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TICKS
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FOREST DRAGONS
PIRATING CHOUGHS
WILDLIFE CORRIDORS
Free Bird Poster
FEATHERED PORTRAITS
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Up Front

Gripping a disgustingly engorged body with a pair of tweezers and pulling it gently from the head of my pet is definitely *not* my idea of a good time. But the tick had to be removed, or the life of the dog would be at risk. Still, it could have been worse—the tick could have been on me! There wouldn't be too many Australians who haven't had some sort of an encounter, either directly or indirectly, with ticks. Yet despite our familiarity with these tiny bloodsuckers, most of us know surprisingly little about them. For instance, did you know that they are related to spiders, or that of the 60 species found in Australia, humans need only worry about three or four of them? Or how about this one—in America, Lyme disease, which is spread by ticks, has become the second most important emerging disease behind AIDS, with around 10,000 new cases annually. And this is where it gets really interesting for us, because it begs the question: does Lyme disease occur in Australia? Unfortunately, the answer is not a simple one and there is currently quite a heated debate going on among scientists as to whether the disease is here or not. We provide you with all the latest on ticks, and the debate, beginning on page 40.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

An Ornate Kangaroo Tick.

In three of our other main features, you can discover all about the lifestyles of some rather unusual Australians. At first glance, you might think White-winged Choughs are fairly straightforward birds, but it appears there's not a lot they won't stoop to in the name of bringing up baby. Gang warfare, piracy, kidnapping, even incest are all part of this bird's amazing repertoire. Boyd's Forest Dragon, on the other hand, seems to specialise in doing not very much at all and has managed to remain cryptic and mysterious despite being one of our most spectacular reptiles. Their particularly unusual lifestyle seems to have been developed in response to their choice of habitat. However, as cryptic and mysterious as Boyd's Forest Dragon may be, it is nothing compared to that of our truffles. Australia's eucalypt forests host such an amazing diversity of truffles, it is taking the combined efforts of scientists, both here and overseas, to identify and document them all. But it is what they do for our forests and the frenzy they send some of our mammals into that will surprise.

Finally, if you were struck by the beautiful Green Rosella on our cover, then you will love this issue's Photoart and poster. They provide a spectacular gallery of bird images taken by Dave Watts, who is, as you can see for yourself, a very talented photographer. Based in Tasmania, his photographs never cease to take our breath away.

—Jennifer Saunders

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

EDITOR
Jennifer Saunders, B.Sc.

SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.

PHOTO RESEARCHER
Kate Lowe

DESIGN AND PRODUCTION
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Michelle Atzemis
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Front Cover

The Green Rosella (*Platycercus caledonicus*) is endemic to Tasmania and the islands of Bass Strait where it is very common. Photo by Dave Watts/Nature Focus.

CONTENTS

Articles

Regular Features

THE BACKYARD NATURALIST

SNAILS: WHERE BOYS WILL BE GIRLS

Being a hermaphrodite doesn't mean your safe from Cupid's arrow!

BY STEVE VAN DYCK

18

RARE & ENDANGERED

WESTERN BARRED BANDICOOT

Currently surviving only on offshore islands, this small bandicoot looks set to get another chance at life on the mainland.

BY JACQUI RICHARDS & JEFF SHORT

20

WILD FOODS

A BUSH FOODS BOOM?

For better or worse, bush tucker has come a long way in the last ten years.

BY TIM LOW

22

PHOTOART

FEATHERED PORTRAITS

Wildlife photographer Dave Watts has captured an impressive collection of Australian birds.

BY DAVE WATTS

64

VIEW FROM THE FOURTH DIMENSION

TIGER, TIGER OUT OF SIGHT

What do UFOs and Thylacines have in common?

BY MICHAEL ARCHER

70

THE LAST WORD

MARINE RESOURCES: CURE ALL OR LOSE ALL?

Oceans all around the world are being combed by bio-prospectors, but at what price?

BY MARY GARSON

80

Columns

LETTERS

Frogs; Watch & Learn; Toadfish Lesson; Are Canids Eusocial?; Marigold Mixup.

4

NATURE STRIPS

Fish Brains Take the Record; Lizards Walk on Water; Autumn Leaves Questions; Martians at Last?; Faithful Seahorses; Tapir Penis; Gastric Grooming and Right-handed Toads; Scare Tactics for Endangered Animals; I'iwi Bills; Frog-eating Fly; Webs of Stone; Some Like it Hot; The Geography of Snakebites; Quick Quiz.

8

REVIEWS

Frog Calls of the Greater Sydney Basin, Frog Calls of North-eastern News South Wales, and Frog Calls of Brisbane and South-eastern Queensland; Frogs Tasmania; Wildlife & Woodchips; Rocks & Fossils; Seaweeds of Queensland.

72

SOCIETY PAGE

Interested in nature but not sure what to do or where to go? Nature Australia's *Society Page is a great place to start.*

74

THE GUIDE

Nature Australia's *market place.*

76

Q & A

Practice Makes Perfect; Means of Survival; Seamoths; Pic Teaser.

78

LETTERS

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

Frog Declines

We were dismayed to read the article by William Laurance on frog declines (*Nature Aust.* Autumn 1996). Although we fully support studies that address the possible role of disease (including viruses) in frog population declines, this article reached much stronger conclusions than most scientists would support, given the data available. If government bodies and the general public are convinced by it that the declining frog problem has been solved when in fact it hasn't, a variety of management decisions may be made that will ultimately have negative consequences for frog populations.

One of the most serious problems with this article is that the scenario it presents to explain the introduction and dispersal of the virus throughout the world (by aquarium fish) is pure speculation, supported by no evidence. Even the speculation that an iridovirus might be responsible now appears to be untrue, as virologists working on the possible frog disease agent have informed us that they now believe it is not an iridovirus.

Another major problem with the epidemic virus theory is the assertion that declines have swept northward at an average rate of about 100 kilometres per year. The article itself shows that this average is actually based on only two data points (the intervals and distances between the south-east Queensland and central Queensland declines, and between the central Queensland and north-east Queensland declines). Laurance asserts that the causes of declines in these clusters of populations are the same. This means that, for statistical purposes, each cluster of populations is a single data point, not many data points. The procedure he has followed is similar to someone who sets out to establish the average height of Australian men and does so by choosing three men at random and repeatedly measuring their height a large number of times. This is obvious if one examines a graph used to support this idea in a paper by Laurance, McDonald and Speare (*Conservation Biology* 10: 406–413; 1996). If one examines the pattern within the wet tropics area in northern Queensland (roughly 400 kilometres north-east x 5–50 kilometres east-west), it is apparent that there was no south-to-north spatio-temporal pattern in this large region, although there certainly should have been if the 'sweeping wave' notion is correct. Laurance had access to a more extensive data set regarding the patterns of declines (*Pacific Conservation Biology* 1: 66–77; 1993), which shows that frogs of some species were missing from sites throughout the wet tropics by the summer of 1991–1992, but chose not to use it.

We believe that Laurance's article seriously distorts the picture of the status of research on the declining frog problem and should be corrected.

—Ross A. Alford & Steven J. Richards
James Cook University, Qld

The recent article in *Nature Australia* by William Laurance (Autumn 1996) regarding the "frog-killing virus" is of great concern to the many amphibian biologists (not mentioned in the article) that are currently involved in the declining-frog research throughout Australia. The notion that the amphibian declines in Queensland have been caused by a pathogenic virus is an untested hypothesis that remains unproven and relies on many assumptions.

I believe the article presented on the "frog-killing virus" has misled the Australian public into believing that the declining-frog problem in Australia has been solved. This is far from the truth and only an enormous amount of research by amphibian biologists in conjunction with the epidemiologists will enable us to solve one of the greatest challenges currently facing Australian biologists. The real issue is who is going to pay for the badly needed research?

—Jean-Marc Hero
James Cook University, Qld

Why are the rainforest frogs croaking? In your Autumn 1996 issue William Laurance considers one possible hypothesis. To me, the more general problem for biologists is what to do when confronted with declines of unknown cause. In his final work, ecologist Graeme Caughley suggested the following guidelines: (1) study the natural history of the species; (2) list all conceivable agents of decline; (3) measure these agents where

H. EHMANN/NATURE FOCUS

The Mountain Mistfrog (*Litoria nyakalensis*) is one of the disappearing frogs from Queensland's rainforest streams.

the species is and was; and (4) design experiments to test whether the agents are actually causing the decline.

Research on declining frogs in north-eastern Australia is coordinated through the Australian Nature Conservation Agency (ANCA) 'Queensland and Northern NSW Threatened Frogs Recovery Team'. Essentially the recovery team is following Caughley's prescription, at present we are at steps 1 to 3 (above). Viral disease is only one of several hypothetical causes that deserve support but require testing. Given the urgency of continuing frog declines, experimental translocations and research on captive breeding should form a vital part of the testing process. The tasks for management agencies are to produce regional recovery plans that list potential agents of decline, to provide sufficient funds to test these hypothetical causes and to consider responses to each proposed agent of decline.

The disappearance of frog species is highly distressing and many biologists wish to bring more public attention to this conundrum. I welcome informed speculation on the cause of declines and possible ameliorative actions, indeed I hold that this is a necessity. However, I believe it essential that public attention, and funding, are directed toward Caughley's common-sense prescription of comparing, testing and validating the diversity of all conceivable causes of decline.

—Michael Cunningham
University of Queensland

J.M. CORNISH/NATURE FOCUS

An adult female Thorny Devil (*Moloch horridus*).

Ross Alford, Steve Richards, Jean-Marc Hero and Michael Cunningham suggest my article in Nature Australia *overstates the evidence for epidemic disease as a likely cause of the dramatic frog declines in Queensland. Below I will try to address their concerns.*

Firstly, I certainly agree that the disease hypothesis developed by Keith McDonald, Richard Speare and myself is exactly that—an hypothesis—although I personally believe the evidence is much stronger than Alford and his close associates are willing to recognise.

For example, our hypothesis (described in detail in Conservation Biology*) is actually based on eight lines of evidence. Alford disputes only one of these, in which we use a standard epidemiological technique to estimate the direction and rate of frog declines in Queensland. He suggests the 15 sites we used in this analysis are really only two localities, an assertion that is unjustified both biologically and statistically. For Alford's argument to be valid, for example, the entire wet tropics region would have to be considered a single locality—even though it spans over 400 kilometres! It must be emphasised, moreover, that other researchers (such as Glen Ingram of the Queensland Museum) have also recognised the distinctive south-to-north pattern of the frog declines, so our general view of this trend is hardly in the minority.*

Secondly, we do speculate that aquarium fish could have been involved in the introduction of an exotic pathogen to Australia. However, consider these facts. Each year Australians import six to ten million aquarium fish and such fish have been released into the wild by misinformed aquarists on many occasions. To date, at least 42 exotic pathogens of high quarantine significance have been identified in fish due to be imported and a number of these have become established in Australia's native fish populations. Foreign pathogens such as 'white spot disease' have spread via the aquarium-fish trade throughout much of the world, causing epidemic mortality in natural fish populations. Moreover, all 14 of the frog species that have declined in Queensland are closely associated with streams where they could readily contact a waterborne disease, while none of the local land frogs has declined. Is this "pure" speculation? Draw your own conclusions!

Finally, although a number of researchers like Alford, Richards, Hero and Cunningham are actively studying the Queensland frog declines, there has been no serious alternative forwarded to challenge the disease hypothesis. Many possible factors have been considered—such as pollutants, habitat destruction, unusual weather and a diminishing ozone layer—but none has ever been strongly supported. So I challenge any researcher who doesn't like the disease hypothesis to provide a compelling alternative.

—William F. Laurance
Smithsonian Institution/National Institute for Research in Amazonia, Brazil

Watch & Learn

Sometimes it's difficult to bury an old, intuitively appealing hypothesis, even if it's been proven incorrect. In the Autumn 1996 issue of *Nature Australia* a reader attempted to correct, erroneously, a report on some of my research on the drinking behaviour of the Thorny Devil that appeared in the Autumn 1995 issue. (A related article on similar drinking behaviour in Texas Horned Lizards in North America appeared in the Winter 1992 issue.)

The scientific issue is this: how do these desert lizards imbibe water that comes into contact with the external surfaces of their skin on those infrequent occasions when this may occur, either during rain, dew, or fog events? To understand the answer, it is important to recall that the outer surface of the integument (scaly skin) of reptiles is designed to prevent the passage of water out of the animal (or into the animal), which facilitates its existence in arid regions.

Early naturalists and scientists working in Australia reported on the ability of the Thorny Devil to stand in a puddle and soon have water covering its skin. They sup-

posed, like the writer of the letter, that the lizards were drinking through the skin, as toads and frogs might. That hypothesis was demonstrated to be incorrect in 1962 by the use of coloured water, which was carried over the skin surface to the edge of the mouth where it was ingested, rather than being absorbed through the skin. Later (in 1982) it was postulated that the water is carried by capillary forces generated by tiny channels between the lizard's scales.

In 1990 I discovered a similar phenomenon in the Texas Horned Lizard which I called "rain harvesting". And, in 1993 Phil Withers (University of Western Australia) and I reported that this capillary water collection system in the Thorny Devil, extending across all the lizard's skin surfaces, appears to be used to 'suck' water out of the upper surface of damp sand for oral drinking. The lizards rub their bellies on the damp sand after light showers. These were the reports that your reader found difficult to believe.

It is an amazing experience to stand in the desert on a hot day and watch water move across the skin surface of a Thorny Devil as it stands in a puddle. One's first impression is, wow, what a way to sponge up a drink! Understanding what is happening has taken the careful attention of trained observers over many decades. Such is the nature of the realities of the natural world. They are not necessarily constructed for our easy interpretation. But once we do understand their truths, we need to listen and remember if we are to truly understand anything.

—Wade C. Sherbrooke
American Museum of Natural History
Arizona, USA

Toadfish Lesson

Len Drake's Q & A observation of a pelican with a toadfish in its beak (*Nature Aust.* Autumn 1996), may have been a case of avian education. How does a young bird learn not to eat dangerous food?

About 40 years ago at Point Peron in Western Australia I was watching a group of Silver Gulls on the sea edge. A toadfish came floating by. All the adult gulls ignored this titbit while an immature bird, probably not being able to believe its luck, dived on the fish.

This was curious behaviour, so through my binoculars I watched the youngster devour the toadfish. After a few seconds its eyes looked glazed, then it vomited up the meal, walked to a nearby freshwater pool and drank. I am not sure if this was part of the cure, however the young gull had learned a lesson. Learn from adults and don't look a gift toadfish in the mouth!

—Vincent Serventy
Pearl Beach, NSW

A toadfish came floating by. All the adult gulls ignored this titbit while an immature bird, probably not being able to believe its luck, dived on the fish.

Are Canids Eusocial?

I was interested by the discussion of the eusociality of the Damaraland Mole-rat in *Nature Australia* (Winter 1996). The piece mentioned that only two mammalian species exhibit this social system. How does eusociality differ from the situation in many canids, where only the alpha female bears offspring to the alpha male, but other members of the pack assist with suckling the cubs, hunting and guarding the den? Do mole-rats, like canids, exhibit pseudo-pregnancy, which allows non-breeding females to lactate and thereby suckle the alpha female's cubs?

Your splendid journal has reached me for the first time in the foggy isles, and has helped to dispel the gloom.

