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SUMMER 1995–96

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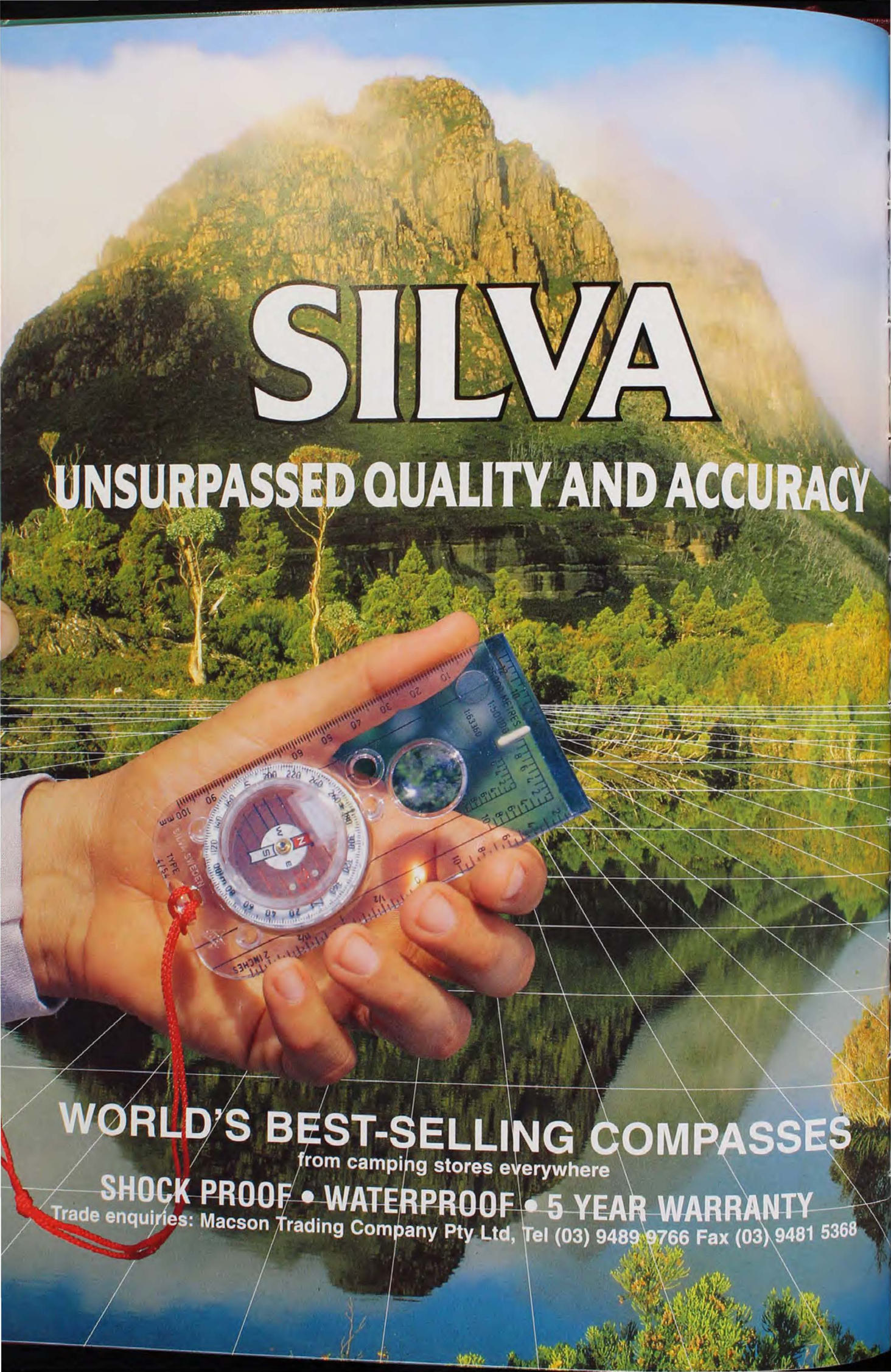
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Up Front

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The Australian Dingo.

They say any publicity is good publicity, but if there was ever an Australian sorely in need of good press, it's the much maligned Dingo. To most people, the Dingo is a wild dog with a ravenous and uncontrollable appetite that was brought here by Aborigines some tens of thousands of years ago. Not so, according to a group of researchers who have spent the last 30 years looking past the myth and misinformation that has clouded our view of this animal. The Australian Dingo is an Asian import that arrived on our shores some 4,000 years ago. A subspecies of wolf, it is the ancestor from which all true dog breeds evolved; a specialist feeder that focuses on a narrow range of prey; and it is facing possible extinction, not from all our poisoning, shooting and trapping, but from cross-breeding with domestic dogs! It's quite a story and one, I'm sure, that will change your opinion of this animal forever.

Also in this issue we take a look at why anything would want to live in the inhospitable environment of a tropical cave; our rarest and most threatened bird of prey—the Red Goshawk; and the amazing rats of the Queensland rainforest which, according to some of the locals, are smart and fearsome enough to run for parliament. And to top it all off we have one of the most spectacular Dingo posters you are ever likely to see. Joe Shemesh is one determined photographer who spent many wet and frustrating days on Frasier Island in order to capture on film an image that is definitely worth framing.

MICHAEL CERMAK

An assain bug may spend its entire life inside a cave.

Finally, some important news. A worldwide paper crisis has forced up the price of paper dramatically in the past year (in some cases, as much as 60 per cent). This has resulted in an increased print bill for every magazine published, including *Nature Australia*. We've held off for as long as we could, but unfortunately as a non-profit magazine we have no alternative but to increase our subscription rates. So, starting with this issue (Summer 1995–96) our rates have increased by about ten per cent, but that's not too bad considering our last price rise was in 1989. We do, however, want to say thankyou to all our current subscribers for their generous support and encouragement. If you are an existing subscriber, we have a special renewal offer for you on the back of the address sheet that came with this magazine. I hope that you will be able to take up the offer and continue to enjoy reading all the fascinating articles we have planned for the upcoming issues of *Nature Australia*.

—Jennifer Saunders

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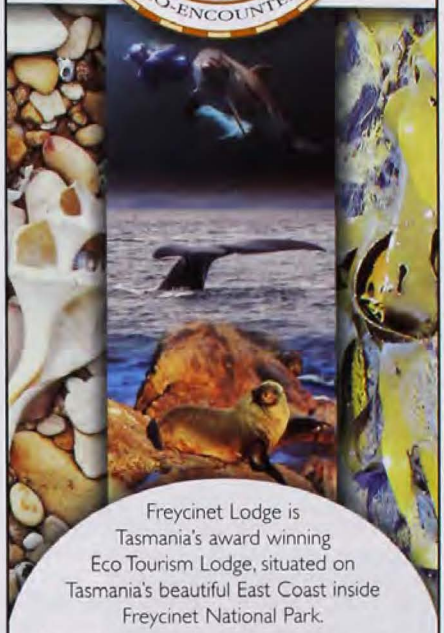

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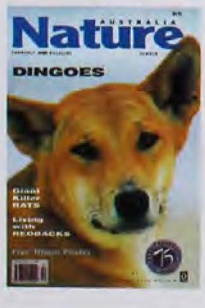

Front Cover
The Dingo: beloved Australian or introduced pest?
Photo by Joe Shemesh.

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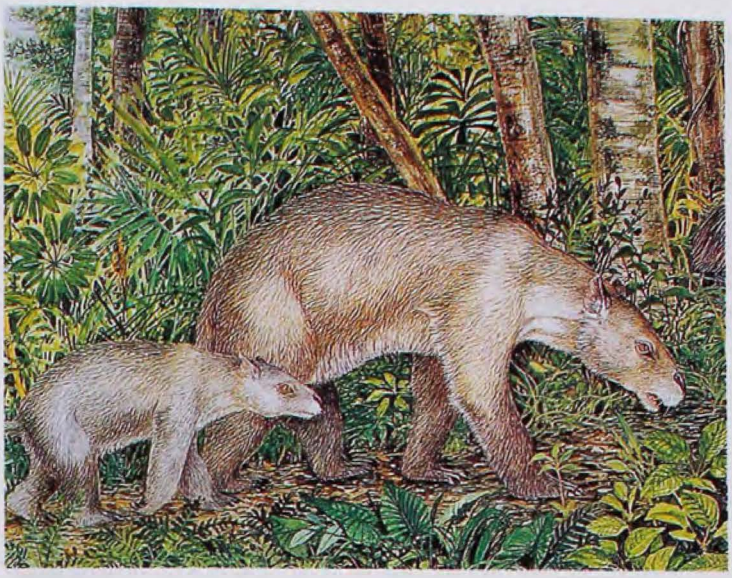

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MIOCENE MADONNA & CHILD

For 20 million years, their tragic story remained buried within the limestone. That is, until the impact of a hammer and the skilled hands of a palaeontologist brought their story back to 'life'.

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LETTERS

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

Hanging Out for Rain

At the end of 1994 very dry conditions prevailed in much of Australia, including south-eastern Queensland. And it was not just farmers and garden-owners who suffered. While sitting on our verandah on one of the last days of December a few clouds gathered, one of which, surprisingly, gave a brief, heavy shower. As the rain started three Black-faced Cuckoo-shrikes (*Coracina novaehollandiae*) silently landed on some bare branches in the top of a large fig tree in our backyard and in slow motion ruffled up their feathers and positioned themselves in the most bizarre configuration—hanging upside down and resembling dead birds. The whole event lasted about eight minutes and during this time the birds were completely silent, although they did finally fly off while sounding their typical calls. It seemed quite obvious to us that the birds were freeing themselves of dust or other irritants, accumulated over the long dry months. Despite their daily presence in our garden in all types of weather, including (light) rain after several dry weeks, we have never before (or since) observed this type of behaviour. It would seem they were just as desperate for rain as the rest of us.

—H. Bielefeldt-Ohmann & D.R. Fitzpatrick
Windsor, Qld

Prehistoric Infections

A recent letter by Obendorf-Reid (Winter 1994) that discussed the impact of cat-borne diseases on native fauna was of great interest to me and has prompted me to consider a similar exotic disease impact in prehistory. It has been previously suggested that when the Aboriginal hunter-gatherers arrived in Australia (circa 40,000 BP) they may have represented only part of a wave of invading species, including parasites and pathogens, that attacked the native fauna (including those species that are commonly and, in my opinion, quite incorrectly referred to as the megafauna).

It is very difficult to establish what diseases were introduced by the Aborigines, although yaws and trachoma have been tentatively suggested. Neither of these diseases are zooanthroponic (that is, are passed from humans to animals) and under normal conditions it is highly unlikely that they were passed on to other species. Adverse conditions such as those that characterised the late Pleistocene may have created a stressed environment favourable to virus mutations, although such a proposal at this stage is purely speculative. The Dingo however, represents an introduced animal that may have harboured diseases capable of infecting the native fauna. Diseases identified in Dingoes include intestinal parasites, a bronchial parasite, distemper, mange and anthrax.

Thylacines and Devils represent native marsupials that may have been greatly reduced in numbers and placed on the threshold of extinction on mainland Australia due to diseases introduced by the Dingo. In Tasmania in 1910 a disease resembling distemper was reported killing many native carnivores. The Common Wombat is greatly affected today by Sarcoptic mange. Although the disease's origin is uncertain, it may be plausible to suggest that it was introduced by the Dingo during the Holocene. Anthrax is essentially a soil-borne infection largely influenced by climate and may also have been introduced by the Dingo. The disease has the potential of infecting a broad range within the biota and indeed its occurrence in Kruger National Park in 1959–60 resulted in the death of over 1,000 animals from 27 different species of birds and mammals. Animals are contaminated in periods of drought when they graze close to the soil. Flies are known vectors of the disease and are capable of dispersing it over broad areas. By coming into contact with an infected carcass and by alighting on vegetation, they can contaminate grazing areas. Animals scavenging on carcasses are also infected.

If we are to understand the impact of introduced diseases on the native fauna, then perhaps information from prehistory may provide further insights. Unfortunately the discipline of palaeopathology is currently limited in its scope due to the general inability of recovering organic material from archaeological and palaeontological sites. However,

ROGER BROWN/AUSCAPE INTERNATIONAL

Black-faced Cuckoo-shrikes.

PAVEL GERMAN/NATURE FOCUS

Many native animals, like the Common Wombat (*Vombatus ursinus*), are greatly affected by diseases that may have been introduced by the Dingo.

recent work concentrating on the recovery of bacterial DNA is already providing valuable insights into diseases in prehistory. To gather a more accurate picture of an extinction event it is necessary to consider the interaction of all living organisms within the biota. It may well be that the last surviving *Diprotodon* did not yield to the spear of an Aborigine or the stress of prolonged aridity, but rather succumbed to microscopic diseases and pathogens.

—Michael Westaway
Coogee, NSW

Frog Attractant

I bought your magazine because a friend told me there was a magazine about frogs in the newsagent around the corner. Being president of the newly formed Tablelands Frog Club, I rushed in and bought it, what's more I got two for the price of one! I thoroughly enjoyed reading them and not just the frog articles, but the others as well. The photography is superb and the text is scientific without being boring. So, congratulations to everyone involved in producing this publication.

—C. Grandjean
Yungaburra, Qld

Silly Statistics?

Give me a break! "Each human on this planet runs a risk of about 1 in 20,000 of dying from a cosmic collision" said Ken Russell, as quoted by Geoff McNamara in your Autumn 1995 issue. Therefore, 1 in 20,000 could expect to die in one. Therefore, in a city the size of Adelaide, where I live, with its approximately one million residents, 50 of my fellow citizens might expect to be splattered by asteroids! I'm buying a stronger umbrella! Please don't publish any more statistics this palpably silly.

—Bill Toyle
Exeter, SA

The odds given by Ken Russell were meant to put the risk of death by asteroid impact into some sort of perspective. Similar odds calculated for a range of causes of death in the United States include: death by food poisoning 1 in 3 million; flood 1 in 30,000; murder 1 in 300 (!); car accident 1 in 100. (If anyone has statistics for Australia I'd love to receive them.) Such statistics are used by insurance companies to determine insurance premiums.

There is, however, an important difference between domestic and cosmic catastrophes. If you live in an area that never suffers from floods, say on the top of a mountain, the 1 in 30,000 risk would mean very little to you. Your personal risk factor would be zero. When an asteroid slams into the Earth, on the other hand, it won't matter who you are or where you are on the planet. Everyone will suffer; many will lose their lives.

The odds are certainly not based on the risk of an individual being hit on the head by a falling lump of rock. This is like saying only 1 in 20,000 dinosaurs should have died 65 million years ago!

As I concluded in the article, the impact last year of comet Shoemaker-Levy 9 with the planet Jupiter is ample proof that cosmic collisions do happen. The comet broke up into several fragments. Most of those fragments produced fireballs hundreds of kilometres across, throwing debris thousands of kilometres out into space. If an object of similar size strikes the Earth, an umbrella will make little difference.

—Geoff McNamara

Locusts: Insects or Trees?

In your Autumn 1995 issue, Tim Low tries to persuade us to eat insects. Well, why not? We're constantly fed garbage by the media, what's wrong with the odd bug? But in his beat-up he quotes the Bible, not a habit I indulge in myself, except to correct its many misprints and mistranslations, like 'on the water' for 'beside the water', and 'virgin' for 'female type person of marriageable condition', among innumerable others. He says two blokes therein ate 'locusts'. But I also understood that the word has been identified as being one used for any of several species of trees, members of the *Mimosa* family I think, at least a legume, some of which had sweet pulp that could be fermented and/or fed to stock. The honey locusts (*Gleditsia* spp.) in fact.

I believe those locusts of the Bible were most likely trees, not locusts as in plague grasshoppers, nor even locusts as in cicadas, which is what all bush people used to call cicadas.

—Des Petersen
Dalby, Qld

Some commentators have suggested that John the Baptist's "locusts" were really Carob Beans, and 'Locust Bean' is an alternative name for this plant in the Oxford English Dictionary. However, the more definitive Bible commentaries do not follow this view. The Interpreter's Bible *(1951), edited by G.A. Buttrick (Abingdton Press) has the annotation: "Several species are still eaten by Arabs and are permitted by Jewish food laws". Here is further evidence for my contention that insects were, and in some cases still are, significant human foods. Pork is not Kosher, but grasshoppers are!*

—Tim Low

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

Nature Strips

COMPILED BY
GEORGINA HICKEY

The Dilemma of Domestication

There are 148 species of big (over 40 kilograms), wild, land mammals in the world today that could be useful to humans if they were domesticated. Yet only 14 have been successfully tamed and selectively bred in captivity to be used as sources of meat, milk, fertiliser, transport, wool or hides. Why is the domestication rate so low?

Jared Diamond, UCLA physiologist and evolutionary biologist, believes that a wild species must fulfil at least six basic criteria to be a successful candidate for domestication. Firstly, diet is important. Carnivores, apart from their dangerous ways, are too inefficient at converting food to flesh (in other words they are too hard to fatten) to make them suitable. Overly finicky eaters would be excluded too.

Growth rate must be rapid, making the Gorilla and elephants, which take 10–15 years to mature, unsuitable despite their herbivorous ways and usefully large size. As well as diet, problems of captive breeding preclude species like the Cheetah which, despite many attempts, has not been domesticated because the courtship requirements are too difficult to replicate in captivity.

A nasty disposition has

Too hard to fatten and complex courtship requirements rule Cheetahs out for domestication.

FERRERO/LABAT/AUSCAPE INTERNATIONAL

made zebras unsuitable. Although closely related to wild horses, they become dangerously vicious and unpredictable as they get older. A tendency to panic has maintained gazelles as wild species. And finally, social structure is important. Good candidates for domestication need to live in herds with a well-developed dominance hierarchy that can be taken over by humans. Herds need also to occupy overlapping home ranges rather than mutually exclusive territories.

Only animals that meet all six criteria, argues Diamond, have been successfully domesticated. All large mammal species meeting these conditions were domesticated quickly by early herding peoples, beginning with sheep, goats and pigs around 8000 BC and ending with the Arabian and Bactrian Camels around 2500 BC. No more have been added since.

—K.McG.

Head Start for Peripatus

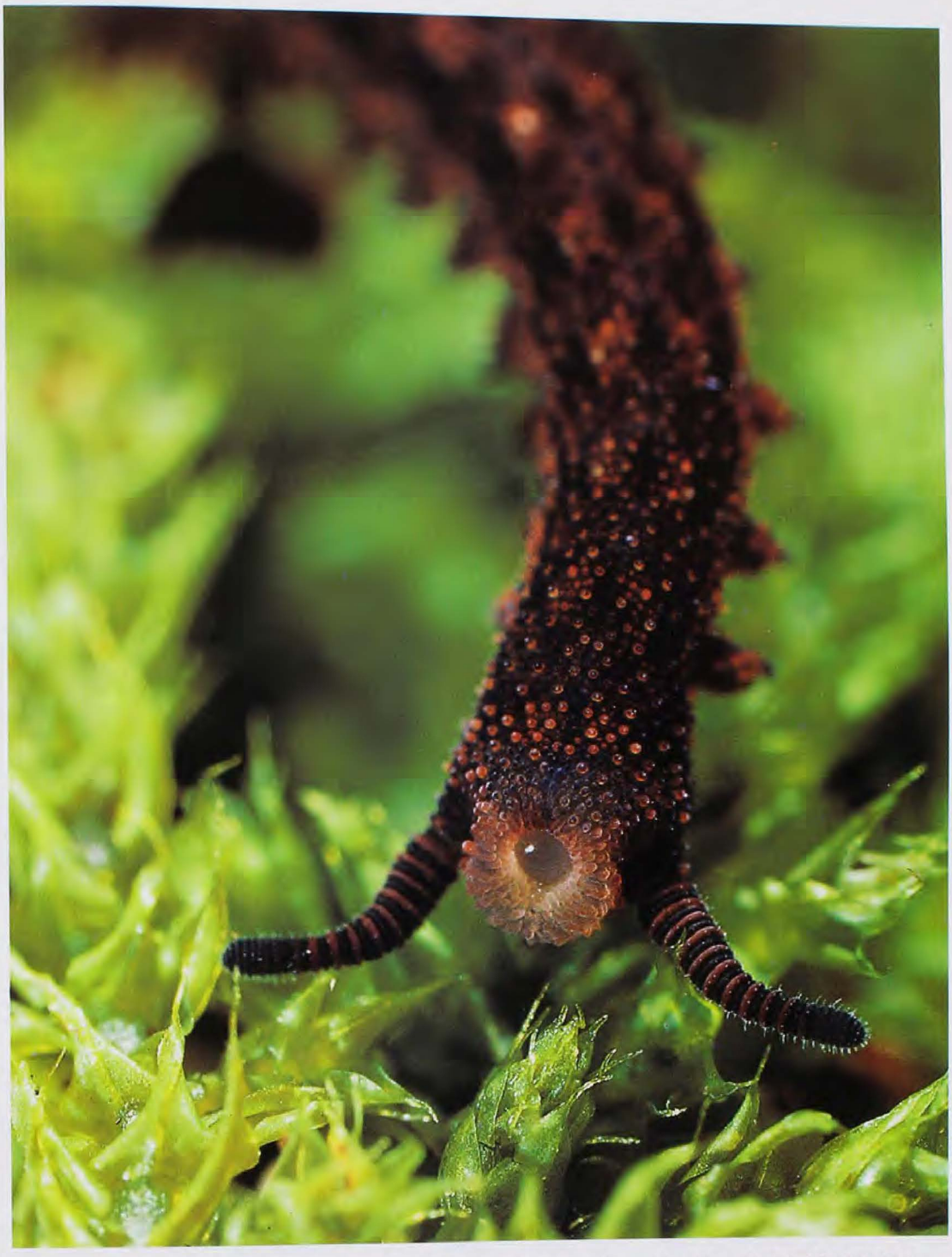
The males of about 20 species of Australian peripatus, or velvet worm, have curious head structures, consisting of a pit that is often adorned with hooks, spikes or syringes. Since discovering two of these species with a spermatophore (or sperm bundle) contained within the head structure, Noel Tait of Sydney's Macquarie University had suspected that the male uses the head structure to scoop up the spermatophore from his genital opening, and then stores it there until he is ready for mating (see *Nature Aust.** Autumn 1989). But how did he deliver the sperm to the female?

Tait at first took his cue from African peripatus. African male peripatus, which lack head structures, place spermatophores directly from their genital opening onto any part of the female's body. The female's blood cells then dissolve a hole in her skin and the spermatophore envelope, enabling the sperm to enter her body cavity and migrate to her ovaries.

However, the sharp head ornaments of some Australian species made Tait think that, instead of the female dissolving her skin to allow the sperm in, the males would use these to puncture the skin (and possibly also the spermatophore) and thus insert sperm directly into the body. But that's not how it turned out.

The truth came to him recently while he and his wife Robyn Stutchbury were searching for peripatus in the Nightcap Ranges of northern New South Wales. They were collecting specimens of a small 'head-structure' species that had recently been discovered in this region, when they came across an unusually large one. However, on closer inspection it turned out to be two joined head to tail.

The male's head was firmly attached to the female's genital opening, being held tightly in the grip of her last pair of legs. When the two specimens parted company, they were preserved for future forensic examination. Back in the lab, Tait was able to show that the spermatophore was attached to the female's genital opening, and sections of the specimen revealed that sperm had been released and were making their way along the female's genital tract.



KATHIE ATKINSON

A male peripatus (*Cephalofovea tomahmontis*) with a glistening spermatophore held in its dimpled head structure.

Having found out how one of the Australian peripatus species with head structures mate, Tait is yet to work out why there is such a diversity of elaborate head structures in the various species, and what role the hardened spikes, claws and syringes play in the process. Also, do the males of Australian species that lack a head structure mate like the African ones? Or is there a third as yet undiscovered technique?

—Peter Meredith

*Previously *ANH*

DENSEY CLYNE

The St Andrews Cross Spider (*Argiope keyserlingi*) decorates its web with UV-reflecting silk to attract insects on the lookout for UV-reflecting flowers.

UV Invitations

It's true! Spiders really do invite flies into the parlour. And they do it using ultra-violet (UV) light. Although spiders cannot actually detect UV light, some insects can, and spiders (and plants) take advantage of this.

Bees and other insects use UV-reflecting patterns to locate attractive areas in their environment. The sky and the sun are the only natural source of UV light. When insects leave dark areas, such as within vegetation, they use UV brightness to guide them to open spaces. UV light may also be reflected from important feeding areas, such as flower petals, fungi and liquid surfaces.

In an effort to fine-tune pollination, insect-pollinated flowers have developed complex signalling systems that allow insects to recognise individual plant species. These signals involve perfumes, textures, and visual patterns that operate in both white and UV light.

The most usual UV patterns involve petals that reflect UV light, arranged around a central area that does not reflect UV. The result is a conspicuous bulls-eye pattern. This guides the insect to the part of the flower where both pollen and nectar are waiting.

By contrast, most birds cannot see light in the UV range. Brian Rowland (Adelaide University) and I surveyed the UV-reflectance patterns of wildflowers near Adelaide. We found several species of emu bushes (*Eremophila* spp.) that were known to be insect pollinated had UV-reflective patterns on the petals surrounding a dark throat, while bird-pollinated species of *Eremophila* were not UV-reflective.

The interaction of the plants' use of UV-reflecting pigments and the insects' UV vision results in more efficient pollination for the plant, and more efficient feeding for the insects. But there is another group of organisms that takes advantage of the insects' UV vision, and this time the insects do not benefit from the interaction.

All spiders produce silk, and many of them weave it into webs to trap insects. The strands of silk are often thick enough to be seen, yet many insects still do not avoid being trapped. As outlined by Catherine Craig and Gary Bernard from Yale University, this seeming paradox can be explained in part by the fact that some of the webs reflect UV light.

Primitive spiders (such as *Hexurella* and *Hypochilus* species from America) spin sheet webs of UV-reflective silk. Others create a maze of reflective silks above a non-reflective 'catching net'. They hang these webs in dim sites, or at night. Insects moving from the dark towards UV-bright open spaces are apparently confused by the webs' similar properties, and become trapped.

The webs of most of the more advanced orb web weaving spiders, such as *Eriophora* spp., do not reflect UV light. However, other species, including the banded orb web weavers, *Argiope* spp., decorate their webs with patterns of UV-reflecting silks, which may be similar to the UV-reflective patterns in flower petals. The spiders' bodies are also UV-reflective and the webs are hung near areas where flowers are common. Insect pollinators on the look out for flowers are attracted to the deceptive UV-bright webs, and die in their strands.

So it's true. The flies have accepted that invitation to walk into the spider's dining parlour.

—Barbara Randell

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KATHIE ATKINSON

A new species has been found that links, once and for all, the freshwater water striders (such as shown here) and the marine sea skaters.

Giant Stride for Skaters

Using diversity as a measure of success, nothing can match the insects on land. But the little six-legged creatures have not fared as well in the marine environment: five species of sea skaters (*Halobates*) are the only truly oceanic insects. Small and flightless, these skaters are found elegantly gliding across the tropical surfaces of the Indian and Pacific Oceans, never setting even a modified foot upon terra firma. Where they came from, in the evolutionary sense, has been a matter of much speculation.

It's long been thought skaters are close relatives of the water striders, insects with a similar lifestyle in fresh water. But entomologists have been unsure of the connection between the two groups. Now an insect, found on the surface of Lydia Creek on Queensland's Cape York Peninsula, has been dubbed the 'missing link' between the freshwater striders and marine skaters—a freshwater skater.

Entomologists Dr Nils Andersen, from the University of Copenhagen, and Tom Weir, from Australia's CSIRO, have named the new species *Austrobates rivularis* and identified it as the closest living relative of the sea skaters. They believe that sea skaters evolved from a species like *Austrobates* somewhere in the far northeast of Australia when it was still part of the ancient landmass known as Gondwana. From there, reason Andersen and Weir, the sea skaters became adapted to the marine environment and diversified and expanded their distribution across the tropics.

—K.McG.

Obstetric Bats

Fruit-bats have recently joined a select sisterhood of mammals that are known to help others during birth.

While studying a captive colony of endangered Rodrigues Fruit-bats (*Pteropus rodricensis*), Thomas Kunz (Boston University) and colleagues watched as one of the females licked and groomed an expectant mother's genital and anal regions, and fanned and occasionally embraced her with her wings. The mother-to-be initially assumed the feet-down birthing position, which is normal in other pteropodid bats. However, a few times during the birth she shifted to a horizontal 'cradle' position or a head-down roosting posture, and would only assume the conventional birthing position after the helper had demonstrated the correct way in front of her.

ROD MORRIS

Caught in the act: a Kea attacks a live sheep.

tree crops. The most promising crops are oil-producing mallee eucalypts.

With researchers from the Western Australian Department of Agriculture and Professor Allan Barton of Perth's Murdoch University, Bartle has investigated uses and potential markets for eucalyptus oil. While now mostly used for pharmaceuticals, there is enormous potential for using eucalyptus oil as an industrial degreaser, replacing solvents that contribute to ozone depletion. One such solvent is trichloroethane, which is used, for example, in some correction fluids. Worldwide 750,000 tonnes of trichloroethane are used each year. Ten million hectares of eucalypts would be needed to produce sufficient oil to replace it.

Bartle estimates that the market for eucalyptus oil as an industrial solvent would require 300 times the volume presently produced for pharmaceuticals and, most significantly, that the income generated from oil-producing eucalypts would make land care lucrative for farmers. The major challenge facing the development is to reduce production costs to the level where it will be profitable to sell at market prices.

—C.B.

Kea Attack

Rumours about the predatory nature of the Kea (*Nestor notabilis*), New Zealand's mountain-dwelling parrot, have been widespread. Purported to have attacked sheep (although seldom if ever seen doing it), these large bronze birds were shot in their thousands and a bounty paid for their beaks. This continued until 1986, when they were granted full protection.

It wasn't until 1992 that hard evidence for the bird's predatory nature was obtained. During the filming of a documentary for Television New Zealand, Keas were recorded, for the first time, active at night and attacking sheep. Landing on the sheep's back, the Keas used their sharp, strongly curved bill to dig through the wool into the flesh and started feeding from the area around the kidneys. Observing this skilled and deliberate strategy has shed new light on the Kea's lifestyle.

Many parrots require a high-fat diet and this is especially true of the Kea, which lives and breeds in extreme mountain conditions. The alpine meadows were once a rich source of fruits and berries high in plant fats. The Keas supplemented this plant diet with animal fats obtained by taking seabird chicks and eggs from burrows in high-altitude colonies, and scavenging larger carcasses. It has even been suggested that Keas may have 'ridden' and attacked New Zealand's extinct moas (large, flightless, grazing birds) in the same way they do sheep today. So, rather than being acts of 'rogue' birds, Kea attacks on sheep can be seen as part of a skilful and diverse foraging strategy that makes the Kea such a successful mountain dweller.

—Julia Morris

Fat-bellied Females Can Be Fatal

In the House Fly (*Musca domestica*), males prefer mates with large abdomens: big-bellied females carry more eggs than their slender sisters. But the attraction becomes fatal when the parasitic fungus *Entomophthora muscae* enters the picture.

Hosts die within a week of infection by *E. muscae* but the fungal threads anchor the flies' proboscis and legs to the substrate, making them look surprisingly alive. The abdomens of *E. muscae* victims also bulge noticeably with the invading parasites. Within 12 hours after death, fungal spore-bearing organs sprout out between the flies' abdominal segments, forming white bands and making infected bellies even more conspicuous.

Investigating *E. muscae*'s transmission modes, zoologist Anders Møller, now at Copenhagen University, Denmark, found male flies were attracted to dead infected females and attempted to mate with them. In field experiments, he offered prospective mates a choice between infected and uninfected dead female flies. The infected were preferred. Other experiments, in which the bellies of infected and uninfected female flies were swapped, indicated it was indeed the swollen bellies that were more attractive to males.

Møller believes that *E. muscae* spreads from host to host by altering the appearance of its victim's corpse and manipulating the sexual behaviour of male House Flies. Despite this, argues Møller, the selective advantages of large bellies in female House Flies appear, for most of the year, to outweigh the high mortality attributable to the feature during the summer peak infection period.

—K.McG.

