on foot and using trip-set cameras. Although the requirement for *replicability* is also not met, this test is not really suitable for examining the credibility of sightings.

Finally, is the evidence *sufficient* to support the belief? Paraeidolia ('other mind') is a term used to describe what happens when we 'see' things, such as familiar shapes in clouds, that are not really there. When confronted by incomplete or ambiguous sensory evidence, our brain, without being asked, tries to help by filling in the missing information. Sightings of a creature under less than perfect conditions in terms of, for example, lighting and time for detailed examination, are grand opportunities for paraeidolia to make us believe we are seeing something that is not actually there. A similar paraeidolic effect occurs when we read the 'foggy-speak' of astrological horoscopes—their vagueness enables them to seem tailor-fit to any true believer. Conclusion: unfortunately for those of us who would like to believe that Thylacines survive, the FiLCHeRS test provides little comfort.

Obviously it's important to keep an open mind particularly when confronted with new evidence and new ideas. If we don't, science won't progress. But we have to be careful; a mind that is too open can allow the brain to fall out. For this reason, it's equally important to be inoculated with a dose of scepticism as protection against flim-flam virus. You can get one from the Australian Skeptics website, an excellent and fun place to begin facing the ghosts of childhood. ■

Further Reading

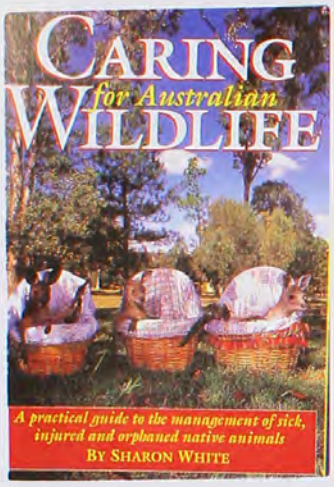
Australian Skeptics Homepage. *http://www.skeptics.com.au*

Lett, J., 1990. A field guide to critical thinking. *Skeptical Inquirer* 14: 153–160.

Jones, R.E., 1987. Evolution and creationism: the consequences of an analysis for education. *Interdisciplinary Science Reviews* 12(4): 324–332.

Michael Archer is the Director of the Australian Museum, Professor of Biological Science at the University of New South Wales, and recipient of the 1998 Australian Skeptic of the Year award. His major research interests are the fossil faunas of Riversleigh, north-western Queensland.

REVIEWS



Caring for Australian Wildlife: A Practical Guide to the Management of Sick, Injured and Orphaned Native Animals

By Sharon White. Australian Geographic, NSW, 1997, 152pp. $19.95np.

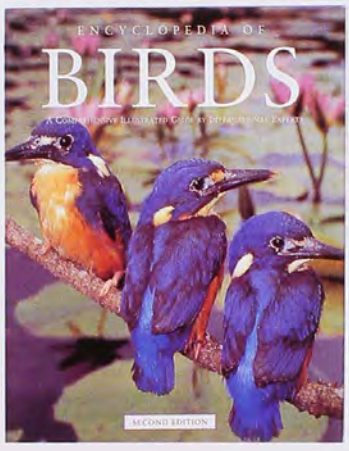
This is a 'how-to-do-it' type book designed with the animal carers in mind. It includes a glossary, commercial products for wildlife, a list of wildlife authorities, and covers two broad areas—principles of wildlife care, and wildlife rehabilitation. The various chapters are colour-coded for easy reference. The 'principles' part contains chapters on, among other things, the effects of humans, first aid and emergency care, captive management, release into the wild and ethics of wildlife care. The 'wildlife' part deals with the specific groups of animals and their requirements (birds, possums and gliders, bats, reptiles, frogs etc). The book is accompanied throughout by either colour photos or line illustrations.