—Kurt Verkest
Essex, England

The question as to why many canid species are not referred to as eusocial is very interesting. Most canids do not exhibit the same level of social organisation or degree of reproductive suppression that is seen so clearly in mole-rats. In the more social species of canids (wild dogs and hyenas) there is usually more than one female in the group that breed. The canids differ from mole-rats in that, while several females can produce young, it is normally the alpha female's offspring that seem to do best out of the deal, since they receive preferential treatment by being suckled by the beta female as well as the alpha.

In mole-rat colonies only *the reproductive female reproduces and suckles the young; the non-reproductive females exhibit cooperative care of the young by foraging for food, and returning them to the nest if they venture from the burrow. The term 'eusocial' is strictly an entomological term that mammalian behavioural ecologists have 'borrowed' to describe these unusual mammalian social societies.**

Mr Verkest has raised an interesting issue: can some species be considered 'eusocial' in the true sense of the word? We feel that mole-rats really do fit the description because, unlike the canids where several females are involved in reproduction, in mole-rats we can genuinely say that non-reproductive females exhibit socially induced fertility, as is so clearly demonstrated in the Damaraland Mole-rat. However, use of the term 'eusocial' in mammalian studies remains a contentious issue and I am sure it will result in many hours of intellectual debate!

—Nigel Bennett
University of Pretoria

**And not just mammalogists! The latest species to hit the 'eusocial' list is a marine shrimp* (Synalpheus regalis) *from the coral reefs of Belize.*

—G.H.

Marigold Mixup

Thank you for an excellent magazine that is enjoyed by the children and adults alike in my family.

I wish to comment on the photograph accompanying the Q & A item "Plants versus Pests" in the Autumn 1996 issue. The photograph shows *Calendula officinalis*, also known as English Marigold, Pot Marigold, Garden Marigold or Calendula. This is the marigold that is commonly used in cosmetic preparations for its anti-inflammatory and skin-healing properties. In herbal medicine, it is also used internally in the treatment of ulcers and inflammatory conditions of the digestive tract.

However, the item that the photograph was supposed to illustrate concerns the use of 'marigolds' in companion planting for their pest-repellent properties. The plants used for this purpose do not belong to the illustrated species but are members of the genus *Tagetes*, in particular the species *T. erecta*, commonly known as African Marigold. The flowers of this species contain pyrethrins with insecticidal activity. *Calendula officinalis* does not contain pyrethrins and is not generally recognised as having insecticidal properties.

While planting *Calendula* instead of *Tagetes* is not going to harm your garden, the ingestion of the latter instead of *Calendula* flowers (for example as a herbal tea) may not be a pleasant experience. A few years ago a garden magazine featured an article about the wonderful medicinal properties of 'marigold'. The article clearly referred to medicinal uses of *Calendula officinalis*, but the accompanying photograph showed *Tagetes*! This confusion surrounding the identity of 'marigolds' is one of many examples highlighting the value of using botanical names.

—Hans Wohlmuth
Lane Cove, NSW

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


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Nature Strips

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Fish Brains Take the Record

While you are quietly sitting there reading this, your brain is consuming about 20 per cent of the total amount of oxygen your body is using. Until recently that rated as a record, most other vertebrate brains only consuming about two to eight per cent of their body's resting oxygen consumption.

But now an unlikely challenger has stolen that record from under our noses. Göran Nilsson of Uppsala University in Sweden has demonstrated that in the African Elephantnose Fish (*Gnathonemus petersii*), a species that uses its elongated chin (not nose) to probe the muddy bottom of lakes for food, the brain is responsible for 60 per cent of the body's oxygen consumption and energy demands. This high rate of oxygen consumption is a consequence of the fish's extremely large brain, which makes up about 3.1 per cent of its body mass, compared to less that one per cent for most other fish and around 2.3 per cent for a typical human.

But why the need for such a large brain? The Elephantnose Fish uses modified muscle cells to generate an electrical field around its body, using distortions in the field to find its way around in the dark murky waters it inhabits and to communicate with others. Nilsson suggests that the fish's large brain, with its impressive energy demands, has evolved in order to cope with this complex sensory information.

—G.T.

Lizards Walk on Water

It's official. It doesn't take a miracle for Jesus Christ lizards to walk on water. Found in Central America, basilisks (*Basiliscus* spp.) gained their biblical common name when they were observed skipping across the water's surface to escape predators. Using high-speed video recordings, Jim Glasheen and Thomas McMahon of Harvard University have recently shown exactly how the lizards do it.

Glasheen and McMahon ran some medium-sized (90-gram) Jesus Christ lizards (*Basiliscus basiliscus*) down a three-and-a-half-metre tank and videoed their flight across the water. Careful analysis of the recordings revealed that, as a lizard's hind foot strokes downwards and backwards, pushing the lizard upwards and forwards, an air cavity is produced above the foot. The lizards move so fast that they can pull the foot out of the cavity before it has had a chance to collapse, preventing them from getting 'tangled' in the water.

But before anyone gets any ideas about using this as an explanation for the water-walking abilities of the real JC, the researchers point out that, for a human to make use of this technique, they would have to be able to run at 108 kilometres per hour and generate 15 times the amount of power produced by someone running uphill. The technique doesn't even work for adult basilisks, which are just a little too heavy.

—G.T.

JEAN-MICHEL LABAT/AUSCAPE INTERNATIONAL

The bizarre probing chin of the Elephantnose Fish belies an even more extraordinary feature: in terms of oxygen consumption, it has the most expensive brain of any vertebrate.

GERRY WHITMONT

Autumn colours protect leaves from the still-damaging effects of the sun as they pack up their goodies for winter.

Autumn Leaves Questions

As the end of summer approaches, days shorten and the first cold snaps of autumn herald the imminent arrival of winter. Deciduous trees prepare to cope with the coldest, bleakest months by packing up their precious photosynthetic apparatus and slipping into a dormant state.

This process of 'bunkering down' for the winter, however, is a lingering operation in which materials such as coloured leaf pigments are broken down and resorbed for storage until the arrival of spring and its opportunities for new growth and reproduction.

Green chlorophyll is one of the first pigments to break down, but others, known as carotenoids, remain for some time, giving rise to the recurring botanical spectacle of yellow, orange, red and mauve autumn leaves.

What is the purpose of the striking period of autumn tonings before leaves eventually brown, wither and drop to the ground? Why aren't all leaf pigments simply absorbed in one hit? By investigating the optical qualities of autumn leaves from the deciduous maple *Acer platanoides*, biologist Mark Merzlyak of Moscow State University, and physicist Anatoly Gitelson of Israel's Ben Gurion University of the Negev, have found some answers.

They discovered that the amount of light absorbed by the leaves remained constant, even when only small amounts of chlorophyll remained. So, although the leaves changed colour and appeared to be dying, they continued to absorb and reflect light almost as if they were still green.

The lingering carotenoids that give autumn foliage its colour appear to protect leaves against damaging blue and ultra-violet rays in sunlight, giving trees the time they need to pack up and store away all the precious reusable components of their leaves.

—K.McG.

Martians at Last?

The recent announcement that evidence had been found of life on Mars caused quite a stir in the media. The evidence turned up in a two-kilogram meteorite called ALH84001. Found in Antarctica, it is believed to have been thrown from Mars 15 million years ago during the impact of a small asteroid or comet onto Mars. After drifting through the solar system for millions of years, ALH84001 eventually landed on Earth some 13,000 years ago. But how sure are the researchers that they've found evidence for—albeit extinct—Martians?

After drifting through the solar system for millions of years, ALH84001 eventually landed on Earth some 13,000 years ago.

Although ALH84001 was found in 1984, the advances in electron microscopy that were needed to reveal the evidence have only recently been developed. Using the new techniques, NASA researchers David McKay and colleagues found tiny fossil-like features, associated with secondary carbonate estimated to be 3.6 billion years old, within the sample. The largest is less than one-hundredth the diameter of a human hair. They also detected compounds known as polycyclic aromatic hydrocarbons (PAHs), which are common leftovers when micro-organisms die and their organic molecules degrade. PAHs are also found in other kinds of meteorites and in cosmic dust where they are interpreted as remnants of early solar system formation produced by inorganic processes. However, the composition fingerprint of the PAHs found in ALH84001 is what scientists expect when micro-organisms are fossilised and is different from that in other types of meteorites. They also found unusual compounds (iron

KATHIE ATKINSON

No extra marital flings for *Hippocampus whitei*; and that's the truth!

oxides and sulfides) similar to those that are produced by anaerobic bacteria. Each of these pieces of evidence was found along with carbonate globules, thought to have formed when Mars was warmer and wetter, and hence more conducive to life.

What compels the scientists to claim the discovery of extraterrestrial life is the proximity of each of these things to each other—within a few ten-thousandths of a millimetre. It would be an extraordinary coincidence for this to occur if life was not involved and if all of the features were produced by inorganic processes.

The scientists dutifully point out, however, that nothing is certain. As Everett Gibson, one of the three co-leaders of the research team, stated: "We are putting this evidence out to the scientific community for other investigators to verify, enhance, attack—disprove if they can—as part of the scientific process. Then within a year or two, we hope to resolve the question one way or another."

—Geoff McNamara

Faithful Seahorses

A spate of genetic studies has shown that sexual fidelity, even among supposedly monogamous animals, is rather rare. But not so for partners of one species of Australian seahorse, which have eyes only for each other.

Amanda Vincent from the University of Oxford and Laila Sadler from the University of Melbourne conducted the first-ever underwater study of seahorses and found that *Hippocampus whitei* form male–female pairs that are both socially and sexually monogamous.

The researchers observed the tagged seahorses performing their daily greeting rituals, which included colour changes and a well-coordinated dance. The seahorses mated only with their partner, an observation made easy by the corresponding changes in girth of both sexes as the eggs were transferred from female to male.

The seahorses shunned opportunities to interact with other seahorses and ignored temptation from unattached animals. They also remained faithful to injured partners or those unable to reproduce.

As to why they remain monogamous, the researchers say that pregnant males are unable to remate because the intrusion of salt water would damage the embryos in his sealed pouch. Females are unhampered by the hassles of pregnancy, and appear free to mate again, but Vincent and Sadler suggest that, because it takes a female about the same time to produce another batch of eggs as it takes for a male to incubate the batch in his pouch, and because reproductive efficiency increases with pairing, the benefit of multiple matings to the female would not outweigh the costs in lost reproductive output. It also appears that all males in an area give birth and remate in the same week, further reducing opportunities for bigamy.

—R.S.

Tapir Penis

Looking for all the world like a collection of cast-offs from other species, tapirs (genus *Tapirus*) with their short, prehensile trunks and large pig-like bodies have another outstanding feature: an enormous penis with an oversized, club-shaped head.

Weighing between 180 and 365 kilograms, tapirs are known to have the greatest penis to body size ratio of any vertebrate. So large is the penis that captive tapirs have frequently been observed stomping all over their erect member in their eagerness to get to food. While working at Taronga Zoo, a colleague and I observed the fully erect penis of a Brazilian Tapir (*T. terrestris*), known affectionately as Toby, to be approximately one metre long with the head of it about 30 centimetres wide.

But why so large? Tapirs belong to the order Perissodactyla, which includes horses and rhinoceroses and with which they share a complicated vascular penis. The club-shaped head is formed by large fleshy lateral processes, which are noticeable on either side when the penis is fully erect.

Until recently the function

STEVE THOMAS

Toby the Brazilian Tapir displays his extraordinary penis.

NEW VISION

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The freedom to see.

of these processes in tapirs was unknown. But after watching an unsuccessful mating attempt by an injured Sumatran Rhinoceros (*Dicerorhinus sumatrensis*), the staff of Melaka Zoo in Malaysia noticed that the lateral processes became erect some time after the main shaft was erected (which in normal circumstances would be after the penis is inserted). Unfortunately the injured rhino was unable to manoeuvre himself into place quickly enough; the processes inflated before he was properly inserted, and this kept him out. Colin Groves (Australian National University) suggests that, because rhinos and tapirs have such long matings, the flared processes might serve to lock the penis in place.

Perhaps this has another advantage for the endangered tapirs. They inhabit dense rainforest on the steep slopes of Malaysia and South America, and maybe the processes offer some sort of additional traction to the mating couple on the rare occasions when they meet!

—R.S.

COURTESY TOMIO NAITOH

The prolapsed stomach of a vomiting frog (*Rana catesbeiana*) hangs to the right.

Gastric Grooming and Right-handed Toads

Handedness or footedness, where animals preferentially use their right or left limbs to complete tasks, has been reported in birds and mammals and now, for the first time, in amphibians. In a series of experiments, Angelo Bisazza from the University of Padova in Italy and colleagues showed that European Toads (*Bufo bufo*) used their right front paw to remove foreign material stuck to their head and face.

Since their report, however, an adaptive explanation for why toads might use their right paws for this grooming activity has been suggested. Tomio Naitoh (Shimane University, Japan) and Richard Wassersug (Dalhousie University, Canada) point out that it doesn't take much for frogs and toads to vomit (nature's way of getting rid of any toxic material in the stomach) and that, when they do, they not only regurgitate the stomach contents, but the stomach itself! They explain that the stomach is asymmetric, with the membrane that anchors it to the body wall being shorter on the right than the left side, so that the stomach tends to hang out the right side of the mouth when expelled. Frogs and toads automatically wipe away any remaining (and potentially noxious) contents from the prolapsed stomach

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Sometimes you have to be cruel to be kind: frightening the wits out of captive-bred Rufous Hare-wallabies may be their only chance of survival in the wild.

before re-swallowing it. Since the stomach is often well out of reach of the left paw, it is not surprising that 'gastric grooming' is carried out by the right front paw.

Neat as this explanation is, however, it cannot fully explain preferential paw use in toads. Bisazza and colleagues, in their original study, also showed that Cane Toads (*Bufo marinus*), unlike European Toads, used their right and left paws equally to remove material from their mouth, despite the fact that these amphibians, like other *Bufo* species, have asymmetric stomachs. Yet, Cane Toads did show preference for using their right paw in another test in which they had to right themselves from an inverted position under water.

It seems that in amphibians, as well as in birds and mammals, there are different levels of asymmetries, and to establish causal links between behavioural and anatomical asymmetries is, at present, difficult.

—G.H.

Scare Tactics for Endangered Animals

With the increasing success of captive breeding programs for endangered species, conservation biologists are being faced with a dilemma: what to do when you're ready to release your captive-bred animals but the introduced predator responsible for their decline is still present where you plan to release them. Now Ian McLean of the University of Canterbury in New Zealand, Geoffrey Lundie-Jenkins of the Conservation Commission of the Northern Territory and Peter Jarman of the University of New England have come up with part of the answer: give them a good scare.

One of the reasons that introduced predators like foxes and cats have had such a devastating effect on Australia's small mammals is that, historically, Australia has lacked these sorts of predators and so the prey are 'naive'. So McLean and his colleagues set out to make one species of endangered mammal a little more 'streetwise'.

Rufous Hare-wallabies (*Lagorchestes hirsutus*) became extinct on the mainland in 1991 due to a combination of fire and foxes. They survive on two islands off the coast of Western Australia and in two captive populations in the Northern Territory.