Buzzing to a Different Tune

Many plant species rely on bees to act as pollination go-betweens, carrying pollen from flower to flower as they feed and occasionally brushing some off onto another flower of the same species. At first it might seem that a plant that relies on such a mechanism would shower its would-be carrier with pollen in the hope of increasing the chance that some will end up serving its designated purpose. However, as bees fly between flowers they groom and displace much of the pollen they carry. The more pollen they receive from a plant, the more they groom, resulting in less pollen reaching other

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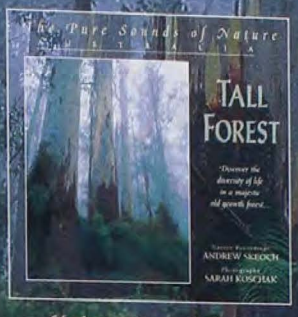

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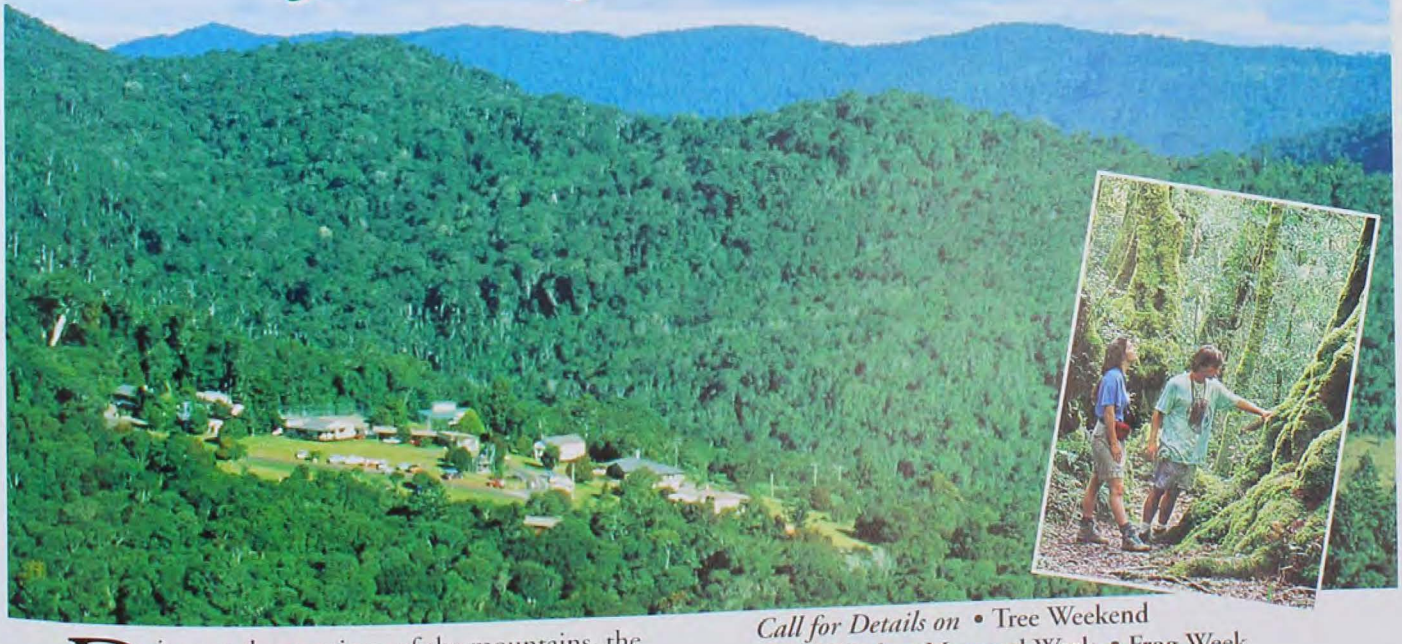

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The pup finally emerged after three hours (about two hours more than average) and with one foot and wing first, as opposed to the normal head-first presentation. The helper immediately groomed and supported it with her wings during its crawl to the mother's nipple.

The awkward presentation of the pup and the longer-than-usual delivery time led the researchers to believe that this was a difficult birth, and that the assistance was both necessary and welcome. Kunz suggests that midwifery may be common in bats that roost in colonies and may simply be unfamiliar to humans because expectant mothers tend to be wary and secretive while giving birth.

—R.S.

COURTESY T. BIRMINGHAM/CALM

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Growing Money on Trees

We could be thinning our typing correction fluid with eucalyptus oil rather than chlorinated hydrocarbons if Western Australian tree experts have their way. They are hoping that a eucalyptus oil industry will be developed that would make it worthwhile for farmers to plant trees on their properties and help the ozone layer.

Buying and planting trees is expensive. Even with known land-care benefits such as reducing salinity, water logging and soil erosion, trees take up land that could be used to earn an income. And, in the wake of recession and drought, for most farmers that sacrifice is too great.

John Bartle, a Tree Planting Adviser with the Western Australian Department of Conservation and Land Management, has been trying to find ways of making money grow on trees. He has researched the viability of different kinds of commercial

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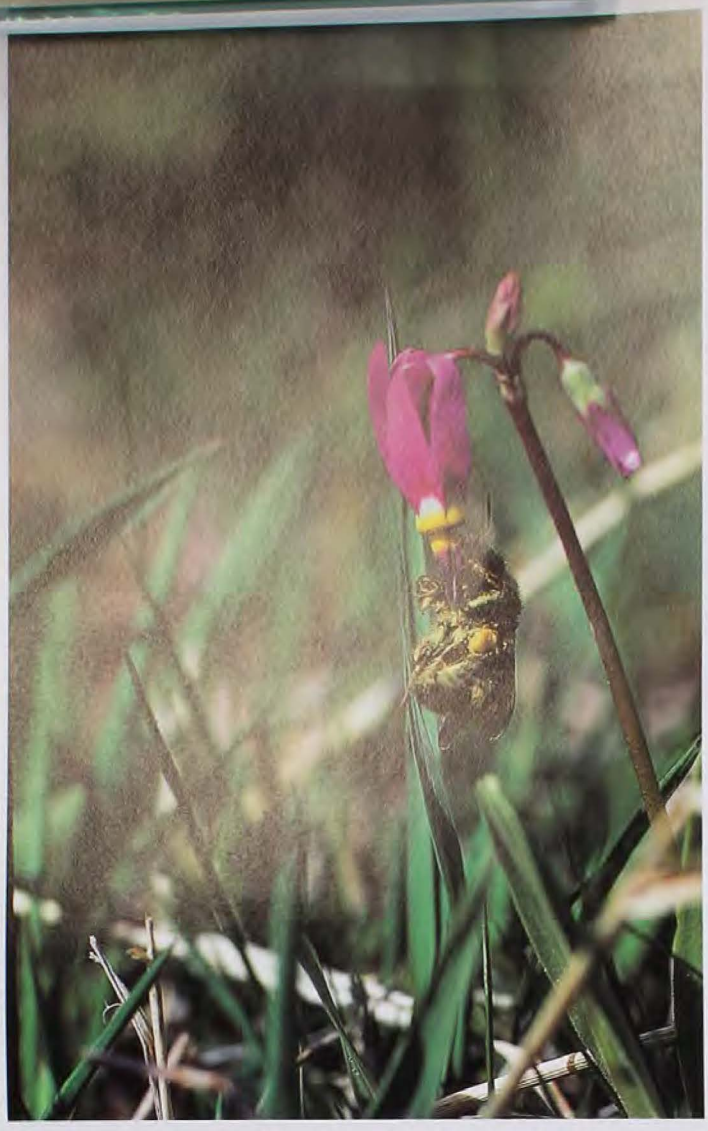


COURTESY LAWRENCE HARDER

When a mismatch is a perfect match: a bumble bee pollinating a Shooting Star flower.

plants. Also, the more pollen received by one bee means there is less available for other bees. So, to maximise the chance that pollination will occur, the plant must ensure that each bee takes only a small amount of pollen. That way a greater proportion of the bees that visit the flower will transport its pollen elsewhere. Lawrence Harder and Robert Barclay of the University of Calgary in Alberta, Canada, have found a way in which some flowers manage such a feat.

Certain flowers have specially designed anthers (the pollen-producing part of a flower's male reproductive organ) that dispense pollen when shaken at the correct frequency. These are known as buzz-pollinated flowers. When a bee visits the flower, the buzzing of its flight muscles shakes the anther and the pollen is released.

Harder and Barclay studied one such species, a herbaceous perennial called Shooting Star (*Dodecatheon conjugens*). They found that its anthers are tuned to a frequency above that of the buzzing of pollen-collecting bumble bees (*Bombus* spp.). Because the frequencies aren't well matched, it reduces the amount of pollen each bee can obtain.

The researchers also found that the longer a flower has to wait before it gets its first buzz, the more pollen it provides the buzzer. If a flower is only going to be visited rarely, it may as well give more pollen to the bees that do visit to assure that some of the pollen will be brushed off onto another flower.

—G.T.

Crickets Tell the Temperature

How do you tell the temperature on a warm night without a thermometer? Simple. All you need is a watch and a cricket...but not just any cricket.

What makes a good 'thermometer cricket'? First of all, the cricket needs to have a large surface area to volume ratio (giving it a delicate, slender appearance) so that it is particularly sensitive to changes in air temperature. It has to also sing from an elevated position on a plant, not from a burrow where the temperature is more constant and different from the air temperature. Finally, the cricket's song must be broken into loud, distinct chirps and the chirp rate must be regular and slow enough to count. The crickets that fit these criteria are tree crickets (subfamily Oecanthinae) in the genus *Oecanthus*, which occur in several countries, including Australia. By timing their chirps and applying a simple but species-specific mathematical formula, you can calculate the temperature.

Rob Toms, an entomologist from South Africa's Transvaal Museum, has recently developed accurate 'chirp formulae' for two species of African 'thermometer crickets'. If you're listening to *Oecanthus karschi*, count the number of chirps over six seconds, add 12 and you have the temperature in degrees Celsius. For *O. capensis*, count the chirps in three seconds and add 11.

Although a great party trick on a summer's evening, the real value of such 'chirp formulae', of course, is in identifying species in the wild from just their song. They can also be used to teach people about insect communication, insect physiology and the physics of sound.

—C.B.

MICHAEL CERMAK

Tree crickets, such as *Oecanthus rufescens*, are long and slender, and particularly sensitive to changes in air temperature.

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

JAN FERRARI

KOALA IN THE POND

Koalas are not normally attracted to water, yet sometimes during hot, dry summers they have been observed crossing creeks. I found this particular Koala sitting and drinking in my garden pond, which is situated in the middle of 40 hectares of native bush in north-eastern Victoria. The temperature had reached the high thirty degrees mark and, although Koalas have effective cooling mechanisms, this one must have thought a dip would have been refreshing. Koalas have been known to drink free water if it is available, and not just sick individuals as was once thought. This Koala had been visiting the garden frequently for the previous few months and appeared to be in perfect health.

—Jan Ferrari

Thy Will Be Dung

In the dim light of the rainforest understorey, the splatterings on the leaves and rocks look to be no more than bird droppings. However, a closer inspection reveals the craftily disguised Costa Rican Rove Beetle (*Leistotrophus versicolor*).

Camouflaged by its bird-dung appearance, the beetle attracts fruit-flies by discharging a pungent pinkish secretion from its abdomen. When a fly comes close enough, the beetle lunges at it with its sickle-shaped mandibles.

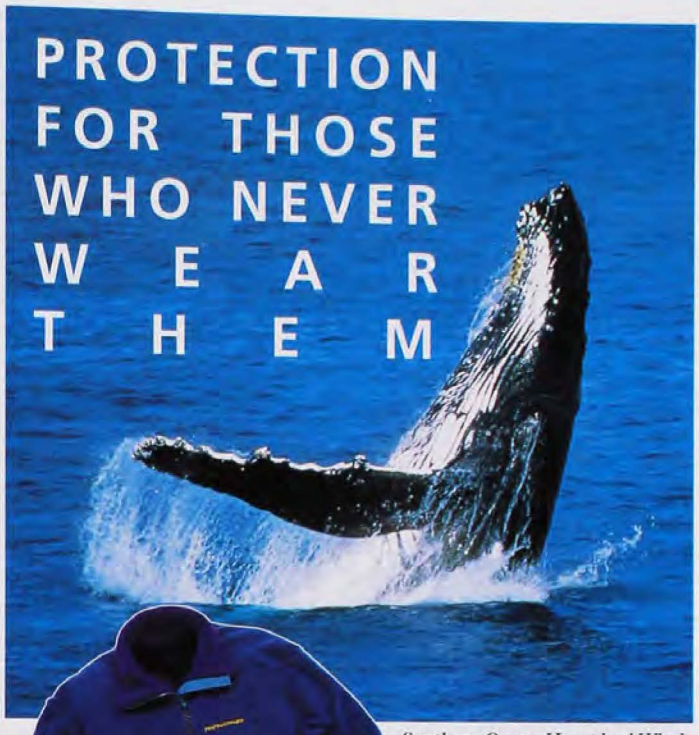
Known as the only beetle to prey exclusively on adult flies, a recent study by two US biologists, John Alcock and Adrian Forsyth, revealed that the Rove Beetle employs more than one strategy for capturing its prey. As well as sit-and-wait tactics, the Rove Beetle actively hunts large tropical blowflies that are attracted to rotting carcasses or manure. By stalking and snatching up the distracted prey while they feed, the beetle can consume a relative banquet in comparison to the tiny fruit-flies it attracts with its chemical lure.

So why bother with fruit-flies at all? Alcock and Forsyth believe it has to do with the relative availability of foraging sites. Dung and carrion, which attract large blowflies, are uncommon in the tropical environment because of the speedy process of decomposition. The beetle must make do in the interim by luring small flies with its aromatic secretion...at least until the next sloth or deluge of manure falls from the mighty canopy.

—Karina Bull

Making a Meal of Reproduction

When katydids or long-horned grasshoppers (family Tettigoniidae) mate, the male secures a sperm package (spermatophore) to his partner's genital opening.



Southern Ocean HumpbackWhale –'Roxanne'1994. Hervey Bay, Queensland. Photo: PaulHodda

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DENSEY CLYNE

During courtship a male katydid (*Salomona* sp.) passes the female a 'nuptial gift', which she consumes.

This consists of two parts: a sperm-rich capsule plus a nutritious sperm-free meal, which the female eats.

The supply of a 'nuptial gift' for the female to eat during courtship is a common phenomenon in insects. The most extreme manifestation is sexual cannibalism, where the male sacrifices himself as the meal. Captured prey or parts of the male (such as wing tips) can also be offered, as well as 'home-made meals', as is the case in katydids. Explanations for nuptial gifts are divided. The gift, by nourishing the female, may increase egg quality or numbers. Or, by occupying the attentions of the female, it may increase the time a male's sperm has for fertilisation and improve his reproductive success.

In katydids, the female bends down and consumes the gift component of the spermatophore while sperm make their way up her genital tract. Once finished, she then removes and eats the sperm capsule along with any remaining contents, after which she enters a refractory period when she is unreceptive to further courtship attempts by other males and begins to lay eggs.

The most extreme manifestation of the nuptial gift is sexual cannibalism, where the male sacrifices himself as the meal.

A comparative study by zoologist Nina Wedell, of the University of Stockholm, on courtship feeding in 28 katydid species found that, as the size of the spermatophore increased, so too did the female refractory period and male fertilisation success. The spermatophore's food component was also proportionally larger in species with larger sperm capsules, suggesting the gift serves for sperm protection (the more sperm there is to be transferred, the longer the female needs to be kept occupied). In contrast, Wedell found no relationship between egg number or quality and male gift size.

Nuptial gifts among katydids, it seems, are not a direct paternal investment but a simple gambit to enhance mating.

—K.McG.

Laws of Attraction

Hollywood labels the allure between men and women as that indefinable something called 'chemistry'. There have been countless attempts by social scientists to provide more precise explanations and most have resolved that human attraction is arbitrary and culture-bound.

However, the largest study on human mate selection provides solid support for a contrary view. In a six-year survey that began in 1984, University of Michigan psychologists David Schmitt and David M. Buss collaborated with 50 other scientists worldwide to investigate the parameters of attraction in 10,000 men and women in 37 countries. They found a remarkable consistency across the human species that transcends the limits of geography, culture, politics, ethnicity, religion, race and economics.

And why wouldn't they? If other animals have evolved highly patterned, species-wide mating rules and strategies in response to adaptive problems, then why wouldn't humans?

From the results of the international study and smaller-scale investigations on the same subject, Schmitt and Buss have developed a 'theory of human sexual strategies' that accounts for widespread patterns of attraction.

One of the theory's key (and perhaps most controversial) predictions, borne out across different cultures, is that men looking for a long-term mate prefer women of good reproductive potential. How can men best identify reproductively valuable women? By observing features linked to age and well-being. Apart from variations in attitudes to plumpness and thinness, men in all known cultures are sexually attracted to the physical cues of youth and health in women. "In no culture do people perceive wrinkled skin, open sores and lesions, thin lips, jaundiced eyes, poor muscle tone and irregular facial features to be attractive", writes Buss.

Male fertility, however, is

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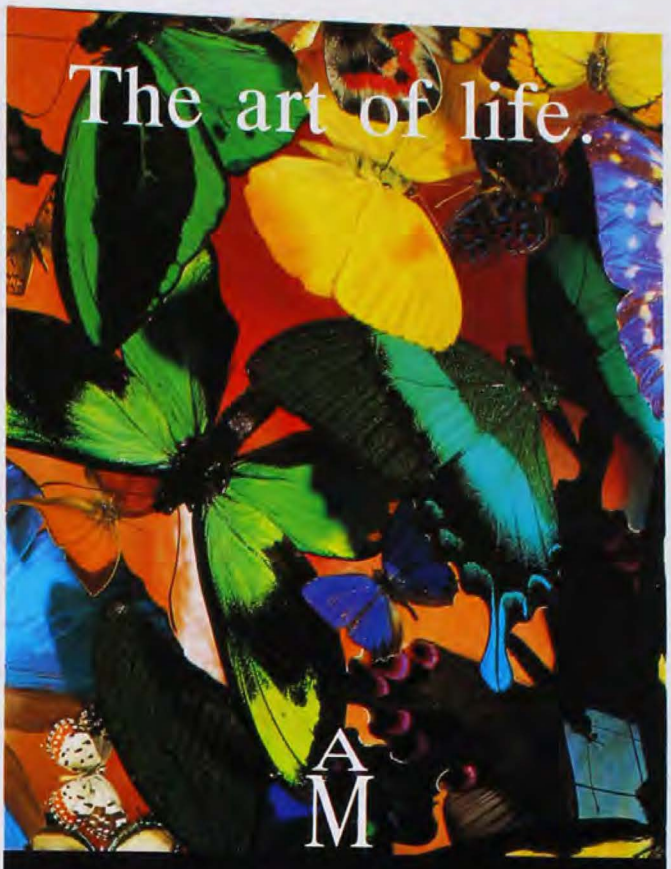

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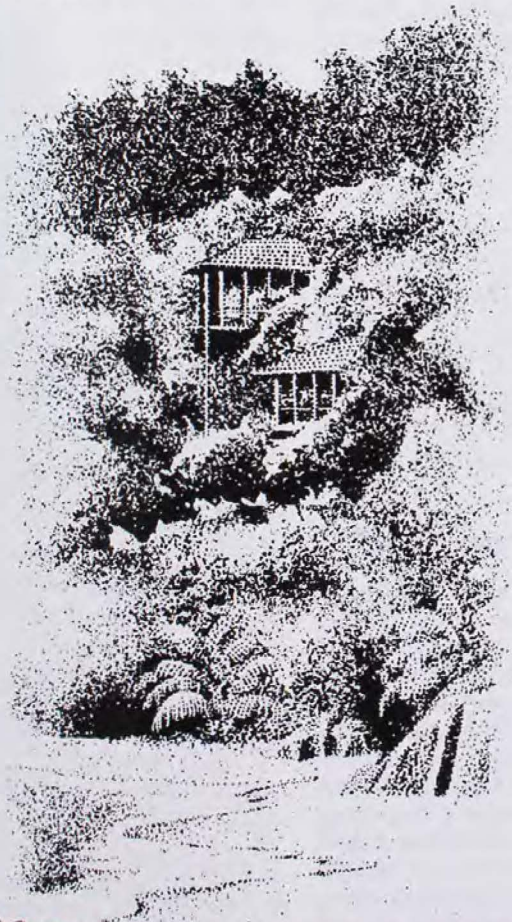

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PAVEL GERMAN

Like most insectivorous bats, the Brown Bearded Sheathtail-bat (*Taphozous achates*) from the Kai Islands off New Guinea, is very small.

not as age-dependent as it is in women and is more difficult to determine from physical appearance. While men worldwide "place a premium on physical appearance", women seeking long-term mates are more inclined to look for signs that indicate he can provide for her offspring.

There is, however, far more to human mating strategies than cues for sex and success. One of the strongest and most enduring observations is that men and women alike regard mutual love and kindness as being extremely important in long-term pairings.

People the world over, believe Buss and Schmitt, are attracted to the same sorts of qualities in their choice of partners. Perhaps that is why, as movie-makers well know, a love story is a love story in whatever language it is told.

—K.McG.

Microbats: Why Are They So Small?

Insectivorous bats are among the smallest mammals in the world, usually weighing in at less than ten grams. But why are they so small? After studying 57 species of bats, Gareth Jones of the University of Bristol believes that it may be due to a link between the rate at which they flap their wings and the production of the intense pulses of sound they use in echolocation.

Many insectivorous bats use their own natural 'sonar' system to navigate and locate their prey while flying. They send out powerful bursts of sound that bounce off obstacles and prey, and their sensitive ears pick up the echoes. These pulses are energetically expensive to produce but, by coupling them with flapping of the wings, they add no extra cost to that of flying. Calls are produced at the end of the upstroke and occur when the bat exhales.

This coupling of sound production to wing beats may put a limit on the body size of bats that catch insects on the wing. As body size increases, the number of times the bat flaps its wings—and hence the number of sound pulses it produces—will decrease. Thus larger bats may not be able to echolocate often enough to catch enough insects to supply the increased energy requirements of their larger bodies.

The fact that bats never glide is also explained by Jones' theory. Because the search pulses are linked to flapping, a gliding bat would be unable to catch prey and navigate properly.

—G.T.

Blood on the Bread

In 1263, a priest giving mass in the town of Bolsena, Italy, noticed 'blood' oozing from the sacramental bread wafer. Sure that it was Christ's blood, and miraculous proof of God's existence, the event became known as the 'Miracle of Bolsena', and is even recorded by Raphael in a fresco in the Vatican. 'Blood' has also been recorded on bread, potatoes, polenta and other starchy foodstuffs, much to the terror of the hungry finder. Some peasants thought it was the Devil's work and priests were called in to exorcise the food. However, after the discovery of a particularly 'bloody' collection of food in a farmer's cupboard in Legnaro, Italy, in 1819, scientists were commissioned to investigate the phenomenon. They independently concluded that the 'blood' was a result of microbiological, not divine, intervention (although opinions as to the exact nature of the 'beast' were still at odds), and that conditions necessary for its growth were warm temperatures and humidity.

It is now known that the red-coloured substance was a bacterium, *Serratia marcescens*, named by one of the original 19th-century investigators. It starts off as small red spots that grow quickly to cover the food, and then turns to slime, often dripping to give the appearance of blood.

More recently, Johanna Cullen (from George Mason University in Virginia)

attempted to produce the appearance of 'blood' in a contemporary laboratory setting. She inoculated a sample of polenta and some priests' hosts with *S. marcescens* and incubated them overnight at 30°C. Within three days, she noted, the rich red growth could easily have been mistaken for blood, supporting the view that the events at Bolsena were more the results of a microbe than a miracle.

—R.S.

Pregnant Males Can Still Be Macho

It's every male-chauvinist's worst nightmare: she's not just asking you to change the nappies, she wants you to carry the baby. But to a male seahorse this is all part-and-parcel of being a father. Male seahorses have a brood pouch on their tails into which the female places her eggs (see *Nature Aust.** Spring 1989). The male then looks after the embryos until they are released as independent young.

But what are the consequences of this bizarre reversal of sex roles? Amanda Vincent from the University of Cambridge has been investigating how male pregnancy has affected some of the other sex roles in seahorses.

For instance, it's long been assumed that, because it's the males that carry the eggs, the other sex roles would also be reversed so that, instead of males competing for females as is usually the case, it would be the females that would fight for access to males. However, in a series of laboratory experiments Vincent demonstrated that, when it comes to sexual rivalries, seahorses are boringly conventional. Only the males exhibited competitive behaviours such as wrestling and snapping. The meek may be due to inherit the Earth one of these days but it's the bigger, more competitively active male seahorses that get pregnant.

The fact that seahorses exhibit conventional sex roles brings another long-held assumption into question. If, as previously assumed, females compete more intensely than males for mates, one would expect that males would be in demand. But if males are competing for females we would expect the opposite. In fact, Vincent's research has shown that, because males and females have roughly equal reproductive rates (in other words, it takes a female about as long to produce another clutch of eggs as it takes a male to incubate the clutch he's already carrying), neither sex is in any more demand than the other.

—G.T.

**Previously ANH*

EVA BOOGAARD/LOCHMAN TRANSPARENCIES

A male seahorse (*Hippocampus angustus*) from Western Australia, showing his brood pouch.

QUICK QUIZ

1. What is the name of the whale that sports a single tusk?
2. How many species of bed bug are native to Australia?
3. Name the mountain range on which Alice Springs is situated.
4. Which tree, discovered in late 1994, was dubbed "the botanical find of the century"?
5. What colour are juvenile Wandering Albatrosses?
6. Which British popular science writer living in Australia is the author of the recently released (1995) book *Are we alone?*
7. What do the names *Dingiso, Nemenaki* and *Wanun* all refer to?
8. Give the name of the largest planet in our galaxy.
9. What type of plant is depicted on the $2 coin?
10. The catchcry ESD stands for what?

(Answers in Q&A)

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His gut-wrenching contribution toward the production of her spiderlings is a sado-masochistic passion-pit performance replete with self-sacrifice and de facto digestion.

A REDBACK AFFAIR

BY STEVE VAN DYCK

AS LATE AS 1927, WHILE buttocks were smarting on the domestic front, tempers were flaring in the medical fraternity. The fuss had to do with Redback Spiders (*Latrodectus hasselti*). Many doctors could simply not accept that somewhere 'twixt the thunder box and the coffin, a pea-sized spider was hanging in flagrante delicto. "I have handled these spiders on many occasions for years past and have not yet succeeded in making one bite me", wrote Dr F.A. Rodway in a letter to the *Medical Journal of Australia* in May 1927.

So the deaths of 13 Redback-bitten Australians up to 1956 came as a complete mystery to some. To others, however, the Redback carried with it a reputation as black as its flanks, and a warning as bold as the chilli-red slash down its 'spine'.

Dr A. Watkins, incensed by the blasé attitude of Dr Rodway, and in reference to the alleged reluctance of Redbacks to bite him, suggested that "if Dr Rodway placed the spider under his shirt, I fancy he would be accommodated" (*Medical Journal of Australia*, 11 June 1927).

Today, notwithstanding the demise of the outdoor dunny with its odious 22 per cent record for derriere-directed nips, the Redback still manages to bite Australians at a higher frequency than all the snake bites and marine stinger envenomations recorded in any particular year.

Redback-induced deaths, however, are a tragedy of the past since Redback antivenom became available in 1956. Before that date, an initially painless bite could be followed within five minutes by pain so intense that many victims could become uncontrollable with hysteria. Within three hours this could be accompanied by sweating, local swelling, dizziness, swelling of the lymph nodes, nausea, muscle weakness, paralysis, insomnia, vomiting, and increases in heart beat and blood pressure. Most victims could expect, at the very least, a week of continuous pain and aching, accompanied by drenching sweats. Some fared much worse.

Today the administration of antivenom can bring relief from the distressing symptoms within an hour or two of the injection. And because the toxic components of Redback venom act so slowly, the antivenom, whether given two minutes or two hours after the bite, is usually just as effective. This also means that, while complacency should be avoided, panic is an unnecessary component of Redback first aid.

But to other creatures such as large beetles, lizards, slaters, bugs and flies, a Redback bite is the end of the line. Even House Mice are bitten and consumed if they wander into the messy web, and snakes as long as 45 centimetres have been recorded being bitten and killed.

The tangle of tough dry silk that forms the Redback's untidy web is made up of a funnel-cum-nursery built in the dark seclusion of an old tin, behind gutterings and window sills, among tools, or inside boots or clothing. This is connected to a dry, trampoline-like snaring net that is festooned with sticky globules and held in position by dry guy-rope threads anchored to the ground below. This snare is usually built in a more sunny or open position than the nursery.

If an animal brushes against the sticky blobs, it sets off a chain reaction, breaking many of the guy-ropes. This release of tension from the ground up causes the prey to be hoisted toward the snare where the lovely lady waits to welcome all and sundry into her parlour. If the prey is too large for the catapult, then the ever-accommodating hostess will rush out to greet dinner guests, which are first sprayed with an immobilising blast of liquid silk before being wrapped, bitten and then sucked dry.

In Redback circles, hypodermic clout and stunning looks are definitely women's issues. The male Redback is runt-like (three millimetres long) with black, white and red markings, and almost harmless compared to his expansive and deadly spouse. Symptoms resulting from his bite are mild and localised, and it is thought his venom is less toxic than that of a female. His life of six or seven months is short compared to her two years, but his gut-wrenching contribution toward the production of her thousands of spiderlings is a sado-masochistic passion-pit performance replete with self-sacrifice and de facto digestion.

When the combined influence of the procreative mood and a courting male overtakes a female Redback's natural tendency to liquidate visitors first and greet them later, she hangs belly-up in the web and allows a male to straddle her awesome black-and-red bulk from on top. Mating in spiders is a whole new ball game compared to the process seen in vertebrate love circles, and the nitty gritty of eight-legged hanky panky consists of the male deftly hand-delivering a pre-packed, takeaway container of sperm (spermatophore) into the female's genital aperture on the underside of her abdomen, using one of his modified feeding limbs or 'palps'. The male inserts the corkscrew tip of the

REDBACK SPIDER

Latrodectus hasselti

Classification
Family Theridiidae (comb-footed spiders)

Identification
Females jet black to fawn, with dorsal slash red to orange. Underside of abdomen always with a red hourglass or two-triangled pattern. Abdomen pea-sized (up to 10 mm), overall size may cover a 50-cent coin, legs always thinner than a toothpick. Males (practically harmless) minute, white to brown with dorsal slash red to brown or with white streaks off the main slash.

Distribution and Habitat
Found Australia-wide but mostly in disturbed (settled, urban, rural) habitat.

Life Cycle
Food mostly beetles but includes any snarable living creature up to the size of a small mouse or lizard. Females mature at 4 months old and may lay a batch of eggs every month especially during summer. An egg batch consists of up to about a dozen egg sacs, which might contain up to 5,000 eggs. Eggs hatch in 2 weeks. Females can draw on the packaged sperm of a single mating for up to 2 years. Without food, Redbacks can live for around 10 months.

palp (containing the spermatophore), twists it like a front door key and locks it in place. Then he does a headstand and a somersault and finally comes to rest with his abdomen lying between the jaws of his attentive mate. She responds by seizing his rear end and savaging it.

Five to 20 minutes later the stunned male snaps off the locked-in tip of the palp (this helps exclude other would-be fathers) and staggers off to the edge of the arena, collects his wits while preening his other remaining mating palp, then with restored resolve, re-enters the ring, mounts the huge black steed, locks in the palp tip, and somersaults to again land between the jaws of his mate who, seemingly bored by the action replay, again ravages and mauls what

Even House Mice are bitten and consumed if they wander into the messy web.

was left of his abdomen. This final assault puts the poor gutless wonder out of his misery and she hangs him up in the company of the other spent suitors he hadn't noticed on the way in. (Ritual killings earned the name 'Black Widow' for a cosmopolitan overseas species *Latrodectus mactans*, to which the Redback is closely related.)