Initially I thought the book might end up being very similar to another I'd reviewed some years ago (Sue Hand's *Care and handling of Australian native animals*, 1990) but it is sufficiently different to be of value even if you have the other book as well. It is quite a practical book. Right at the front is a quick reference chart, so in a situation where would-be carers are confronted with an unfamiliar event or animal, they need to just run down the chart until they get to the appropriate subject matter. This gives them a page number to turn to. For each animal there is a section that deals with useful equipment and how to use it, methods of picking up the animal without damage to it or you, and how to transport it. Throughout the book there are practical tips to help make the care job easier on both carer and 'patient'. For example, feather dusters make ideal artificial mothers for bird chicks, and record-keeping is both useful and essential to compare past attempts and to check progress (a blank record sheet is provided to photocopy). There are also various handy tables. One, for example, charts growth in baby Common Ringtails and gives relative weights, ages, appearance (features), and food and housing requirements. This enables you to guess the age of your young possum (by its features), establish the weight it should be at that age, and decide what to feed it. This is all useful stuff to a carer.

Some of the charts and recommendations, however, are a little too generalised to be of use. Take the feeding table for lizards, for example. A carer who ends up with a Burton's Legless Lizard (one of our more widely distributed species) and tries to feed it on any of the "Natural food in captivity" listings is doomed to failure as it will only take smaller lizards or snakes. The housing for frogs also suggests loose soil in the floor of the tank. I've found that this can often lead to a rapid bacterial build-up and that washed sand, gravel, sphagnum moss, or something else that is relatively inert (even damp kitchen towelling is OK if changed every few days) is better for preventing disease. I appreciate that the book would be overly long if too much detail was included but there is a bit of a bias towards the 'fluffy' animals.

All in all a very useful book to have on the shelf, or in the glove compartment of the car, for anyone with an interest in helping out some fellow Australians down on their luck.

—Martyn Robinson
Australian Museum



Encyclopedia of Birds

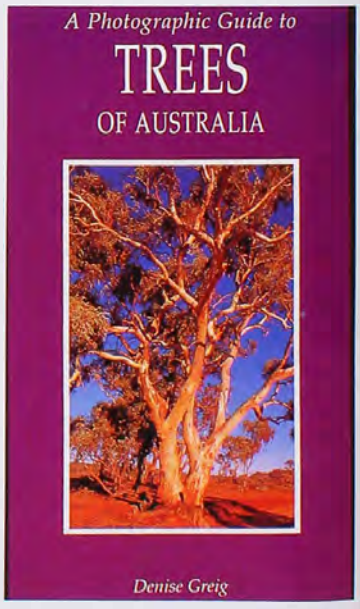
Second edition by Joseph M. Forshaw. UNSW Press, NSW, 1998, 240 pp. $49.95rrp.

Encyclopedia of birds is an overview of the world's avifauna—numbering about 9,000 species—so you might wonder how relevant it would be to Australia (which has only eight per cent of the fauna). In fact, Australian examples are well represented in illustrations and text, thanks to an Australian editorial team and many Australian contributors.

An introductory section of six chapters summarises the characteristics of birds, their evolutionary history and classification, and endangered species. It includes diagrams of external features, feather structure and skeleton, and a list of orders and families of birds. The remaining 48 chapters describe the different kinds of birds in a taxonomic sequence based on the *Checklist of birds of the world* by Peters *et al.* (1931–1987). Each chapter opens with a distribution map for the order or family and a box of key facts—number of genera and species, largest and smallest, and threatened species. The book concludes with two pages of further reading and an index to scientific names and bird groups (for example choughs, keas). The common names of individual birds are not included in the index, nor is there a subject index.

A wealth of information has been condensed into 240 pages without sacrificing literary style, and the text is illustrated with numerous colour photos supplemented by painted portraits. I recommend this book for reference centres and naturalists whose interest in birds extends beyond Australia.

—Elizabeth Cameron
Australian Museum



A Photographic Guide to Trees of Australia

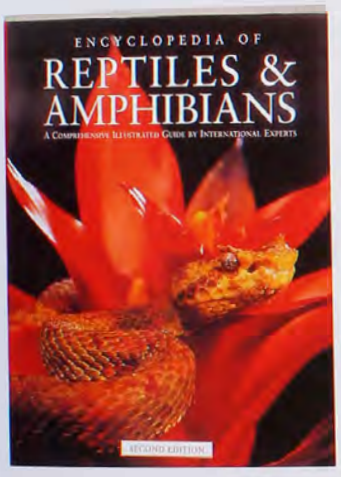
By Denise Greig. New Holland Publishers, NSW, 1998, 144pp. $16.95rrp.