Working with these captive populations the researchers introduced models of foxes and cats and observed the wallabies' responses. They then reintroduced the models in such a way as to give the wallabies a fright. One method was to make the model leap from its box, making a loud noise as it did so and playing hare-wallaby alarm calls as it moved through the enclosure. The alternative method, which they called Puppet-and-Squirt, had the model leap at any wallaby that ventured near, followed by a well-placed squirt of water, compounding the shock.

They found that the captive-reared wallabies were naturally cautious of the models and became even more-so after they'd been taught to associate the models with a fright. Together with techniques to teach captive-bred animals to find food in the wild, this new research may help naive mammals to cope out there in the real world.

—G.T.

The alternative method, which they called Puppet-and-Squirt, had the model leap at any wallaby that ventured near, followed by a well-placed squirt of water.

Webs of Stone

Think of spiders, and sticky, prey-catching snares usually spring to mind. But, among the many spider species that adopt this wait-and-pounce approach, webs are not always constructed from silken thread alone.

Corolla spiders (*Ariadna* spp.) from the gravel plains of the Namib Desert live in vertical burrows, around the entrance of which they construct rings of stones. Joh Henschel, from Namibia's Desert Ecological Research Unit, recently investigated these structures in the species *Ariadna* cf. *masculina*.

He found consistencies in their arrangement that suggested the stones were being used as tools to extend the foraging range of the spiders. The shape, type, size and orientation of the stones all appeared to be aimed at transmitting prey vibrations to the waiting spiders.

Seven or eight stones were usually placed around each burrow in a single-layered, daisy-like arrangement, with the sharpest point of each stone directed towards the burrow entrance. Given a choice of quartz, granite, schist, felspar and marble, quartz stones were preferred. And, although the spiders are capable of moving stones almost 100 times their own mass, they tended to select small stones, a little over twice their mass.

Short silken trap-lines extended from the burrows to the stones. Spiders positioned themselves at night with their three front pairs of legs on the silken collar around the burrow entrance.

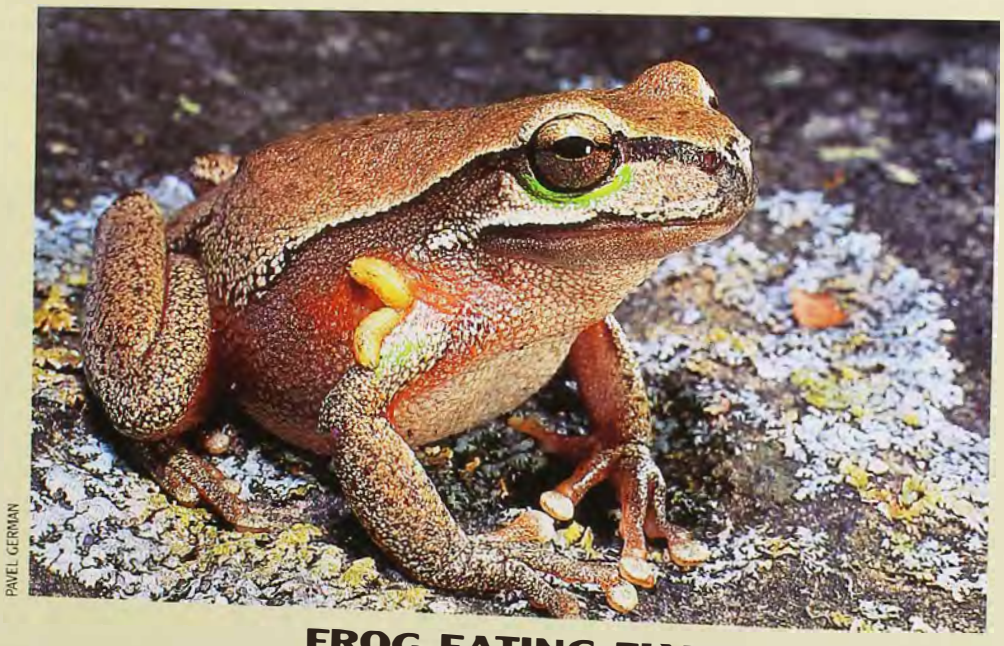
A corolla spider's burrow entrace, in which stones replace silk in the harsh gravel plains of the Namib Desert.

COURTESY JOH R. HENSCHEL

Henschel observed spiders pouncing upon ants that had merely brushed against the outside edge of the stones. He elicited the same response by touching the stones with a human hair.

In other areas, close relatives of corolla spiders maintain webs made only of long silken trigger lines. Such structures would be destroyed by the constantly blowing sands of the Namib Desert's gravel plains. Henschel believes that circles of stone may be an effective alternative in this harsh environment.

—K.McG.



PAVEL GERMAN

FROG-EATING FLY

It is well known that many frogs eat flies, but here is a fly (or maggot) that has turned the tables. The maggots are larvae of a frit or grass fly (family Chloropidae) in the genus *Batrahomyia*. Most frit flies feed on rotting vegetation, new shoots and the like. *Batrachomyia* species, however, feed on the blood of frogs.

According to David McAlpine (Australian Museum) the adult fly most probably lays its eggs in damp places where frogs are likely to occur, and when the tiny maggots hatch they surreptitiously climb on board. Once there they chew a hole through the skin and burrow underneath. The two projections at the back end of the maggots are the breathing spiracles, which allow the maggots to breath while feeding. The maggots only leave the frog (as they are doing here) when they are ready to pupate. They crawl away slowly, presumably to avoid drawing attention to themselves as frogs usually only strike actively moving prey. Throughout the whole ordeal, the host frog remains unharmed.

Very little is known about this fly genus. The species shown here, for example, may be an as yet unnamed parasite of the Blue Mountains Tree-frog (*Litoria citropa*).

—Martyn Robinson

I'iwi Bills

Extinction is rarely an isolated event. When species crash they often take others with them or carve out new directions for natural selection.

In Hawaii where, like other islands, ecosystems can be very delicately balanced, human development has caused dramatic declines in native plants and animals, particularly over the past century, and the impact is becoming increasingly evident in surviving species.

A recent study by Thomas Smith and colleagues, from the University of California at Berkeley, links changes in the bill of a small nectar-feeding bird, the honeycreeper known as the I'iwi (*Vestiaria coccinea*), to the recent demise of lobelioids, bird-pollinated plants that once dominated Hawaii's forest understories.

In what has often been suggested as a case of co-evolution, the long downward-curved bill of the I'iwi is perfectly shaped and sized for feeding on the deep, tubular, nectar-rich flowers of lobelioids. These flowers used to be the primary food source of I'iwis.

Over the past 100 years,

however, a quarter of Hawaiian lobelioid species have become extinct, and most of the remainder are rare or endangered. I'iwis have adjusted by turning to the shorter, more open ohia flowers as their primary food source. This transition has been helped by the extinction early this century of another nectar-feeding bird, the 'O'o (*Moho nobilis*), that once fed on ohia.

Honeycreepers that have traditionally specialised on ohia flowers have short bills. And that now appears to be the direction that the I'iwi bill is headed. When Smith (now at San Francisco State University) and his colleagues compared I'iwis caught recently in mist nets with those of museum specimens collected before 1902, they found that the upper mandible of the species' bill has become noticeably shorter and straighter. For I'iwis feeding on ohia, it appears natural selection favours those with shorter bills.

—K.McG.

Some Like it Hot

The sex of a crocodile depends on the temperature at which it develops inside the egg. This phenomenon of 'temperature-dependent sex determination' (TSD) is widespread in reptiles. There are, however, also many reptile species that have 'genotypic sex determination' (GSD), where sex is genetically pre-ordained regardless of the temperature at which eggs are incubated.

Scientists generally agree that TSD in reptiles has evolved independently several times from GSD. But there's been a lot of disagreement about why natural selection should favour evolution in that direction. According to a theory formulated in the 1970s, TSD has evolved because it "allows an embryo to develop as the sex best suited to its incubation environment". This implies that temperatures required for optimal development are inherently different for male and female reptile embryos.

Richard Shine and colleagues from the University of Sydney recently put this theory to the test by incubating batches of eggs from an Australian GSD skink, *Bassiana duperreyi*, at different temperatures.

The sex ratios of hatchlings did not vary between batches but there were some very strong size effects. Among the hatchlings from eggs incubated at lower temperatures, males were larger and ran faster than females. The situation was the reverse for the hatchlings of eggs incubated at higher temperatures.

This is the first real proof of what may be a fundamental trait in the reptiles as a group: the optimal temperature for embryonic development in females differs from that for males.

If this is true, it explains why TSD has evolved repeatedly. The larger and faster a hatchling is, the better its chance of survival. From an evolutionary standpoint, the crucial thing is not whether males or females are produced, but the fittest possible offspring. A mechanism such as TSD would allow embryos to develop as the sex with the best chance of survival.

—K.McG.

The Geography of Snakebites

If bitten by a snake, identification of the species responsible is often critical for treatment. But where you're bitten—that's the geographical, not just the anatomical, location—can also be important.

Consider, for example, the Malayan Pitviper (*Calloselasma rhodostoma*), a major cause of venomous snakebite to humans throughout South-East Asia. The digestive enzymes of this snake are so potent that, if you do survive, tissue damage can be severe enough to leave you with permanent deformities. The exact nature of the symptoms, however, often depends on where you are when you're bitten, suggesting the composition of

COURTESY W. WÜSTER

The composition of Malayan Pitviper venom varies according to the snake's location.

pitviper venom varies between geographic locations.

To investigate why, biologist Jennifer Daltry and colleagues from the University of Wales, UK, collected the venom of wild adult Malayan Pitvipers from locations across Vietnam, Malaysia, Thailand and Java.

Venom analysis revealed that composition variations were closely related to dietary differences. The principle function of viper venom is to immobilise and digest prey, and different prey animals may vary in their susceptibility to toxins. The researchers suggest that in Malayan Pitvipers, and perhaps other venomous snakes, natural selection fine-tunes the venom in particular populations in line with their main food sources.

The researchers found that venom from captive-bred pitvipers varied according to the geographical location of their wild relatives and not according to the unnatural diet upon which they were fed in captivity. This indicates that the venom–prey association is inherited within populations and is not a direct consequence of the environment.

The work of Daltry and her colleagues has important implications for the way in which snake antivenoms are developed.

—K.McG.

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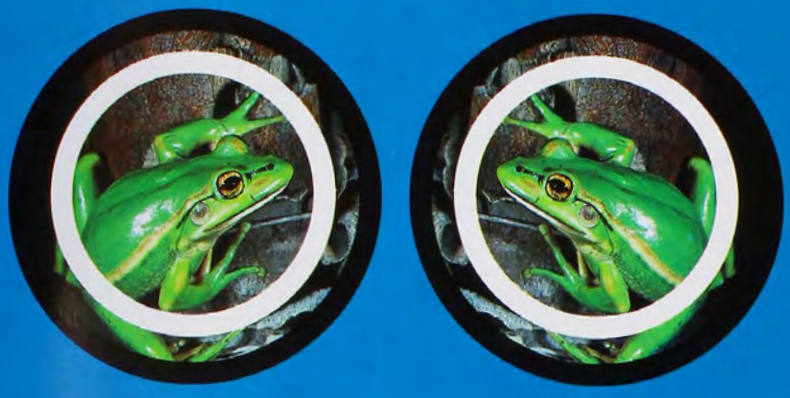
Karen McGhee, Rachel Sullivan and Geordie Torr are regular contributors to Nature Strips.

QUICK QUIZ

1. Off which State of Australia would you find Wardang Island?
2. What is the more common name for bovine spongiform encephalopathy?
3. On which planet would you be simultaneously asphyxiated, crushed, roasted and dissolved?
4. What is the bird emblem of Victoria?
5. Which mosquito bites: the male or the female?
6. Give the more familiar name for O_3.
7. What is the largest mammal in the world?
8. Where did the extinct Dodo once live?
9. Which geological period is the oldest: Triassic, Jurassic or Cretaceous?
10. What is palaeontology?

(Answers in Q&A)



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When a snail gets a gleam in its eyestalk, it's not for its better (other) half that it yearns, but for another snail's other half.

SNAILS: WHERE BOYS WILL BE GIRLS

BY STEVE VAN DYCK

WHEEDLING MORE OF a wallop from your home brew can be as risky as Russian roulette; the loaded vessels, the straining caps...the awful bang. And even if the batch makes it as far as the schooner, its unpredictable quality may be enough to nearly blow your head off.

Toward the end of the '80s we lost two undercover agents—Nos 3 and 12—to a bottle of OP home-brewed stout that was off. After tasting and condemning it, I'd emptied the bottle outside into the dog's bowl (I'd often wondered if dogs got drunk). But when morning came with its bright light and headaches, the dog was sober, and the bowl of murky stout was untouched, but it had taken its toll. For there, bobbing around in the black liquor were two big snails, both full as googs, drowned and gone on the slow boat to heaven.

If they had been ordinary introduced Brown Garden Snails (*Helix aspersa*) that rasp their rough 15,000-toothed tongues up baby lettuces and portulacas, we might have shelved the Defender and set up sly grog traps all around the garden. But they were Australian natives called Fraser's Land Snails (*Sphaerospira fraseri*) with thick, darkly banded shells larger than walnuts and appetites geared to the compost heap rather than the vegie garden.

Fraser's Land Snails are found from Grafton in New South Wales north to Cooloola in south-eastern Queensland, where they live in moist gullies and gardens that have tended to get away from their owners. The two that had slid into the stout for a quick slug had been given the numbers 3 and 12 by us the previous year. It is a matter of no distress for a snail to have a blob of white-out painted onto its shell, then a number applied in Indian ink, but it can be a matter of much interest to be able to watch the comings and goings of known individuals over the years.

For instance, on the night of 15 November, No. 3 had crawled onto the verandah and slipped into a torn plastic bag of lily bulbs packed in moist peat moss. The surroundings must have tickled its fancy because by the time it left it had mothered about 50 white eggs, each the size of those tasteless, cusp-cracking silver pearls they put on wedding cakes.

At the same time, in some other corner of the garden, another snail was laying her five dozen eggs which, presumably, had been fathered by the same (late) No. 3, which is all very modern, and a little confusing, but only goes to show that, in sticky snail-circles, boys will be girls and vice versa.

This makes them (and all other lung-bearing snails) hermaphrodites, but not necessarily narcissists, because when a snail gets a gleam in its eyestalk, it's not for its better (other) half that it yearns, but for another snail's other half. Not long after a courting pair of Brown Garden Snails gets swept along in the lather of lust, either one of them may thrust a three-to-ten-millimetre calcareous dart, looking like a curved Moroccan dagger, up, sometimes as far as the hilt, into the genitals or body wall of its mate. That tender bit of primal sado-masochistic pre-copulatory pricking was once thought to heighten arousal and stretch out the affair on account of a liqueur of aphrodisiacs carried by the dart. Results of more recent research, however, suggest that the sexual effect of the dagger is still unresolved. Dart or no dart, the snails then lock together, for up to three hours, and swap take-away pre-packaged containers of sperm that ensure far more genetic diversity in their offspring than if they'd pulled the whole performance off by themselves.

However, the marriage ceremony of two Fraser's Land Snails is a much more touching affair. The two may meet over a romantic meal of toadstools or dog biscuits whereupon they begin to check one another out. They face each other, and while the top pair of telescopic eye tentacles keeps a lookout on the horizon, the bottom pair, which is used for smell and touch, comes up and does a delicate braille reading of a small wart that swells and rises like a unicorn's horn out from each snail's head, right between the eyes.