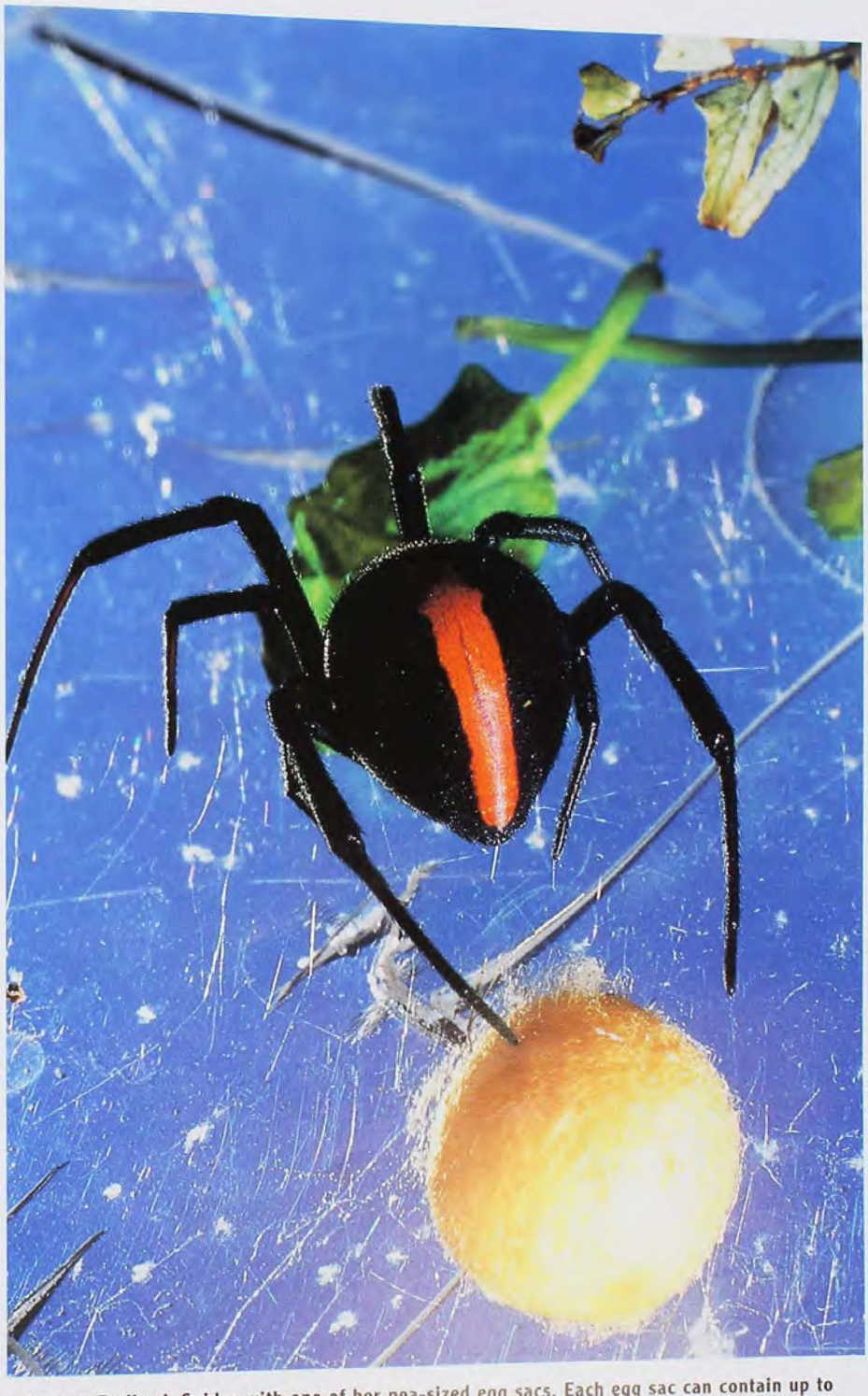
After mating, the female constructs between nine and 12 pea-sized web-balls, in each of which she lays from 40 to 300 eggs. The last balls, however, usually contain the egg dregs, and many in those final packs may be infertile.

She defends the silky time-bombs fiercely and after two to three weeks her gruesome brood emerges to either disperse or to eat one another until only one or two dominant individuals remain. Those intent on leaving before the meal raise their abdomens toward the sky, feed out a long gossamer thread and wait for the wind to carry it up, and them, away to fresh fields.

But not all fields are fine for Redbacks; in fact, they are rarely found away from buildings, barbeques, pot plants, stormwater drains, cow paddocks, rubbish dumps and other expressions of human activity. This trend, according to Dr Robert Raven, spider specialist at the Queensland Museum, immediately puts a cloud over the Redback's claim to dinkum status. Combine this suspicion with his observations that the Redback eluded Europeans for 80 years after settlement in Australia, that 200 new Australian spider species were recorded before the Redback reared its terrible head in the literature, and that it is unknown in Aboriginal legend...and a potentially nasty picture emerges where our most celebrated crawly ends up in bed with those scruffy illegal animal immigrants like ship rats, pigs and sparrows that have rushed in and called Australia home.

Not all spider scientists sit comfortably with this 'introduction' theory and some see aspects of the Redback's biogeographic history and behavioural ecology as support for its endemic status.

Thinking of Redbacks as second-class citizens doesn't help much to get rid of them but, when push comes to shove, it does make twisting the stick into their untidy nests just that bit easier. ■



ESTHER BEATON/TERRA AUSTRALIS PHOTO AGENCY

A female Redback Spider with one of her pea-sized egg sacs. Each egg sac can contain up to 300 eggs and will take about two weeks to hatch.

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After 25 years of often dead-ended detective work, the elusive and enigmatic turtle gave itself up to science.

MARY RIVER TURTLE

BY ARTHUR GEORGES

JOHN CANN

Knowledge of Australia's freshwater turtle fauna is poor. Two very distinctive species, the Pig-nosed Turtle (*Carettochelys insculpta*) and Fitzroy Turtle (*Rheodytes leukops*), were only added to the list of Australian species in 1970 and 1980 respectively, and there are numerous other species that are known to be different but which await description. One of the most recent additions to this continent's list of turtle species was made by John Cann. After 25 years of often dead-ended detective work, the elusive and enigmatic turtle gave itself up to science.

The story begins in the late 1950s and early 1960s when pet shops in Adelaide, Brisbane, Melbourne and Sydney began receiving large numbers of unusual hatchling turtles, with sales ranging from 3,000 to 10,000 individuals per year. Some even made it as far as Los Angeles in the USA. These hatchlings were referred to as the common Saw-shelled Turtle (*Elseya latisternum*) because they shared a head shield and serrated margin to the shell. However, for John the hatchlings had some superficial differences that made him suspect they were not Saw-shelled Turtles. He began to make enquiries about where the turtles had come from.

The pet trade's 'code of ethics' proved to be a major obstacle and John was led on a merry goose chase. Contacts within the industry, and contacts' contacts, indicated that Torres Strait was their natural location, then Swan Hill in Victoria, northern Queensland and even Papua New Guinea. After many thousands of kilometres of fruitless searching, the first concrete lead was provided in 1987. The Victorian distributor of the turtles, by then out of the trade because it had become illegal, opened up a little and provided a name that ultimately led John to someone in Maryborough, southern Queensland. Deeply seated suspicions remained however, and John was directed to the bore drains of the Bollan region of south-western Queensland, an unlikely location that became immediately apparent on John's arrival.

Deciding he'd been led up one garden path too many, John thought he'd let go of the search for a while and travel to Darwin to gather photographs for a turtle book he was preparing. But not long after he had arrived, he received a photograph from his Maryborough contact with a note saying "I've got one!". So back he came. Almost immediately they were taken to a large drum containing a medium-sized turtle. John's mouth dropped, for in the drum was a very ordinary-looking specimen of the Northern Snapping Turtle (*Elseya dentata*). All the kilometres of past trips, and 22,000 on this current trip alone, flashed before John's eyes. He was speechless. He was set to explode. And then his host said to him, "Well if that's not him, have a look in this drum"...and at last John saw, for the first time, an adult female specimen of the species he had sought for so long.

The hatchlings and sub-adult specimens known from the pet shops belie the distinctive features of the adult. It is a very large animal, growing to about 40 centimetres in carapace length, larger than any other short-necked turtle in the family Chelidae, and the oval shell bulges at the lateral edges, reminiscent of the winged keel of *Australia II*. The tail of males is long, up to 70 per cent of the shell length, laterally compressed and massive, as thick as a human wrist. No other turtle is known to have such a large tail. The head and neck of a mature male dwindle in comparison. The distal tail vertebrae also bear chevron bones or haemal arches, a feature unique among Australian chelid turtles and the primary justification for regarding this not only as a new species, but as a new genus. John, along with colleague John Legler, named the species *Elusor macrurus* in reference to its elusive nature and large tail.

Not a lot is known of the species' behaviour. Despite their penchant for basking on rocks, they seem extremely wary and are hard to catch. Two thousand trapping hours did not produce a single specimen and only one was caught in four days of intensive gill netting. Diving for them is slightly more successful but still very difficult because of the poor visibility in the dirty water of the Mary River.

Perhaps the most significant aspect of their behaviour is that they congregate and nest in sand banks in response to rain. Although rain is known to trigger other turtles to nest, none does it to the extent of the Mary River Turtle. This egg-laying strategy probably serves to satiate potential predators, however it also makes them vulnerable to human exploitation. No doubt pet shop suppliers took advantage of this knowledge, collecting bulk eggs after rain, incubating them at home and shipping off the hatchlings for sale.

He was speechless. He was set to explode. And then his host said to him, "Well if that's not him, have a look in this drum"...and at last John saw, for the first time, an adult female specimen of the species he had sought for so long.

The species has been listed as endangered in the recent Action Plan for Australian Reptiles and funding has been made available by the Australian Nature Conservation Agency to prepare a recovery plan. Hopefully soon we will know much more of the biology of this elusive species. ■

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After the war the tea tree industry collapsed due to the rising popularity of antibiotics.

THE TRUTH ABOUT TEA TREES

BY TIM LOW

TEA TREE OIL IS BECOMING EVER more popular as a home remedy, especially for infections and injuries of the skin. Medical research confirms its effectiveness at killing bacteria and fungi without irritating sensitive tissues. But while the oil is becoming famous, the tree that provides it remains largely unknown; it doesn't even have a common name. It is not, as many believe, the well-known Paperbark Tea Tree or Broad-leaved Paperbark (*Melaleuca quinquenervia*), but a much smaller tree (*M. alternifolia*) confined to a small area of eastern Australia.

The name 'tea tree' has been widely but wrongly attributed to explorer Captain Cook. The 1777 journal of his second expedition refers to a "tea-plant" harvested in New Zealand for brewing beer and tea. An illustration of the shrub shows it to be Manuka (*Leptospermum scoparium*). Manuka also grows in south-eastern Australia, but not at Botany Bay, and Cook did not meet with it in Australia.

Instead the name 'tea tree' was first recorded by First Fleet Surgeon General John White, in his 1790 book *Journal of a voyage to New South Wales.* He illustrates a "tea tree" that can be identified as the Flaky-barked Tea Tree (*Leptospermum trinervium*). White does not say this plant was used in any way, but its leaves were presumably brewed into tea like the more popular Sweet Sarsaparilla (*Smilax glycophylla*), known to the First Fleet colonists as "sweet tea".

By the 1870s the term 'tea tree' was used for shrubs and trees of the genera *Melaleuca, Leptospermum, Kunzea* and *Callistemon*, which are all in the eucalypt family (Myrtaceae). Most if not all of these plants produce aromatic oils in their leaves, so that a flavoured tea of sorts can be brewed from the leaves, although not all such species were used in this way. Nowadays the name 'tea tree' is restricted to the first two genera, and the best-known species are probably the Paperbark Tea Tree and Lemon-scented Tea Tree (*Leptospermum petersonii*).

The genus *Melaleuca* has many representatives in northern Australia, and about a dozen of these were used in Aboriginal remedies, mainly those species rich in cineol, which has several medicinal applications. To treat coughs and colds, leaves were crushed and inhaled or soaked to make an infusion, and infusions were also applied to sores and burns. In Asia, medicinal cajuput oil has been extracted from two tea trees also found in Australia: the Weeping Paperbark (*Melaleuca leucadendra*) and Cajuput (*M. cajuputi*).

To treat coughs and colds, leaves were crushed and inhaled or soaked to make an infusion, and infusions were also applied to sores and burns.

However, none of these species is the tea tree from which the famous oil is distilled. This plant (*M. alternifolia*) grows only on the swampy coastal plains of northern New South Wales, and on the nearby highlands of the Granite Belt of southern Queensland, where it fringes streams growing in sand comprised of eroded granite. These habitats are surprisingly different: the plains have a subtropical climate, whereas the elevated Granite Belt occasionally receives heavy snowfalls.

Promoters of tea tree oil often claim it to be a traditional Aboriginal remedy, but there is very little evidence to back this up. The published accounts of Aborigines using "tea tree" invariably refer to other species of *Melaleuca* in northern Australia. The only evidence I can find that Aborigines did use *M. alternifolia* comes from Christopher Dean, the Manager of Thursday Plantation at Ballina, New South Wales, and a pioneer of the modern tea tree industry. A trained anthropologist, Dean tracked down an elderly Aboriginal woman in northern New South Wales who remembered using the leaves as a medicine.

The virtues of *M. alternifolia* oil were discovered by white Australians when

PHOTOS: TIM LOW

Crushed leaves of the Weeping Tea Tree are used by Northern Territory Aborigines as a sniffing remedy for colds.

Lemon-scented Tea Tree is farmed in Kenya and other parts of the world as a source of citral and citronella—lemon-scented aromatic oils used in shampoos and soaps.

A.R. Penfold of the old Technological Museum in Sydney tested its germicidal properties in the 1920s. The oil became popular in the 1930s, and during World War 2 ammunition factories incorporated it into their machine oils to reduce infections in workers' cuts. After the war the tea tree industry declined and eventually collapsed due to the rising popularity of antibiotics, a lack of promotion, and unreliable supplies of tea tree foliage (all oil was extracted from wild trees).

The modern tea tree industry began in the late 1970s, and is entirely plantation based. Thanks to effective marketing and to increasing interest in alternative remedies, it continues to expand, with growing sales around the world. ■

Tim Low is a nature writer and consultant living in Brisbane. He has written four books about wild foods and medicines published by Angus & Robertson.

The medicinal tea tree (*M. alternifolia*) has small flowers, fine leaves and papery bark.

Sons are costly for mothers to produce, growing faster and heavier than their sisters. Daughters, however, present their own problems.

LIKE MOTHER LIKE DAUGHTER

BY DANIELLE CLODE

AT FIRST SIGHT THE BROWN Antechinus (*Antechinus stuartii*) is hardly the most exciting Australian marsupial. This small, drab, nocturnal creature spends its life scuttling through the undergrowth of the south-eastern forests. Yet the mousy appearance of the Brown Antechinus belies a harsh and frantic life. In the world of this marsupial carnivore, life is a whirlwind race against time to find food and mates, and leave behind competitive offspring.

Like many other marsupial carnivores (family Dasyuridae) Brown Antechinuses are short-lived. Females may live for three years, but all male Brown Antechinuses die after only one year. Both sexes become sexually active at ten months of age and the resultant winter rut is a frantic and competitive affair. Males confine their activity to nest trees where they can encounter females. Up to 15 males may huddle together in the hope of a mating. Because mating takes place at the coldest time of year, and often great distances from their own foraging grounds, males need to live off their own bodies to keep going. They use stress hormones (corticosteroids) to strip their bodies of protein and fat, but this takes its toll. All the males die from immune failure or gastrointestinal ulcers shortly after the mating season.

The female antechinuses spend a considerable amount of time constructing a safe and dry nest in tree hollows lined with grass and leaves. A month or so after mating the females give birth to as many as ten tiny young, each weighing just 16 milligrams. These offspring spend the first month of their lives permanently attached to their mother's teats inside her pouch. Spending much of their time grooming their vulnerable young, female antechinuses are a picture of maternal devotion . . . or are they?

During a long-term study of female antechinus reproduction in the Monga State Forest in New South Wales, Andrew Cockburn from the Australian National University noticed that most (about 90 per cent) of Brown Antechinuses lost young between birth and weaning. What happened to these young, and why they disappeared during a time when they should have been safe inside their mother's pouch, was a mystery.

The diet of Brown Antechinuses consists primarily of large insects and other arthropods from the forest litter.

Direct observation of Brown Antechinuses in their lofty tree hollows is difficult but, in captivity, maternal infanticide is a common occurrence—even when food is unlimited. But why would mothers eat their own offspring?

Cockburn suggests that antechinuses use infanticide to alter the sex ratios of their offspring. Sons are costly for mothers to produce, growing faster and heavier than their sisters. Mothers appear to either wean all of their sons or none of them. Female antechinuses can breed twice in their lifetime (although many only breed once). First-time mothers are far more likely to raise all of their sons, whereas the sons of second-time mothers are more likely to fail. Older females, it seems, are less able to raise costly males to maturity and instead invest in less-costly daughters.

Daughters, however, present their own problems. Whereas sons rapidly disperse from their natal territory after weaning, daughters tend to stay nearby and breed in the vicinity of their mother's territory. First-year mothers thus have to compete with their own daughters during the next breeding season. Presumably for this reason, typically only a couple of female young are weaned, irrespective of the number of daughters born. The more daughters that are born to first-time mothers, the more that disappear before weaning. However, future competition with daughters is not a problem for second-year mothers that may have reached the end of their reproductive lives.

The males use stress hormones to strip their bodies of protein and fat, but this takes its toll.

Such maternal manipulation of sex ratios is not unique among mammals. Biased sex ratios have also been observed in species as diverse as the Red Deer (*Cervus elaphus*) and the Coypu (*Myocastor coypus*), a South American rodent resembling an oversized Guinea Pig. In both of these species, the manipulation of sex ratios seems to be related to the body condition of the mother. Sons are a risky investment. If they are successful, sons will sire many offspring, but if they are unsuccessful they may not sire any. Daughters, on the other hand, are more reliable, but the potential benefits are fewer. A successful daughter can only produce a few more offspring than her less successful sister, but even a 'low-quality' daughter is likely to produce some grandchildren. Thus, if a mother can produce strong and healthy children, she will maximise the number of descendants she can produce by having sons. However, if a mother is not able to produce strong, healthy children, daughters are a better option.

The difference between these examples and the antechinuses is that Red Deer and Coypu both manipulate the sex of their offspring before they are born.

C. ANDREW HENLEY/NATURE FOCUS

This female Brown Antechinus will use infanticide to manipulate the number and sex of her offspring.

ESTHER BEATON/TERRA AUSTRALIS PHOTO AGENCY

Brown Antechinuses spend their short, frantic lives scuttling through the undergrowth of the south-eastern forests.

Coypu selectively abort small litters with a high proportion of females. As a result, small litters (with bigger, healthier pups) are usually male-biased and this is more likely to occur when the mother is in good condition.

High-ranking female Red Deer are also more likely to give birth to sons, while low-ranking females in poorer condition are more likely to give birth to daughters. Presumably mothers are failing to carry foetuses of the 'undesirable' sex to full-term. Cockburn's antechinuses, in comparison, give birth to a litter with a normal 1:1 sex ratio and then selectively remove the undesirable sex.

Such post-partum pruning of offspring is very expensive for a mother that has already invested a considerable amount of energy in pregnancy.

The difference between these examples and the antechinuses is that Red Deer and Coypu both manipulate the sex of their offspring before they are born.

However, marsupials give birth to very under-developed young compared to the comparatively precocial young of placental mammals. The post-natal infanticide of antechinuses may be occurring at a similar stage of development as some of the abortions observed in Red Deer and Coypu.

So despite using such an unsavoury method as brood reduction to regulate the numbers and sex of their offspring, the result is a strategy that enhances the female Brown Antechinus' own survival and the future success of her offspring. Such are the requirements for life in the fast lane! ■

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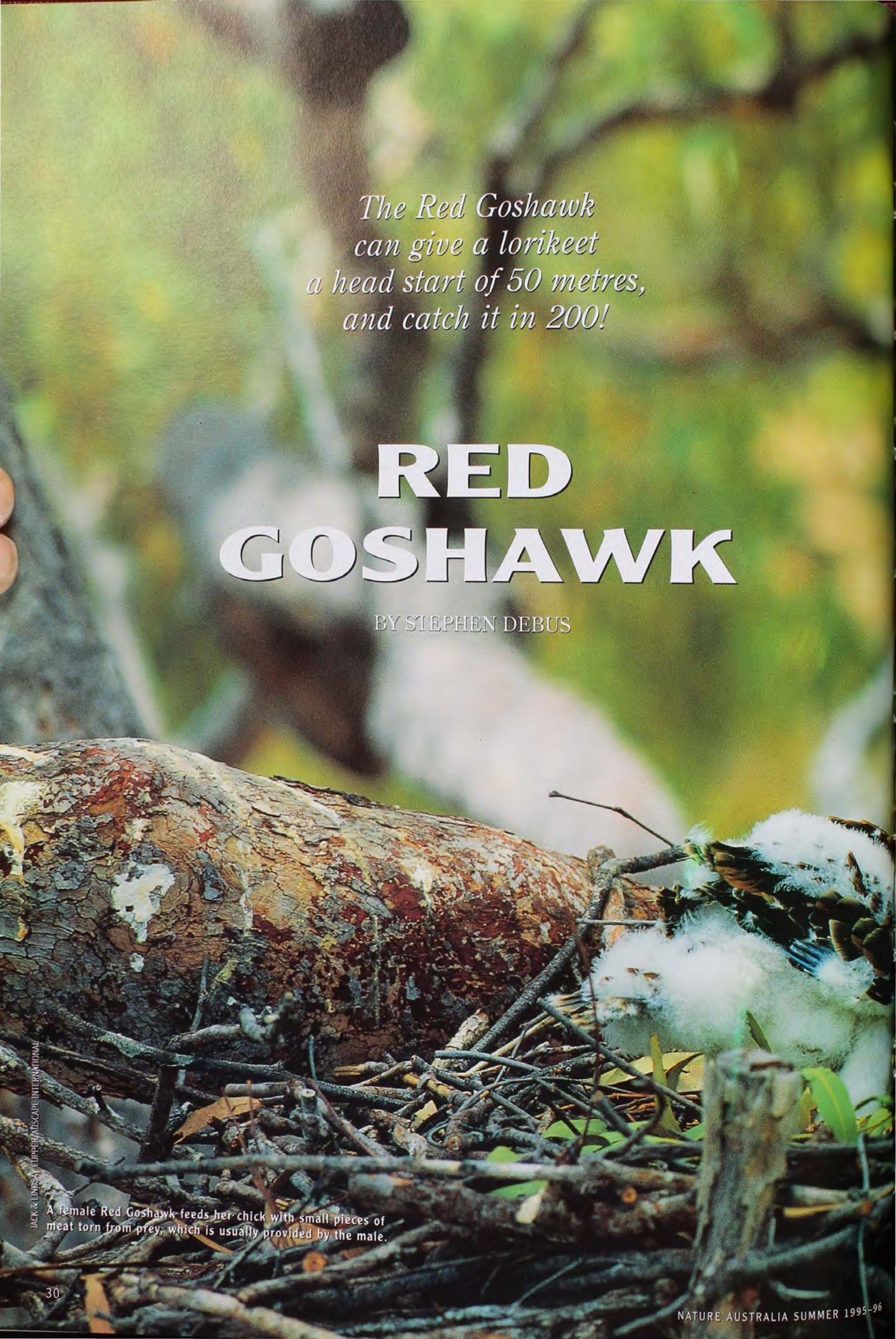
C. ANDREW HENLEY/NATURE FOCUS

Mating is a deadly affair for male Brown Antechinuses, which die of stress-related diseases after their first and only mating season.

The Red Goshawk can give a lorikeet a head start of 50 metres, and catch it in 200!

RED GOSHAWK

BY STEPHEN DEBUS



A female Red Goshawk feeds her chick with small pieces of meat torn from prey, which is usually provided by the male.

JACK & LINDSAY CUPPER/AUSCAPE INTERNATIONAL

KATE FITZHERBERT

THE RED GOSHAWK (*ERYTHROTRIOCHIS RADIATUS*) is a large, reddish brown raptor, or bird of prey, with boldly banded wings and tail. It was called a 'goshawk' because it superficially resembles the Northern Goshawk (*Accipiter gentilis*) of the Old World, formerly 'Goose Hawk'. In medieval times, hawks were trained in falconry to hunt geese and other game for the pot.

The Red Goshawk is Australia's rarest and most threatened bird of prey. It lives on the coastal and subcoastal fringe from the Kimberley region of Western Australia to northern New South Wales, and is largely restricted to riverine forest within the tropics and subtropics. Historically it has always been regarded as scarce, but over the last century its range has contracted coastwards and northwards in eastern Australia. It is officially classified as 'vulnerable'. It is also easily confused with other reddish brown raptors (see box), meaning that some reports of 'Red Goshawks' have been false and the species is even rarer than hitherto believed.

In 1987–1990 the Royal Australasian Ornithologists Union conducted a study of the Red Goshawk in the Top End of the Northern Territory and in the Kimberley region. Researchers David Baker-Gabb and Tom Aumann searched for nests, observed the birds and their breeding cycle, collected the hawks' regurgitated pellets and prey remains, and tracked a pair that was caught and fitted with tiny radio-transmitters on the tail feathers. I was among several volunteer assistants. The project determined most of what we now know about the goshawk's biology, what it needs from its environment, and an appropriate action plan to ensure its survival. Before this study, little was known about the bird because it is thinly scattered in remote country and is seldom encountered by ornithologists.

By mid 1988 David had found, or been directed to, several Red Goshawk nests in the Top End. At the end of August I arrived at Kakadu National Park to start a fortnight as an observer and nest-finder. My first view was of a female goshawk's head and tail over the nest rim, as she brooded her tiny, just-hatched chick. Next morning I started the first of almost a fortnight's daily watches from an observation hide. The male flew in swiftly and strongly with prey, his rufous plumage glowing in the rising sun. Hearing his calls, the female rose from the nest and flew to collect the food from their regular exchange perch. The male accompanied her back to the nest and soon departed, while

Studying the Red Goshawk is not for the faint-hearted as a typical nest site is a platform of sticks located high in the canopy of a very tall tree.

she fed the chick. This became the usual pattern, with occasional variations. Once the male took food to the nest while the female was collecting fresh green leaves for nest-lining, and once he swooped in from a height, with a rush of air through closed wings, to swing up and alight directly on the nest with food. The female gently fed her two white, fluffy chicks with small pieces of meat torn from the prey.

A diversion from the long hours in the hide came in the form of a four-day expedition to find new nests. Just before the expedition, my wife relayed news of a nest found by other birdwatchers in an area we intended to search. We therefore combed the site—David walking along the riverbed while I walked along the 'flank', scanning the tops of the riverbed trees. We had found other occupied raptor nests and were beginning to have doubts, when I saw a Red Goshawk on the top of a tree. A shout to David, and it flew directly to its nest!

Our next stop was a site where one of David's informants had reported a successful Red Goshawk nest the previous year. Directions were rather vague, but we thought we were on the right track. As we approached the anticipated river crossing and nest site, I saw a large stick nest in a tree. As we stopped, I could see a bird on it. David raised his binoculars: "Red Goshawk!" The eventual total was ten nests in the Top End. Tom found another four in the Kimberley in 1989, making a grand total of 14 pairs. This was two-thirds of the total number of nests (21) found in the preceding two centuries.

WITH PROPORTIONALLY THE LARGEST feet and claws of all the Australian raptors, the Red Goshawk is indeed a powerful hawk. Its body weight ranges from just over 600 grams in males to over a kilogram in females, and is thus comparable in size to our common Little Eagle (*Hieraaetus morphnoides*). The Red Goshawk's size and 'armament', together with its ability to fly swiftly and to dive from a great height, allow it to catch relatively large and potentially dangerous prey. It preys mainly on other birds, and takes only live prey, not carrion as some other hawks do. Important prey species include pigeons, parrots, cockatoos and kookaburras, and range up to waterfowl, small herons and the Australian Brush-turkey in size. Mammals such as hares and flying-foxes, reptiles such as snakes and dragon lizards, and large insects such as grasshoppers are taken occasionally. A consequence of the goshawk's sexual size dimorphism is that the female tends to take cockatoos and kookaburras, whereas the male concentrates on smaller birds such as doves and lorikeets.

The Red Goshawk's hunting and feeding behaviour is typical of active, bird-hunting raptors. It searches for prey from a series of concealed perches within the tree canopy, by flying for long periods through or just over the treetops, or by soaring high and scanning the scene below. Most hunting is done in riverine forest and coastal open forest. When prey is sighted, the hawk launches a surprise attack that may become a chase if the prey is alerted, or descends in a long dive to intercept a flying bird. The Red Goshawk can give a lorikeet a head start of 50 metres, and catch it in 200.

The prey is seized in the very wide spread of the long toes, and the kill made by the shock of impact or completed by the crushing grip and piercing claws. The beak is used to behead, pluck and dismember prey that is firmly anchored in the hawk's feet, using the pull of opposing forces much as a human uses a knife and fork. The female Red Goshawk's particularly powerful feet and huge claws may be used to quickly dis-

KATE FITZHERBERT

Red Goshawk nestlings temporarily removed for banding. These birds will spend eight weeks in the nest and a further two to five months in their natal territory.

RED GOSHAWK

Erythrotriorchis radiatus

Classification
Family Accipitridae

Distribution
Rare in riverine forest of the coastal fringe between Kimberley (WA) and far northern NSW.

Biology
Hunts live prey, mainly other birds; particularly doves, cockatoos, lorikeets and kookaburras. Home range about 200 km^2 per pair; adults apparently sedentary, juveniles dispersive. Nest of sticks built in a tall, emergent eucalypt or paperbark in mature forest near water. Clutch of 1 or 2 eggs laid in the Dry in the tropics, spring in eastern Australia; incubation about 40 days, by female. Young fledge in about 55 days, remain dependent for at least a further 70 days. Male supplies all food from nest-building until young nearly fledged, then female contributes. On average, each attended nest produces about 1 fledgling per year.

Threats
Mainly deforestation, particularly of waterways; also perhaps residual pesticides and intensive forestry. Locally, illegal egg-collecting and shooting.

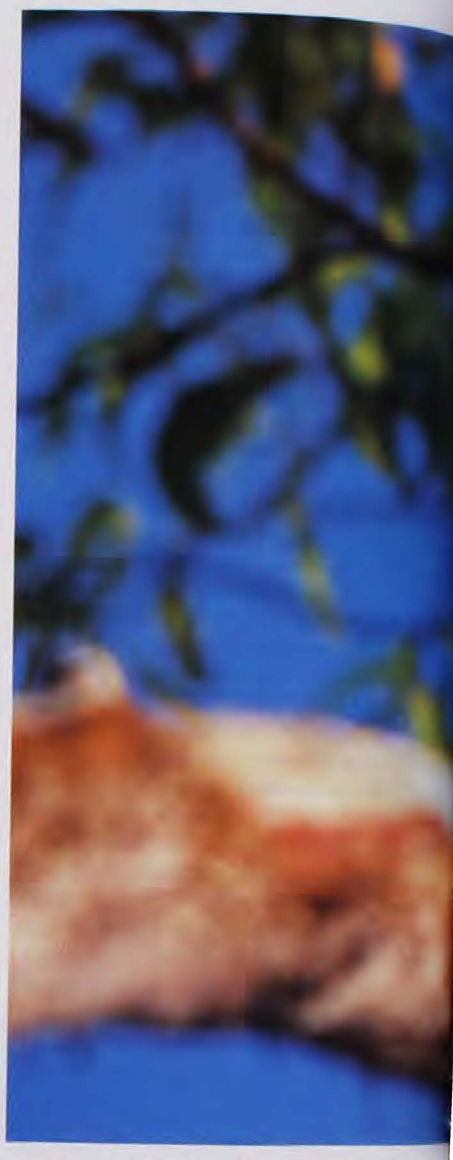
Status
Nationally vulnerable; endangered in southern Qld, and critically endangered in NSW where almost extinct.

patch Red-tailed Black Cockatoos (*Calyptorhynchus banksii*), a common dietary item that could easily bite through a hawk's leg. Some hours after feeding, the indigestible remains of the hawk's meal are regurgitated as a pellet or 'casting': a ball of feathers or fur encasing bone fragments, scales, teeth or claws. This efficient process is performed by the muscular gizzard and highly acid secretions that dissolve all the tissue and most of the ingested bone.

Red Goshawks are naturally scarce, occurring at a low population density, whereas their major avian prey species are abundant. The impact of predation is therefore of no consequence as long as those species can reproduce successfully each year. For this to occur, mature eucalypt and paperbark forests are needed to provide the mainly nectarivorous and hole-nesting prey species with their essential resources, namely tree hollows and profuse blossom.

Nests of neighbouring pairs of Red Goshawks in the Top End were six kilometres apart in coastal forest, and eight to 22 kilometres apart in subcoastal riverine forest. A male ranged up to ten kilometres from the nest, and his mate up to seven kilometres, in all directions, giving a home range of about 200 square kilometres. From these figures, and the extent of suitable riverine habitat in the predicted distribution of the Red Goshawk, there may be about 350 pairs in Australia. Owing to habitat clearance, this is down from an estimated historical population of 440 pairs.

At the start of the breeding season, which occupies the dry season in the tropics and spring in eastern Australia, Red Goshawks perform aerial displays to advertise their territories and attract a mate. To proclaim ownership, single Red Goshawks soar high and sometimes perform undulating dives, or circle with their legs lowered to display their taloned 'armament'. Male and female soar together in manoeuvres of ritualised attack and defence, the male diving at the female, which dives or jinks away, or rolls to present her talons. She may also soar with bursts of deep, exaggerated wing beats. These displays finish with the pair diving to the nest site, and the male presenting food to the female. The male also performs fast, low-level, acrobatic flights about the perched female. These displays of speed and agility, and courtship feeding, probably allow the female to judge a potential mate's prowess as a hunter and provider. Supplementary feeding by the male also enables the female to attain the body condition necessary for producing eggs.