To undertake a photographic guide to trees of Australia in a format that will fit into your pocket would seem an impossible task. Especially when there are roughly 900 species of eucalypts alone! However, Denise Greig has carefully selected eye-catching species that are

either so striking, like the brilliant orange of the Flame Tree in flower, or so dominant in an area, that people's curiosity is aroused. She has then provided the book that satisfies this curiosity. The format is excellent, with clear photographs, descriptions and distribution maps, as well as interesting snippets on horticulture, wildlife, taxonomy, Aboriginal usage, and timber products and uses. The trees are placed in family groups and these are indicated by a small symbol in the top right-hand corner of each page, making it easy to flick through the book to find the tree you're looking for.

This compact, lightweight and informative guide is ideal for the interested traveller and would fit perfectly into the glove box of a car or the side pocket of a backpack.

—Tracey Armstrong
Royal Botanic Gardens, Mount Annan



Encyclopedia of Reptiles and Amphibians

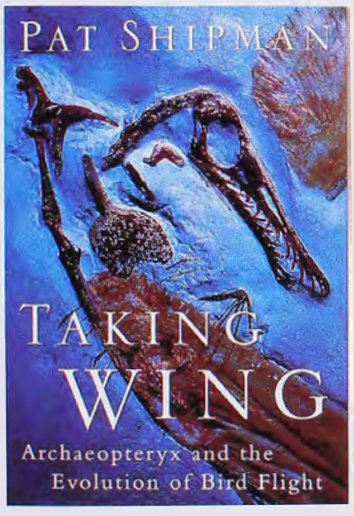
Second edition by Harold Cogger and Richard Zweifel. UNSW Press, NSW, 1998, 240 pp. $49.95rrp.

To the general public, reptiles and amphibians are not yet as popular as birds, but here is just the book to stimulate a lifelong interest in these fascinating animals. Collectively, reptiles and amphibians are called herps (a name derived from the Greek word *herpo*, to creep or crawl) and the study of them, herpetology. In this volume, 18 leading herpetologists have shared their knowledge and enthusiasm through informative text, drawing on many examples from the world's herpetofauna of more than 12,300 species.

This companion to *Encyclopedia of birds* has a similar format and sequence of introductory chapters. These are followed by taxonomic accounts occupying nine chapters—one each for the amphibian orders (caecilians, salamanders and newts, and frogs and toads) and six for reptiles (turtles and tortoises, lizards, snakes, amphisbaenians or worm-lizards, the Tuatara, crocodiles and alligators). More than 20 boxes scattered through the book explain intriguing aspects of biology and behaviour, such as how geckos stroll across ceilings and chameleons catch their food.

The illustrations have been chosen to emphasise diversity of colour and form, and capture many subjects in action (for example, Frilled Lizards kick-boxing, and a Cane Toad devouring a frog). The index includes common names of individual species and numerous subject entries, as well as scientific and group names.

—Elizabeth Cameron
Australian Museum



Taking Wing: Archaeopteryx and the Evolution of Bird Flight

By Pat Shipman. Weidenfeld & Nicholson, London, 1998, 336pp. $49.95rrp.

Flight has always been one of the features of birds that has captured our attention (and not without a bit of envy). Always accepted as a defining character of birds, its origin is still far from understood, with competing theories drawing the efforts of biologists in a range of fields. A fundamental focus of this debate has been whether bird flight started from the trees down or from the ground up. This discussion is itself intricately connected with the larger debate on the origin of birds, in particular the hypothesis that they evolved from dinosaurs.