DENNIS SARSON/LOCHMAN TRANSPARENCIES

An introduced Brown Garden Snail with its eggs. These snails will lay up to 100 eggs within two weeks of mating.

KATHIE ATKINSON

Having thrust a calcareous dart into the body wall of its chosen partner, these Brown Garden Snails set about the business of sperm exchange.

The sensory information exchanged between the wonder-wart and the titillating tentacles quickly separates the men from the boys and the right species from the wrong; and if that information isn't entirely up to scratch, each snail does an abrupt about-face, puts its trail between its leg and goes on its phlegmatic way. However, if the data from both head-warts jell, and if the sluggish pace hasn't sent them both into a coma, then the two rise up in a slimy double slap-and-tickle that, for snails, is poetry in slow motion.

Sadly, it has been about eight years since we last had regular visits from Fraser's Land Snails, and coincidentally their disappearance marked the time when we hung up our gumboots because summer wet seasons in south-eastern Queensland began to consistently fail. The connection appeared less coincidental when it was pointed out that, on a much broader scale, the presence and absence of certain snails (including fossils) in particular habitats has long been used as a biological indicator of a wide range of local environmental conditions from moisture and pollution to changes of calcium carbonate in the soil. From analyses of the assemblages of snail species in excavations, archaeologists have good indications that farming in the British Isles began about 4,000 BC.

To many though, the attraction of gastropods is purely gastronomic. The Romans used to cultivate snails (being high in protein and containing mineral salts and vitamin C) as a nourishing food for the poor. Today, snail-raising is a multi-million-dollar industry in Europe. If we Aussies would only gobble as many introduced Brown Garden Snails as we annually try to poison...the trouble is they do have an image problem. Those long eye-stalks are a bit of a worry, not to mention all that foaming and hissing they do when you are trying to kill them. And there are those long strings of something that float in the saucepan too, and often something gritty in the chewing. But there is a hidden agenda that keeps me eating one escargot meal after the other...the titillating prospect of getting a flight of those love-darts stuck somewhere in my internal anatomy during the digestive process. Perhaps that is why the French are renown for being more than just great snail lovers.■

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

BROWN GARDEN SNAIL

Helix aspersa

Classification
Class Gastropoda (snails, whelks), subclass Pulmonata (lung-bearers), family Helicidae.

Identification
Grey body, brown to yellowish shell with dark brown spiral banding and rough growth ridges. Shell up to 40 mm across.

Distribution and Habitat
Introduced to Australia in the early 1800s from western Europe. Now Australia-wide and worldwide in warm temperate zones.

Food
Lettuce leaves, cabbage, porridge, milky bread, carrots, marigolds etc.

Life Cycle
Hermaphroditic (both male and female reproductive organs in each animal). Mate for 2–3 hours, 40–100 eggs laid 1.5–2 weeks after mating. Eggs hatch 17–25 days later. Three to 10 batches laid per year. Live for approx. 4 years.

Good Points
Food for wide variety of mammals, birds and reptiles. Although an ointment of crushed snails was once used to treat human eczema, warts, corns, boils and tumours, today they are more usually just eaten (make sure you 'purge' them by feeding only corn meal and water for a week before cooking; that gets out the grit and strongly flavoured food in their guts).

Gerard Krefft, an early naturalist, had several Western Barred Bandicoots around his camp that "proved as useful as cats".

WESTERN BARRED BANDICOOT

BY JACQUI RICHARDS & JEFF SHORT

THE WESTERN BARRED Bandicoot (*Perameles bougainville*) was first recorded from Peron Peninsula in Shark Bay, Western Australia, in 1817, where it was reported to be "quite common". At that time, it was also widespread across Australia through the southern arid zone, from the Liverpool Plains in New South Wales to the north-western coast of Western Australia. Today, however, the species is extinct on the mainland and survives only on Bernier and Dorre Islands off the coast of Western Australia in Shark Bay.

The extinction of the Western Barred Bandicoot from the mainland was probably due to predation from introduced animals such as cats and foxes, combined with habitat alteration caused by the introduction of domestic stock and rabbits, clearing, and changes in fire regimes. Fortunately, Bernier and Dorre Islands have remained free of introduced mammals. These island refuges were set aside as nature reserves in 1957 and are home to a suite of endangered native mammals that have become extinct on the mainland.

Western Barred Bandicoots are the smallest and most delicate members of the bandicoot family (Peramelidae), with adults weighing around 250 grams. They are nocturnal, nesting each day under low shrubs in a depression beneath dense litter. Living above ground makes them easy targets for predators such as foxes and cats, which utilise a similar habitat. Their diet is predominantly insectivorous, although they will also eat spiders, earthworms, berries, seeds, roots and small herbaceous plants as they hunt and dig for their food. Gerard Krefft, an early naturalist, reported a Western Barred Bandicoot from the Liverpool Plains in New South Wales back in 1866 as being adept at catching mice (species unknown). The animals would "tumble the mice about with fore paws and break their hind legs" and could kill up to 20 with "astonishing quickness". He had several Western Barred Bandicoots around his camp that "proved as useful as cats".

However, like many mammals, bandicoots soon become 'trap happy'. With multiple captures they will sit quietly in a capture bag and require little restraint during handling.

Bandicoots have a high reproductive output, which makes them excellent prospects for reintroduction to the mainland. Precise breeding information for the Western Barred Bandicoot is unknown, but the closely related Eastern Barred Bandicoot has a gestation period of only 12.5 days (one of the shortest gestation periods recorded in mammals). Western Barred Bandicoots usually produce two offspring per litter, with newborns only ten millimetres in length and weighing about a quarter of a gram. Their breeding is concentrated in the wetter winter and spring months, but they may also breed opportunistically throughout the year when unseasonal rainfall promotes good conditions.

Bandicoots have a backward-opening pouch with eight nipples. Eastern Barred Bandicoot young remain in the pouch, suckling for approximately 45 to 60 days before venturing out into the world. The high number of nipples relative to the number of young seems to be an adaptation to having many litters in quick succession (a litter every 80 days). Pouch young of successive litters are thought to alternate teats, as previously suckled teats take about a month to return to a size that newborns are capable of attaching to. By about 70 to 80 days of age the young become independent and disperse from their mother. Male Western Barred Bandicoots have a home range of up to 14 hectares, while females range over less than six hectares on Dorre Island. While their home ranges overlap, each individual has a central core area that is not encroached by other bandicoots.

Western Barred Bandicoots have been bred successfully in small enclosures in captivity and can become quite tame. During trapping on Dorre Island the bandicoots are often wary and try to escape as quickly as possible. On release, they display a distinctive nervous leap as they spring to the safety of spinifex or dense shrubs. However, like many mammals, bandicoots soon become 'trap happy'. With multiple captures they will sit quietly in a capture bag and require little restraint during handling. After release, the bandicoots observe us for a few moments, before hopping slowly off into a nearby shrub to sniff and snuffle amongst the litter.

CSIRO, with support from Shark Bay Salt Joint Venture, recently transferred 12 Western Barred Bandicoots from Dorre Island to a nearby conservation reserve at Shark Bay, in the first attempt to re-establish a mainland population and to provide a more secure future for the species. The most successful reintroductions of endangered mammals have been in areas where cats and foxes have been controlled or eradicated. Predator control is thus a major priority for any mainland reintroduction. At Heirisson Prong, site of the Western Barred Bandicoot reintroductions, predators have been eliminated from an area of 1,200 hectares and reinvasion is prevented by a barrier fence across the base of the peninsula. In addition, control is supplemented by monthly trapping and poisoning of foxes and cats within a buffer zone of approximately 200 square kilometres to the south of the fence.

Several other reintroductions of this species are planned by the Western Australian Department of Conservation and Land Management. If all these populations are successfully established, then perhaps the status of the Western Barred Bandicoot may become sufficiently secure for it to be removed from the list of endangered species.■

Jacqui Richards and Jeff Short are scientists with the CSIRO Division of Wildlife and Ecology based in Perth.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

I could never in my wildest dreams have guessed that the little fruits at my feet would one day end up 1,600 kilometres away in my local supermarket.

A BUSH FOODS BOOM?

BY TIM LOW

TWELVE YEARS AGO WHILE I was researching wild foods, I came upon descriptions of an obscure fruit from the dunes of eastern South Australia and western Victoria. It was called Muntries (*Kunzea pomifera*). I couldn't find any pictures of this fruit in books, nor a recent description of its size and colour. Even botanists at the Adelaide Herbarium couldn't tell me what it looked like. I finally tracked down the fruiting shrubs in 1986 near Robe in South Australia, and featured the photos in my books.

My mind was on other things when, a few months ago, I was shopping in my local Woolworths and came across bush tucker vinegars in the delicatessen section. I looked in one of the bottles and was startled by what I saw: pickled Muntries. In Woolworths! This idea still amazes me. Eleven years ago, standing on those remote dunes, I could never in my wildest dreams have guessed that the little fruits at my feet would one day end up 1,600 kilometres away in my local supermarket.

The growth of the bush foods industry in Australia has been astounding. In 1986 there was no industry to speak of; ten years later there were about 150 players and a $14 million turnover. If the current growth rate continues, by the year 2000 the industry could be worth about $100 million.

It was against this backdrop of remarkable progress that I attended the first conference of the Australian Native Bushfood Industry Committee (ANBIC) in Brisbane in May 1996. ANBIC was funded by the Rural Industries Research and Development Corporation to help develop the fledgling industry, especially the plant foods.

It was exciting to meet wattle seed harvesters from outback deserts, effusive inner-city chefs, trendy pasta and pickle makers, and dour researchers, all gathered together and enthused by the prospects of a booming bush foods industry.

But I soon realised that the industry, despite so much energy and imagination, has a way to go. It is fragmented and provides scant financial security for most of its players, many of whom are undercapitalised. The bulk of the harvest is coming from wild supplies, a limited and unsustainable resource, and while there are many farmers and land-holders eagerly planting native orchards, no-one is yet making a living from selling cultivated tucker—it has not been proved

Muntries were once traded by Aborigines for stone tools. Now they are traded by inner-city bush-food dealers.

PHOTOS: TIM LOW

Round-leaf Mintbush is under trial at Tarnuk Bush Food and Flower Farm in south Gippsland. The leaves are very aromatic but most unlike the cultivated mints.

viable. Even the established crocodile farms depend upon tourism to supplement income.

Nor is there any guarantee this will change. Bush foods are much costlier to obtain than regular fruits and vegetables, so they will always be expensive gourmet items. It is unclear whether Australians are willing to buy them on a regular basis, or whether they will remain as novelty or special occasion foods, bought mainly by overseas tourists as jams and pickles, or by restaurateurs.

Another problem, aired at the conference, is the very name. Food writer Diane Holuigue argues strongly that 'bush foods' and 'bush tucker' are too down-market for expensive gourmet foods. 'Bush' suggests food from a bush and 'tucker' is ocker. One conference resolution was for market research into the name.

The names of individual foods also need stabilising. Should it be 'Muntari', or 'Munthari'? 'Bush Tomato or 'Akudjura' for *Solanum* 'Billygoat Plum' or 'Kakadu Plum' *Terminalia latipes* (the former preferred by Kakadu Aborigines)?

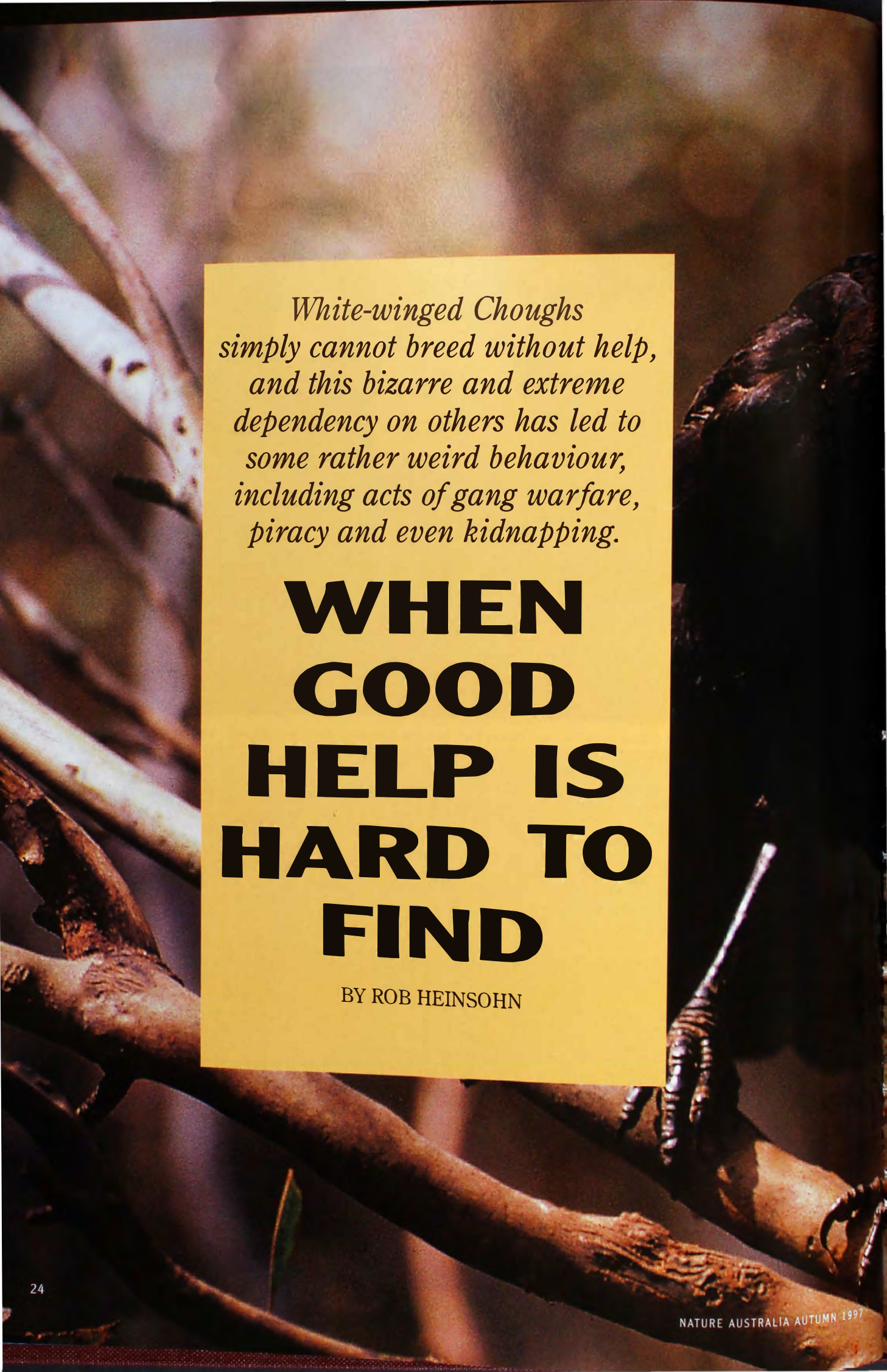
There was talk about the role of bush foods in Australian cuisine. Industry pioneer Vic Cherikoff argues sensibly that Australia's international-style cuisine will never be replaced by bush tucker, but that native ingredients can be incorporated to Australianise our diet, in the way that macadamias are already used. Aboriginal cooking techniques can be introduced, and Vic envisages restaurants with hot sand ovens baking bush tucker in paperbark.