Red Goshawk nesting and hunting habitat is characterised by tall trees with massive limbs and an open canopy structure. The large stick nest is typically built about 20 metres up in one of the tallest (about 30 metres) and most massive eucalypts or paperbarks, in a stand of exceptionally large, old trees, within a kilometre of a watercourse or wetland. For a given pair the nest-building phase occupies about two months, during which the male does most of the stick-collecting and construction, with the female assisting only towards the finish. The clutch of one or two eggs is incubated solely by the female, and takes six weeks to hatch. The male sometimes stands guard over the eggs while his mate is off collecting fresh foliage. When the young hatch they are covered in white down; by the age of eight weeks they are fully feathered and ready to leave the nest. During the nestling period, the food is provided by

DAVID BAKER-GABB

An adult female Red Goshawk.

PICKING THE RIGHT RED

Rarely seen, particularly in the more settled parts of Queensland and New South Wales, the Red Goshawk is often confused with other reddish brown, much more common raptors. The Square-tailed Kite (*Lophoictinia isura*), Brahminy Kite (*Haliastur indus*), juvenile Spotted Harrier (*Circus assimilis*), female Swamp Harrier (*Circus approximans*), juvenile Brown Goshawk (*Accipiter fasciatus*) and rufous individuals of the Little Eagle (*Hieraaetus morphnoides*) and Brown Falcon (*Falco berigora*) are often misidentified as Red Goshawks. Reference to modern field guides, handbooks and photographic raptor books assists greatly with the identification of these difficult birds.

When perched, the Red Goshawk shows a slight crest, and mottled back and wings with strong rufous scalloping on the shoulders. The long wings almost reach the tip of the long tail. The head and underside are heavily streaked. The breast and belly vary from rufous to white, with plain rufous thighs and massive, bare yellow legs with long toes and large claws. In flight, its main features are its long wings, strongly barred underwings and tail, massive yellow feet and flying style: bursts of rapid flapping and gliding with strong, deep wing beats like a fast-flying Brown Falcon. Juvenile Red Goshawks are rufous on the head and underparts, whereas adults have a grey face and pale throat. Adult females have much white on the belly.

DAVID BAKER-GABB

An adult female Red Goshawk defends her nest and displays the rufous scalloping on her wings, the streaking on her chest, and the rusty thighs and thick yellow feet characteristic of these birds.

the male, with the female later catching some prey when the young are large enough to be left unattended. Under the intense sunlight of the tropics, females often stand with open wings to shade their nestlings.

After leaving the nest, the young stay in the vicinity for the first three or four weeks, waiting to be fed on or near the nest by their parents. They then start to range more widely, but remain partly dependent on the parents for food for at least two months after fledging. They may remain in the natal territory for as long as four or five months. After that, they face an uncertain future, dispersing up to hundreds of kilometres in search of a territory of their own. During this dispersal phase, in which the young goshawks are inexperienced, most probably die from starvation, accidents or persecution by humans.

The Red Goshawk's size and 'armament', together with its ability to fly swiftly and to dive from a great height, allow it to catch relatively large and potentially dangerous prey.

What of the Red Goshawk's future? In order to survive, it needs a large area (perhaps 200 square kilometres per pair) of riverine open forest and woodland for hunting; an abundance of bird prey, the main species of which also depend on elements of mature forest for their survival; and stands of large, old trees near water for nesting purposes. At the moment the goshawk seems reasonably safe in remote northern Australia, where human impacts such as habitat clearance, urbanisation and direct persecution of raptors are minimal. The hawks are confiding, and not easily disturbed by benign or neutral human activity near their nests. The main threat may be the highly destructive widespread fires, particularly those deliberately lit late in the dry season, which incinerate some nestlings and singe the nests or nest trees of others. The European fire regime may also affect habitat quality and prey availability in the long term. Other impacts of the pastoral industry and feral animals include overgrazing, wallowing and soil trampling, leading to loss of riverbank trees by direct damage and by undercutting of banks. Such fallen trees then form log jams against standing trees, causing further tree loss or damage when these jams burn fiercely during the next fire.

In the north, Red Goshawks can simply be left alone and undisturbed, with no need for acquisition of land for special reserves. Some pairs are safe in existing national parks. All that is required is some regular monitoring of known nests to ascertain breeding suc-

cess and causes of failures, active discouragement of egg-collecting, and the removal of any log jams that form against the trunks of known nest trees.

By contrast, it is clear that the Red Goshawk is on the retreat in New South Wales and southern Queensland. The first Red Goshawk specimen known to science was collected near Sydney soon after the First Fleet arrived. The bird was shot and nailed to a settler's hut, where it attracted the attention of Surgeon-General John White who transcribed the shooter's verbal account of the event. White then had an artist, apparently the convict Thomas Watling, record its likeness for posterity. White took the paintings and notes to England in 1794, where ornithologist John Latham formally described and named the bird from the paintings rather than from a tangible specimen. All that survives of this bird is two colour illustrations in the British Museum of Natural History.

A second Red Goshawk was collected in the Sydney region within the first 20 years of European settlement, by the famous naturalist George Caley. Its mortal remains also reside in the British Museum of Natural History. Other specimens were collected on the north coast rivers last century, making a total of at least six shot in New South Wales before 1900. The only two known nests in the State, in the Richmond Valley, were robbed of their eggs between 1910 and 1920. Meanwhile, the first nests were discovered by grazier-naturalist J.B. White in southern Queensland in the 1870s, and other nests were found a little farther north by the Barnard brothers in the 1880s.

The first Red Goshawk specimen was collected soon after the First Fleet arrived. The bird was shot and nailed to a settler's hut.

At least ten specimens had been collected in south-eastern Queensland, several from the Brisbane region, by 1900.

The situation is very different today. The Red Goshawk no longer breeds in the areas known to White or the Barnards. The Barnards were first to record its demise early this century, following the clearing of their grazing property and degradation of the waterways. Other observers in south-eastern Queensland have also commented on its disappearance from areas where the forest has been cleared. There was one known nest in Queensland near Shoalwater Bay in the early 1970s, and another in the Conondale Range in the late 1970s. The latter was robbed by egg-collectors. Since then, there has been circumstantial evidence that a few pairs may attempt to breed in remote areas of south-eastern and mid-eastern Queensland. Fortunately, there are breeding populations on Cape York Peninsula, and in the Kimberley and Top End.

The New South Wales National Parks and Wildlife Service commissioned a preliminary survey of the Red Goshawk in New South Wales in 1987, which I conducted. In mid 1988 there may have been three pairs of Red Goshawks in the State. In spring 1988 there was only one known pair, and in spring 1989 there was only a female at that site. Since then there has been about one sighting per year, of single birds, in New South Wales. The last known pair in the State had disappeared by 1990. If the Red Goshawk still breeds in New South Wales, it is likely to be on or near the coast north of the Clarence River. There has been no confirmed breeding in the State for almost 80 years, with confirmed sightings in the last three decades averaging only two per year. The goshawk must now be regarded as virtually extinct as a breeding species within the State.

The Red Goshawk's demise in the south-eastern part of its former range is attributable mainly to deforestation, particularly of stream-side trees in the fertile coastal valleys. Rivers where the goshawk once occurred, such as the Hunter, Manning, Clarence and Richmond, now have treeless banks and excessively cleared catchments, and the rivers are wide, silted up and flood-prone. Local heavy use of DDT in northern New South Wales and eastern Queensland in recent decades may also be implicated. DDT is a pesticide that accumulates in the food chain and concentrates in the bodies of raptors, causing eggshell thinning and embryo death, and therefore population decline through breeding failure. Although DDT was banned in Australia in 1987, there may be residual effects for many

DAVID BAKER/ABB

Red Goshawk chicks in their nest. Clutches of two eggs are more common than one, but usually only one young is successfully fledged.

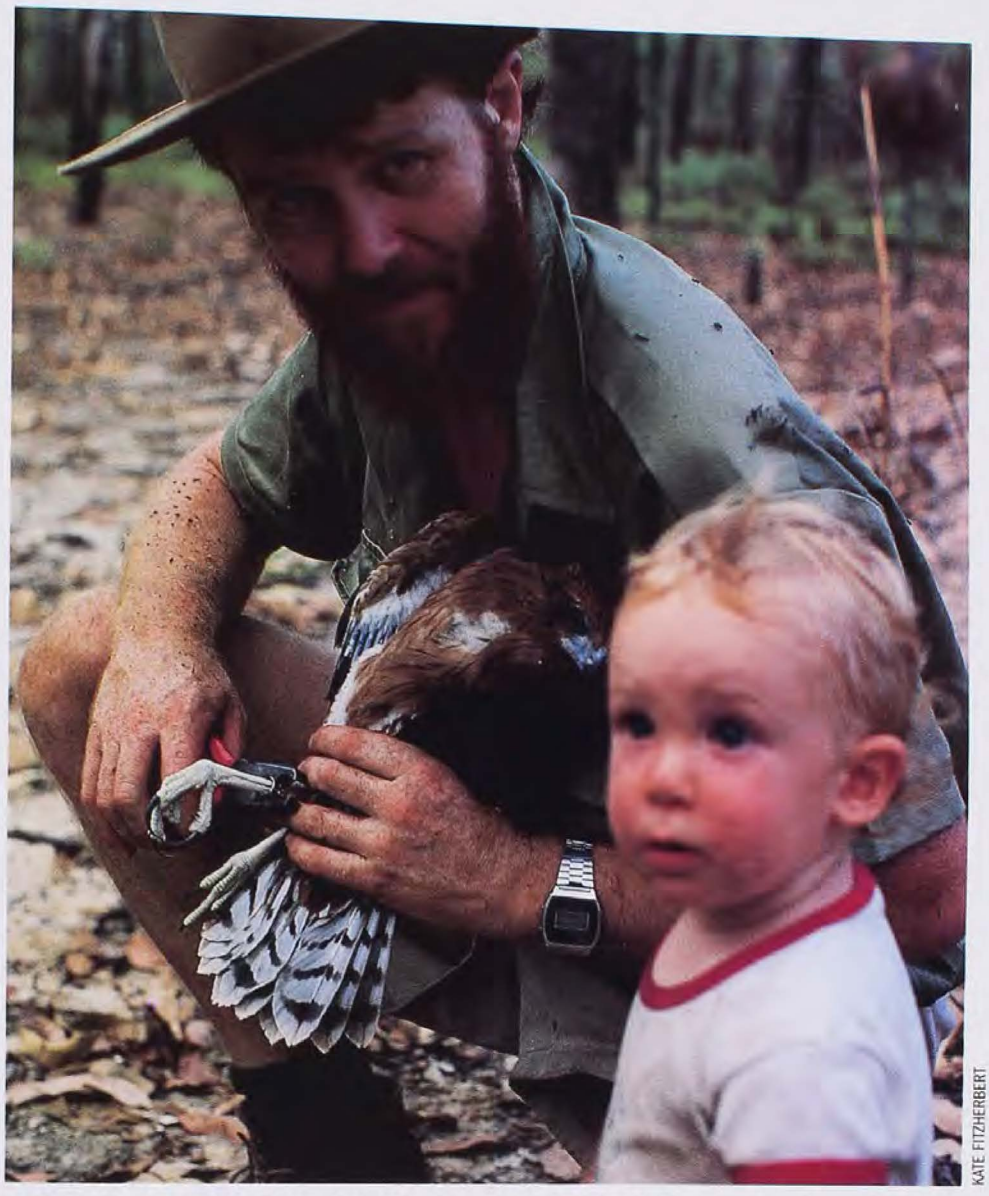
years. Other threats to the Red Goshawk in eastern Australia include egg-collecting and the illegal shooting of birds that occasionally attempt to take unguarded poultry or free-flying domestic pigeons. With such a rare and special hawk at risk, the first step should be to roof the chicken yard, rather than reach for the gun. All birds of prey are native wildlife, and legally protected throughout Australia.

BEING AT THE TOP OF THE FOOD CHAIN, and therefore sensitive to chemical pollution and changes in their prey populations, raptors have a special role as biological indicators of the health of our environment. They can alert us to dangers to ourselves, or to the functioning of ecosystems that provide humanity with essential services. This role is best exemplified by DDT and the Peregrine Falcon (*Falco peregrinus*), whose numbers crashed in Europe and North America in the 1960s. I believe the decline of the Red Goshawk is an indication that all is not well in eastern Australia. Perhaps it is a symptom of overclearing, abuse of watercourses and wetlands, pesticide pollution, and the general decline in biodiversity caused by excessive human demands on the Earth's ecosystem services.

In order to conserve the Red Goshawk in the south-eastern part of its range, the most urgent task is a survey in New South Wales and Queensland to locate remaining pairs and secure their breeding habitat if threatened. Any active nests found will require monitoring, study and perhaps wardening if they are near human settlements. Limited recovery of the goshawk population may be possible through a rehabilitation program for the river banks and their catchments, by restoring the original tree species. The goshawk would also benefit if samples of intensively logged, dry coastal forests, such as of Spotted Gum, were allowed to return to old-growth condition.

There may be solitary Red Goshawks in captivity in northern Australia, in private zoos, wildlife parks, the backyard facilities of wildlife carers, or even caged as curiosities at remote farmsteads. If so, I believe that these birds should be brought together in one scientifically managed facility, for the purpose of captive breeding. Such birds should not be kept if they can be rehabilitated and released, nor should Red Goshawks or their eggs be deliberately obtained from the wild for such a program, but any unreleasable captives should be managed optimally for the benefit of their species. Although a captive-breeding and release program is not the immediate answer to the goshawk's plight, we should at least know how to do it in case reintroduction is needed in the future. There is scope for limited reintroduction trials in New South Wales, once habitat restoration is under way. There are possibilities for young captive-raised birds to be released wearing radio-transmitters, so their progress can be monitored and perhaps some clues gained as to what's limiting the wild population. I would certainly welcome any news of captive Red Goshawks being held, but it is essential that identification is correct, so there are no wild goose(-hawk) chases. Identification can be confirmed by showing colour photographs of such captives to an ornithologist.

Conservation of the Red Goshawk, through protection and restoration of its breeding habitat, will have benefits for the many other wildlife species sharing its environment. There will also be benefits for humans, through stream-bank stability, run-off regulation and flood mitigation, and a dependable supply of clear water. Raptors are the inspiration for much human endeavour, and our world would be the poorer without them. I have a vision of the Red Goshawk again flying free in the skies of my home State of New South Wales. ■



KATE FITZHERBERT

A Red Goshawk fledgling being banded by David Baker-Gabb. Clearly visible are the rich rufous head and underparts characteristic of juveniles.

Further Reading

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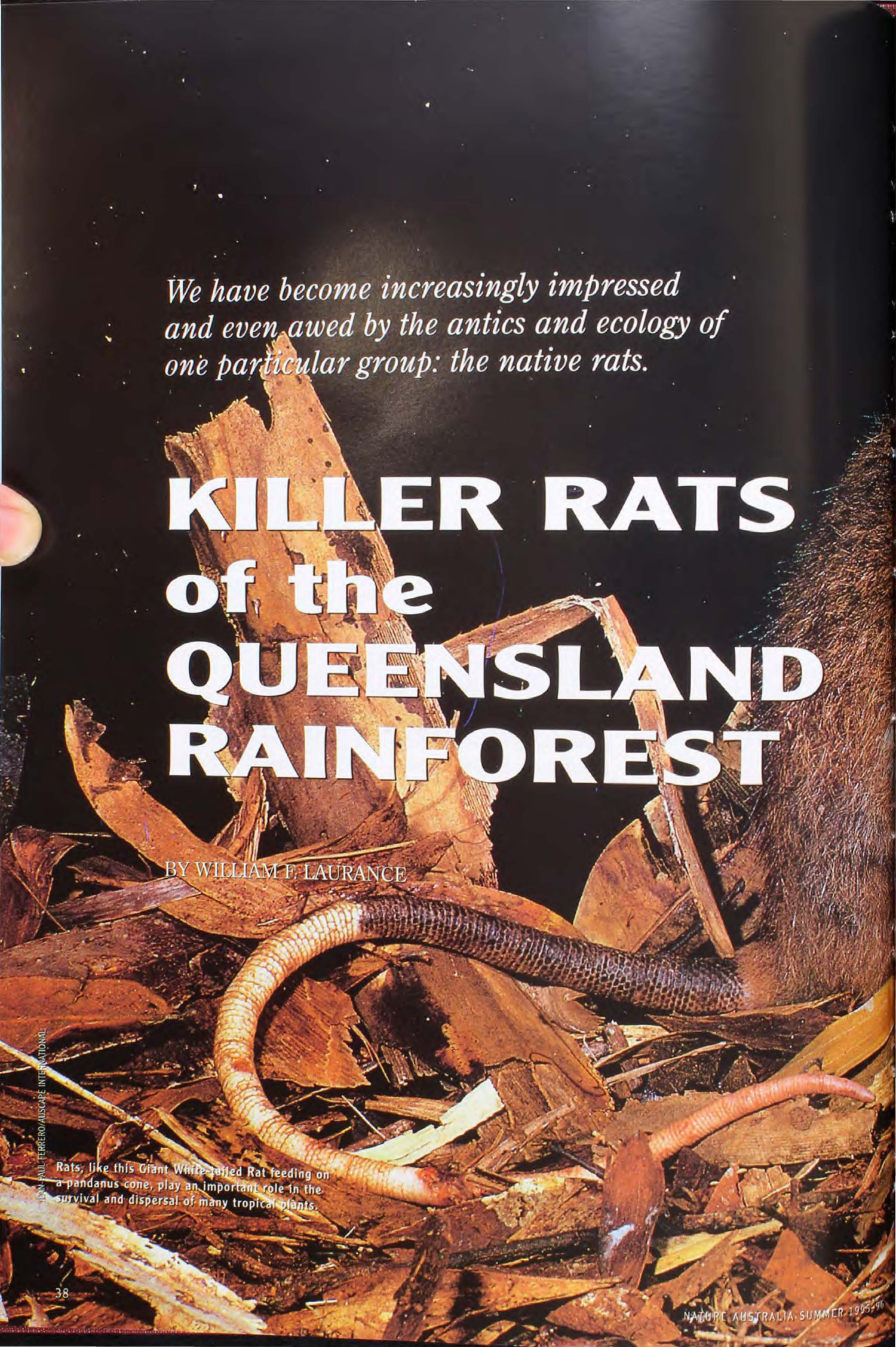
Stephen Debus is an ornithologist attached to the Zoology Department, University of New England. He has studied various raptors and conducted fauna surveys for government departments and private industry. He is editor of the Australian Bird Watcher *and the* RAOU Conservation Statement *series, and the NSW representative of the Australasian Raptor Association.*

We have become increasingly impressed and even awed by the antics and ecology of one particular group: the native rats.

KILLER RATS of the QUEENSLAND RAINFOREST

BY WILLIAM F. LAURANCE



Rats, like this Giant White-tailed Rat feeding on a pandanus cone, play an important role in the survival and dispersal of many tropical plants.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

I HONESTLY THOUGHT HALF MY FINGER had been bitten off. There, staring at me from the inside of a large cage-trap a few feet away, was the culprit. It was nearly as big as a house cat, with coarse grey fur, a naked tail, and a deep, reverberating growl that made the back of my neck start tingling

A long-lost thylacine? A ferocious quoll? No, a rat. The Giant White-tailed Rat (*Uromys caudimaculatus*), to be precise. At one kilogram in weight, it is one of Australia's largest rodents—and a formidable denizen of northern Queensland's ancient rainforests.

And I had been foolish enough to stick my finger inside its trap, trying to coax the animal to turn slightly so I could read the number printed on the small brass tag attached to its ear. Number 1163. I would remember this fellow, I thought, as one of my field assistants tried to staunch the bleeding. We still had over 100 traps to check this day, and would probably encounter and handle another dozen Giant White-tailed Rats before we were finished.

COURTESY WILLIAM F. LAURANCE

The author live-trapping small mammals in heavily disturbed rainforest on the Atherton Tableland.

FOR THE PAST DECADE MY COLLEAGUES and I have been studying the ecology, behaviour and conservation of mammals of northern Queensland's rainforests. During this time we have become increasingly impressed and even awed by the antics and ecology of one particular group: the native rats (see box). There is still much to be learned about these secretive, nocturnal mammals, but we can say one thing with confidence: they are having a profound impact on the ecology of Queensland's rainforests.

You first begin to appreciate the rats when you lay out a line of mammal traps. In northern Queensland, biologists almost invariably use two types of traps: smaller, aluminium box-traps known as Elliot traps, and much larger traps constructed of heavy wire mesh, called cage-traps. The traps are usually baited with an aromatic mixture of rolled oats, peanut butter and vanilla essence. Once caught, the animals are

KATHIE ATKINSON

Rodents, like this Bush Rat, are a vital part of the normal functioning of the forest, preying on seeds, insects and fungi, and providing food for many of the other forest predators.

briefly examined, tagged and released, with no ill effects other than a pierced ear from a numbered tag and perhaps a minor loss of dignity.

One of the main purposes of cage-traps is to catch the Giant White-tailed Rats. In fact, if you forget the cage-traps, you might as well go home. The Giant White-tailed Rats will simply run along the trap line and trip, flip, shake and generally disrupt nearly every Elliot trap. They seem to delight in causing maximum havoc for mammal trappers.

Perhaps the most impressive thing about the rainforest rats is their sheer numbers. We have captured over 10,000 small mammals during the past decade and about 98 per cent of them have been rats. In terms of their biomass—the sheer mass of living material—the rodents probably overwhelm all other groups of rainforest vertebrates, including birds, bats, marsupials and reptiles.

Walking though the rainforest at night, one is often assaulted by a cacophony of loud cracking and popping noises. These are the sounds of rats attacking large, hard-coated seeds produced by many rainforest trees. Biologists have long suspected that rodents are devastating the seeds of many trees. One need only walk through a rainforest in daytime and witness the vast numbers of gnawed seed husks to realise the importance of rats as seed predators.

A few years ago I asked several of my university students to perform a simple experiment. Each was given 100 raw peanuts and told to place them out in the rainforest just before dusk. The next morning, they were to return and count how many seeds remained. Most students found no seeds left. Even those who had hidden their peanuts under dead leaves, or had cached them in the roots of buttress trees, were astonished to find nearly every peanut gone. On that day, I think they began to appreciate the rainforest rats.

COURTESY WILLIAM F. LAURANCE

Caught in the act, a Giant White-tailed Rat attacks an egg in an experimental bird nest.

Of course, other nocturnal animals may have helped remove the peanuts. But careful observations suggest this is rarely the case. One hardy soul who has spent many wet, chilly nights studying the seed-eating habits of rodents is Graham Harrington of the CSIRO Tropical Forest Research Centre at Atherton. Graham would place small piles of tree seeds out on the forest floor then sit very quietly, waiting for an animal to discover the prize. When he heard noises, he would switch on a small red light (which is invisible to most nocturnal animals) and identify the culprit. In every single case it was a rodent—invariably a Giant White-tailed Rat—that was seen scurrying off with the booty.

But the rats attack more than just seeds. A series of experiments that several of my colleagues and I conducted suggests some species are bonafide killers. In the rainforest, birds such as the Australian Brush-turkey (*Alectura lathami*) and Chowchilla (*Orthonyx spaldingii*) build nests or egg-mounds on or near the ground, and some suffer high rates of predation on their eggs or nestlings. We decided to mimic these birds by creating artificial nests. Each consisted of a bowl-shaped grass nest and contained one or more small chicken eggs. Over a period of nine months we set out over 600 fake nests in a wide range of tropical habitats.

RAINFOREST RATS

In northern Queensland rainforests, the native rats are diverse and lead highly varied lifestyles. The large (600–1,000 grams) and powerful Giant White-tailed Rat (*Uromys caudimaculatus*) forages throughout the forest canopy and on the ground for large seeds, insects and small animal prey. The small (50–90 grams) but highly pugnacious Fawn-footed Melomys (*Melomys cervinipes*) is also an excellent climber and feeds on leaves and fruits in smaller subcanopy trees. Two other species, the Bush Rat (*Rattus fuscipes*) and Cape York Rat (*R. leucopus*), are both medium-sized (120–160 grams) ground dwellers that eat insects, fungi and some seeds and fruits. One of the most unusual species is the Water Rat (*Hydromys chrysogaster*), a large (600–1,300 grams), otter-like rodent with dense, waterproof fur and partially webbed hind feet that preys on fish, yabbies and other aquatic animals.

Some rainforest rodents are very poorly known. For example, the Prehensile-tailed Rat (*Pogonomys mollipilosus*), a small (50–70 grams), arboreal rodent that apparently eats mostly tree leaves, has been captured on only a few occasions, usually by house cats. The Thornton Peak Melomys (*Melomys hadrourus*), a medium-sized rat (150–200 grams) that may feed on insect larvae dug out of rotting logs, was originally thought to occur only on Thornton Peak near the Daintree River, but was recently discovered further south, on the Atherton Tableland.

Two introduced rodents—the House Mouse (*Mus musculus*) and Black Rat (*Rattus rattus*)—have been recorded from Queensland's tropical rainforest, but at very low densities. They tend to prefer the more degraded habitats associated with human settlement.

Bush Rats eat a variety of fungi. Most importantly they are involved in the dispersal of mycorrhizal fungi ('truffles'), which are crucial to the survival of many rainforest trees.

At the beginning of the experiment we had expected that many animals—butcherbirds, snakes, monitor lizards, feral pigs—would attack the nests. But again, the rats surprised us. The majority of nests were attacked at night—ruling out most of the birds that are diurnal—and the attacked eggshells had large serrated holes and looked suspiciously like they had been chewed open by rats.

However, we needed more than just our suspicions to prove the case. We had to catch the rats in the act. To accomplish this an electrical engineer and I spent several days designing and building two fully automatic cameras that were instantly triggered whenever an invisible, infra-red beam was tripped. The cameras worked beautifully, and within two months we had nearly 300 photographs of nests being attacked. And just as we had expected, the rats stole the show—more than 96 per cent of the photos were of rodents, mostly the Giant White-tailed Rat and Bush Rat (*Rattus fuscipes*)—some literally caught with egg on their faces. We are now convinced that rats are important predators on some types of bird nests, insects and many small animals in the rainforest.

WHILE BIOLOGISTS ARE JUST BEGINning to appreciate the true importance of rainforest rodents, rural residents have known for decades that the native rats are formidable invaders of farmhouse attics and pantries. Giant White-tailed Rats, for example, are especially fond of tins of condensed milk, which they easily rip open with their powerful incisors. In fact, they are so efficient at finding and opening the tins that some residents swear they can read the labels!

Many locals who live near rainforest have resorted to storing their food in heavy containers. Some have cats, but this is not advisable given the devastating effect cats can have on native fauna. In fact, a cat is no guarantee of protection from Giant White-tailed Rats. A friend of mine was given three young cats to help protect his pantry. Within a week, the Giant White-tails had killed two of the cats. The third survived, but it has never shown an inclination to confront the large rodents!

There is no question that the rainforest rats are both quick to learn and remarkably adaptable. These traits may help explain why they survive so well in both natural and heavily disturbed habitats. On the Atherton Tableland, for example, much of the rainforest has been cleared for cattle pastures and only small fragments of forest remain. Many rainforest specialists—such as

NATURE AUSTRALIA

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Highly adaptable, rainforest rats are able to survive and flourish in disturbed and fragmented areas where other rainforest specialists, like this Southern Cassowary, cannot.

the Southern Cassowary (*Casuarius casuarius*), the Lemuroid Ringtail Possum (*Hemibelideus lemuroides*) and the Spotted-tailed Quoll (*Dasyurus maculatus*)—cannot survive in these small fragments but the rodents flourish. Their ability to eat a wide range of foods and their tolerance of agricultural habitats probably explain their success in forest remnants.

The rats' adaptability and opportunistic nature may also explain why they are generally so abundant in Queensland rainforests. During the Pleistocene—from about two million to ten thousand years ago—the Earth experienced a number of ice ages that profoundly changed the planet's ecology. In the tropics of northern Queensland, the climate during the ice ages became much cooler and drier. As a result, the rainforest temporarily contracted into several small, isolated refuges, often on very wet mountain tops. These refuges probably became too small to support some of the highly specialised rainforest animals, opening up new ecological niches and opportunities for the native rats to exploit. The last ice age ended quite recently—only 10,000 years ago—and there probably has been too little time for new, highly specialised animals to evolve and displace the ubiquitous rats. In a dramatically changing environment, the rats' adaptable nature is clearly a great advantage.

A Giant White-tailed Rat gradually unscrewed a jar of jam then greedily consumed its contents.

Although some might disparage the rodents, it is important to realise they are vital natural components of Australia's tropical rainforests, and have many ecological roles. Rats are important prey for many rainforest predators, such as owls, pythons and quolls. By digging up and eating 'truffles', which contain tens of thousands of fungal spores, the rats also are the only known dispersers of mycorrhizal fungi. These fungi form crucial symbiotic relationships with many rainforest trees, without which many trees could not survive. (The fungus is intimately associated with the tree's roots and exchanges nutrients it absorbs from the soil for sugars produced by the tree.) Our research suggests the rodents are also major predators of seeds, insects and small animals, but

this is simply part of the normal functioning of the forest. In northern Queensland, a rainforest without rats simply would not be a natural rainforest.

In fact, over the years some local residents have developed a grudging respect for their native rodents. One old logger recalled to me the time he was camping in the rainforest and watched in amazement as a Giant White-tailed Rat gradually unscrewed a jar of jam then greedily consumed its contents. "You know", he said, "they're so smart I reckon we ought to put 'em in Parliament!" ■

Further Reading

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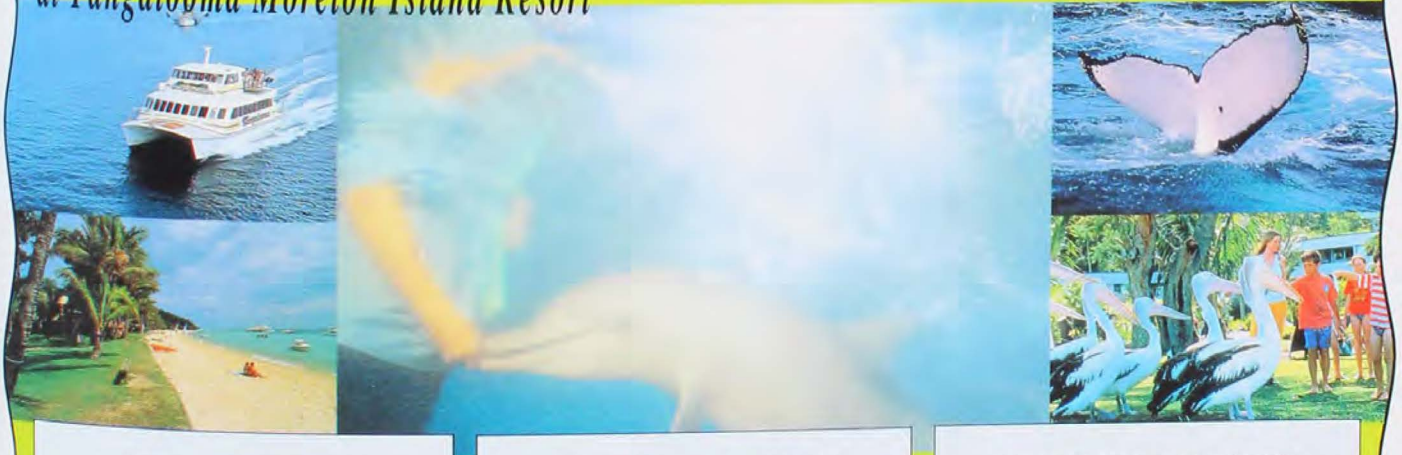
HANS & JUDY BESTE/AUSCAPE INTERNATIONAL

Giant White-tailed Rats are agile climbers and can often be found up trees searching for seeds, fruits, birds' nests and any live prey they can find.