Pat Shipman addresses these and other related topics in her wide-ranging book. She introduces her story with a review of the history of the finding of *Archaeopteryx*, represented by some of the most beautiful fossils ever found and accepted by most workers as the earliest known bird. From this starting point she launches her narrative across a wide range of topics, touching on the question of bird flight. This often includes side trips into areas such as the flight of insects, bats and pterosaurs, and early human attempts to take to the air.

This is a timely book for, in its compilation, the author has incorporated recent studies that have not yet made it into textbooks. As well she has interviewed many of the major players in the current debates on the origins of birds and bird flight. Although at the conclusion she comes down on one side of the argument, Shipman is fair to the proponents of all persuasions, clearly presenting their views and interpretations of the studies and specimens.

While certainly not the last word on the subject—new fossil finds have already rendered parts out of date—this is the most in-depth and even-handed treatment on the origins of bird flight to have appeared. Further, it shows how scientific ideas ebb and flow as new information appears and is interpreted by workers, initially often in several different ways. Science is very much a human endeavour and this book illustrates how it proceeds with fits and starts and diversions but inevitably draws closer to the right answer. Taking wing is engagingly written in a style accessible to all readers, amateurs and professionals alike. Recommended.

—Walter E. Boles
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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Contact: Glenys Oogjes

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PO Box 218
Wauchope, NSW 2446
Ph: 0500 861 405 (24 hr duty); (02) 6553 9658
Contact: Sue Emerton

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Wildcare Inc.

PO Box 464
Palmerston, NT 0831
Contact: Mignon McHendrie

Membership: $20.00 full; $10.00 associate; $7.00 junior; $50.00 corporate

WRIN (Wildlife Rescue & Information Network Inc.)

30 Collins St
Kangaroo Flat, Vic. 3555
Ph: (03) 5441 3211 or (03) 5432 2315 after hours
Contact: Rob Schrieber

Membership: $15.00

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Queensland Ornithological Society Inc.

PO Box 97
St Lucia, Qld 4067
Ph: (07) 3870 8076
Contact: Dawn Muir

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PO Box 84
Whittlesea, Vic. 3757
Ph: (03) 9716 1626
Contact: Geoff Williams

Membership: $30.00 adult; $45.00 family; $20.00 student

National Parks Association of NSW

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

Membership: $43.00 adult; $48.00 household; $23.00 concession

National Parks Association of Qld

PO Box 1040
Milton Centre, Qld 4064
Ph: (07) 3367 0878
Website: www.bit.net.au/~npaqld
Contact: George Haddock

Membership: $40.00 single; $57.00 household; $25.00 student

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Contact: Dianne Hayes

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PO Box 16
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Ph: (02) 9817 5621
Contact: Cath Hitchcock

Membership: $40.00

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State Tree Centre
Brookway Drive
Campbelltown, SA 5074
Ph: (08) 8207 8757
e-mail: pitman@adam.com.au
Contact: Sheryn Pitman or Rebecca Royle

Membership: $25.00 single; $55.00 family

Launceston Field Naturalists Club

PO Box 1072
Launceston, Tas. 7250
Ph: (03) 6344 1076
Contact: Dr A Pegler

Membership: $15.00 single; $20.00 family

MICRO-LIFE

The Postal Microscopy Club

PO Box A1017
Sydney South PO, NSW 1235
Contact: Michael Dingley

MUSEUMS

TAMS, The Australian Museum Society

6 College St
Sydney, NSW 2000
Ph: (02) 9320 6225
Contact: Michelle Ball

Membership fees: $55.00 single; $70.00 household; $40.00 student/pensioner

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Ph: (07) 4054 7317
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Contact: Michael Anthony

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The Guide.

Q&A

Ladybird, Ladybird . . .

Q: *Last week while I was pruning a hibiscus plant I came across more than 20 ladybird beetles on the one bush. I also found what looked like the empty shells of what I think were once ladybird beetles. Do ladybird beetles moult?*

—Steve Wynniatt
Victor Harbour, SA

A: Ladybirds, like all beetles, hatch from eggs and progress as larvae through several stages called instars, which are separated by moulting. The external skeletons of insects limit their growth, so larvae must moult to accommodate their increasing size until they pupate. After pupation, the adult beetle emerges from its pupal case and undergoes no further moults. There is a common misunderstanding that a small insect is a young one that will simply grow bigger, however in most cases this is not so. A small fly will not grow into a larger fly, nor a small butterfly into a larger one. Without having seen your "empty shells", I would guess these are the pupal cases from which the adult ladybirds emerged. If, however, they looked just like the adults, they were probably just dead adults.