ANBIC has identified 11 'core' species as the industry's mainstay. Using ANBIC's choice of common names, they are: Bush Tomato, Kakadu Plum, Muntries, Illawarra Plum (*Podocarpus elatus*), Lemon Aspen (*Acronychia acidula*), Lemon Myrtle (*Backhousia citriodora*), Mountain Pepper (*Tasmannia lanceolata*), Desert Quandong (*Satalum acuminatum*), Riberry (*Syzygium luehmannii*), wattle seed (*Acacia* species) and wild limes (*Eremocitrus glauca* and *Microcitrus* species). These are the main ingredients used in bush tucker restaurants, and plied into sauces, chutneys, jams, biscuits, cakes, condiments, vinegar and even 'rainforest pasta'.

I doubt that all these foods will do well. Muntries, for example, taste remarkably like dried applies, at a much heftier price. A couple of other plants should probably be highlighted, especially Davidson's Plum (*Davidsonia pruriens*) and Sacred Basil (*Ocimum tenuiflorum*). Vic suggests there are 200 plants with market potential, and some growers are punting on such unusual crops as Common Appleberry (*Billardiera scandens*), Round-leaf Mintbush (*Prostanthera rotundifolia*) and Cape Barren Tea (*Correa alba*).

I am not sure where the industry is heading: it is all happening too fast for me. But I hope it goes well. I hope the idealists prevail over the get-rich-quick entrepreneurs, and I hope there is more involvement by Aboriginal people, who were scarcely represented at the conference. Lastly, I hope that all that talk about sustainable harvesting and organic farming bears fruit; I don't want to return to South Australia one day and find that all the Muntries plants have been torn up by greedy harvesters. ■

Tim Low's books, Wild foodplants of Australia *(1988) and* Bush Tucker *(1989), helped fuel the bush foods boom. He has been writing this Wild Foods column since 1986, all the time watching the amazing rise of the bush foods industry.*



White-winged Choughs simply cannot breed without help, and this bizarre and extreme dependency on others has led to some rather weird behaviour, including acts of gang warfare, piracy and even kidnapping.

WHEN GOOD HELP IS HARD TO FIND

BY ROB HEINSOHN

Which one will I give it to? Chicks compete for food but adults have some choice in regards to whom they give it to. In poor times they favour the oldest chicks, but when food is plentiful they share it around.

ROGER BROWN/NATURE FOCUS

DANGLING FROM A ROPE HIGH off the ground inevitably leads to the odd close call; but my most recent experience during tree-climbing takes the cake. A judicious aim with a slingshot allowed us (my wife Sarah and I) to pull our rope up over a big eucalypt branch so that we could climb to a Chough nest about eight metres up. I toiled up using special ascending gear, but halfway up we heard a loud crack, and Sarah calmly but urgently suggested I abseil down—quickly. As my feet hit bottom, Sarah was getting me detached from the rope. We scrambled away as the whole branch with a diameter of 30 centimetres or so broke from the trunk and javelined to where we had been standing a second earlier. The eucalypt was a Yellow Box (*Eucalyptus melliodora*), aptly referred to as a 'widow-maker' because of its tendency to drop big branches unexpectedly!

I began working on White-winged Choughs (*Corcorax melanorhamphos*) as a PhD student between 1985 and 1989, and returned to them again in 1994. They are large black birds (with white wing patches) and are fairly common and obvious in eucalypt woodlands in south-eastern Australia. What drew me to them originally was their intensely social behaviour. They are always found in groups of four to 20 birds, and in fact they have no choice but to live that way. The groups are composed of family members, usually two parents and their offspring from previous breeding seasons. These younger birds become 'helpers', and make essential contributions to feeding and guarding the new eggs, nestlings and fledglings.

ROB HEINSOHN

Out on a limb! Honours student Chris Boland climbs to a Chough nest to mark and weigh nestlings.

Such 'cooperative breeding' contrasts with the breeding system of most birds in which the young disperse when mature, and usually attempt to breed in pairs as soon as possible. In this respect Australia is especially interesting as cooperative breeding occurs more frequently here than on any other continent, and eucalypt woodlands are 'hot spots' for such behaviour. The best explanation for why these habitats promote cooperative breeding is that, although providing benign living conditions, they lack the resource peaks such as burgeoning fresh foliage and flowers and insect flushes, which boost the springtime breeding efforts of many northern hemisphere birds. In eucalypt woodlands, birds apparently have little trouble supporting themselves, but they may find it difficult to provide the extra food required to feed young.

Choughs, it seems, find life particularly hard. They simply cannot breed without help, and this bizarre and extreme dependency on others has led to some rather weird behaviour, including acts of gang warfare, piracy, and even kidnapping. To appreciate just what it is that pushes Choughs to these extremes I have been catching, aging and marking individuals with unique combinations of coloured leg bands, and following them from the time they hatch out of eggs, fledge and develop into adults. Fortunately, Choughs can be aged up to four years old by their eye colour, which changes gradually from brown through orange to deep red.

THEIR WHOLE SOCIAL SYSTEM DERIVES from the difficulties they face in foraging: young Choughs take years to master the art of finding food efficiently. Choughs do not mature sexually until they are four years old, and it seems they are programmed for a long apprenticeship so that they can take the time they need to learn the necessary skills before attempting reproduction. They get a large proportion of their food from beneath the surface of the soil, and consequently spend a lot of time digging holes up to 20 centimetres deep. Because this is so labour-intensive, choosing to dig in the wrong spot wastes valuable time and energy. Older birds learn that digging in moist soil, especially around grass roots, is more likely to yield a tasty beetle larva. Even more importantly, they learn when to give up

Choughs spend most of their time combing the woodland floor. They often stop to dig beneath the soil surface in search of beetle larvae and worms.

digging in an unproductive patch. Young Choughs often carry on digging fruitlessly in one spot and get nothing for their trouble. The little craters they leave behind are very characteristic, and Choughs are truly comical to watch as they toss soil and leaf litter left and right and become totally absorbed in their task.

The time and experience required to find food has huge implications for the breeding system. One pair alone cannot get all the food required for their brood of four chicks, and on the few occasions when I have seen a pair attempt the feat, they have lost the chicks one by one to starvation, starting with the youngest. In fact the minimum viable group size is four individuals, and even so they will only manage to raise one chick to fledging. Each additional helper increases the output of fledglings to the point where groups of ten-plus can occasionally fledge all four chicks. But the hard work

C.A. HENLEY

has only just begun at fledging, and it is then that the full implications of a difficult foraging niche become apparent.

Many songbirds (passerines) continue to look after their fledglings for a period up to twice that of the nestling period. Here Choughs hold the record. They continue feeding their fledglings for up to eight months, or eight times the length of the nestling period! The reason for this is that the young simply must have extended support while they master the basics of foraging, especially as they enter their first winter when food is even harder to find. Youngsters in large groups with more helpers to feed them are fatter and more likely to survive their first winter. So they continue begging from the adults while they begin to search the ground and go through the motions of foraging. A wonderful sight in the eucalypt woodlands in late summer is a large group of Choughs combing the ground for morsels to stuff down the throats of their clumsy and noisily begging juveniles. During this period one is most likely to see their spectacular display, in which the adults' eyes bulge as they engorge the conjunctiva (the mucous membrane surrounding the eye) with blood, bob their heads, and wave their tails and wings. This 'wing-wave–tail-wag' display is conducted in many contexts, but is most often performed between group members and especially from adults to young. The post-fledging period is probably the most interesting time to watch Choughs, not only because of their antics, but because this is also when kidnapping takes place.

Kidnapping in nature is rare, and is usually limited to primates (including humans) and some species of slave-making ants. In Choughs it relates directly to their desperate need for help. Large groups gang up on small groups, and on many occasions I have seen some Choughs engage a smaller group in battle, while their cronies have approached the juvenile to entice it away using their

Kidnapping in nature is rare, and is usually limited to primates and some species of slave-making ants. In Choughs it relates directly to their desperate need for help.

C.A. HENLEY

The white wing patch is only seen in flight and during the wing-wave–tail-wag display in which the conjunctiva of the eye is engorged with blood causing the eyeball to bulge out of the head.

wing-wave–tail-wag display. If successful, they feed their new recruit immediately, and within a very short period (as little as half an hour) the juvenile acts as if it has always been part of the family. Often the small group will mount a raid to recapture their fledgling, but these are rarely successful. I suspect that the juveniles are easily confused and have not yet had time to establish who's who in their own group, and that the kidnappers take advantage of their naivety. Kidnapping never occurs more than a month or so after fledging, possibly because by then the juveniles have developed a sense of identity. The kidnappers willingly invest the remaining seven months of care to raise this new group member; this indicates just how desperate they are to gain a future helper.

Other dastardly deeds also occur such as attempts by neighbours to destroy each other's nests. These are built high on the branch ends of eucalypts and are superbly crafted from mud. Some are so perfectly round they look as if they have been constructed on a potter's wheel. The intruders alight on the rim and peck at the foundations of the mud structure. If the nest is dislodged, this inevitably spells the end of any eggs or chicks within, and often it also means that the victimised group is delayed from building a new nest until mud is again available after rain. In a hot Australian summer the irregularity of rainfall can curtail a group's reproductive effort for that season. On other occasions, possibly when the nest is too difficult to dislodge, I have seen a marauding Chough pick the eggs up in its beak one at a time and toss them overboard. It seems that delaying tactics such as these successfully decrease the amount of competition for food from neighbouring groups.

I witnessed the ultimate destructive behaviour from Choughs in the 1995–1996 breeding season, a year that saw some very unusual behaviour in the Chough population of Campbell Park, near Canberra. The preceding year had been a bad drought: only two out of 15 groups bred successfully, and many did not even attempt to breed. Coupled with this, a lot of Chough deaths caused the breakdown of the family group structure. There were an unprecedented number of group reformations, accompanied by lots of squabbling and further break-ups. In late 1995 a motley collection of 13 Choughs originating from at least five different groups banded together and went on a rampage. They roved Campbell Park, and between October and January disrupted the

The rare breaks from foraging are a time for mutual preening and social bonding.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

WHITE-WINGED CHOUGH

Corcorax melanorhamphos

Classification
Family Corcoracidae

Distribution and Habitat
Dry and open eucalypt woodlands on Great Dividing Range (excluding Tasmania) and inland to western slopes, north to about Rockhampton, Qld. Also encountered in lower numbers in wet sclerophyll coastal and mountain forests, and along coastal plains in some areas.

Reproduction
Permanent groups of 4–20 birds, usually a breeding pair and their offspring from previous years. Four years to reach sexual maturity; bowl-shaped mud nest approximately 35 cm diameter; 4 eggs laid that take 3 weeks to hatch, young take 4 weeks to fledge. Immature Choughs help in every aspect of reproduction from building nest to caring for fledglings.

Status
Although neither rare nor endangered, their large size and noisy behaviour make Choughs appear more common than they really are. They have become scarce around major highways because of road deaths.

C.A. HENLEY

Excitement all round as two adults bring food to hungry nestlings. The adults mark all such returns to the nest with 'eye-boggling' and the wing-wave–tail-wag display.

breeding efforts of at least six other groups by either knocking the nests out of the tree or tossing the eggs. Their marauding behaviour finally stopped when they nested themselves very late in the season, and finally produced two fledglings of their own. I was fascinated to see that such cranky birds had become extremely devoted parents and extended family to their own youngsters.

THE MAIN REASON I RESUMED MY STUDIES of Choughs in 1994 was that a new and powerful technique for studying the mating system, DNA-fingerprinting, had only recently become available. By isolating genetic material (DNA) from blood samples and comparing between individuals, it is now possible to establish exactly who the parents are. I had always been intensely curious to find out whether the helpers in the group contributed to the clutch genetically, or whether the breeders dominated them into purely helping roles. A major revelation about birds in general is that, whereas over 90 per cent were thought to be monogamous, DNA-fingerprinting has revealed that many engage in extra-pair copulations such that females mate with males other than their social partners. Males in social pairs often lose paternity from being cuckolded in this way, but they also cuckold others whenever they have the opportunity.

Incest is just the latest in a long list of surprises I have uncovered about White-winged Choughs.

Choughs occasionally have double clutches, which suggests that more than one female may contribute, but of course it is harder to determine whether more than one male has been allowed to mate. A recent round of DNA-fingerprinting revealed that, when group structure of Choughs is stable, one pair does indeed go on dominating reproduction year after year, even when there are other birds of breeding age in the group. When groups have been fragmented by deaths in the family, birds that were helpers try out different combinations with others they meet in their travels, amidst general agitating and internal politicking until they work out who gets to breed. One bird I followed went

On the verge of fledging, a nestling practises flapping its wings. Fledging is usually more of a controlled plummet, with youngsters taking a week or two to learn how to fly.

through four different group structures in which it failed to breed itself, until it finally formed a combination where it achieved the ultimate hallowed goal of being a parent.

Another use of DNA-fingerprinting is to work out the effect of group breeding on the genetics of the population as a whole. Chough groups are in fact highly inbred, and often even the breeders are closely related (for example, mother and son). Although inbreeding may not be as serious as we have traditionally believed, it can still have negative effects. It is interesting that the drought effectively broke up many cohesive inbred units, and forced the population into higher levels of out-breeding. Incest is just the latest in a long list of surprises I have uncovered about White-winged Choughs. Little did I suspect when I first started my research that this apparently peaceful group-living bird indulged in such extreme, and even violent, behaviour.■

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Dr Rob Heinsohn is a research fellow at the Australian National University, Canberra. His main research interests include the behavioural ecology and conservation biology of birds and mammals. He is currently working on White-winged Choughs, Glossy Black Cockatoos, and small mammals of tropical rainforests.

G.A. HENLEY

Forest Dragons move with an amazing fluidity and, if you try to follow them around the trunk, the only thing you'll get to see is a small, black eye peeking around the side.

FOREST DRAGONS

BY GEORDIE TORR

Boyd's Forest Dragons (both male and female) have a large yellow dewlap beneath their chin which they use to communicate with one another during courtship displays and territorial disputes, and to startle predators.

M. PROCIV/WETRO-PICS PHOTO LIBRARY

HANGING OFF THE SIDE OF A TREE in the middle of a tropical downpour is a fairly unusual place to find a lizard. But then Boyd's Forest Dragon (*Hypsilurus boydii*) is a fairly unusual lizard. The Jackie O. of the lizard world, they are much photographed, appearing on more promotional literature than just about any other Australian lizard. But even so, in the 110 or so years since it was first described, the scientific literature on this species amounts to little more than a short anecdote or two.

It was this lack of knowledge, combined with their unusual and attractive appearance, that made me decide to study these lizards and, over a period of three-and-a-half years, I've slowly built up a picture of how they live. Found only in the rainforests of Queensland's wet tropics from just north of Townsville to Cooktown, it is probably their choice of habitat that has been most responsible for their peculiar lifestyle.

Although they look almost prehistorical, Boyd's Forest Dragons appear to be relatively recent arrivals to our shores. The other members of the genus are found in and around New Guinea, with the Southern Angle-headed Dragon (*H. spinipes*) their only close relative in Australia. What little we know of the ecology of all these species suggests they are mainly closed-forest dwellers and will probably be found to share many traits with Boyd's Forest Dragons.