'WILD' DOLPHIN FEEDING NIGHTLY

at Tangalooma Moreton Island Resort

VIA BRISBANE



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Wild dolphin feeding cruise.
Departs Brisbane 5.30pm
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and view or feed the dolphins.
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tropical breakfast, dolphin feeding
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Conditions apply to validity.
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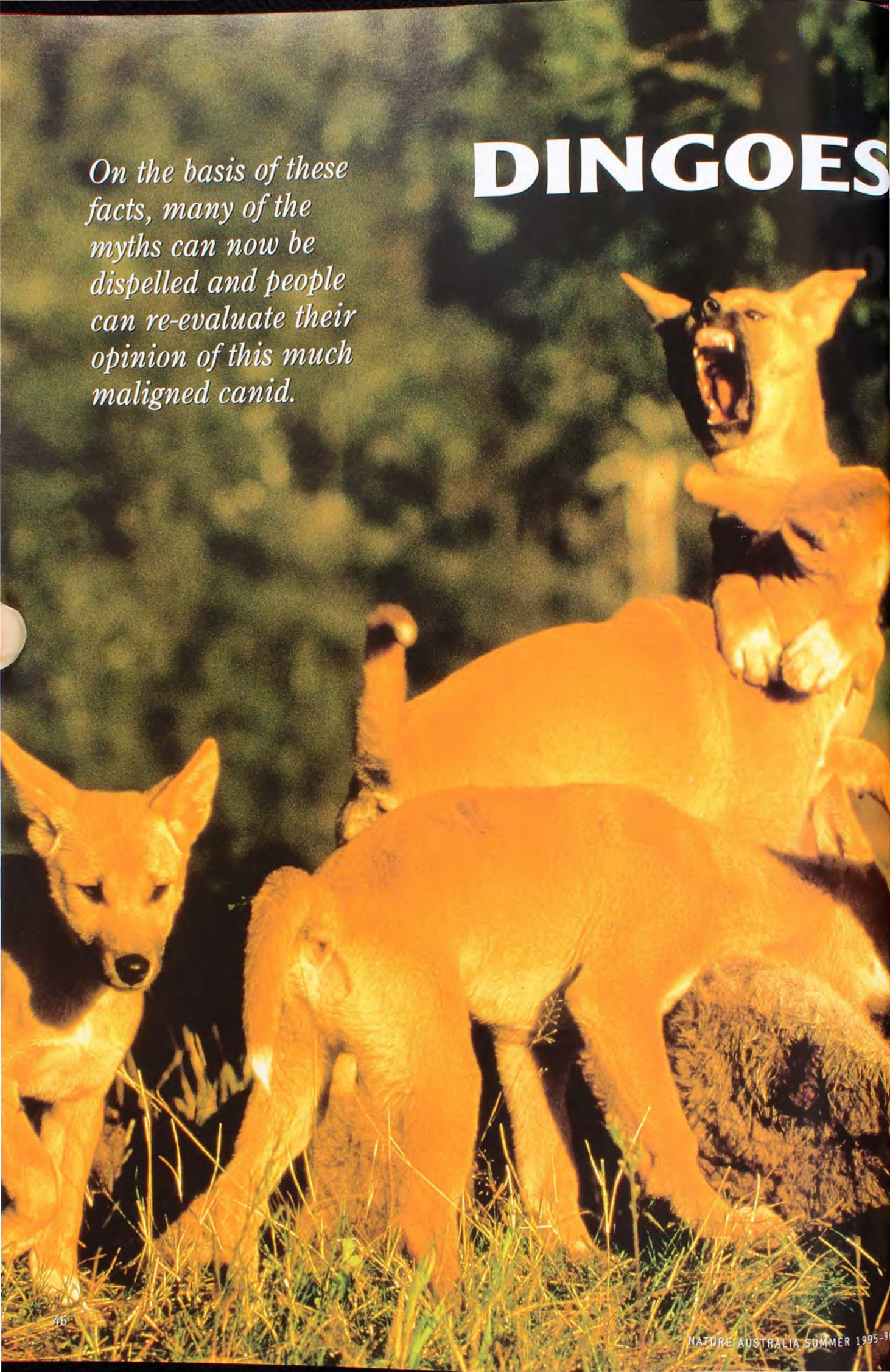
DINGOES

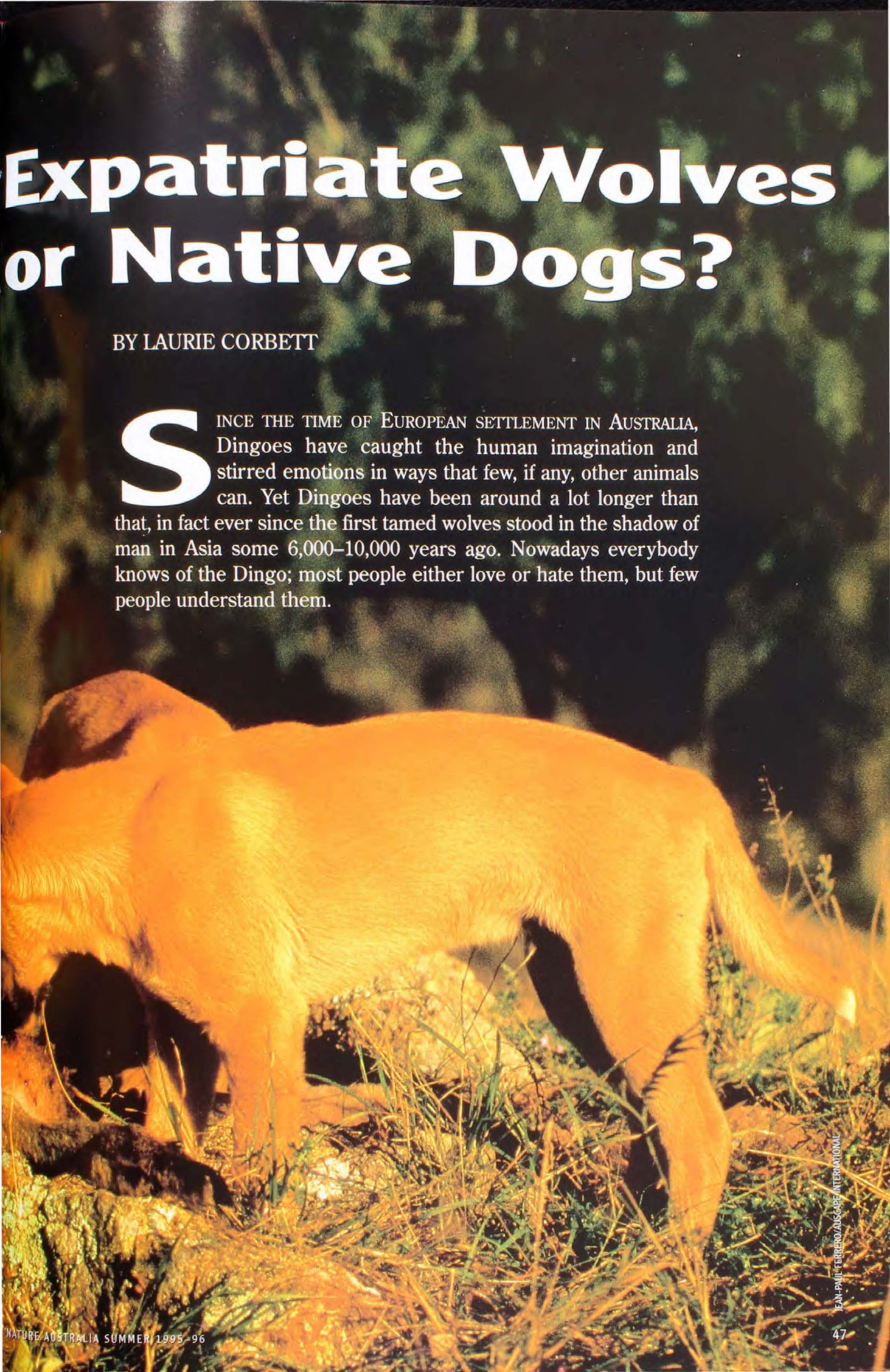
On the basis of these facts, many of the myths can now be dispelled and people can re-evaluate their opinion of this much maligned canid.



Expatriate Wolves or Native Dogs?

BY LAURIE CORBETT

SINCE THE TIME OF EUROPEAN SETTLEMENT IN AUSTRALIA, Dingoes have caught the human imagination and stirred emotions in ways that few, if any, other animals can. Yet Dingoes have been around a lot longer than that, in fact ever since the first tamed wolves stood in the shadow of man in Asia some 6,000–10,000 years ago. Nowadays everybody knows of the Dingo; most people either love or hate them, but few people understand them.



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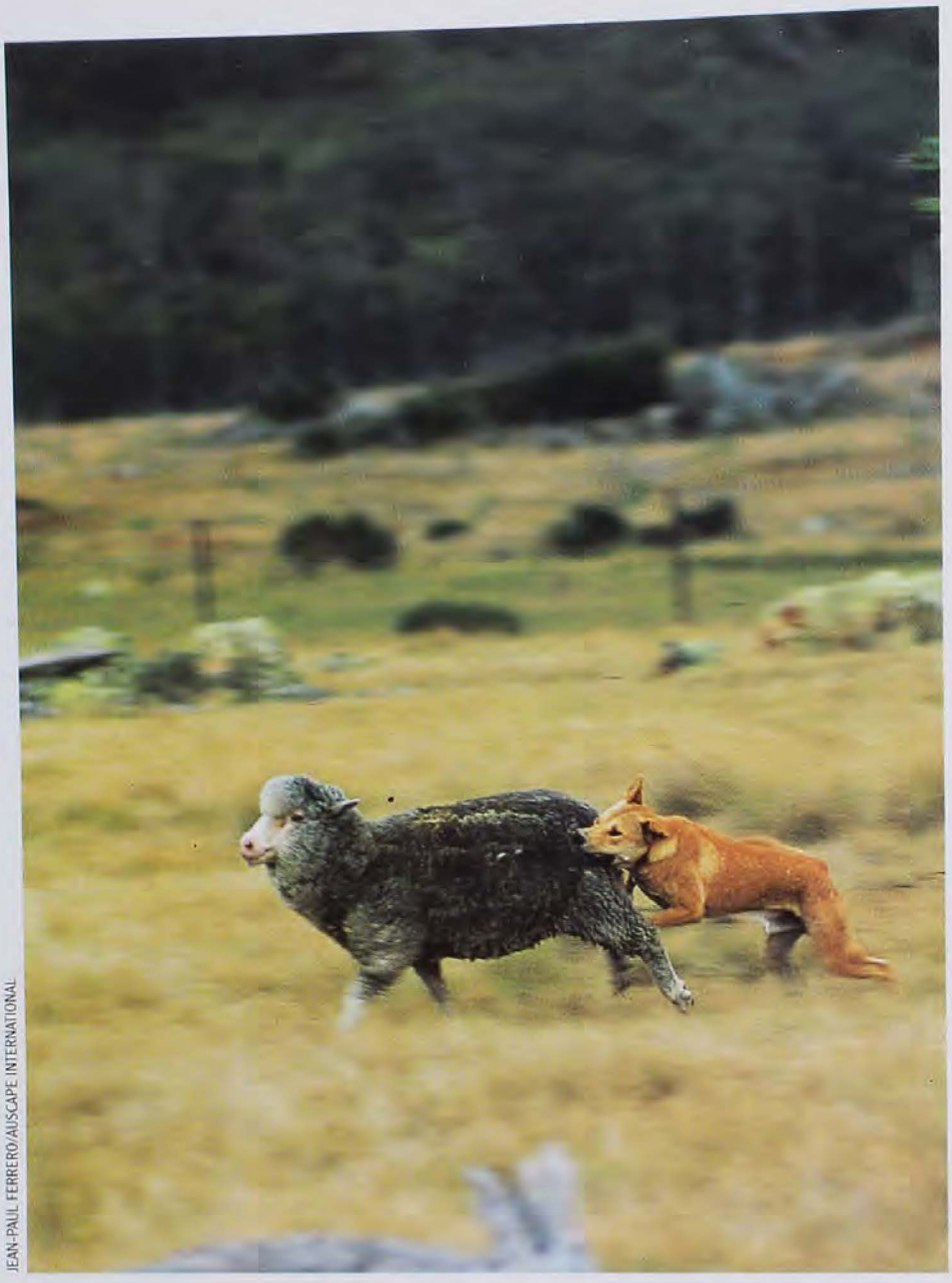

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The love–hate emotion is based on misconception, myth and folklore, essentially handed down from the early settlers who brought with them their European prejudices of wolves, the Dingo's forebears. Those people that hate Dingoes do so because of their predation on cattle, sheep and other stock, and because they contributed to the extinction of Thylacines, Devils and other mammals on the Australian mainland. On the other hand, some people have time for Dingoes because they recognise the benefits of them eating pests, such as rabbits, rodents, pigs and some macropodid species. Other people respect Dingoes because they are the largest living Australian predator and, despite decades of persecution, still defy humans and thus represent the spirit of the wild. Yet other people, more recently, love Dingoes because they are dismayed at the prospect of yet another extinction and so strive to preserve them as show dogs and status symbols; and in this respect, others are happy to exploit Dingoes for profit.

Like everything else in life, there is a balance between these extreme views. Over the past 30 years, a core of researchers has steadily pieced together the inner secrets of the Dingo and its interactions with other animals both in Australia and overseas. On the basis of these facts, many of the myths can now be dispelled and people can re-evaluate their opinion of this much maligned canid.

Pastoralists have long feared the Dingo, whose attacks on sheep are well known. In an attempt to control them, one of the world's longest fences was built from Queensland to South Australia.

C.A. HENLEY/AUSCAPE INTERNATIONAL

Persecution of the Dingo by humans has been intense and widespread, however many of the methods used to control them have proved inefficient and in some cases may actually result in a population increase.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Dingoes are specialists and focus on a narrow range of prey. Only ten species comprises almost 80 per cent of their diet.

CONTRARY TO POPULAR OPINION, Dingoes are not indigenous to Australia. They do not share an antiquity with the marsupial megafauna, and they were not transported to Australia by Aborigines. Dingoes began and evolved in Asia. The earliest known fossils are from north-eastern Thailand and northern Vietnam (both dated about 5,500 years BP). Based on skull measurements, these fossils are midway between Asian wolves and modern Dingoes, implying that Dingoes evolved from a subspecies of the Grey Wolf, either the Pale-footed (or Indian) Wolf (*Canis lupus pallipes*) or the Arabian Wolf (*Canis lupus arabs*). This is most likely to have occurred when people changed from being hunter–gatherers to having a more sedentary lifestyle growing crops, thus allowing for increased commensal interactions between humans and wolves, and providing the opportunity for domestication, which occurred between 6,000 and 10,000 years ago. However, it is now apparent that the early evolutionary pathway of Dingoes diverged into two distinct streams, one in western Asia and the other in eastern Asia.

In western Asia, the early Dingoes were subjected to intense artificial selection pressures by humans from the very beginning. Canine–human interactions depicted in early cave paintings, etchings and frescos in tombs, pyramids and middens suggest that the major reasons for selective breeding (domestication) were to improve the characteristics of Dingoes for hunting, herding, hauling, guarding, scavenging and fighting. Later on, Dingo 'breeds' were created and kept for their comfort and companionship. The ultimate outcome of the many mechanisms of domestication is the immense range of sizes, shapes, colours and temperaments found in modern breeds of dogs. Few people are aware that this plethora of about 600 true dog breeds was derived from a single uniformly structured canine, the Dingo.

Few people are aware that this plethora of about 600 true dog breeds was derived from a single uniformly structured canine, the Dingo.

By contrast, in eastern Asia (particularly Thailand), the early Dingoes were never subjected to selective breeding or other artificial selection pressures. They have remained virtually unchanged in morphology for at least 5,500 years, during which time they were transported by Asian seafarers to other parts of the world including Australia. Such visitors (and their Dingoes) to Australia included the Austronesians (1,000–5,000 years ago), the Macassan trepangers (90–350 years ago) and, most recently, the 'boat people' from Vietnam and the so-called 'illegal' Indonesian fishermen. Most probably, Dingoes accompanied the Asian seafarers mainly as a source of fresh food during long sea voyages, as well as to warn of intruders at temporary campsites along the way. As discussed later, however, ever since Europeans began exploiting the resources of Asia, some 400 years ago, the integrity of these Dingo populations began to be eroded, thanks to hybridisation with the Dingo's evolutionary progeny—domestic dogs.

In this respect it is interesting to note that a wild Dingo may be tamed, but not domesticated. If particular standards are selectively bred into 'show

Dingoes', they eventually will cease to be Dingoes and become just another breed of dog.

Another important offshoot from these evolutionary studies concerns the naming of Dingoes. The name *Canis familiaris dingo* was originally proposed over *C. dingo* to reflect the idea that Dingoes were feral dogs. But because we now know this not to be true, and that Dingoes in fact evolved from wolves and domestic dogs evolved from Dingoes, a formal recommendation was made in 1982 to change the name to *Canis lupus dingo*, although this is yet to be ratified by the International Commission on Zoological Nomenclature. This would also mean that the scientific name for dogs must be *C. lupus familiaris* (not *C. familiaris*).

WHAT ROLE HAVE DINGOES PLAYED IN shaping and maintaining ecological relationships in Australia? New arrivals to a continent must, to some extent, affect native species by preying on them or competing for resources, particularly those with similar living requirements (ecological niches). This is true of Dingoes in Australia where they contributed to the extinction of Thylacines (*Thylacinus cynocephalus*) and Devils (*Sarcophilus harrisii*) by outcompeting them in times of food shortages during droughts and after fires. Essentially Dingoes could form integrated packs but the marsupials could not. In more recent times, some of the Dingo's interactions have been mediated by the European exploitation of Australia, leading to the extinction of bandicoots, small kangaroos and other mammals in central Australia. How did this occur?

After Dingoes came to Australia about 4,000 years ago, their numbers would have been kept low by natural influences; social factors and diseases would have systematically and periodically reduced them. The main social factor was infanticide, whereby the dominant (alpha) female kills all the pups of all other females in the pack. With European settlement and the development of the pastoral industry in inland Australia about 100 years ago, Dingo

DINGOES

Classification
Family Canidae. Four of the 26 subspecies of Grey Wolf, including the Thai Dingo and 3 from Australia: the Alpine, Desert and Tropical Dingoes. The specific designation of *Canis lupus* over *C. familiaris* has been recommended but awaits ratification from the International Commission on Zoological Nomenclature.

Distribution
Dingoes most likely evolved from the Pale-footed Wolf (*C. l. pallipes*) on the South-east Asian mainland 6,000–10,000 years ago and were subsequently transported to most regions of the world. Today pure Dingoes are only found in southern mainland Asia, especially Thailand; central southern Africa; and some islands including Madagascar, Indonesia, Borneo, Philippines, New Guinea and mainland Australia.

Size
Total length 1.23 m, height at shoulder 0.57 m, weight 15 kg (mean measurements). Males are larger than females, and Australian Dingoes are larger than Thai Dingoes.

Coat Colour
Ginger, varying from sandy yellow to red-ginger, black-and-tan, solid black, white. Most have white markings on the feet, tail tip and chest; some have black muzzles.

Breeding
Females are sexually mature at 2 years (sometimes 1 where packs are fractured) and have an annual oestrous cycle. Males breed continuously except in hot arid areas where there is a seasonal testis cycle. Gestation is 63 days and litters of 1–10 (mean 5) are born in the cool months, but can be in all months in the tropics.

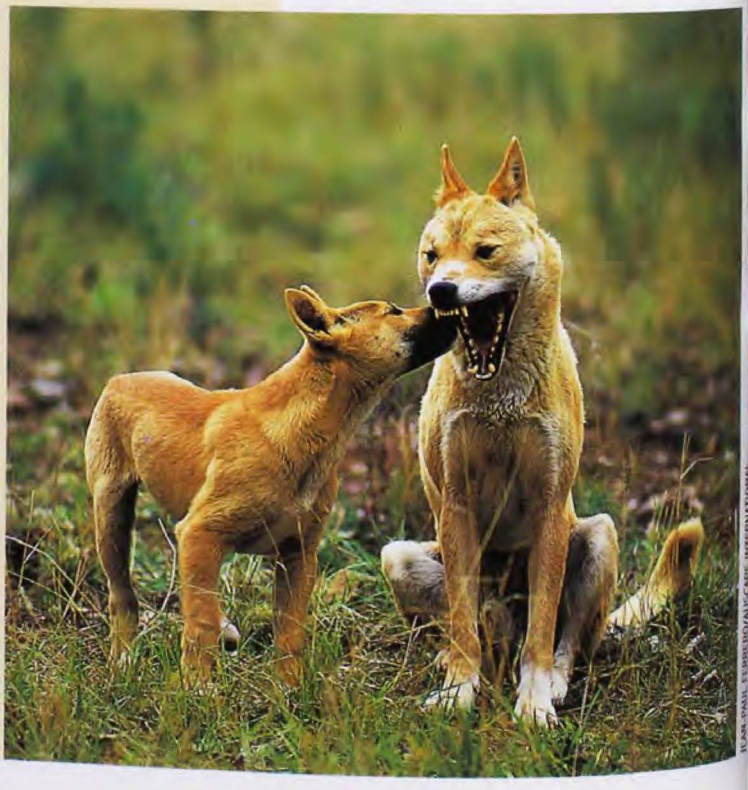
Social Behaviour
Packs of 3–12 in remote wilderness areas with a strong social hierarchy; breeding usually confined to the dominant alpha pair. Solitary to loose associations (tribes) of several animals in pastoral areas. Howling and scent posts frequently used for communication especially in the breeding season.

Habitat
All habitats from cool temperate mountains to hot arid deserts to tropical wetlands. Dingoes have been excluded from sheep lands in SE and SW Australia.

Territory
Size varies with local resources, not pack size; mean size of 77 km^2 in NW Australia, 67 km^2 in the Simpson Desert, 39 km^2 in Kakadu NP and 21 km^2 in Kosciusko NP.

Diet
Dietary specialists with a broad range of generalist hunting strategies. Over 177 prey species recorded but about 80% of the diet is made up of just 10 species.

Population Control
Natural methods include disease, particularly heartworm and distemper, and infanticide. Human control methods (trapping, poisoning, shooting) can be inefficient and may actually increase Dingo numbers.



In the hope of a feed, a young Dingo attempts to get an adult to regurgitate a piece of meat.

DAVE WATTS/NATURE FOCUS

This female Dingo searches for food in the snow. Skull measurements seem to indicate that the Australian Dingo is made up of three regionally distinct populations: alpine, desert and tropical.

numbers exploded as food (rabbits, stock and kangaroos) became more plentiful and artesian bores and dams increased water supplies during drought. Also, control methods for Dingoes (trapping, poisoning and shooting) were usually ineffective and in many cases probably only fractured packs into smaller units, each with a breeding female. In this way the Dingo's population suppression method, infanticide, was discouraged, so that Dingo numbers increased abnormally during flush periods. In addition, most of the victims of many Dingo control programs were probably young and old individuals so that surviving populations tended to consist mainly of middle-aged Dingoes; these animals were probably the most likely to mate and raise litters successfully by themselves. The total Dingo population in Australia probably peaked between 1930 and the late 1950s.

At that time in central Australia, predation on medium-sized, surface-living marsupials would have become increasingly severe as Dingo populations grew. The open plains, which once supported stands of long perennial grasses, would have been depleted by cattle and rabbit grazing, and stripped bare during drought. Any creatures depending on long grass or small shrubs for shelter were thereby rendered homeless and vulnerable to predation. Rather than feral cats and foxes, whose populations also crashed in drought, the Dingo was undoubtedly the main culprit in the extinction of these species in central Australia.

Not only has the Dingo shaped the Australian environment, but the Australian environment has shaped the Dingo. Recent scientific evidence indicates that Australian and Thai Dingo populations are sufficiently distinct in skull and body morphology to warrant subspecific status. Further, analysis of skull measurements of Dingoes within Australia indicates the existence of three regionally distinct populations: alpine, desert and tropical. The appropriate nomenclature for these subspecies, when recognised, should be *Canis lupus dingo* (Alpine Dingo), *C. l. macdonnellensis* (Desert Dingo), *C. l. cobourgensis* (Tropical Dingo) and *C. l. siamensis* (Thai Dingo).

In Australia, the life history of Dingoes has been shaped by drought. In pre-European times, droughts meant huge changes in food and water sources, compared to the situation today where carcasses and artesian waters buffer Dingoes through droughts. During extended drought, when all prey became scarce, most Dingoes were faced with starvation and the mortality rate was probably high, particularly for pups. Dingoes could not maintain their large packs with one alpha pair, and members hunted and bred separately or in small units. Such a capricious environment may have demanded the common reproductive selection strategy of the more pups born, the greater the chance that some would survive adverse periods. Since most breeding Dingoes would have been closely related, at least some of the alpha pair's genes would survive to the next generation if all pregnancies went to term and if some of the smaller pack units were able to survive. This hypothesis explains why Dingoes perform infanticide rather than suppression of copulation as occurs in their wolf forebears.

MOST PEOPLE PRESUME DINGOES ARE opportunistic generalists that eat everything in sight but, in reality, Dingoes are specialists and focus on a narrow range of prey. An examination of almost 13,000 dietary samples gathered throughout Australia over 20 years revealed a total of 177 prey species but only ten of these species comprised

almost 80 per cent of the Dingo's diet. In order of greatest frequency these were: Red Kangaroo, Rabbit, Swamp Wallaby, cattle (mostly carrion), Dusky Rat, Magpie Goose, brushtail possums, Long-haired Rat, Agile Wallaby and Common Wombat.

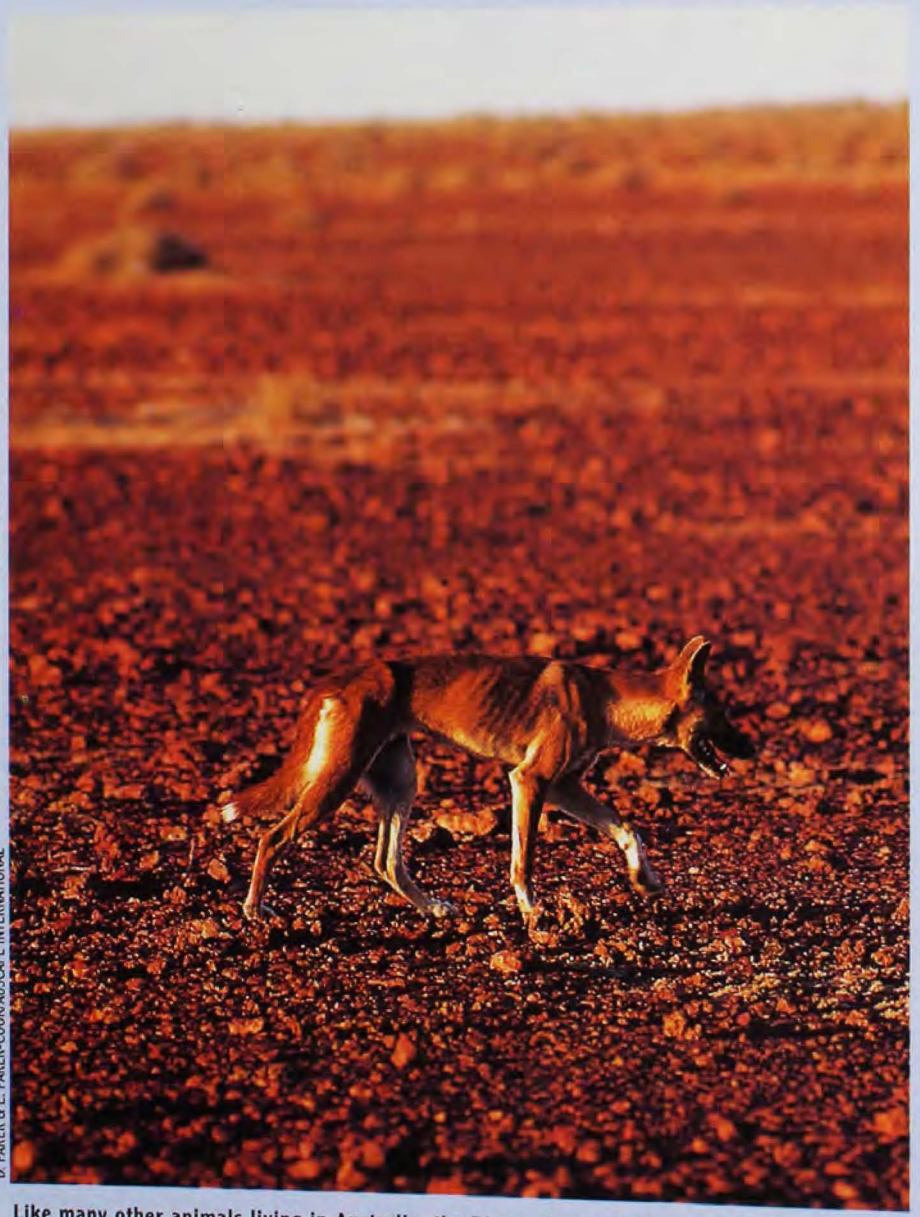
That Dingoes seem to ignore many potential prey species, especially reptiles, is surprising and difficult to explain. One reason may involve a 'search image' for particular prey that Dingoes sometimes develop. For example, several generations of Dingoes lived on rats on the Barkly Tablelands, but when rat populations crashed, so too did the Dingoes. They starved even though alternative food was in abundance. Sometimes, however, Dingoes are justifiably renowned for their adaptability. Dingoes living in the gibber country on the western edge of the Simpson Desert, for example, normally subsist on a variety of small vertebrates. During one drought year when these prey were rare, Dingoes capitalised on large flightless grasshoppers that suddenly appeared.

Although Dingoes may be dietary specialists, the methods they use to capture prey are diverse and Dingoes justifiably deserve their reputation as feared and relentless killers. Tactics used to catch prey may differ from those used to kill them, and hunting success depends on many factors including the number of attacking Dingoes, the age and size of prey, the anti-predator behaviour of prey, hunting terrain, Dingo social status, health of prey and Dingo, and the Dingoes' hunting experience.

Large kangaroos (mean adult weight 17–66 kilograms) are sighted, bailed up, and then killed. Packs of Dingoes are more than three times as successful at bailing up kangaroos and more than twice as successful at killing them than are Dingoes hunting by themselves. Small and medium-sized macropodids (mean adult weight 3–20 kilograms) are similarly killed, but Dingoes hunting alone rely more on scent than sight to trail the quarry, so they are often several hundred metres behind them and the chase may last several hours.

Nearly all attacks on cattle are aimed at young animals, from the newborn to sub-adults; healthy full-grown adults are rarely attacked. There are three basic hunting tactics. Dingoes may constantly harass a mother with a dependent calf so that when she eventually tires or

ARE DINGOES NATIVE AUSTRALIANS?



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

Like many other animals living in Australia, the Dingoes' way of life has been shaped by drought.

According to the Oxford Dictionary, a native animal is one that is inborn, indigenous, or derived from one's country. That disqualifies Dingoes because they evolved in Asia and were transported to Australia by Asian seafarers. (It also disqualifies Aborigines because they too originated outside Australia.) The definition is clearly inappropriate. Over the past 4,000 years or so, the Dingo has interacted with indigenous animals in Australia, and responded to and changed aspects of the environment. For example, competition and predation from Dingoes probably caused the extinction of Thylacines. Thus, in a functional and evolutionary sense, Dingoes are as much a part of the Australian environment as, for example, kangaroos, which are indigenous, having evolved within Australia from the megafauna of earlier times.

Defining a native Australian animal as one that arrived in Australia before European settlement is also inappropriate because some, such as rabbits, that arrived in Australia after 1788 are now unique to Australia. The physiological and genetic differences between rabbits in Australia and the original Spanish rabbits are due to their interaction with the peculiarities of the Australian environment. Australia is unlikely to ever be free of rabbits so the implication is that we have a native Australian rabbit. Similarly, feral cats and foxes have caused extinctions and modified environments, and will probably be in Australia forever; so, in that sense, they also can be considered as Australian mammals.

So, what constitutes a native animal? It is simply one that lives in Australia and has ecological and/or cultural impact, regardless of taxa, birth site, race, language, length of time in Australia etc. Accordingly, the Dingo most certainly is a native Australian.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Three-week-old Dingo pups at their den entrance. Such pups have been taken for the pet trade as they are easily handled, however tamed adult Dingoes do not necessarily make good pets.

relaxes her guard, the Dingo delivers a crippling bite to the calf. Dingoes may also spook a mob of cattle while drinking, with the aim of separating a mother from her calf. Alternatively, Dingoes sit, wait and watch a mob of cattle for any debilitated calves. Once spotted they may attack it directly or wait until it dies. There are many anecdotes about Dingoes' prowess at killing sheep, none better than the assertion of a Queensland farmer who believed a single Dingo ripped out the throats of 600 sheep in one night. Research, however, indicates less spectacular success. For example, one study observed 61 attacks of which 26 sheep were seriously injured and only eight were killed. Many of these attacks were not motivated by a Dingo's need for food and clearly constituted general harassment.

Dingoes usually hunt alone to catch rabbits. They may locate individuals by sight or scent, but will often make a regular tour of known rabbit warrens, especially warrens containing rabbit kittens, for greater success. Many adult birds are captured when they are moulting (and thus unable to fly), otherwise Dingoes eat young nestlings or newly fledged birds that are easily captured. Dingoes also usually hunt alone to catch small prey and rely mainly on their hearing and smell to find rodents, grasshoppers etc. moving about in grass and other vegetation. They capture these prey by pouncing on them with their forepaws. Dingoes also readily scavenge food, particularly cattle carrion, which becomes plentiful during drought in arid regions of Australia.