—Margaret Humphrey
Australian Museum

Whistling Wings

Q: *Why do the wings of Crested Pigeons make a whistling noise?*

—Catherine McGahey
St Ives, NSW

A: The distinctive ringing or whistling noise heard when Crested Pigeons (*Ocyphaps lophotes*) fly is caused by a modified primary flight feather, the third inwards from the end of the wing. The tip of this feather is notched, giving it a different shape from the surrounding primaries. It is not certain why these pigeons make this sound, although it may function to maintain contact between members of a flock during flight. Sound production by modified feathers is known in a range of different birds from around the world. In some of these, the sound is produced during courtship displays.

—Walter E. Boles
Australian Museum

T. & P. GARDNER/NATURE FOCUS

A range of birds, including Crested Pigeons, have sound-producing wings.

Winter Basking

Q: *On several sunny but cold days over this past winter I noticed an Eastern Brown Snake (*Pseudonaja textilis*) basking on the ground just outside its hole. The most extreme example of this 'sun-baking' occurred at 10am after a frosty morning in early July when the temperature was only 3.5^0 C. This behaviour intrigues me as I had been led to believe that snakes hibernate. Also I understood they only bask in the sun to raise their body temperature in order to hunt and then digest their prey. Do snakes in south-eastern Australia normally hibernate or undergo some form of torpor over winter, or do they simply become less active? Do they feed at all during this period?*

—David Wakefield
Strath Creek, Vic.

A: In the more temperate parts of Australia, snakes generally become dormant during the autumn and winter. They will, however, occasionally bask on sunny days. The purpose of winter basking is unclear, because not much is known about how winter dormancy affects important body functions such as feeding and reproduction in Australian snakes. Do the snakes treat it as simply any other cool spell

C. ANDREW HENLEY/NATURE FOCUS

A newly emerged adult ladybird beetle sitting on its pupal case.

T.P. MORLEY/NATURE FOCUS

Why do Eastern Brown Snakes bask in winter?

when their body temperature falls temporarily and their activities are briefly curtailed, or does their physiology change in some more permanent way, preventing them from carrying out certain activities, such as digestion, even if short warm periods occur? Given that keepers sometimes notice their snakes reduce feeding with the approach of winter, and, indeed, even reproduce better after being put through a winter dormancy, it is likely that winter dormancy involves some seasonal adjustment in physiology. If so, winter basking may still serve some useful functions, such as preparation of the reproductive organs and energy stores for the next activity season. Brief periods of basking may also provide the snake with some clues about its internal physiological clock and where it is in the annual cycle.

—Allen E. Greer
Australian Museum

Answers to Quiz in Nature Strips (page 17)

1. Mating
2. Michael Archer
3. Homebush Bay, Sydney
4. Both happened in the same year (1859)
5. Two toes forward, two back
6. Horse meat
7. In its eyes
8. Photosynthesis
9. Beetles
10. Gorilla

P I C T E A S E R

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *The Graham Pizzey & Frank Knight field guide to the birds of Australia* from the Australian Museum Shop. Autumn's Pic Teaser was the burrow entrance of a wolf spider (*Lycosa* sp.) that had been disguised with soil and covered with a silk membrane.

HELEN TAYLOR

The loss of Wingecarribee Swamp will go down in history as a classic example of our collective stupidity and inability to read the signs and take action.

WINGECARRIBEE SWAMP—GONE!

BY GEOFF SAINTY

WINGECARRIBEE Swamp—the largest montane peat swamp on the Australian mainland—is gone. Originally more than 500 hectares, she lay between Robertson and Moss Vale in the New South Wales Southern Highlands. For those who were privileged to see her and walk across her broad expanse, she was something special—even though signs of her demise were already obvious. She was loaded with history going back more than 20,000 years. She was a living entity. If you go there now, you will not believe your eyes.