Unlike mammals, which produce their body heat internally, reptiles rely on outside heat sources and have to use behavioural means to keep their temperature reasonably high and stable. A reptile's body temperature affects the performance of many of its physiological processes such as growth, digestion and locomotion. Most reptiles have a narrow range of 'preferred' temperatures at which these processes perform at their peak. They will bask in the sun whenever their body temperature is too low and move into the shade when it is too high.

The closed rainforest canopy makes it difficult for a lizard to find a nice sunny patch in which to warm itself, so both the Southern Angle-headed Dragon and Boyd's Forest Dragon have dispensed with this chore altogether. For them, the cost of searching for a sunny patch to bask in, both in terms of the amount of energy expended and the increased risk of predation, is greater than any benefit they might gain from being a little warmer. Instead they simply let their body temperature fluctuate with that of the air around them. I've caught active forest dragons whose body temperatures have been between 19 and 30° C and they've virtually always been within a degree of the surrounding air. So, while most lizards start looking for a dry place to hide as soon as a cloud covers the sun, to a forest dragon even a heavy downpour is of little consequence.

Boyd's Forest Dragons blend into their surroundings so well that it's easy to understand why people thought they were rare.

So, while most lizards start looking for a dry place to hide as soon as a cloud covers the sun, to a forest dragon even a heavy downpour is of little consequence.

But if they aren't reliant on the sun, what regulates the length of a forest dragon's daily activity period? During the day, forest dragons have a character-

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GEORDIE TORR

Hatchling Boyd's Forest Dragons generally sleep on the ends of branches, their heads pointing in towards the trunk. Although the function of this behaviour is unclear, it may be a defence against predation by snakes.

istic perching posture, hanging out from the tree with their front legs fully extended so that they have the maximum field of view. At night, larger lizards 'hug' the trunk, sleeping vertically with their whole ventral surface in contact with the tree, while smaller lizards can be found sleeping horizontally on the ends of branches, their heads pointing towards the trunk. By watching lizards switch between their daytime posture and their sleeping posture, I found that they were awake from dawn to dusk, unlike most lizards that won't emerge from their night-time retreats until mid morning and return to them in the late afternoon. As expected, the surrounding temperature had little effect on when the forest dragons commenced and ceased their activity; instead they were responding to the amount of light available, remaining active until it was almost too dark to see.

Of course 'active' is only a relative term when it comes to Boyd's Forest Dragons. They employ a foraging strategy known as 'sit-and-wait' or ambush predation, an energy-efficient method that involves two things that forest dragons do very well: sitting and waiting. Chances are that at any given moment they'll be sitting motionless on the side of a small tree, surveying the forest floor for food, predators and other forest dragons.

Their diet reflects this somewhat sedentary lifestyle. They seem inordinately fond of ants, with around 80 per cent of the stomach contents I've analysed containing them. But ants probably only represent forest dragon 'snack food'. Just as a hungry human couch potato will reach for the nearest packet of chips, its reptilian counterpart simply snaps up any ants that walk along the trunk beside it. When they want something more substantial though, they have to venture down onto the ground. This can be just about any invertebrates they can find—beetles, spiders, crickets—anything that moves into the range of their watchful eyes. Earthworms are a particular forest dragon delicacy, and these are snaffled up during the frequent tropical deluges when the rain drives the worms to the surface. Rainforest fruits on the other hand, although occasionally on the menu, are less sought after.

When a lizard spies a likely looking morsel it quickly does a 180° spin on its perch and runs down the trunk head-first. Leaping to the ground, it stands up on its rather spindly hind legs and runs in a most awkward manner towards its prey. Once the lizard's big, fleshy tongue has caught the sought-after morsel and its sharp teeth have chewed it into oblivion, it will either hop back up onto its perch or move elsewhere, on the lookout for something else to eat as it goes.

When Boyd's Forest Dragons emerge from the egg they are only about 4–5 centimetres from snout to vent.

'Active' is only a relative term when it comes to Boyd's Forest Dragons.

GEORDIE TORR

GIVEN THEIR APPARENT LOW LEVEL OF activity and their awkward terrestrial locomotion, I was curious about how far they actually move on the ground each day. A technique that's much in vogue these days for following the movements of secretive animals is cotton spooling. A small spool of cotton is attached to the animal and, as it moves, the cotton runs out behind, leaving a trail that tells you exactly where the animal's been.

When I first started spooling forest dragons, I assumed they would stay on their trees for most of the day, jumping down occasionally to catch something to eat and then climbing another tree a few metres away. So, although I had two sizes of spool, I chose the smaller with about 100–150 metres of thread, enough for a couple of weeks I thought. Talk about naive. When I went back the next day to check my first spooled lizard I found a lovely trail of cotton...but no lizard. She'd used up the entire spool. I switched to the larger

The trail of thread running out from the spool taped to this lizard's tail will reveal a great deal of information about its movements over the next few days. The green reflective tape makes it easier to find the lizard at night.

MICHAEL CERMAK

size (with about 250 metres of thread) and have since gained all sorts of interesting insights. I've followed cotton trails all over the rainforest, along fallen logs, into hollow trees, down burrows and between trees in the canopy.

Regular spooling of particular lizards also gave an indication of the sizes of their home ranges. Typically males use an area of about 1,000 square metres while the home ranges of females are slightly smaller. The home ranges of lizards of the same sex don't overlap, suggesting that forest dragons are territorial, but the larger male territories usually contain one or more smaller female territories. Sometimes lizards have one or two 'favourite' trees within their territory to which they regularly return.

Spool trailing also led to the apparent discovery that the lizards are sometimes prey for birds (or they occasionally grow wings). One spool trail I was following went along the ground, up a tree and then left the tree horizontally, suspended in mid air at a height of about three metres between several trees for the remainder of the spool (about 100 metres). Events such as these are quite rare though, and mortality of adults is very low. Small forest dragons are probably prey to various sorts of snakes but, once they reach an adult length of around 45 centimetres (which takes about two years), there's not much in the rainforest that's big enough to eat them. The row of sharp spines that runs down their back probably helps a little too.

Although in general forest dragons seem relatively unaffected by the air temperature, seasonally it does have some impact on their daily movements. During summer lizards will frequently move more than 100 metres a day but during winter they may not move at all, sometimes spending several weeks perched in the same tree, high in the canopy.

As the days get warmer in late spring and early summer, a forest dragon's thoughts turn to reproduction. In the cooler, higher-altitude rainforest, females leave their normal home ranges in search of a warm place. At my upland study site in the south of their range, the most popular sunny spot is a dirt road and females can be found there from September to December. I usually find them sitting in the middle of the road in the morning and afternoon in a shaded area, presumably using the road's warmth to help speed up the development of the eggs inside them. In some cases the lizards will have travelled hundreds of metres through the forest.

In early December they lay their eggs and then return to their normal home ranges. Just before they were ready to

BOYD'S FOREST DRAGON

Hypsilurus boydii

Classification
Family Agamidae (dragons)

Identification
Colouration ranges from green to brown. Large yellow dewlap below the chin, pronounced nuchal crest and row of sharp dorsal spines. Males slightly larger than females (females: 15 cm snout–vent, 30 cm tail; males: 16.5 cm snout–vent; 33 cm tail).

Distribution and Habitat
Endemic to wet tropics, from Paluma to Cooktown, Qld. Found only in rainforest and margins of associated wet sclerophyll forest.

Reproduction
Lays 1–6 eggs in shallow nest during late spring/early summer. Eggs and clutch sizes are larger in upland populations. Females in lowland populations may lay more than one clutch in a season. Eggs take 2–3 months to hatch. Lizards mature at 1–3 years of age.

Behaviour
Arboreal and diurnal. An opportunistic predator feeding on a variety of invertebrates, especially ants and earthworms, and occasionally fruit.

GEORDIE TORR

Hatchling Boyd's Forest Dragons start life a rather drab brown colour, only taking on the more varied hues of the adults when they're a year or so old.

lay though, I placed cotton spools on a few females. Their trails led me to their nests, which were situated at the side of the road. The nests are pretty uncomplicated affairs—just a shallow hole into which one to six eggs are laid with a thin layer of dirt and leaf litter on top. In the warmer lowland rainforest, the lizards nest in more shaded areas under the forest canopy. Temperature-sensitive dataloggers placed in nests in both habitats revealed that, despite temperatures being generally cooler in the upland forests, the eggs actually got warmer because they were laid in more exposed positions.

However, use of the dirt road by the upland females has two rather unfortunate consequences. Firstly, the females' habit of sitting in the middle of the road results in them being run over by cars. Secondly, the annual grading of the road, which usually occurs in mid summer, just after the lizards have laid their eggs, ends up destroying many of the nests. This problem was resolved, however, after a quiet word to the local council, convincing them to grade before the nesting season in early spring, rather than after it.

The roadward migration does have a fortunate consequence for me though: it makes the job of finding forest dragons much easier. Although I found forest dragons in the lowland rainforest easily enough, I spent several months wandering around in upland rainforest without seeing a single lizard, until the beginning of the breeding season when they came out to where I could find them.

In their usual habitat, sitting on tree trunks, forest dragons can be very difficult to spot, a fact that many disappointed visitors to northern Queensland will attest to and one of which the forest dragons themselves seem well aware. Rather than fleeing from a potential threat, be it a predator or a curious tourist, forest dragons rely on their superb camouflage, freezing in place and only moving when it's clear they've been spotted. I once almost stepped on a lizard that was sitting in the middle of a forest path, apparently pretending to be a piece of wood. When perching lizards feel threatened they fold their legs in and slowly move around the trunk, keeping it between them and the threat. Forest dragons move with an amazing fluidity and, if you try to follow them around the trunk, the only thing you'll get to see is a small, black eye peeking around the side.

My decision to study forest dragons necessitated my being able to find them. In the upland forest I found that the only way to find new lizards was to stumble across them at night when they were asleep and couldn't use the 'tree-trunk technique' on me. In the lowland rainforest, however, my methods were a little more sophisticated. I slowly walked through the rainforest, carefully scanning the sides of trees at about head height and stopping to examine any large bumps or knee-like protuberances. Their impressive ability to escape detection led people to believe that forest dragons were quite rare, but by regularly returning to the same places and marking each lizard I encountered, I found that in suitable habitat they can be quite common.

So, thankfully, these wonderful lizards don't appear to be in any danger of extinction. If there is a threat, it comes from feral pigs. A recent study of the diets of feral pigs in northern Queensland found forest dragons in two of the stomach contents and I've seen evidence that pigs also eat their eggs. But for now at least these charming rainforest denizens will be hanging off trees for some time to come.■

JOE SHEMESH

Boyd's Forest Dragons are masters at escaping detection, and it takes a sharp eye and a lot of patience to spot them in their native habitat.

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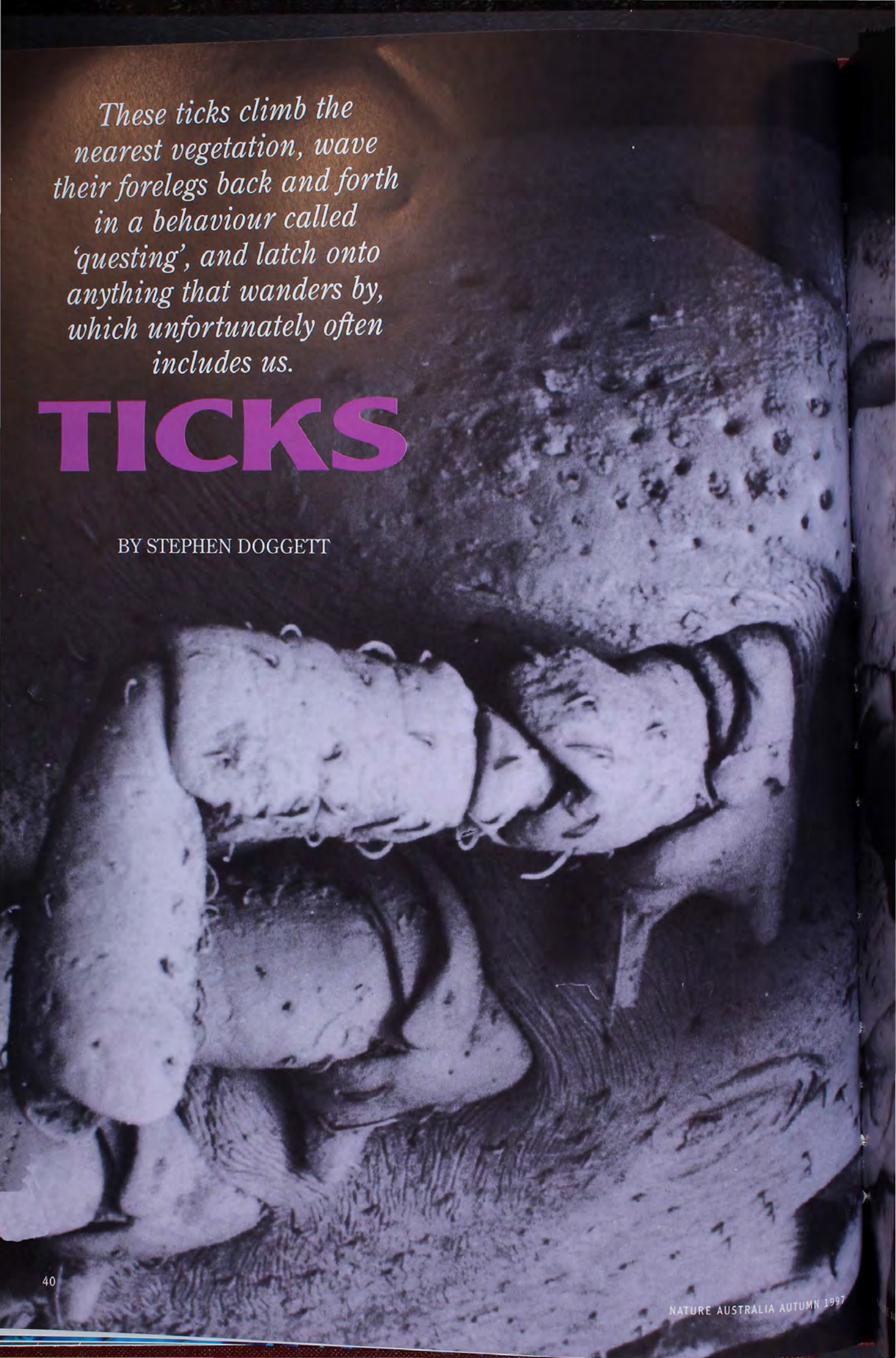
Geordie Torr is a graduate student in the Department of Zoology at James Cook University. His research interests include evolutionary biology and behavioural ecology of reptiles and amphibians.

These ticks climb the nearest vegetation, wave their forelegs back and forth in a behaviour called 'questing', and latch onto anything that wanders by, which unfortunately often includes us.

TICKS

BY STEPHEN DOGGETT



Many ticks do not possess eyes. The eye-like structures on the head of this hard tick are called 'porose areas', which have a sensory function.

AUSTRALIAN MUSEUM

I STRUGGLED THROUGH THE NETTLES and sharp-edged matrush that lined the forest floor, dragging the artificial animal behind me. My mission was to collect a deadly beast—one that spreads bacteria, viruses, blood protozoans and other nasties. It's been responsible in the past for the death of several children in Australia and each year kills hundreds of our pets. So what is the horrible creature behind all this misery? The humble tick!