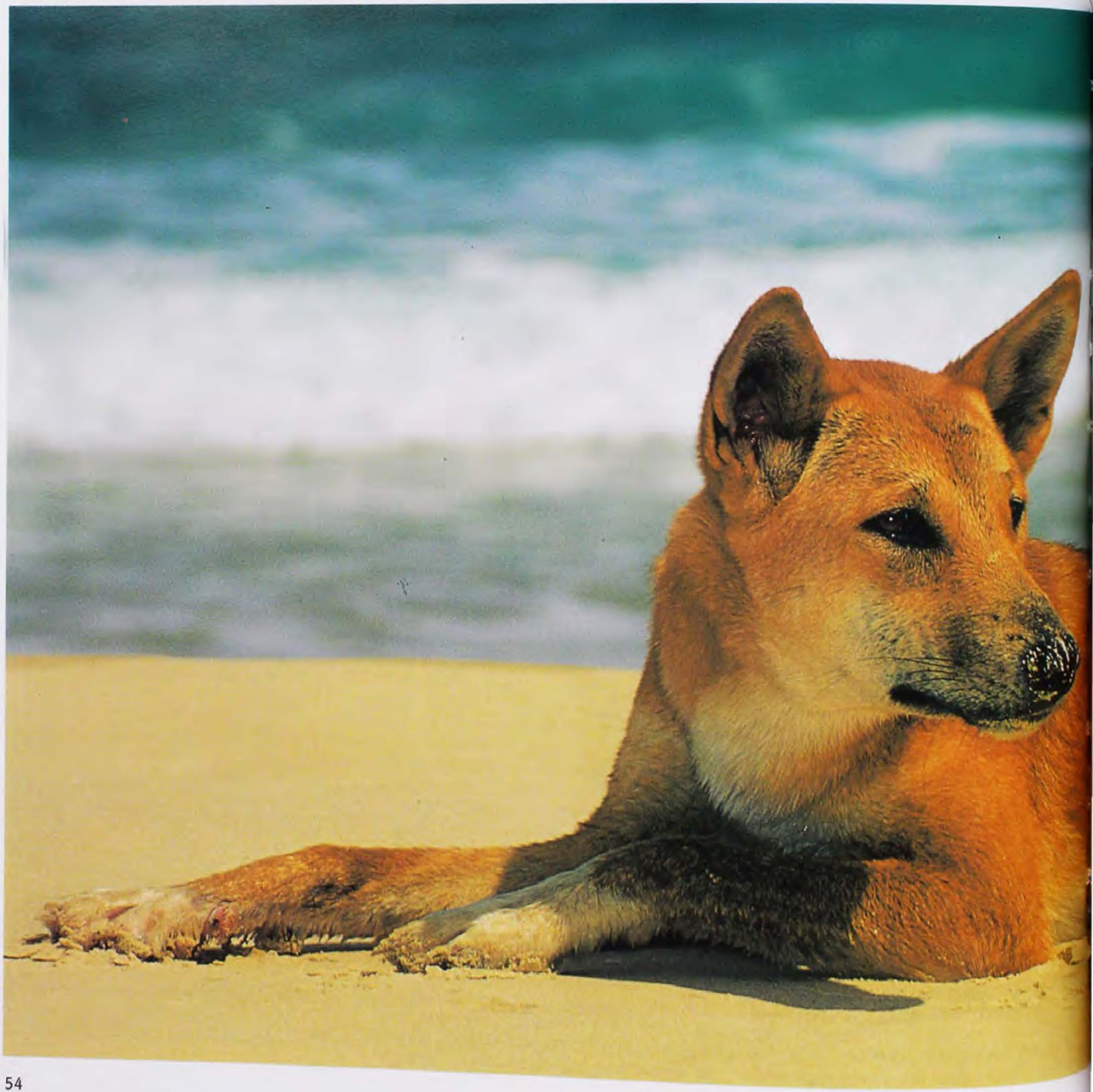
Pastoralists have so feared Dingoes that many millions of dollars have been spent over the past 150 years or so trying to kill them or exclude them from pastoral areas but, in many cases, it has not worked. Recently, in a major turnabout, some pastoralists now use Dingo predation to minimise calf losses, improve cattle breeding and increase grass supplies. In flush periods Dingoes mostly eat rabbits and rodents, the major grass competitors, so it is not the time to kill Dingoes. In the first months of a drought when rabbits and small native prey decline, Dingoes kill calves that might have survived a short drought, so this is the time to kill troublesome Dingoes. If drought continues, suckling may reduce their mothers' chances of survival, so Dingoes should be allowed to kill calves then. Straight

after the drought rodents and rabbits multiply and Dingoes switch back to them. Dingoes sometimes curb the increases in these pests for up to two years, giving pastoralists time to set up other controls such as myxomatosis or warren ripping.

AS INDICATED EARLIER, DINGO NUMbers probably trebled after European settlement. But although the numbers of wild canids living in the bush have remained high, the proportion of pure Dingoes has rapidly declined due to crossbreeding with domestic dogs. If the present trend continues, pure Dingoes will be extinct by the end of the 21st century. What is the nature and seriousness of this threat and can anything be done to reduce it?

The last bastions of pure Dingoes in Australia are in the northern tropical regions (94–100 per cent of samples were pure). There are no areas in southern Australia with populations of pure Dingoes (35–77 per cent of samples were crossbreeds). The two most common situations in which Dingoes and domestic dogs make contact are when dogs go bush, and Dingoes come to town. In past times, when domestic dogs 'escaped' into the bush, the behavioural differences between Dingoes and dogs was great enough to make it difficult for dogs to infiltrate Dingo society and breed, particularly in remote areas where there were more Dingoes. Unfortunately, there is now a trend for town people to (illegally) acquire Dingo pups as pets. The pups may be easily handled, but tamed adults are not good pets. A 'pet' Dingo is likely to use its owner's home as a base from which to roam and do as it pleases, or else it is

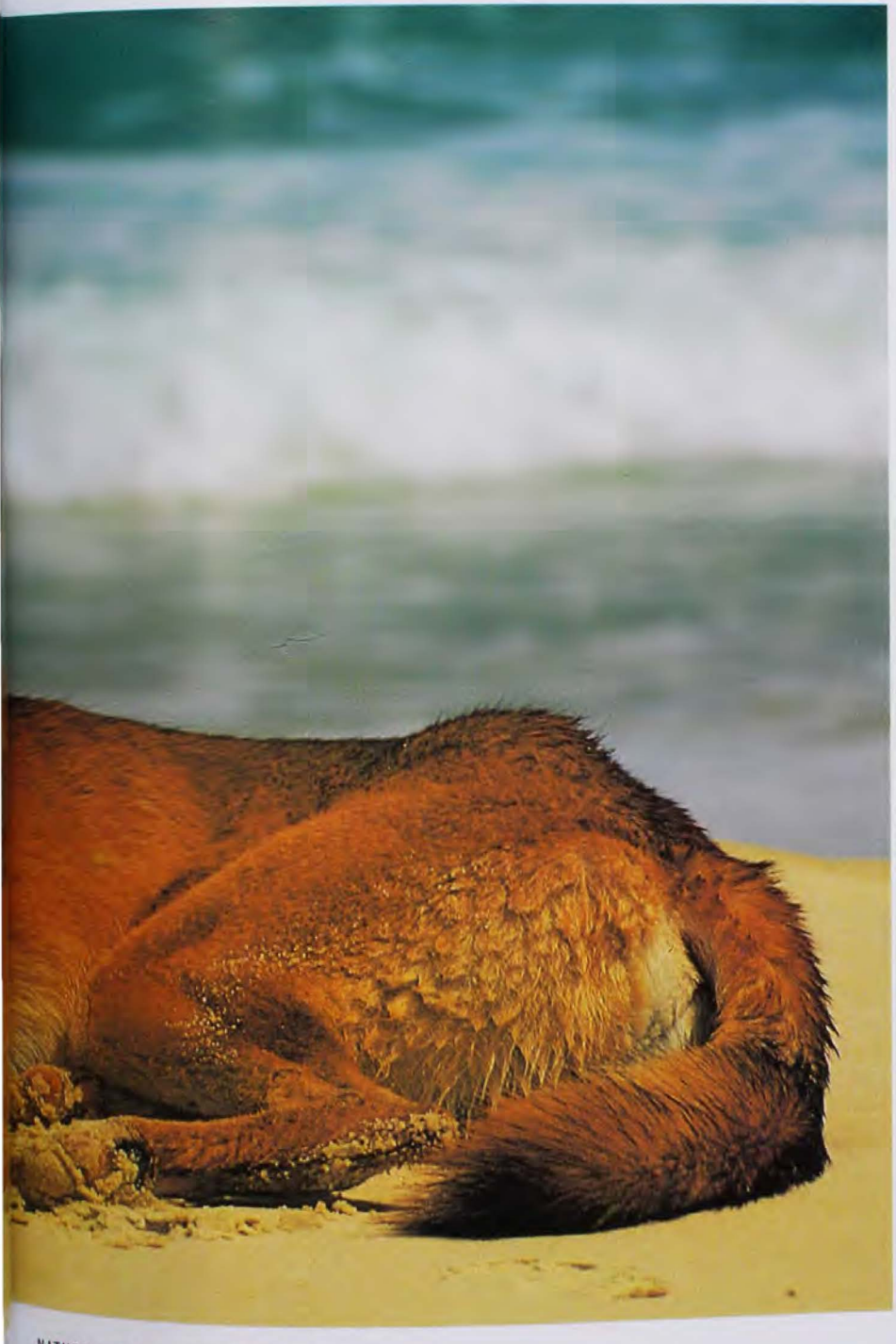
It may be that offshore islands, like Fraser Island, offer the best hope for preserving pure Dingoes in their natural habitat.



JOE SHEMESH

abandoned when it becomes an adult. The upshot of this 'pet' trend is that Dingo–dog contact is increased; because pet Dingoes have grown up in the urban situation without those social behaviours that curb breeding, cross-breeding is also markedly increased. Many such hybrids end up in the bush where their Dingo genes make it easier for them to infiltrate wild Dingo society and breed with pure Dingoes. This process occurs most frequently in semi-rural areas outlying large urban centres, such as near Darwin and Alice Springs where ten per cent of the people live on two- to five-hectare blocks.

Education is the best way to help people understand the Dingo's plight and push for policies to retain the species as part of Australia's national heritage (see "Are Dingoes Native Australians?" box). Part of this push must come from Dingo preservation societies. Members of these societies generally are dedicated people who legally obtain Dingoes to help preserve the species; to keep them as pets; for one-upmanship (bragging); as a human concern that animals should not be unnecessarily killed; and for financial gain. In mid 1993, through the efforts of the National Dingo Association and various preservation societies, the Dingo was recognised by the Australian National Kennel Council as an official breed and adopted as Australia's national 'dog'. However, unless there are adequate safeguards to assess and register pure Dingoes, this landmark decision is likely to speed up the extinction of pure Dingoes by actually increasing the numbers of hybrids. Identification of pure stock can only be done with skull measurements and backed up with scientifically confirmed coat colours and breeding patterns. In future, Dingoes may be assessed for purity by DNA fingerprinting techniques or by skull measurements from X-rays of live Dingoes, but such techniques are presently not available.



Apart from the contamination of the Dingo's gene pool, hybrids pose more of a threat to the pastoral industry than pure Dingoes do; because female hybrids (similar to domestic dogs) can come into oestrous twice each year, they are capable of killing many more calves than pure Dingoes can. This is because sexually excited (breeding) Dingoes attack calves more frequently than non-breeding Dingoes, yet paradoxically do not eat them. Also, in urban areas, hybrids are probably more dangerous to humans than most pure domestic dog breeds, at least if wolf hybrids are anything to go by. There have been eight human fatalities caused by 'pet' wolf hybrids in the past few years.

Given these potential problems, are other options available to preserve Dingoes? Assuming that most mainland Australian habitats will never again be free of hybrids and domestics dogs, perhaps large offshore islands offer the best hope of preserving Dingoes in their natural habitat. There are many islands around the Australian coastline, and they represent many climates and habitats. Many are also big enough for Dingoes to live and breed in partly or completely natural conditions. Fraser Island is perhaps the best known example where people take pride in preserving the integrity of local Dingoes and even enact by-laws to minimise cross-breeding with domestic dogs.

So what does the future hold for the survival of the Dingo? It may well hinge on the traditional love–hate relationship. If people have felt so strongly about Dingoes in the past, they will probably continue to have strong feelings in the future but, from the knowledge we now have of Dingoes, these feelings will be made on an informed basis, rather than on hearsay. Given this, contact between Dingoes and domestic dogs will hopefully be diminished and people will take pride in Dingoes as native species...to be loved or hated. ■

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Dr Laurie Corbett is a Principal Research Scientist with the CSIRO Division of Wildlife Research, based at the CSIRO Tropical Ecosystems Research Centre in Darwin. Over the past 30 years, he has studied the ecology and behaviour of canids, felids, raptors and reptiles in Australia, Scotland and South-east Asia, but his special interest has always been with Dingoes.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Why would any organism take up residence in an environment as inhospitable as a tropical cave?

IN THE DARK ABOUT TROPICAL CAVES

BY PHILIP WEINSTEIN

CAVES ARE ONE OF THE MOST EXCEPTIONAL ENVIRONMENTS on Earth, and they contain some of the strangest creatures known. Pale and blind insects, spiders, crustaceans, pseudoscorpions, millipedes and (more rarely) fish feel their way around in the darkness of deep caves. They have adapted to life in perpetual darkness, where eyes and pigmentation offer no selective advantages.

The total darkness also has other less obvious consequences for the cave ecosystem: because there is no light, there can be no plants at the base of the food chain. Without such primary producers to consume, cave animals are totally dependent on 'fall out' from the surface. If it rains, leaf litter or other organic materials may be washed into the cave. Alternatively, a lost or injured animal may perish in the cave, providing a sudden but short-lived boost of energy to the cave ecosystem. In some caves, bats provide a regular supply of guano upon which many invertebrates feast, but this luxury rarely lasts all year. In short, resources are scarce and unpredictable compared with those in most other ecosystems.

Many animals will make use of the shelter provided by the entrance zones of caves. These Oleander Butterflies (*Euploea core corinna*) are congregating in such an area.

CLAY BRYCE/LOCHMAN TRANSPARENCIES

GEOFF TAYLOR/LOCHMAN TRANSPARENCIES

With no eyes or pigment, this Blind Gudgeon (*Milyeringa veritas*) from Western Australia is well adapted to life in a cave.

Deep caves tend to maintain a fairly constant temperature, averaging the annual temperature in the area. In tropical caves, this temperature is often in the 30s, and cave atmospheres are saturated with water vapour. Tropical cave insects have to cope with this 100 per cent humidity, which makes the caves more akin to an aquatic environment than a terrestrial one. The hot humid atmosphere has another important consequence for the cave dwellers: any organic material that does enter the cave ecosystem decays very rapidly, breaking down under the action of micro-organisms, which thrive in hot humid conditions (see box). These micro-organisms can increase the concentration of carbon dioxide to as much as four to five per cent (over 100 times the concentration at the surface) and sometimes also deplete the oxygen from the cave atmosphere to dangerous levels. In 'foul air' caves, a combination of carbon dioxide levels above six per cent and oxygen levels below 17 per cent can be lethal, and speleologists must consequently use breathing apparatus. The cave fauna has no access to such technological luxuries, and has had to adapt or die.

Perpetual darkness, scarce and unpredictable resources, drowning atmospheres and potentially lethal gas combinations. So why would any organism take up residence in an environment as inhospitable as a tropical cave?

Troglobitic cave-dwelling animals, such as this female blind shrimp carrying eggs, display distinctly different behaviours to their surface-dwelling relatives as they must forage and find a mate by smell and feel alone.

Traditionally, this has been a relatively simple question to answer. Until recently, cave-adapted animals were known in significant numbers only from areas of heavy Pleistocene (1.5 million to 10,000 years ago) glaciation—the bastions of biospeleology in Europe and North America. Animals that became adapted to cold ice-age conditions found that they could only survive by withdrawing into cool valleys, ravines and caves when the glaciers retreated. They became trapped in these refuges, and those that survive in caves to this day have had ample time to evolve, in isolation, into the blind and pale forms that now intrigue us.

Tropical cave insects have to cope with 100 per cent humidity, which makes the caves more akin to an aquatic environment than a terrestrial one.

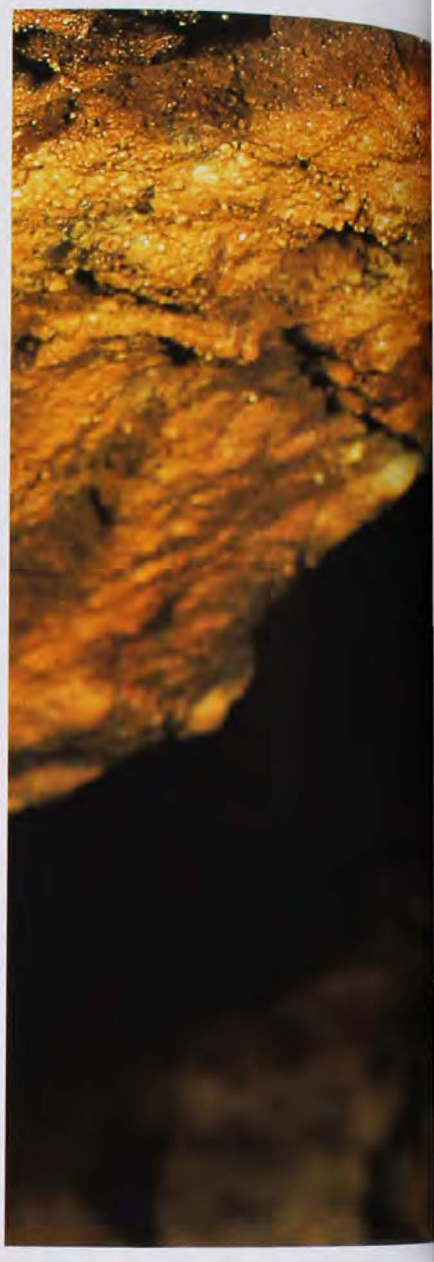
The existence of rich cave faunas in southern Australia, such as those of Tasmania, could also be explained reasonably well by this theory. Cave faunas were viewed as relicts from the Pleistocene, and it was assumed that caves in the tropics contained very few cave-adapted forms (since glaciation had not taken place there). This com-

fortable paradigm was retained until just over a decade ago, when someone had the audacity to actually look in a tropical cave to see if cave-adapted forms were as rare as they ought to have been. Frank Howarth (Bishop Museum, Hawaii) and colleagues investigated caves in tropical Queensland and found an unprecedented biodiversity of cave life. Bill Humphreys (Western Australian Museum) and colleagues did the same at Cape Range in the dry tropics of Western Australia, and tropical cave faunas in Australia were shown to rival, if not better, the biodiversity of their temperate counterparts.

One can still attempt to explain the large number of cave-adapted animals in the tropics in terms of Pleistocene relict faunas. Although no glaciations took place in northern Australia, the land dried considerably during glacial periods. Some invertebrates may have been confined to moist caves by this drying effect for the same reasons they were trapped by temperature constraints in temperate areas. However, many workers were not convinced by this argument, thinking it more likely that some other mechanism was responsible for the evolution of cave-adapted animals in the tropics. Following his research in Australian tropical caves and in Hawaii, Howarth suggested the 'direct invasion' hypothesis. This theory holds that surface-dwelling animals entered caves directly to make use of resources therein (guano, moisture), and subsequently evolved cave adaptations by a series of 'adaptive shifts'.

This 'direct invasion' theory predicts that surface-dwelling animals living near the caves should be somewhat similar to those in the caves: to invade the cave environment successfully, some degree of pre-adaptation, such as having long antennae to feel your way around, would be necessary in the surface forms. Many of these surface 'relatives' of the cave species may have become extinct since the cave invasion. However, if invasions to exploit cave resources are ongoing events, we would expect to find relatives of cave species in the general area surrounding caves in at least some instances. Such pairs of cave species and their surface 'relatives' are in fact known from Hawaii and some other tropical areas, and their existence supports Howarth's theory. On the other hand, the traditional theory, the 'Pleistocene relict' theory, predicts that no such species pairs should exist. If the cave animals evolved because the cave was the only place that their ancestors could survive, all non-cave relatives should be extinct (at least in the general area surrounding the caves). In either scenario, the species have to survive in and adapt to the cave environment. To better understand the problems confronting such cave species, let us take a more detailed look at the environment they face.

Anyone who indulges in midnight snacks knows that kitchen cockroaches are nocturnal, but cockroaches in the deep cave zone demonstrate no circadian rhythm at all.



MIKE GRAY

Lacking pigment and eyes, this troglobitic spider (family Ctenidae) hunts by roaming around until it encounters suitable prey.

CAVES CAN BE SUBDIVIDED INTO SEVERAL ecological zones: the entrance zone, twilight zone and dark zone. The entrance zone is in full daylight and is subject to the same climatic fluctuations as is the surface environment. It may, however, provide attractive shelter in the form of shade, and many animals in the dry tropics will therefore make use of cave entrance zones during the dry season. The large spectacular Old Lady Moth (*Speiredonia spectans*) can often be seen, and is easily identified by the large eye-spots on its forewings. Dragonflies and wasps sometimes also engage in this sheltering behaviour, as do many vertebrates, including lizards

MICHAEL CERMAK

Eastern Horseshoe Bats (*Rhinolophus megaphyllus*) are trogloxenes. That is, although they live in caves, they rely on the outside environment for food.

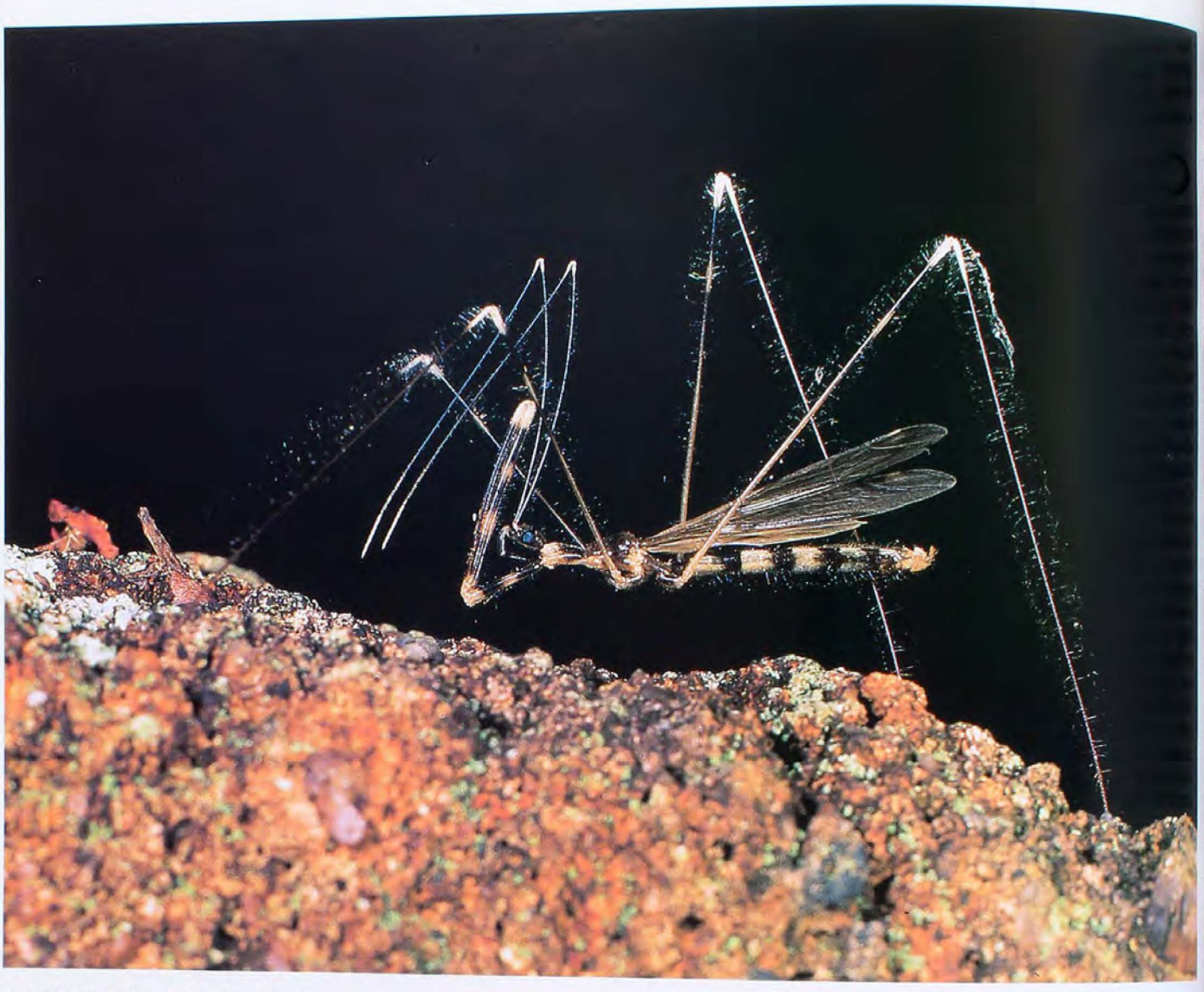
and even possums.

After the entrance zone follows the twilight zone, where, as the name suggests, light is running out. A few algae may 'cling to life' on rock faces in the dwindling light, and animals sheltering in the entrance zone often also wander into this zone. When light totally disappears, we are in the dark zone, where most of the truly cave-adapted animals are found. Because it is part of human nature to classify things, the dark zone itself is subdivided into three zones: the transitional, deep cave and stagnant air zones.

In the transitional zone, the cave insects and other animals still receive clues about what is happening outside the cave, even though they are in perpetual darkness. Most caves 'breathe' at night as warm air rises out of the cave and cold air rolls in, and in the transitional zone the temperature therefore still fluctuates by some degrees. In tropical caves this effect tends to be more marked than in temperate caves, where cave environments are more constant.

Beyond the transitional zone, the cave is totally, almost eerily isolated from the outside world. We are in the deep cave zone where, without a watch, time becomes meaningless. Animals that generally have distinct circadian (daily) rhythms loose these in the deep cave zone, because they cannot re-zero their biological clocks in response to daily changes in the environment. Anyone who indulges in midnight snacks knows that kitchen cockroaches are nocturnal, but cockroaches in the deep cave zone demonstrate no circadian rhythm at all.

Finally, within or beyond the deep cave zone, stagnant air zones can occur. These are generally areas where carbon dioxide, being heavier than air, accumulates in depressions or at the bottom of slopes. Consequently, carbon dioxide levels are high and oxygen levels low. Stagnant air zones may expand or contract, and their gas composition may change depending on the activity levels of the micro-organisms causing them. Thus to survive in these areas, invertebrates need to have versatile respiratory physiologies. These animals are more common in tropical caves, where



MICHAEL CERMAK

Assassin bugs (family Reduviidae) are troglophiles—animals that are just as capable of spending their entire life in a cave as they are in a similarly dark and moist habitat outside the cave.

stagnant air zones occur more often due to faster decomposition of organic matter at higher temperatures.

Having thus classified the cave environment, we can also classify the animals that live in it according to their biologies and their degree of cave adaptation. Animals that are associated with caves only by accident are appropriately named 'accidentals'. They include cave entrance animals that go too far into the cave and get lost, and unfortunate animals like wallabies that fall down a hole and can't get out again! Animals that live in caves but are totally dependent on the outside environment for food are known as trogloxenes. The best example of a trogloxene is the insectivorous bat that must leave the cave every night to catch its dinner. Troglophiles, on the other hand, can complete their entire life cycles in the cave, but need not necessarily do so (facultative cave dwellers). Some tropical cockroaches (in the genus *Paratemnopteyx*), for example, may survive happily in the twilight and transitional zones of caves, but can also live in other similarly dark and moist habitats, such as in leaf litter on the rainforest floor.

In their relatively stable (if somewhat inhospitable) environment amphipods in cave waters grow bigger, live longer and produce fewer, larger eggs than their surface counterparts.

Those animals that complete their life cycles in caves and that can do so nowhere else (obligate cave dwellers) are referred to as troglobites. These are the rarest cave animals and they have the most extreme adaptations. Troglobites may have elongated appendages with which they feel their way around. In troglobitic insects, long legs and antennae are often found in conjunction with elongate sensory hairs. Troglobites may also have reduced or absent eyes, wings and pigmentation, structures that offer no selective advantage in total darkness. They may have physiological adaptations, such as a low metabolic rate, to cope with limited and unpredictable resource availability, or modified respiratory physiology to cope with the stagnant air zones. Their behaviours are usually also distinctive, because foraging and mate finding must take place by smell and feel only. Volatile sex hormones (pheromones) are used extensively by troglobites, and troglobitic spiders and centipedes hunt by detecting the vibrations caused by their prey. The life history strategies of these obligate cave dwellers are often also quite different from those that might be expected on the basis of our knowledge of surface forms. In their relatively stable (if somewhat inhospitable) environment,

for example, amphipods in cave waters grow bigger, live longer and produce fewer, larger eggs than their surface counterparts.

CLEARLY, TROGLOBITES ARE EXCEPTIONAL organisms and provide living examples of the extreme adaptations required to survive in an extreme environment. To cope with such physical and biological constraints, it is clear that the troglobites' ancestors (the theoretical cave invaders) must to some extent have been pre-adapted to cave life. We would therefore expect that a potential cave invader living on the surface would have a very similar biology to its cave-dwelling counterparts, both in terms of morphology, physiology and behaviour. Consequently, if direct invasion occurred and is still happening, we would expect the surface-dwelling relatives of cave insects not only to still live near caves in some areas as discussed earlier, but also to be biologically similar to at least some cave forms. On the other hand, if the Pleistocene relict theory is true for tropical cave faunas, we would have quite different expectations: the surface-dwelling relatives of cave insects would then be expected to be biologically quite distinct from their cave-dwelling relatives (because the former would have been subject to quite different selection pressures on the surface, evolving considerably to survive the climatic changes since the Pleistocene).

These predictions about biological similarities, and those made earlier about the existence of species pairs, can form the basis of quantifiable scientific experiments aimed at testing the two hypotheses—Pleistocene relicts or direct invaders. My colleagues from James Cook University and I are currently examining the morphology, molecular taxonomy, physiology and behaviour of a number of tropical cave dwellers and their surface relatives, with the specific aim of gathering supporting evidence for either of these two hypotheses. Our approach is unique because we are correlating results from investigations in many different fields, in order to provide the broadest biological comparisons yet attempted between cave-dwelling and surface-dwelling members of a given taxon. Research is at an early stage, and so we are still very much 'in the dark' about the evolutionary origins of tropical cave faunas. However, if the direct invasion hypothesis proves to be correct, it will have significant implications for the conservation of tropical cave faunas: the habitat surrounding the caves, which is the source of invading organisms, will need to be conserved to maintain this dynamic, evolving system. ■

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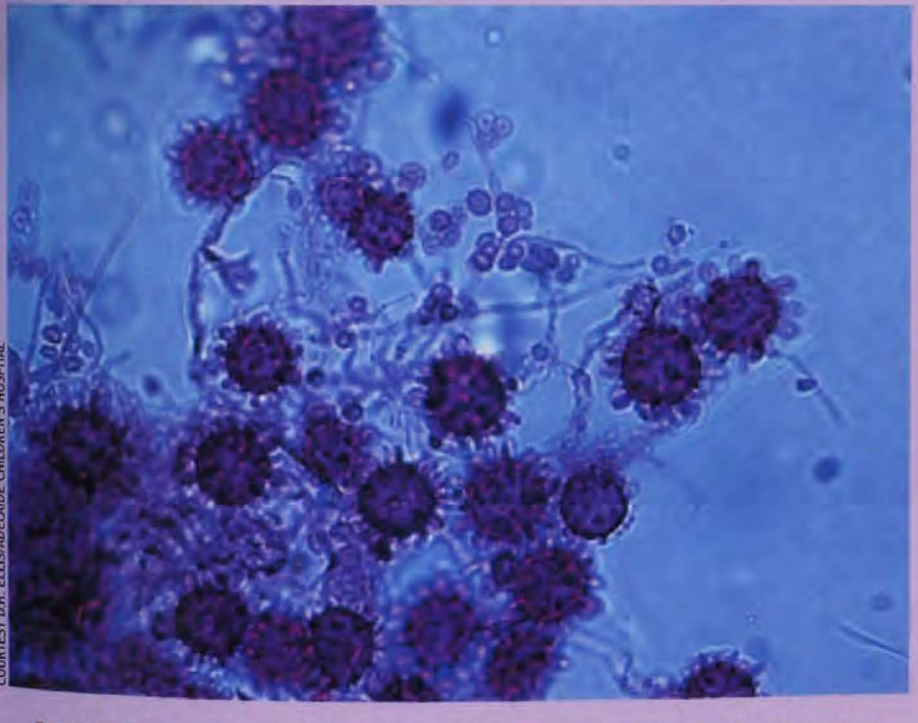
Dr Philip Weinstein is a lecturer in zoology at James Cook University, and is best known as a medical entomologist. Apart from the evolution of tropical cave faunas, he maintains an active research interest in vector-borne disease ecology and epidemiology. He coordinates the Public Health Entomology program at James Cook University, studying dengue fever, Ross River virus and malaria.