When Europeans arrived in Botany Bay in 1788, the area surrounding this magnificent peatland was covered in rainforest. The fertile land was quickly cleared and subsequently used to grow potatoes and dairy cattle. From then on everyone took from her. Slices were cut through her surface to deflect water away from the fledgling peat-mining industry, to improve grazing and to supply water. In 1997 close inspection of her surface showed signs of drying, with blackberries and other dry-loving plants becoming common. The signs were there but no-one was watching. Then on 8 August 1998 a massive deluge took advantage of her weakened state.

The 20-hectare, four-metre-deep pool—created by mining peat from the swamp—had recently been enlarged following approval to harvest a further seven hectares of peat. This extension accelerated drying of the peat on the upstream edge of the pool and so, when the heavy rains came, huge chunks of peat broke away and floated to the downstream edge, forming a temporary dam. Eventually the force of the rising water became so great that it ripped through the barrier, taking with it a dredging machine and cutting a five-metre-deep channel through the peat. Thereafter large areas of peat became undermined and floated downstream into Wingecarribee Dam. The before and after photographs show it all.

Top: Wingecarribee Swamp as it used to be when viewed from the south, showing the extent of the peat area. Wingecarribee Dam, part of Sydney's water supply, can be seen at the bottom left edge of the photo and the peat-mining area is visible as the waterhole in the top right. Bottom: Taken above the peat-mining area and looking west towards the dam, this picture shows the area that was once Wingecarribee Swamp. The peat-mining waterhole is now filled in and the dam is filled with the mud, soil and dead organisms that once made up the swamp. A creek now cuts through the centre and the lines on either side are crevasses about two to three metres deep.

PHOTOS: SKYCAM, COURTESY GEOFF SAINTY

So who is to blame? All of us really, but particularly the mining process for digging that gaping hole in her guts and destabilising her. Others, too, for cutting drains through her and setting the drying process in motion. Farmers for planting pasture species in the peat, further hastening the drying process. Residents and land holders for enriching her when she did not want the nutrients. All of us for knowingly and unknowingly introducing exotic weeds to the area. Sydney Water (the builders of Wingecarribee Dam) for drowning more than 100 hectares of peat on her western flank and, as landlords, for failing to spend any money on her welfare—even though she provided a priceless water-cleaning facility. The Environment Protection Authority and Department of Land and Water Conservation for not comprehending the critical state she was in—they now have to deal with the coffee-coloured water flowing down the Wingecarribee River into Sydney's water supply. And National Parks, which, rather than focussing on the big picture, dillydallied on single rare-species issues, including one plant (Yellow Loosestrife, *Lysimachia vulgaris*) that is far from endangered and possibly an introduced weed!

Then there are those who approved the seven-hectare extension to the peat-mining pool, accelerating her destruction; the State mining authority for believing you could continue to mine her and get away with it; and those consultants and scientists who, by being paid to concentrate on isolated issues, failed to report the obvious desperate state she was in. They all to varying degrees helped in her death.

The loss of Wingecarribee Swamp is a disaster of monumental proportions. It will go down in history as a classic example of our collective stupidity and inability to read the signs and take action. There must be a full inquiry into who said what about her welfare—who flannelled the truth—so that the uninvolved public can see how environmental care and science is lost in the quest for dollars.

Wingecarribee Swamp cannot be restored; small bits may survive, but most of it is now subject to desiccation and death.

The maelstrom as she broke up (and the more than two million cubic metres of her body as it was washed into Wingecarribee Dam) must have been a sight to see. Although she went out with a bang, she did it in style, under the cover of rain and mist, with no-one there to witness her last stand. ■

Geoff Sainty is a wetlands consultant working in Sydney. He has worked on wetlands since 1961, and is co-author of Waterplants of NSW *(1981) and* Waterplants in Australia *(1994).*

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

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