Ticks are external parasites on a variety of land vertebrates. Some are highly specific in their host preference, such as the Cattle Tick (*Boophilus microplus*), Numbat Tick (*Ixodes vestitus*) and Echidna Tick (*Aponomma concolor*), as their common names imply. Other ticks prefer certain groups of animals. Some *Aponomma* ticks, for example, feed almost exclusively on reptiles, while *Ixodes eudyptidis* and *I. uriae* restrict themselves to seabirds. Yet other ticks are quite catholic in their tastes, like the Australian Paralysis Tick (*I. holocyclus*), which attacks humans, other placental mammals, marsupials and occasionally birds. Of the 60 species of tick that occur in Australia, only a handful are a problem for humans and/or their livestock and pets. To understand just how these ticks do their damage, a knowledge of their life cycle and ecology is essential.

Ticks have four distinct life stages—eggs, larvae, nymphs and adults—which, for Australian ticks, take a total of about a year to complete. An adult female may lay between 2,000 and 3,000 eggs in one batch. After hatching, the six-legged larvae (0.5 millimetre in size) must obtain a protein source (blood) to enable them to moult to the next stage in their life cycle. They find their host using a structure known as Haller's organ—one on each of their two forelegs. Haller's organ is essentially a pit containing sensory hairs that can detect body heat, pheromones, and carbon dioxide emitted from an animal's breath. Some ticks may actively search for a host but most wait until a host passes by. These ticks climb the nearest vegetation (contrary to popular belief, ticks do not jump), wave their forelegs back and forth in a behaviour called 'questing', and latch onto anything that wanders by, which unfortunately often includes us. Intrepid tick collectors, such as myself, have long exploited the behaviour of questing, by dragging a blanket (my 'artificial animal') over the vegetation of 'ticky' areas.

After a site is chosen, knife-edge structures called 'chelicerae' cut into the flesh and the sucking mouthparts are inserted.

Once on a host, the tick searches for a site to feed. On humans this is often the less exposed areas of the body such as in the hair on the head, or in the groin area (sometimes on the scrotum). With kangaroos, a favoured locality for attachment is on the soft eyelids. After a site is chosen, knife-edge structures called 'chelicerae' cut into the flesh and the sucking mouthparts are inserted. The lower surface of the mouthparts has a series of backward-pointing barbs that make it difficult for accidental or deliberate removal of the tick. As the tick begins to feed, the host is injected with saliva, which contains an anticoagulant to prevent the blood clotting.

The larvae take blood from the host for several days and progressively swell up like a balloon, increasing maybe ten fold in body weight. After engorgement, the larvae drop off onto the ground and undergo metamorphosis to become nymphs. (There are some ticks, however, that remain on the one individual host animal for the whole of their feeding cycle.) The transition from larva to nymph takes several weeks and an extra pair of legs is gained in the process. The nymphs, which are one to two millimetres long, then attempt to find a new host and, if they're lucky, again engorge themselves with blood and moult to the final adult stage. Adult females feed for six to eight days, enlarging 100 fold to 1.0–1.5 centimetres, and drop off the host to lay their eggs and die. Adult male ticks rarely feed from an animal, however some (such as the Paralysis Tick) occasionally suck the blood (haemo-

RICHARD RUSSELL

Copulating Paralysis Ticks. The male is at the front with his mouthparts inserted in the genital pore of the female. This prepares the female for insertion of the spermatophore (sperm package).

DENSEY CLYNE/MANTIS WILDLIFE FILMS

A fully engorged adult female Paralysis Tick is capable of producing over 2,000 eggs. At the completion of laying she will wither and die.

lymph) of a female tick while she is attached to a host. Why they do this, nobody knows, but it is not uncommon to find three or four male ticks on one female.

Most ticks (family Ixodidae) remain attached to their hosts throughout the feeding phases of their life cycle. There are others, in the family Argasidae, however, that stay in an animal's nest, burrow or other resting place, taking several small blood meals from the host prior to each moult.

An unfortunate consequence of drinking blood is that the tick may acquire a pathogen (disease-causing organism) from its host. This 'nasty' may then be passed onto other hosts, usually through the tick's saliva, as the tick feeds during subsequent stages of its life.

AS MENTIONED EARLIER, A WIDE RANGE of diseases is transmitted by ticks. In humans, some of these diseases, such as Colorado Tick Fever in the United States, produce mild flu-like symptoms that often go undiagnosed. Others, like Rocky Mountain Spotted Fever in North America and Tick Borne Encephalitis through Europe, have high fatality rates (30 per cent) in untreated patients. One bacterial disease spread by ticks, called Lyme disease (named after the town of Lyme in Connecticut, North America, where the disease was first recognised), has become the second most important emerging disease in the United States behind AIDS, with around 10,000 new cases annually.

The symptoms of Lyme disease are many and varied, and can easily be confused with other syndromes. However, the most distinctive clinical feature of the disease is a raised red rash, five to 30 centimetres across, that migrates from the bite site. This rash (called erythema migrans) comes up within a week of being bitten by the tick, as opposed to within several hours for an allergic reation. The causative organisms for Lyme disease are spirochaetes (spiral-shaped bacteria) in the genus *Borrelia*, of which there are now at least five known species or subspecies once thought to be *B. burgdorferi*. If left untreated, the long-term effects of the disease can be extremely debilitating. Fortunately, the condition is readily cured with antibiotics, if caught in the early stages.

Currently, there is debate among scientists as to the presence of Lyme disease in Australia. Although human clinical cases have been reported in eastern

Australia since the early 1980s, and there are reports of Lyme arthritis in cattle, there has been no conclusive evidence for Lyme disease in Australia. No *Borrelia*, or indeed any other, spirochaetes were found in the 20,000 ticks surveyed by our research team at Westmead Hospital, and experiments with the Paralysis Tick, the suspected vector of the disease, have shown it to be incapable of transmitting *B. burgdorferi*. Some researchers, like Bernie Hudson from the Royal North Shore Hospital, are of the opinion that there is some as yet unidentified, possibly *Borrelia*-like and tick-borne organism out there that causes symptoms in humans similar to Lyme disease, but which so far defies detection using current laboratory methods. We do not deny that such an organism may possibly exist (although our dissections suggest it could not be common), however to call the syndrome it produces '*Lyme* disease' or even '*Lyme* borreliosis' is inappropriate.

In Australia, the main human diseases of concern are the two forms of tick typhus (Queensland Tick Typhus and Flinders Island Spotted Fever). These afflictions are both caused by rickettsia, a group of primitive bacterial-like organisms. The signs of tick typhus include multiple rashes, headaches, fever, flu-like symptoms and tenderness of the lymph nodes. Tick typhus can be treated with antibiotics and is rarely fatal. The disease is confined to the eastern coastal strip of Australia where it is transmitted to humans by the Paralysis Tick.

Beyond the human diseases, several blood parasites are transmitted by ticks to cattle within Australia. These parasites are similar to malaria in that they invade red blood cells, eventually causing them to rupture. Anaemia is likely to follow and stock condition can be dramatically reduced. High fatality can occur in cattle that are not immune or are not vaccinated. These diseases, and the ticks that transmit them, were probably brought into Australia with the introduction of domesticated cattle. One of these tick species, the Cattle Tick, can occur in such plague proportions that death of livestock via exsanguination (loss of blood) used to be common. The New South Wales Department of Agriculture has regulations on the transportation of livestock to prevent the spread of the Cattle Tick. Quarantine regulations apply to the importation of livestock into Australia and these serve to prevent the spread of infectious agents from overseas.

In addition to the transmission of dis-

TICKS

Classification
Class Arachnida, order Acarina (mites and ticks), superfamily Ixodoidea (ticks), families Ixodidae ('hard ticks') and Argasidae ('soft ticks'). Approx. 700 spp. worldwide, with approx. 60 in Australia.

Identification
Elongated mouthparts with rows of recurved teeth. Haller's organ (sensory function for host detection) present on forelegs. Four life stages: eggs, six-legged larvae, eight-legged nymphs and adults. Range in size from 0.5 mm for newly hatched larvae to 1.5 cm for a blood-fed adult.

'Hard ticks': dorso-ventrally flattened (when not blood-fed), smooth body surface, dorsal surface with distinctive thumbnail-like shield called a scutum, eyes sometimes present, sexually dimorphic. 'Soft ticks': not flattened, no scutum, body with a roughly textured, leathery covering, eyes not present in Australian species, little sexual dimorphism.

Distribution
Worldwide in a variety of habitats, always in association with the host(s).

Ornithodoros gurneyi **is a 'soft' tick (family Argasidae) having a roughly textured, leathery cuticle. 'Hard' ticks (family Ixodidae) have a smooth body covering.**

DAVID KEMP

KEN GRIFFITHS

Occasionally ticks occur in plague proportions, with hundreds to thousands on a single host. The poor suffering victim with the itchy tail in this photo is a Carpet Python (*Morelia spilota*) and attached are many *Amblyomma* ticks in various stages of engorgement.

AUSTRALIAN MUSEUM

A scanning electron micrograph of an ixodid tick. The central structure, the hypostome (feeding apparatus), is inserted into the host and is maintained in position by the backward-pointing barbs.

ease, bites from various ticks may cause local skin reactions such as swelling and severe itching; but in hypersensitive individuals, anaphylactic shock may also occur. Fortunately this is fairly rare and such people can be desensitised through a course of injections. However, the adverse effects from ticks that we are probably most familiar with are those of paralysis, with the Paralysis Tick, also known as 'Seed', 'Scrub' or 'Grass' Tick, being the main Australian offender.

The Paralysis Tick is distributed along the coastal strip of eastern Australia, occurring more frequently in the moister forest types such as wet sclerophyll and rainforests. The main hosts are bandicoots (especially the relatively abundant Long-nosed Bandicoot, *Perameles nasuta*), although as mentioned earlier it can parasitise a wide range of other mammals. It is the adult female tick that is responsible for the adverse paralytic effects, which result from the saliva as it is slowly injected into the host. Generally, native animals are immune to the saliva, but for animals that have had a short historical association with the tick, the toxic effects may result in death. Dogs, cats, calves and humans, particularly children, are at risk.

Generally, native animals are immune to the saliva, but for animals that have had a short historical association with the tick, the toxic effects may result in death.

The signs of tick envenomation include reduced coordination, swelling of the lymph nodes, facial paralysis (known as Bell's palsy) and general paralysis. Death by respiratory failure will follow if untreated. Symptoms generally subside within two weeks of tick removal. Since the introduction of an antivenom during the 1940s, no deaths have been documented. (A similar antivenom has been developed for dogs.) However, around once every two years a child will be admitted to Westmead Hospital with signs of a mysterious paralysis that is subsequently found to be caused by an embedded Paralysis Tick. For one recent young patient, the tick was found only by accident after the attending nurse felt a lump while patting the child's head. To reduce the possibility of death, prompt removal of the tick is necessary.

SO WHAT IS THE BEST TECHNIQUE TO remove ticks? Well, folklore lists a variety of methods including painting the tick with nail polish remover, kerosene, vaseline or turps. But these may make the tick inject more of its paralysing saliva into the host. For an animal in the late stages of paralysis, this could be fatal. Research in progress has

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Very few ticks directly affect human health, however the Ornate Kangaroo Tick is one of the species that may. Widely distributed throughout inland regions of Australia, the bite from this tick can result in painful, irritating lesions.

shown that, by placing a small amount of insect repellent containing a pyrethrin onto the tick, it will be killed without it first injecting more saliva. The tick can then be removed with a fine-tipped pair of forceps. When repellent is not available, make sure you grip the tick as close to the skin as possible so as not to squeeze out any saliva. Often some of the mouthparts will remain embedded, but these will slough off in time with the skin. On rare occasions a small secondary bacterial infection may occur and, if there are any unusual effects after removing a tick, a physician should be consulted.

Of course prevention is better than cure. By wearing light-coloured clothing, ticks can be easily spotted. After going into a tick-infested area, clothes should be removed and the body examined. Close inspection of the head and behind the ears of children is essential. The use of a repellent containing the chemical DEET, on the skin and clothing (such as the bottom of the legs of pants), is very effective against ticks and should be reapplied every two hours. Avoiding known tick-infested areas is obviously the best method of prevention.

Fortunately for humans, only a few of the 60 species of tick in Australia cause us any concern. Apart from the Paralysis Tick, two other native species (*Ixodes cornuatus* and *I. hirsti*) occasionally cause paralysis, and another (the Ornate Kangaroo Tick, *Amblyomma triguttatum*) has been reported biting humans, causing irritating lesions. Two introduced species, the Cattle Tick and Bush Tick (*Haemaphysalis longicornis*), affect the health of our cattle, and another introduced species, the Brown Dog Tick (*Rhipicephalus sanguineus*), may result in blood loss in dogs if in high numbers. The vast majority of ticks, however, are rarely observed and cause little ill effect to their hosts.

Finally, it must be remembered that Australia's ticks, while not cute and cuddly, still deserve the respect that other Australian animals receive. Humans tend to place a value on everything around us. Marsupials are aesthetically pleasing; plants are also attractive and provide raw materials, foods and medicine. Ticks, on the other hand, are neither handsome, nor are they of any apparent direct benefit to us. But who knows what the future holds? For example, snake toxin is used in one of our most important blood tests to determine if a patient has a clotting disorder. From personal experience, the presence of native ticks indicates a healthy ecosystem. For ticks to survive they must have a blood source, and the presence of many ticks within an area usually indicates high numbers of native vertebrates. But beware, for if you enter the lair of the tick, you may become its prey.■

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Stephen L. Doggett is a Higher Education Officer at the Department of Medical Entomology, Westmead Hospital. He previously has been involved as a researcher and field investigator of ticks and is now a PhD student at the University of Sydney, researching the vector competence of mosquitoes for Barmah Forest virus.

KATHIE ATKINSON

While bandicoots are the main hosts of the Paralysis Tick, they will feed on a range of other mammals including the Short-beaked Echidna (*Tachyglossus aculeatus*). Soft parts of the body, such as around the ears and eyes, are often favoured feeding sites.

The health of eucalypt forests may well depend on the peculiar feeding behaviour of ground-dwelling mammals.

TRUFFLE JUNKIES

BY ANDREW W. CLARIDGE

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

After a successful foraging foray, this Long-nosed Potoroo feasts on the truffle it has excavated from the soil.

AUSTRALIA'S EUCALYPT FORESTS are biologically diverse ecosystems, but much of this biodiversity remains undocumented or poorly understood. Beneath a veneer of trees, shrubs, mammals, birds and other organisms that are easily seen, heard or found, is a myriad of hidden organisms. Take truffles, or underground fruiting fungi, for example. When I mention the word 'truffle' most people think of those terribly expensive gourmet foods that grace only the best tables in Europe, or the chocolates that take their form. Few people realise that Australian eucalypt forests play host, quite literally, to a great diversity of truffles or truffle-like fungi. Mycologists (scientists who study fungi) are just discovering that the diversity of truffles in Australia is probably unparalleled anywhere in the world. It has taken the combined efforts of fungal taxonomists from both Australia and North America to document the range of species in our continent. This list of species continues to expand as areas of eucalypt forest are surveyed for the first time.