COURTESY D.H. ELLIS/ADELAIDE CHILDREN'S HOSPITAL

A close-up of the fungus *Histoplasma capsulatum* showing large spores (macroconidia) with rough walls and small spores (microconidia) with smooth walls. It is the inhalation of the microconidia that may lead to infection in humans.

INVISIBLE KILLER: *HISTOPLASMA CAPSULATUM*

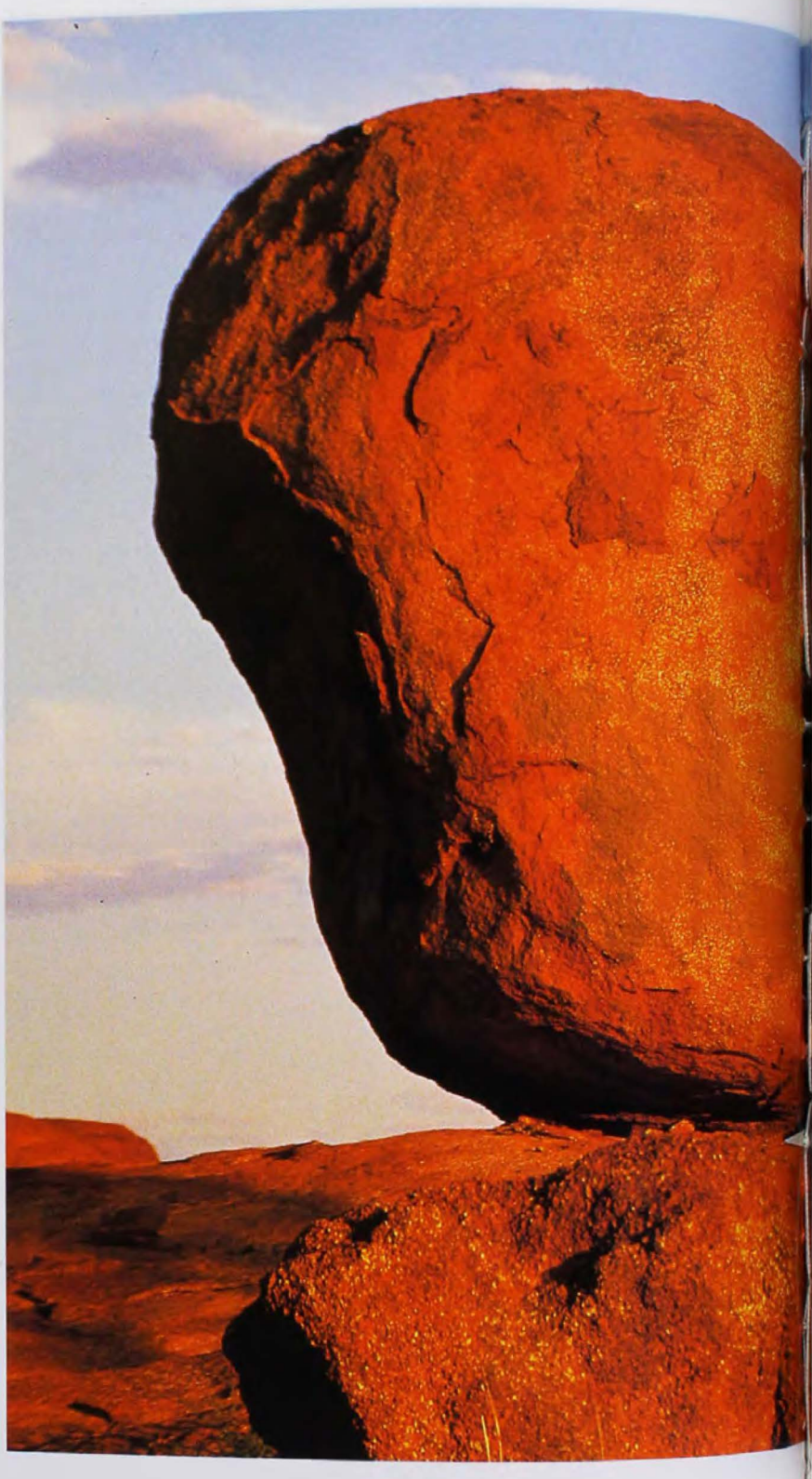
The risks of deep caving are rather obvious: climbing accidents, exposure to stagnant air zones, dehydration and exhaustion. But the warm, moist environment of tropical caves hides another, less obvious killer: the fungus *Histoplasma capsulatum*.

This fungus grows in bat guano and guano-rich soil, producing mycelia (vegetative strands) and spores, much as any other fungus. The spores are minute (two to three microns) and disperse when they become airborne. Cavers and researchers stomping through guano are therefore quite likely to inhale spores that have been stirred up, and this is where the problem starts.

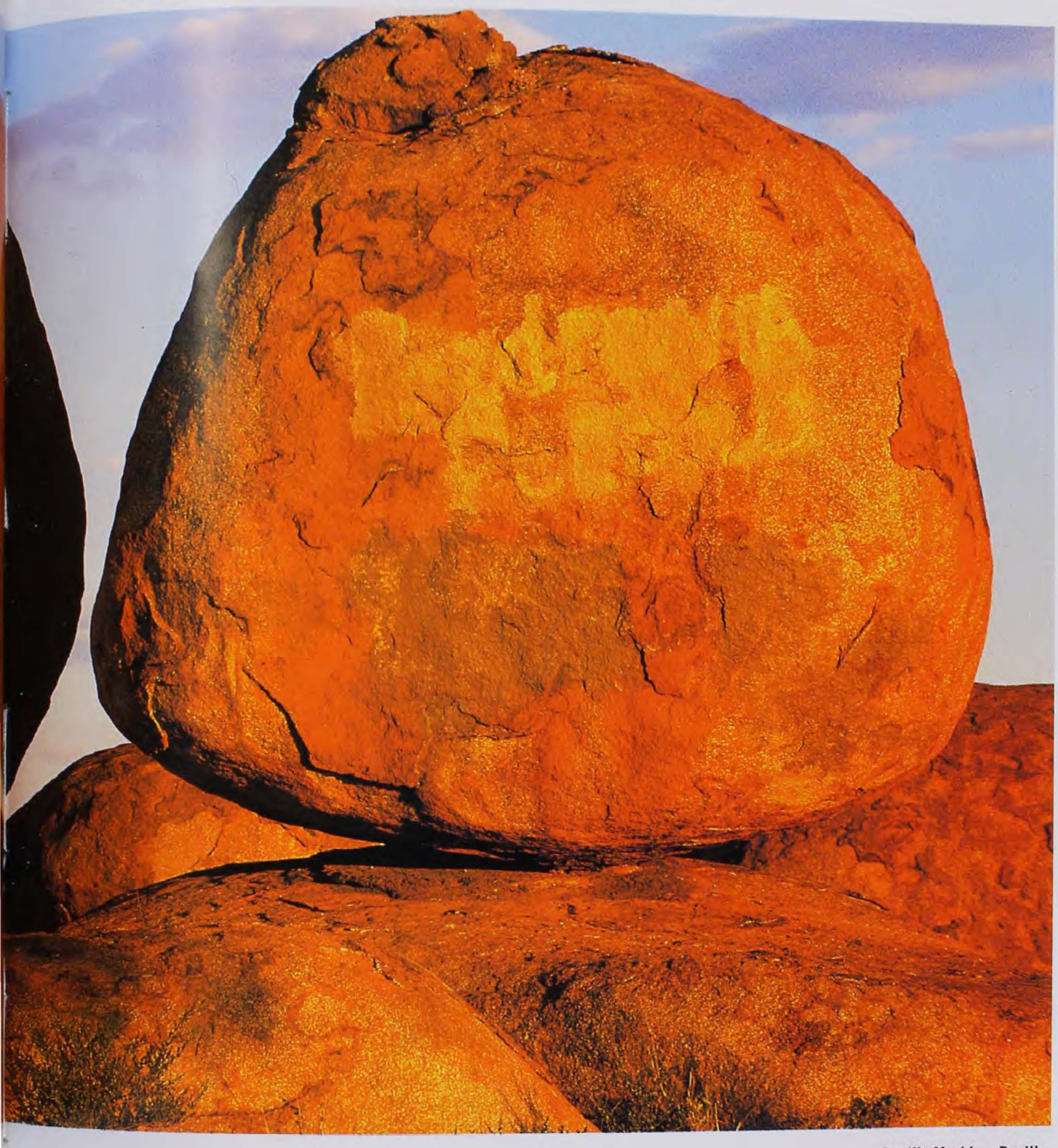
The fungal spores penetrate the alveolar (air sac) walls in the lungs, which become inflamed and produce symptoms of respiratory illness such as cough, fever, chest pain and fatigue. In this mildest form of the disease, known as histoplasmosis, the patient usually makes a full recovery and develops life-long immunity to the fungus. Less usually, the fungus becomes blood-borne, assuming the form of a yeast and disseminating throughout the body. It may then invade the spleen, liver, heart, gut or brain. Chronic infection may result and, without a barrage of antifungal treatments, the outcome is usually fatal.

Keeping this in mind, it pays to stir up as little guano as possible when caving, particularly for first-timers (who are less likely to be immune). In Australia, cases of histoplasmosis are reported every few years, and these are not just from tropical caves. In the 1970s, epidemics of histoplasmosis led to the closure of *Histoplasma*-ridden tourist caves at Wee Jasper, New South Wales.

P H O T O A R T



Wedge-tailed Eagle (*Aquila audax*) in mulga scrub near the MacDonnell Ranges.

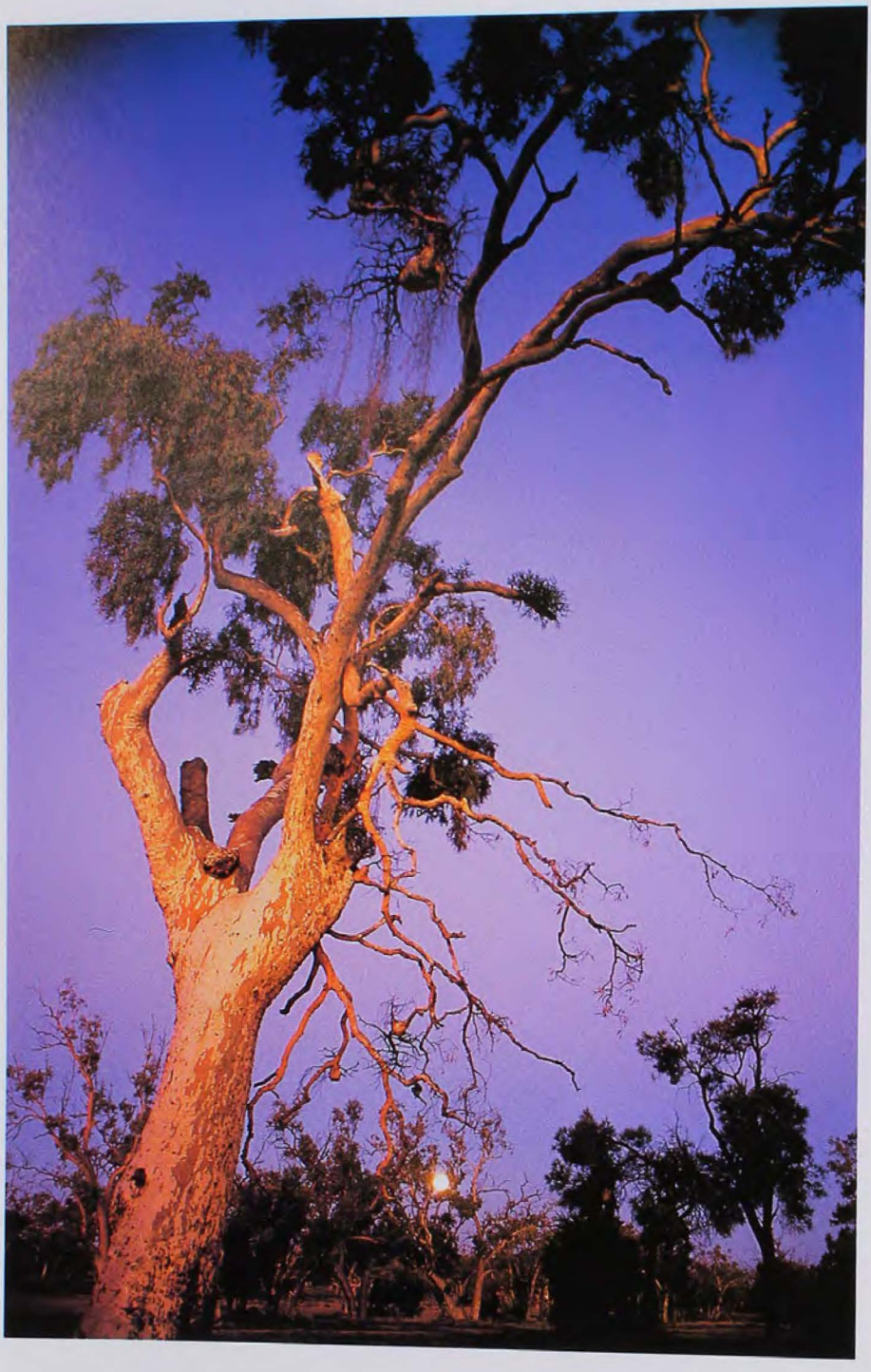


Devil's Marbles, Devil's Marbles Conservation Reserve.

NORTHERN EXPOSURE

BY STEPHAN MARSHALL/TERRA AUSTRALIS

Landscape photography is easy—or so it would seem. But the truth is far from appearances. Once Steve has decided to photograph a feature, he will go to great lengths to study all its aspects. To do this, he has to spend a great deal of time walking and climbing—even in the heat of the baking summer sun—until he knows his subject inside and out. His reward is finding new angles of traditional subjects to make them appear as fresh as if they had never been seen before.



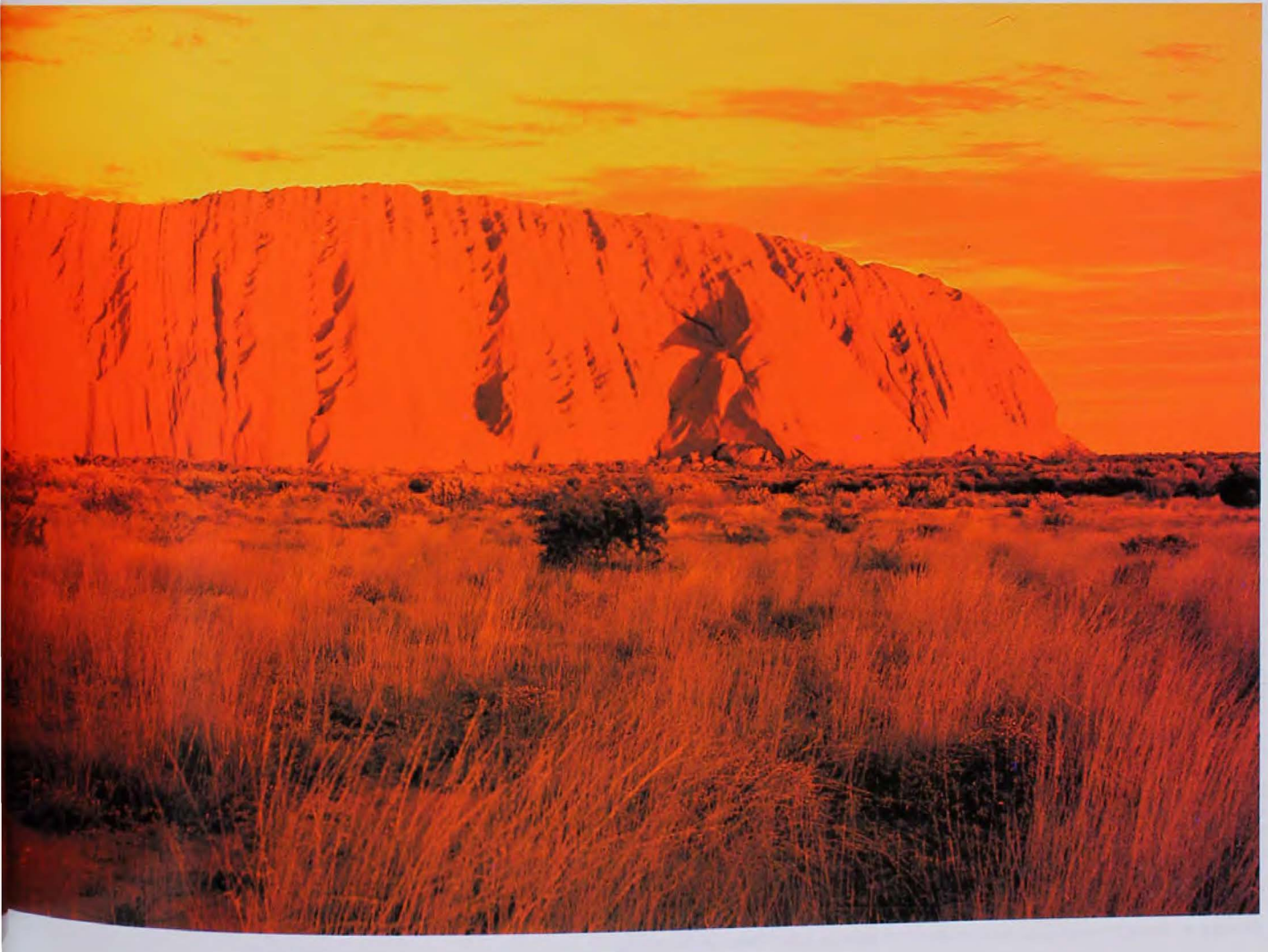
River Red Gum (*Eucalyptus camaldulensis*) at moonrise, Todd River.

NORTHERN EXPOSURE

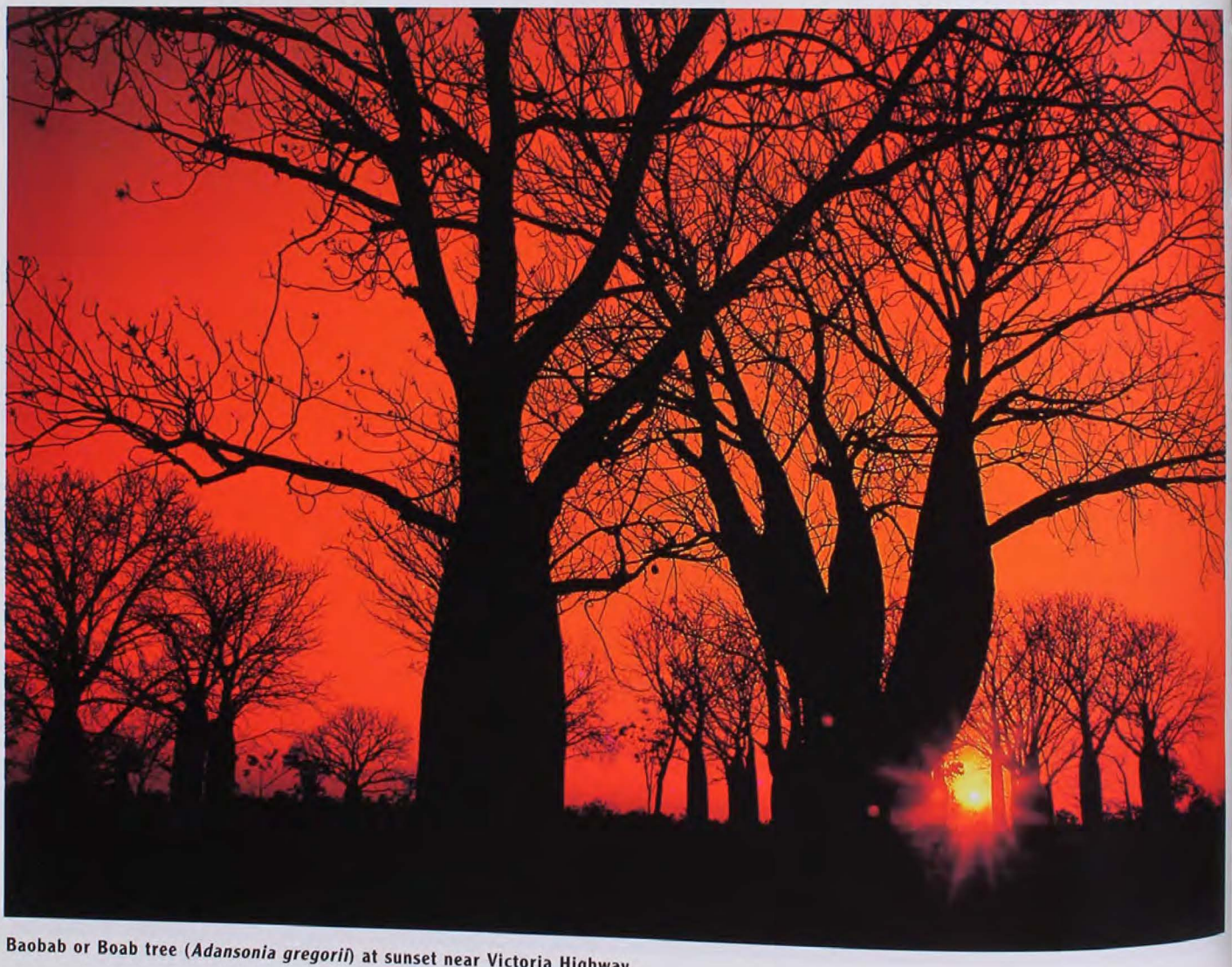
North face of Ayers Rock at sunset.

Reflection of the MacDonnell Ranges, Trephina Gorge Nature Park.

PHOTOART



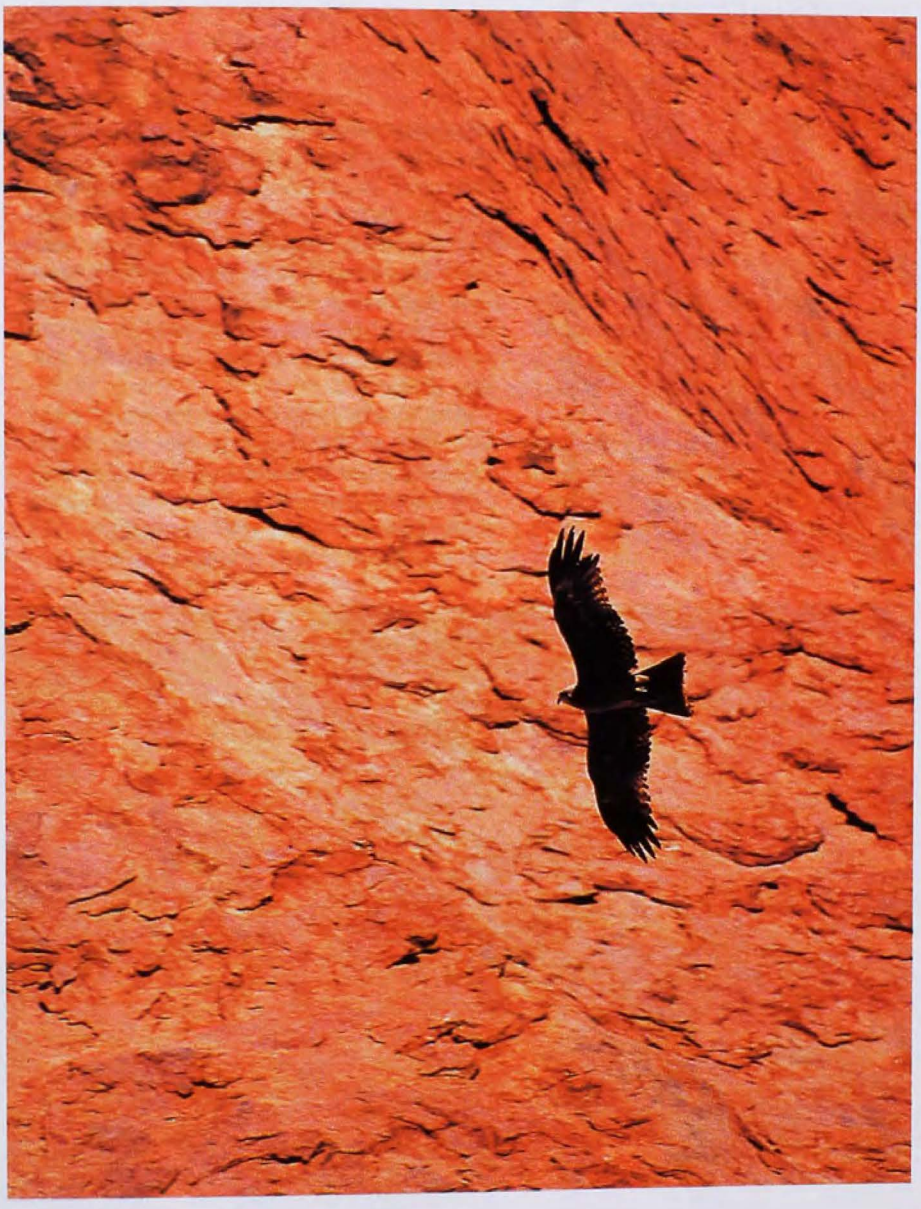
Silhouette of tourists on the climb at Ayers Rock.



Baobab or Boab tree (*Adansonia gregorii*) at sunset near Victoria Highway.

Black Swans (*Cygnus atratus*) by moonlight, Tanami Desert.

NORTHERN EXPOSURE



Little Eagle (*Hieraaetus morphnoides*) soaring in front of Ayers Rock.

PHOTOART

There they both stopped, nose to nose, nuzzled together in their last moments, 20 million years ago.

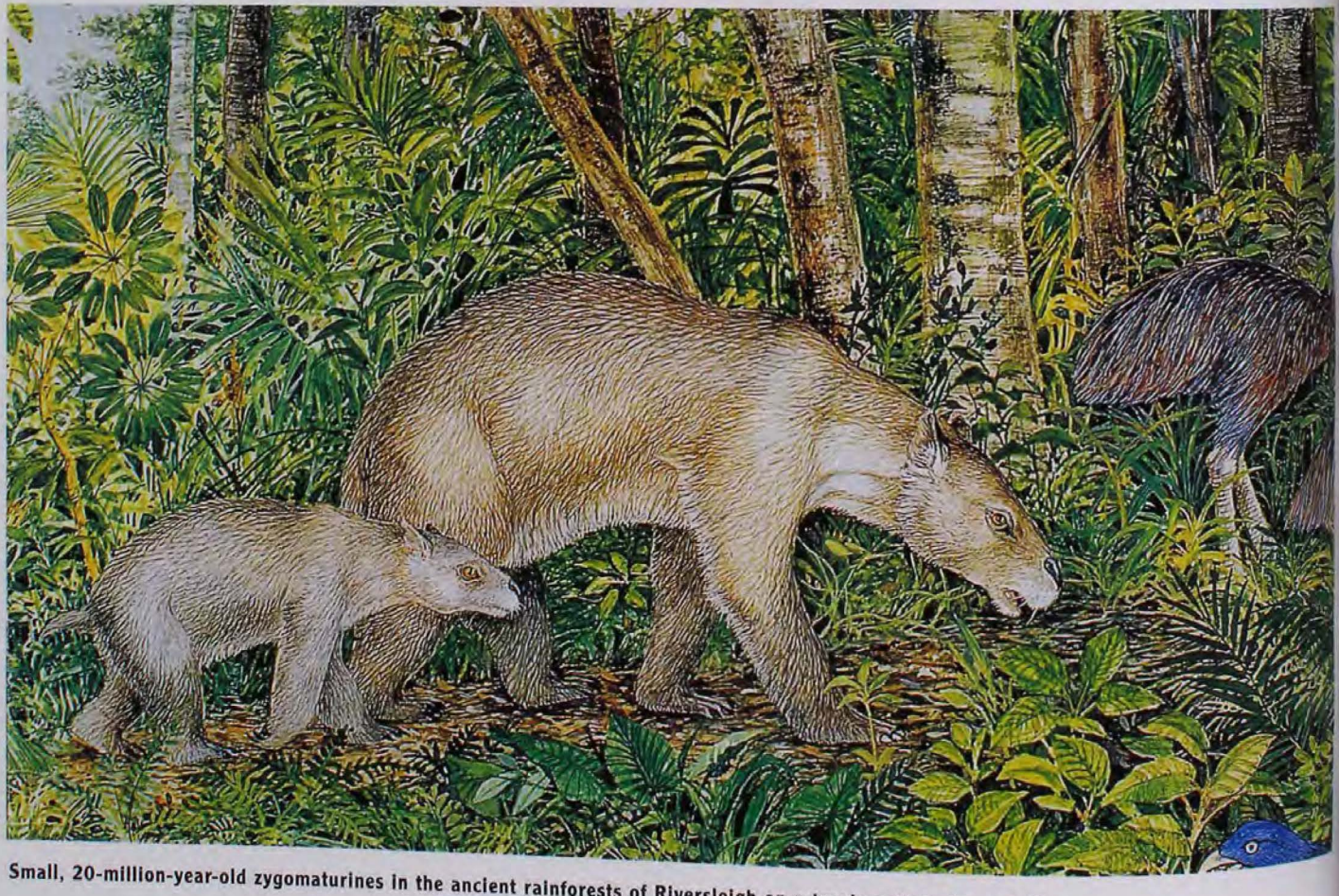
MIOCENE MADONNA & CHILD

BY MICHAEL ARCHER

FRINGED BY THE BUTTRESSED trunks of rainforest trees, the sunlit clearing was filled with green, succulent vegetation. The shattered lower half of a giant Southern Beech tree lay in the clearing. For 400 years, until the violent storm six months ago, it had been an unfailing link in the canopy of this forest. Countless generations of possums, birds and snakes had memorised the slowly changing roadways of its branches. Inside its decaying heart, leaf-lined nurseries for creatures of all kinds had been built and rebuilt. But now torn up, jagged roots, still clutching boulders and sticky soil, were its tallest parts. Days of torrential rain had nearly filled the crater where the roots once gripped. A still and unbroken carpet of leaves and twigs covered the surface of the water.

A deer-sized diprotodontid stood near the edge of the clearing. She cautiously sniffed the air to check that no marsupial lion lurked nearby. Satisfied, she gave in to the allure of the tender new plants. She nibbled the pale tops of several fern fronds before noticing the bright yellow flowers that beckoned from the tangle of roots and earth. It was a mass of epiphytic orchids that had been torn free when the giant tree fell. As she stretched her nose towards the bright morsels, she felt a stirring in her pouch. It was her six-month-old pouch-young. Although he had often watched his mother and the other adults plucking plants from the forest floor, he was not old or curious enough to eat solid foods so his just-erupting teeth had never touched a leaf.

As she leaned over the water-filled crater towards the orchid, her pouch skin tightened over his warm, milk-round body. Suddenly the earth below her forefeet gave way, tipping her headlong into the crater. He heard his mother's sharp cough of alarm. Frightened and confused, he tried to scramble free but her right rear leg had folded up against the pouch entrance. All he could manage to do was force his head out. She dug her short toes into the steep bank trying to halt her descent but the sides of the pit were now a slippery-dip of loose mud. The end came quickly. With one last call of distress, she and her trapped young slid into the cool water below. The last thing she saw was the yellow flame of the treacherous orchid that had lured her to this end. The muscles of her pouch contracted in a vain effort to seal her infant from death but it was already too late. She forced her nose towards her pouch where she felt the heat of life leaving the face of her young one. There they both stopped, nose to nose, nuz-



RECONSTRUCTION BY D. DUNPHY FROM *RIVERSLEIGH*, REED BOOKS PTY LTD

Small, 20-million-year-old zygomaturines in the ancient rainforests of Riversleigh on a tragic path to immortality.

zled together in their last moments, 20 million years ago.

It was the 8th of June 1989. "Alan, could you sledge off a piece of that fossil bat concentration near the edge of the hill there?" Suzanne Hand gestured to veteran fossil finder Alan Rackham. "Not a worry!" he sang out, and a moment later a sledge hammer thundered onto the surface of the limestone block. Radiating cracks signalled a 'pop-in-one'. While Sue investigated the adjacent outcrop at Bitesantennary Site, Alan and others, including the Vice Chancellor of the University of New South Wales (which earned the deposit the name of VIP Site), looked for the piece with the bat bones on it. He pulled the large pieces of freshly broken limestone apart and suddenly stopped. There, unseen from the surface but perfectly preserved within, was the shining tooth row of what appeared to be a medium-sized diprotodontid skull. When the other pieces were examined, it was soon obvious that a complete skull as well as parts of the skeleton were contained in the block. With hoots of excitement, it was all carefully gathered up for transportation to the preparation lab at the University of New South Wales.

Back in Sydney, Anna Gillespie bound all of the pieces of limestone back together with epoxy resin, once again hiding the treasure within. Then, after a few weeks in dilute acetic acid with careful preparation stops along the way to ensure it remained intact, a stunningly perfect skull appeared (missing only its third upper incisors), one that clearly represented a new genus of zygomaturine diprotodontids that was unique to the site. It is now under study by PhD student Karen Black.

Enticed by the thought that more bits of this new, spectacularly well-preserved diprotodontid might be hiding in the unexamined parts of the block Alan had first sledged, the 1990 Riversleigh Expedition returned to VIP Site to look for more. Holes were drilled in the thick projecting slab and light explosives used to cleanly fracture more of the rock into moveable pieces. While some claws, other toe bones and vertebrae of the right size to belong to the adult diprotodontid were found, the most tantalising discovery was of what appeared to be poorly formed limb bones and a tiny skull, barely a third the length of the adult's, only about a metre away from where the 1989 specimen had been found. Even better, what could be seen of its teeth suggested it was the same new and distinctive species as the adult. Most unusually for Riversleigh, no other mammals were found in the slab.

After initial preparation in Sydney, it was clear that the new skull was that of an infant. Its completely unworn teeth were still erupting and most of the bones were unfused. When Anna finally freed the lower jaws from the underside of the skull, its juvenile condition was even more evident. If the jaws were put back into place on the reconstructed skull, there was a gap between the tips of the lower and upper incisors—a gap perfectly suited to a mother's nipple. This juvenile had not yet left its mother's pouch and it was hard to reach any other conclusion than that it was the pouch young of the 1989 adult!

But the most poignant discovery was also the last. When Anna finished final preparation of the nose region of the juvenile, she found two isolated third upper incisors that belonged to an adult diprotodontid—surely the two missing teeth from the mother's skull. How could this have happened because the two skulls were not found next to each other? There seemed only one explanation. As she died, the mother's last thought was to press her nose against that of her dying infant—the one thing in the world that meant more to her than any other. Within weeks of the attentions of yabbies and turtles, only the bones and teeth of the mother and child would have remained. Freed of binding tissue, the mother's two upper incisors evidently dropped out next to the skull of her infant. Then her skull drifted away, nudged perhaps by gentle currents that stirred the pool after a storm. Soon the two skulls became buried by the lime-rich sediments that gradually filled the pool. As new trees replaced the fallen giant and the forest closed in overhead, the buried skulls began to fossilise, exchanging molecules with the ever-changing balance of elements in the ground waters that filtered through the young rock.

Twenty million years of absolute silence and darkness followed, their tragic last moments lost to the world until, with a resounding 'crack', Alan's hammer catapulted them back into the light. Anna's chemical caresses stripped away the shrouds of clinging stone. And now Karen's studies, when complete, will have mother and child restored among their ancient acquaintances, this time to amaze a species whose ancestors were, when these diprotodontids last walked Riversleigh's rainforests, little more than gibbering apes in the rainforests of Africa. United again, hopefully for all eternity, the Miocene 'Madonna and child' are now one of the centrepieces in the treasury of Riversleigh. ■

Further Reading

Archer, M., Hand, S.J. & Godthelp, H., 1994. *Riversleigh*. 2nd ed. Reed Books Pty Ltd: Sydney.

Archer, M. & Black, K., 1994. A moment of motherhood. *Riversleigh Notes* 25: 4–5.

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

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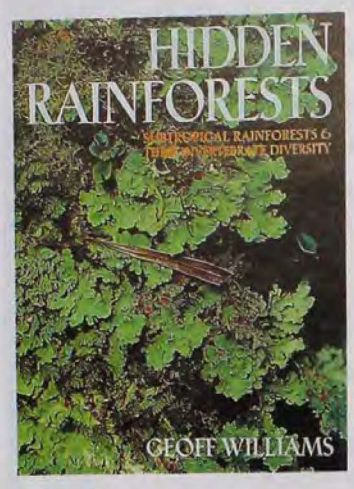


Hidden Rainforests: Subtropical Rainforests and their Biological Diversity

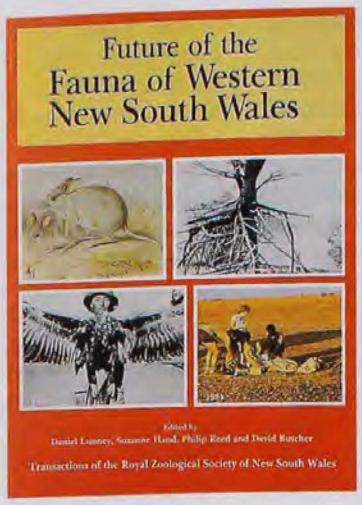
By Geoff Williams. University of New South Wales Press, NSW, 1994, 188pp. $79.95rrp.

The vanishing rainforests of the world contain the greatest potential for the natural resources of the future. Paradoxically the reasons for their value, complexity and diversity are the very reasons why we know so little of the details of their faunas. Yet, understanding their complexity and the interactions of the multitude of life forms in rainforests is essential if we are to keep them. Keep them we must, but time is running out for us...and very fast.

In this book on the rainforests of the Manning River catchment, Geoff Williams shows us what it is that we are losing in a very graphic way. How many people realise that there is not just one kind of rainforest but many kinds, each unique in its own way and that some of them now exist in only very small patches? Geoff writes about the basis of these rainforests—the magnificent trees themselves, as well as the lower storeys of plants, which are smaller but no less important to the makeup and balance of the forest. He gives us a picture of the larger fauna—the birds, snakes, possums, bandicoots and native rodents. He reminds us of the insect-eating and fruit-eating bats that take over at dusk when the birds settle down at the end of the day. But more than that, he looks at that part of the fauna which very few books on rainforests give more than a passing mention—the invertebrates. These are the insects, mites, scorpions, slugs, snails, worms and leeches that move quietly about in the forest at all levels in great numbers but are seldom seen unless we do what Geoff has done—look for them. Between them, by slow and complicated processes, they put back into the forest soil what the plants have taken out. They provide future generations of plants with life. The excellent colour plates give us a chance to see some of these unfamiliar animals and their remarkable adaptations.

This book gives us a feeling for the real rainforest; that is, a rich faunal and floral community in which all the parts are dependent on one another and where the loss of one species leads to wider change and impoverishment of the whole. It gives us a feeling for the rainforest as a vibrant, living entity that, like all living things, has evolved through a long past and that is also as fragile and vulnerable to our maltreatment. It is a feeling that can only be conveyed by someone who has come to know, understand and respect the rainforest. The book is written by just such a person. I am sure that when you have read it you will also have greater understanding and respect for our rainforests.

—Courtenay Smithers
Australian Museum



Future of the Fauna of Western New South Wales

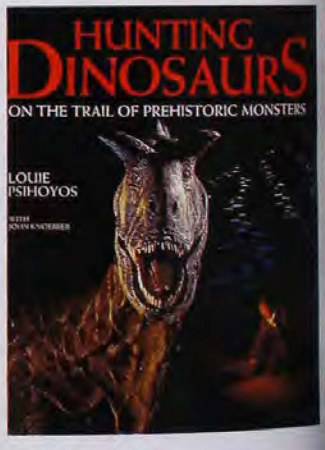
Ed. by D. Lunney, S. Hand, P. Reed and D. Butcher. Surrey Beatty & Sons, NSW, 1994, 246pp. $45.00rrp.

A cynic might quip: why produce a book comprising 22 chapters by 21 authorative authors, when the future of western New South Wales fauna might be stated in one word—stuffed! It is too easy to be pessimistic about the future of our inland fauna, considering the appalling history of mismanagement (much of which is documented in this book). However, this publication does not convey a message of hopelessness and the most relevant issue today is how to spur society into appropriate initiatives to prevent further demise of our inland ecosystems. In this regard, the book is a valuable contribution to the understanding of past and present land management malpractice and its impacts on the fauna, current issues that must be addressed and fertile directions for future initiatives. A general theme to emerge is that the dusty grim reaper might prevail if current trends continue unchecked, but that there is room for optimism—if society so chooses. In the first chapter, Dan Lunney concludes with a vision for achieving an optimistic future. It appears under the loaded heading "Pig-footed Bandicoots Might Fly"—which alludes to the major shift in social attitudes that is required to address the problems of a region in crisis—a region that incorporates up to 70 per cent of New South Wales.

The contributors are zoologists, land managers and a pastoralist. Separate chapters address the conservation status of all major vertebrate groups from mammals to fish and there is a chapter on invertebrates. Other chapters address vertebrate pests, competition with feral animals, historical changes to the landscape, conservation reserves, the Landcare Program, land clearing and agriculture. I urge you not to overlook the thought-provoking Preface and Epilogue.

The book is non-technical and easy to read. Coverage of a wide range of faunal groups and issues assures a diverse readership. I not only recommend the book, but also that you support the independent organisation that produced it, the Royal Zoological Society of New South Wales, which deserves recognition for its production and organising the symposium upon which it is based.

—H. Parnaby
Australian Museum



Hunting Dinosaurs: On the Trail of Prehistoric Monsters

By Louie Psihoyos. Capricorn Link, NSW, 1994, 267pp. $39.95.

Science is a human endeavour but, all too often, we forget the people who generate the science we digest and the influence of their personalities on the work they produce. *Hunting dinosaurs* is as much about the personalities of palaeontologists, past and present, as it is a tour of the most recent thoughts and theories about dinosaurs.

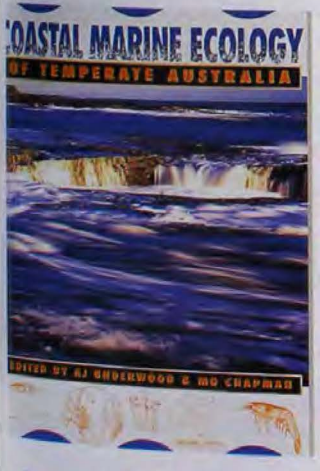
Hunting dinosaurs has been produced in association

with National Geographic and the layout is heavily influenced by that magazine. The text is somewhat bitty; detailed sub-stories and interviews strung together into a reasonably coherent theme. The photography is brilliant with many shots having been produced especially for the book. While many shots have been deliberately and skilfully posed, some reach a point of being overbearingly set up for dramatic effect rather than simple illustration. The same can be said of the text; generally it is fluid and readable but at times it strays into the overdramatic, which introduces an air of incredulity.

Hunting dinosaurs does provide a detailed insight into many of the currently active areas of dinosaur research, focussing on the big and flashy, and ignoring the less spectacular activities in this field. The important excavations of Dinosaur Cove in Victoria are not mentioned but there are 17 pages devoted to the one specimen of *Tyrannosaurus* nicknamed 'Sue'.

In short, this is an entertaining and readable book but it is not a comprehensive look at dinosaur research today and there are better texts available on the history of this research. However, this book is worth having for the photographs alone.

—Paul M.A. Willis



Coastal Marine Ecology of Temperate Australia

Ed. by A.J. Underwood and M.G. Chapman. University of NSW Press, NSW, 1995, 341pp. $39.95rrp.

Most of Australia's population lives in Sydney or Melbourne. Both these cities, and most of our other major centres of population, are coastal, or situated on estuaries, and in temperate Australia. While much attention has been focussed on the wonders of the Great Barrier Reef and the ecological dangers it faces, we have tended to ignore the existing and growing problems associated with the health of the coastal environments nearest to us.

These temperate marine environments, appreciated for their beauty and the recreational amenities they provide, are also a major source of food. In general we have treated them with contempt, using them paradoxically as both an apparently inexhaustible well of resources and a bottomless pit into which we dump our waste and sewerage.

There has been a wealth of significant publications on many aspects of our marine life. Few naturalists would not have at least heard of the pioneering works of William Dakin and Isobel Bennett, and in the last decade we have seen the production of many well-illustrated specialist accounts of various aspects of the fauna and flora. *Coastal marine ecology of temperate Australia* can stand tall among these previous publications.

By describing coastal Australia as a series of ecosystems and habitats, it gives readers a new way of looking at their coast. To even knowledgeable naturalists, biologists and students, it provides a wealth of information, including much from recently published scientific papers, and attempts to explain the many processes that have helped to shape our coastal environment.

The list of contributors reads like a 'who's who' of Australian marine scientists; and there are chapters on all major habitats, and interesting accounts on systematics and marine evolution, genetics of marine populations, and fisheries and aquaculture.

As befits the editors' deep concern for the health of our marine environment, there are substantial and stimulating chapters on environmental disturbances, the problems of waste disposal, and the continuing debate on how best to detect and measure environmental impacts.

The editors have done an admirable job in attempting to produce uniformity among a group of authors with different approaches and with subject areas for which we have quite different levels of knowledge. I suspect that most will treat this book as a source of information on the physical and biological processes that shape our many and various coastal habitats.

There are, however, two slight negatives. The Institute of Marine Ecology and Tony Underwood have developed a fine reputation for ecological research and are well known for their rigorous approach to 'science'. But I was somewhat perturbed to find that the introductory chapter entitled "Introduction to Coastal Habitats" developed into a discourse on their experimental approach as being the only 'true science'. Their views on practising science, the need for null hypotheses, and what constitutes pseudoscience seem rather out of place in this introductory chapter. Perhaps a chapter on how scientists practise their trade would be a useful addition to a future edition. To any potential reader starting logically at Chapter 1 who finds pages 5–13 hard going, my advice is to skip them. Don't be put off reading the rest of the book. Return to null hypotheses later if you wish to ponder on how scientists work.

My second minor concern is over the printing of the black-and-white photographs. Clearly all involved with this book have worked hard to produce a high-quality text with excellent line drawings. It is disappointing that the few black-and-white photographs have reproduced so poorly.

To Tony Underwood, Gee Chapman and their team of authors, congratulations. To all those citizens concerned about and interested in their marine environment, buy the book!

—W.B. Rudman
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Ian Roberts is a South Australian artist specialising in painting Australia's birds & flowers. He is the Artist - in - residence at Medika Gallery, in the Clare Valley Wine Region.

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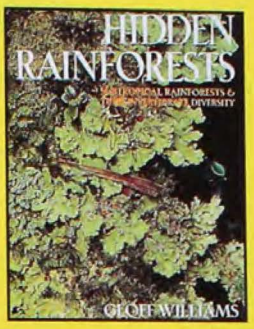

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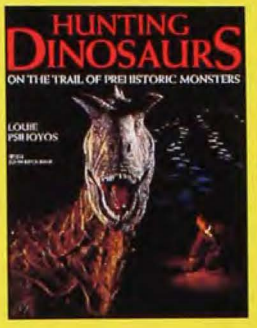

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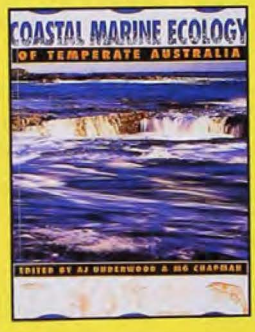

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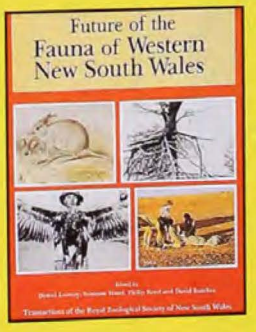

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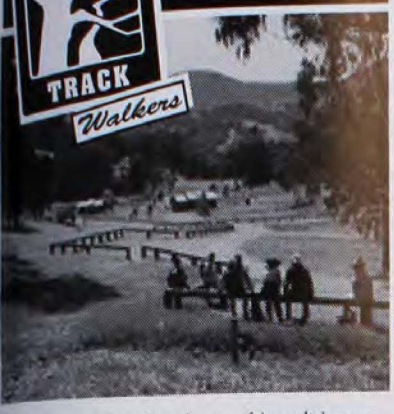

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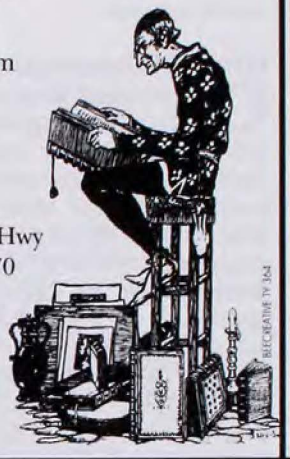

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Q&A

A Magpie is fed from the verandah of a suburban Sydney house.

Bird Behaviour

Q: *For about three years a pair of Magpies has come to our bird table and eaten some of the sunflower seeds. The female has always been bolder than the male but we have never encouraged them to eat from our hands. When we found they appeared to need other food than the seed, we gave them small pieces of cheese. This they took, but the female would shake the cheese, as though killing it, before eating it. This spring the pair had two young and brought them to us as soon as they began to fly. At first they begged food from the female and then eventually began to feed for themselves. We noticed that the young did not shake their food but swallowed it straight down. Now the two young ones come frequently on their own and they too have begun to occasionally shake the cheese before swallowing it. Could you please comment on this?*

—Paul Hicks
Scotts Head, NSW

A: Unfortunately much of Australian bird behaviour has yet to be studied, so I cannot give you a definite answer about the change in your Magpie's feeding methods. The young may be switching from the initial instinct of accepting food from parents, which has presumably been killed and is thus suitable to be swallowed directly. As the young birds become increasingly independent and their own hunting instincts come into play, they must now process the food themselves before swallowing.

I have watched a local family of Magpies, consisting of one adult and two young. The adult is quite adept at dealing with pieces of cheese, as is one of the young. They may eat the smaller pieces directly or use the ground to help position larger pieces for swallowing. The other young bird has considerably more difficulty with food items, picking them up, pressing them against the ground, dropping them and beginning again. These differences are probably due to a combination of innate abilities and past experiences.

There is an element of individualism in the way that a particular bird treats a food item before ingesting it. This is based on the bird's own experiences, its learning, and no doubt individual physical and mental abilities. Birds differ between species in their abilities to manipulate items and their ability to learn new behaviours. Just as in humans, these differences also occur between individuals within the same species. Because Magpies are intelligent birds, their behaviour is not completely stereotyped. They have the ability to learn from experience and incorporate this into their behavioural repertoire. Some are quicker or more astute learners than others.

—Walter E. Boles
Australian Museum

Spider Pyramids

Q: *I took some photographs of a pyramid of spider webs early one morning with the dew on them. As I do not know what type of spider made them, I was wondering if you could identify them for me? They were taken in November on Chatsworth Island, which is on the north coast of New South Wales.*

—Tim Strange
Chatsworth Island, NSW

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P I C T E A S E R

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* magazine. Please don't forget to include your name and address. The first correct entry will win a $20 gift voucher from the Museum catalogue. Spring's Pic Teaser was the shell pattern (test) on the upper side of a sea urchin.

A: These strikingly decorative webs could be the work of several types of spider whose webs look superficially similar. Perhaps the most likely candidate is the small web-building spiders of the family Linyphiidae (money spiders). Their webs consist of platform-like silk sheets tensioned above and below by a scaffolding network of supporting lines so that the sheet may be domed upward or hammocked downward. The tiny spiders run on the underside of the sheet and are easily overlooked. Their webs are common in heathland and forest where they may be built in close proximity on shrubs and grasses.

Some comb-footed spiders (family Theridiidae) also make sheet webs with a supporting tangle of scaffolding threads. A common example is *Achaearanea mundula*. This species has a detritus retreat (usually made of dead leaves) that is built among the support threads above the sheet. The spider runs on the upper side of the sheet.

A third possibility is the tent web spiders of the genus *Cyrtophora*. Their basal sheet is a horizontal orb web, above which is a tent-like silk retreat slung among a tangle of upper support threads. These specialised orb web-weaving spiders (family Araneidae) are larger than money spiders and they run on the top surface of their 'sheet' web. Some species habitually build their webs close together, with web complexes sometimes covering small trees in tropical areas.

A close look at the silk mesh making up the sheets of these webs can reveal whether one is looking at a *Cyrtophora* web. The horizontal orb web that forms this sheet has a tight spiral line supported on many closely spaced radial lines, so forming a fine but very regular meshwork of silk. In money spiders and comb-footed spiders, however, the sheet's structure is much less regular, the meshwork consisting of threads intersecting at all angles. In both of these webs the supporting scaffold threads afford protection to the occupants and act as arresting traps that 'knock down' flying or jumping prey onto the sheet where the spider can capture it.

—Mike Gray
Australian Museum

Webs similar to this one are built by *Cyrtophora* spiders.

Answers to Quiz in Nature Strips (page 19)

1. Narwhal
2. None
3. Macdonnell Ranges
4. Wollemi Pine
5. Brown
6. Paul Davies
7. The new black-and-white tree-kangaroo from Irian Jaya
8. Jupiter
9. A grass tree
10. Ecological Sustainable Development

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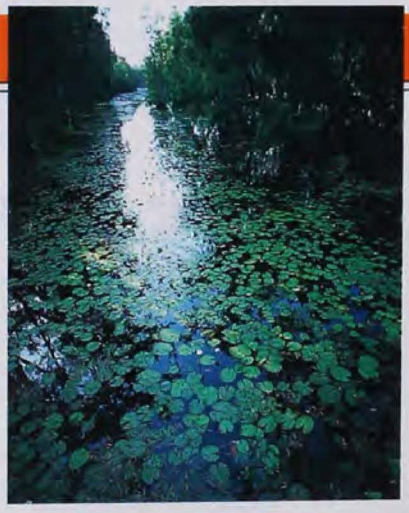

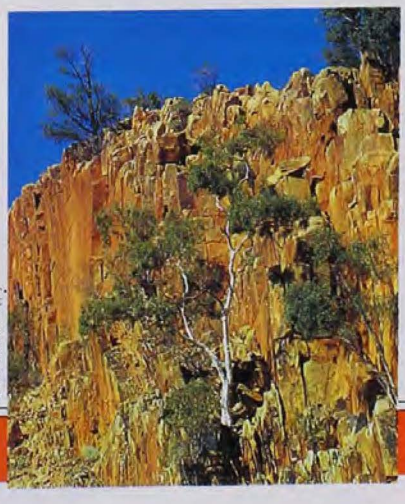

DRAWING ROOM (NT)

The notion of abolishing the rural sector would be counterproductive and understandably invoke opposition.

HUMANS DON'T EAT ROCKS

BY PAUL ADAM & ROBERT J. KING

THERE IS WIDESPREAD RECOGNITION that Australia is one of the centres of global biodiversity. There is also concern that, as a result of human degradation of the landscape, much of this biodiversity will be lost. Part of the Government's response to these concerns has been the endorsement of the concept of Ecologically Sustainable Development. But what forms of land use and activity might be compatible with ecological sustainability? In a recent issue of *Nature Australia** (Autumn 1995), Professor Michael Archer argued that the major cause of degradation of many Australian ecosystems has been agriculture and that in the future our economy should be based on mining and tourism with agriculture being substantially reduced. We share Archer's concerns over the degradation of the Australian landscape and of the urgent need to take restorative action, but we disagree with the solution.

The area of Australia directly affected by mining is very small. On the basis of the relative area devoted to mining and to agriculture Archer argues that mining is 3,500 times less ecologically destructive than agriculture. Ecological destruction is a difficult concept to quantify, but there is not a simple linear correlation between 'ecological destruction' and the area of direct impact. Both the direct *and* indirect impacts of mining, including those from processing, manufacture and use of mining products outside Australia, must be considered. While it is difficult to do this quantitatively, the total impact is considerably greater than Archer implies.

One of the main reasons for this is the 'Trojan Horse effect'. Mines require people, and development of a new mine in a remote area requires the establishment of towns and associated infrastructure (roads, railways, power supply etc.). The infrastructure provision may have considerable environmental impacts over an area much larger than that occupied by the mine; and the people bring with them their wastes, weeds and pets. The impact of mines can thus extend well beyond their boundaries. Although current regulatory regimes aim to reduce these impacts, the recent controversy over the release of water from the Ranger facility into Kakadu National Park indicates there may well be cases where there is still a potential for impact.

Considerable effort is now put into post-mining rehabilitation and Australian companies have made major advances in this field. However, while re-

The impact of mines can extend well beyond their boundaries.

vegetation is increasingly successful, it is still uncertain as to whether full biodiversity can be restored in the short to medium term.

When it comes to the agricultural side of the argument we recognise the huge impacts of agriculture on the environment. However, agricultural land is rarely completely devoid of biological diversity. While ecosystems are highly modified, some native species do survive and remnant areas of relatively less modified habitat remain. The importance of these remnants is increasingly recognised by the rural community and they provide the basis for future landscape rehabilitation. We too argue strongly against the clearance of further areas of native vegetation for agriculture and support much greater activity to reverse past degradation, by withdrawing extensive areas of marginal land from agriculture. However, the process of withdrawal, including both environmental and social aspects, should be managed carefully and not left to chance.

The concept that we should cease to be an agricultural exporting country and rely on imports is not one that we can support. Humans cannot eat rocks! Any increased importation of food is at the expense of environmental costs to other countries. Do we have a moral right to encourage or condone environmental damage simply on the grounds that it is not occurring in Australia?

Food and other agricultural exports from Australia have the potential to relieve environmental pressures elsewhere. The challenge is to develop ecologically sustainable systems. We are far from this goal at present but it is not an impossible dream. It could well be that the distribution and nature of production in the future will have to be different from those at present if sustainability is to be achieved. It is also likely that the ability to produce in a sustainable manner will set limits to population size, reluctant as politicians and some religious leaders are to grasp that particular nettle.

Australia has an enormous opportunity to set an example by moving towards sustainable agricultural systems that maximise conservation of biodiversity at a landscape scale, enable the maintenance of a human population of appropriate size, and support high-value (but possibly limited-volume) agricultural exports. The world agricultural economy is currently based on very few species. Part of the shift to sustainability, not only in Australia but globally, may involve greater diversification, in which utilisation of native species (as recognised by Archer) could play an important part.

For the foreseeable future we would envisage both mining and agriculture to continue as major components of the economy, although public opinion, planning and regulation will increasingly demand greater attention to ecological sustainability in both sectors. Tourism will also remain of major importance, but again will require careful management to minimise adverse environmental impacts.

Land degradation and accompanying loss of biodiversity is one of the most crucial environmental issues facing Australia. Much more public attention needs to be given to the issue in order that imaginative solutions be developed and adequate funding made available. The notion of effectively abolishing the rural sector would be counterproductive and understandably invoke opposition from those whose goodwill and support must be secured if the damage of the last 200 years is to be reversed. ■

** Previously ANH*

The Last Word is an opinion piece and does not necessarily reflect the views of the Australian Museum. This issues' contributors are Associate Professors Paul Adam and Robert J. King who work in the School of Biological Science at the University of New South Wales.

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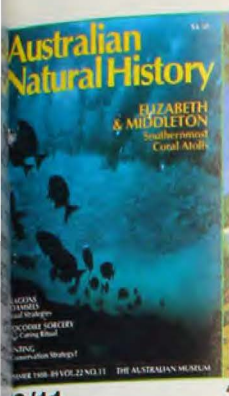

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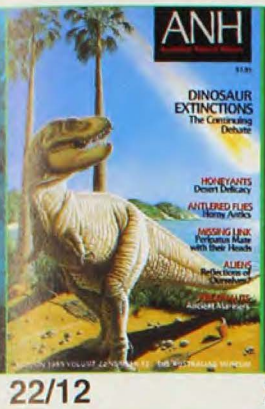

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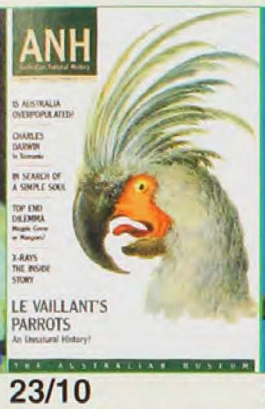

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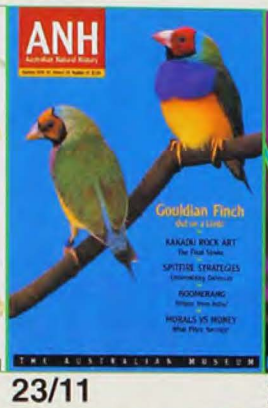

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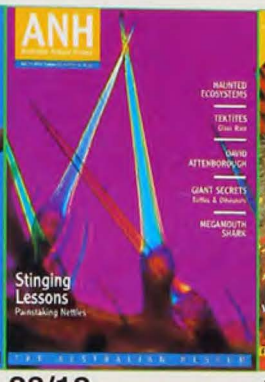

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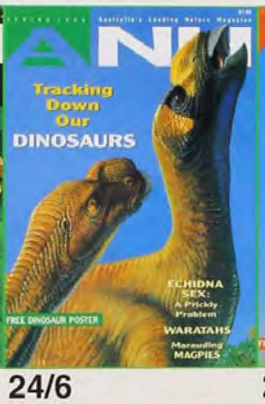

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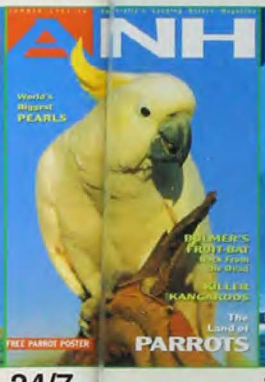

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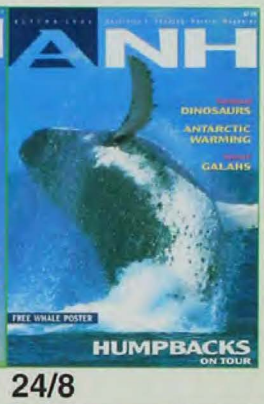

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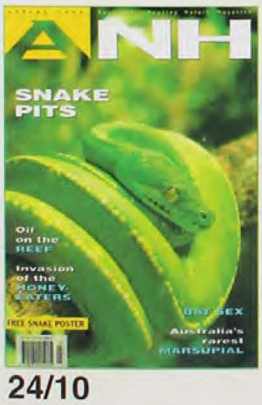

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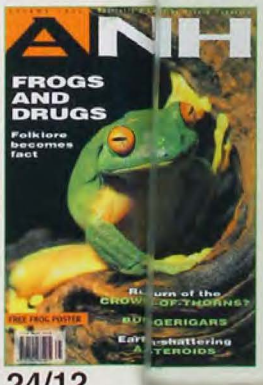

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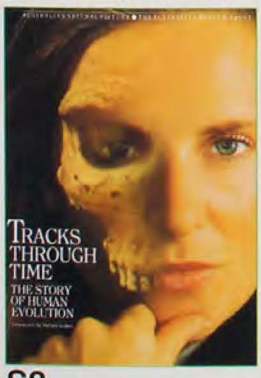

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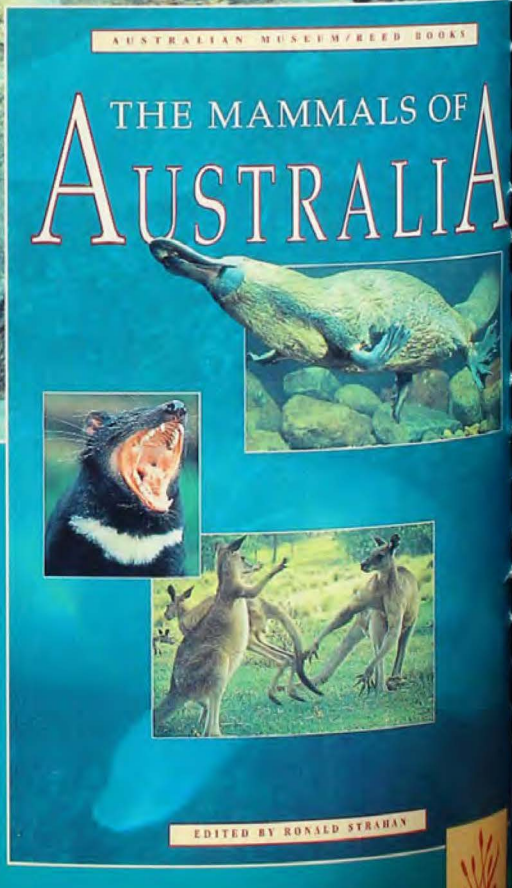

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