Australian truffles are not noted for their edible qualities but for several reasons they are very important components of forested ecosystems. Like many above-ground mushrooms, most truffles form symbiotic associations on the roots of forest trees and shrubs. In these associations, which are aptly named mycorrhizae (literally, 'fungus-roots'), the fungus forms a sheath around the non-woody rootlets of the host plant, from which fine fungal threads (mycelia) extend into the surrounding soil. These vegetative parts of the fungus act as extensions of the host root system by taking in nutrients and water from the soil and transferring these to their plant host. In Australian soils, which are notoriously nutrient deficient, mycorrhizal fungi become critical partners because they trap and accumulate nutrients such as nitrogen and phosphorus—key elements for the growth and survival of plants. They also help protect the plant root system from soil-borne pathogens such as *Phytophthora*. In return for providing these services, the plant provides energy packages in the form of carbohydrates to its truffle associate. The fungus reproduces itself by forming spore-laden 'fruit bodies', which are what the fungal gastronomes relish.

The fruit bodies of truffles are mostly spherical and range from about the size of a pea to a tennis ball. Although they vary in structure, all truffles have an outer skin and an internal mass of spore-bearing tissue. They come in a wide variety of colours including yellow, pink, purple, orange, green, black and blue.

The most bizarre are armed with razor-like teeth or needle-like spines. Like suits of armour, these teeth and spines allude to battles that might be ahead.

B. FUHRER

Why truffles should be so strikingly coloured when most of the time they are buried somewhere in the soil or hidden beneath a layer of organic material remains a mystery. Their colour is, however, often a good guide to the species. But to be absolutely certain of the species identification, it is necessary to observe fragments of the spore-bearing layer under a microscope. In doing so you enter an entirely different world.

Thankfully for fungal taxonomists the spores of truffles come in a wide array of sizes and shapes, the features of which are often species-specific. In particular,

The fruit body of *Mesophellia*, a common and widespread truffle genus, comprises a hard outer shell, a layer of spores (shown grey–green in colour) and a central sterile core. High in lipids and protein, the core is preferentially eaten by truffle-eating mammals, but in order to get to it they must first ingest the spores. Wholly indigestible, the spores pass through the gut of the mycophagists and are dispersed back into the forest through the animals' faecal pellets.

A.W. CLARIDGE

The eucalypt forests of Australia play host to a diversity of organisms, many of which lie hidden from immediate sight and sound.

the outer surface of truffle spores is usually ornamented in some way, but why this is so is unclear. Some spores have bumps and warts, or finger-like tendrils, while others are covered with ridges to form a honeycomb maze. The most bizarre are armed with razor-like teeth or needle-like spines. Like suits of armour, these teeth and spines allude to battles that might be ahead. Indeed this is the case, for the spores of truffles are usually faced with what might seem like a perilous journey: through a digestive tract filled with enzymes and acid secretions!

Unlike mushrooms and toadstools, which live above the ground and disperse spores via wind and water, truffles face particular difficulty when it comes to liberating spores. As their spore-bearing layer is held within an outer skin, and they are buried in the soil, it would seem that the chances for the dispersal of spores are slim. But this is not the case. Dispersal of truffles is dependent on the efforts of a third major player—truffle-eating (mycophagous) animals including potoroos, bandicoots and native rats. These animals dig up the truffles and eat them. The tough and often ornamented spores, held within the ingested fruit body, pass through the gut of the animal unscathed and are deposited in the animal's faecal pellets elsewhere in the forest. They find their way back into the soil through a variety of means, including being washed down by rain, or by dung beetles, which take faecal pellets back underground to the roots of the host plants. When conditions are right, the spores germinate and reestablish their mycorrhizal associations.

HOW DO THE ANIMALS FIND THE TRUFFLES? As truffles are hidden underground, away from immediate sight, a cue other than visibility is necessary. The solution is ingenious. Mature truffles produce distinctive and often pungent or aromatic odours that attract the animals. The smell varies among species; some pleasant to humans, some not so pleasant (rotting onions, freshly laid road tar and even dog faeces!). In

KATHIE ATKINSON

Emerging at dusk from its nest of twigs and leaf material, this young Long-nosed Bandicoot is off in search of food. As an omnivore with a broad-ranging palate, this species often consumes a variety of truffles.

B. FUHRER

Some truffles, such as *Protoglossum luteum*, fruit at the soil surface and can be readily observed by turning over the litter layer.

Spain, Italy and France farmers use dogs and even pigs to sniff out the ripening scent of the gourmet Black Truffle (*Tuber melanosporum*). It comes as no surprise to find that native animals with an excellent olfactory sense are also attracted to the smells that truffles produce. Driven wild by the smell of their primary food resource, these truffle-eaters become 'truffle junkies' (although not junkies in the true sense of the word, which implies some form of detrimental addiction).

Aside from producing odours, some truffles have evolved extra strategies to make them more attractive to animals. The case of *Mesophellia*, a truffle genus endemic to the eucalypt forests of Australasia, is quite unique in this regard. The fruit body is complex, comprising three different layers. The first is a hard outer shell, an amalgam of fungal

The rare and endangered Long-footed Potoroo is almost entirely mycophagous, consuming a high diversity of fungi throughout the year. The future integrity of our eucalypt forests may well depend on the fungus-feeding habits of this shy and largely nocturnal rat-kangaroo.

GARY STEER/TERRA AUSTRALIS

tissue and fine plant roots. Under this is the second layer formed by a mass of grey-green spores. The third layer consists of a jelly-bean-shaped sterile core. The core has no apparent function other than to act as a food reward for truffle-eating animals. The beauty of this truffle is that, in order to get to the food reward, the animal must ingest the spore-bearing layer first! This ensures that the spores of the fungus are dispersed via the animal's faecal pellets.

The most important truffle-eating animals in eucalypt forests are members of the rat-kangaroo family (Potoroidae), nearly all of which are hopelessly 'addicted' to truffles. The rare and endangered Long-footed Potoroo (*Potorous longipes*) of south-eastern Australia is a case in point. This shy and largely nocturnal beast, about the size of a hare, spends most of its active time digging for truffles. It is well equipped for this purpose with a long pointy snout, and sharp claws on front and rear limbs. Two of its relatives, the Long-nosed Potoroo (*Potorous tridactylus*) and Tasmanian Bettong (*Bettongia gaimardi*), are similarly equipped and share an appetite for fungi. At least 40 other species of Australian mammals feed on truffles, although not to the same extent as potoroos and bettongs. Rodents such as the Bush Rat (*Rattus fuscipes*) and Smoky Mouse (*Pseudomys fumeus*), as well as the Long-nosed Bandicoot (*Perameles nasuta*), will usually eat plant material and invertebrates but when truffles are common they are a preferred food resource. Further down the list of truffle dependency are the Mountain Brushtail Possum (*Trichosurus caninus*) and the Common Wombat (*Vombatus ursinus*), but these widespread species seem only to consume truffles incidentally while searching for other foods.

The interaction among truffles and truffle junkies is found throughout the forests of the world. In the coniferous forests of the Pacific Northwest (United States) dispersal of truffle spores is mainly carried out by rodents such as the tiny Red-backed Vole (*Clethrionomys californicus*). Topping the scales at around 20 grams, these animals spend much of their life below ground, close to their truffle food resources. One mammal species, the Northern Flying Squirrel (*Glaucomys sabrinus*), searches the forest floor at night for truffles despite nesting well above ground in hollow trees during the day. Just why it travels so far to find its food, when other types of food might be closer to hand, remains a mystery. Elsewhere, in South America and Europe, other small mammals (mainly rodents) fulfill the role of truffle junkies.

RECENT STUDIES HAVE REVEALED JUST how complex the interrelationship among truffle-eaters such as potoroos and their fungal food resources is. Dietary analyses (using faecal pellets collected from live-trapped animals) indicate that potoroos feed on a great diversity of truffles and at some sites more than 50 species can be consumed over the course of several seasons. Each of the truffle species eaten by potoroos has different habitat requirements but two broad trends are apparent. The fruit bodies of one major group form hard outer shells that allow them to persist in the soil all year round. This group

occurs predominantly in the drier parts of forested catchments (ridges and upper slopes). In contrast, the other group forms fruit bodies with soft outer cases and, as they are prone to desiccation, they fruit more commonly during wet periods of the year. These are usually found in lower parts of forested catchments along creek lines and gullies. As potoroos feed on both types, they have to forage throughout many parts of the forest, shifting from one location to another in response to different fruiting events.

These findings have been used to enhance conservation measures for potoroos and their truffle-food resources in multiple-use forests in south-eastern Australia including those used primarily for logging. In Victoria and New South Wales, in particular, areas set aside for potoroo conservation have boundaries that encompass ridges, slopes and gullies in forested catchments, ensuring that habitat for a broad diversity of fungi is preserved. This differs markedly from previous conservation measures, which focussed on the retention of buffers of unlogged forest of a certain width within logged forest.

It is easy to imagine that the loss of truffle-eating animals from a forested ecosystem will have a series of cascading negative effects. Once the main dispersal agents for the truffles are lost, the possibilities for dispersal of truffle spores are reduced. In turn, if the fungi are not being dispersed, then opportunities for proliferation of mycorrhizal associations on the roots of trees and other plants might also be reduced. Loss of these associations could mean that the host plants' capacity to acquire nutrients and water is diminished, or they may suffer from reduced protection from soil pathogens, leading to poor survival and growth. Although all of these outcomes are purely hypothetical, it does seem that, in heavily disturbed forests, truffle-eating mammals play a critical role in re-establishing fungal populations.

Truffles are largely removed when the litter layer is burnt in a fire, but the fruiting bodies of some fungi persist through the fire or may in fact be stimulated to fruit by fire. Chris Johnson from James Cook University (formerly from the University of Tasmania) has shown that animals such as the Tasmanian Bettong experience a kind of truffle-feeding frenzy immediately after a fire. The same behaviour is mirrored among potoroos and bandicoots on the mainland. Just what drives this frenzy is not clear but my own research indicates that truffles in recently burnt habitat are much more aromatic than truffles in adjacent unburnt areas. Could it be that changes in odour of the truffles help fuel the increased feeding behaviour of these marsupials? This hypothesis can only be resolved through more research. One thing is sure. By eating truffles in the

Animals such as the Tasmanian Bettong experience a kind of truffle-feeding frenzy immediately after a fire. The same behaviour is mirrored among potoroos and bandicoots on the mainland.

While primarily tree-dwelling in habit, the Mountain Brushtail Possum also looks for food on the forest floor, sometimes encountering and eating truffles.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

KATHIE ATKINSON

The humble Bush Rat is probably Australia's most widespread truffle-eating mammal, and occurs in a large variety of habitats, from forests to woodlands to heathlands. Throughout its distribution the species is known to feed on truffles, sometimes seasonally, sometimes throughout the year.

burnt sites and distributing truffle spores in their faecal pellets, these animals act as 'inoculation agents' for the fungi, spreading their spores in an otherwise sterile environment. This process takes place in the first few days after a fire. It is probably important because the trees need to re-establish links with their fungal helpers as quickly as possible to take advantage of the increased availability of nutrients in the burnt forest.

A number of important messages emerge from this fascinating story. Perhaps most significant of all is the reminder that forests are the physical manifestation of many interacting components, some of which like truffles lie hidden from immediate sight. The vital role of truffles as mycorrhizal associates on trees and shrubs is well established, as is the role of animals in their dispersal. It seems fanciful to suggest that the health of eucalypt forests might depend on the peculiar feeding behaviour of ground-dwelling mammals such as potoroos, bandicoots and rats, but the more researchers delve into the underground world of these truffle junkies, the more real this proposition becomes.■

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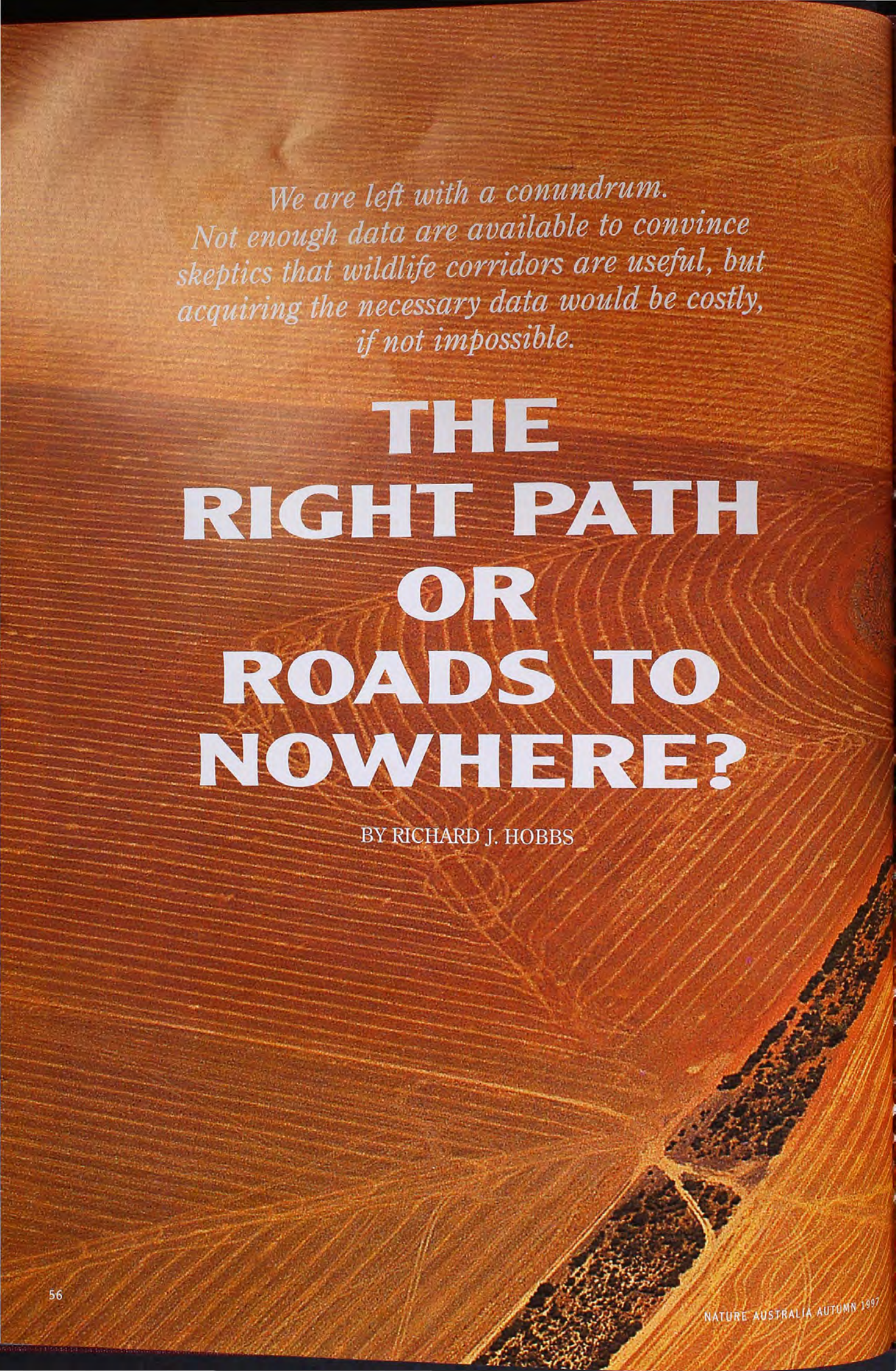
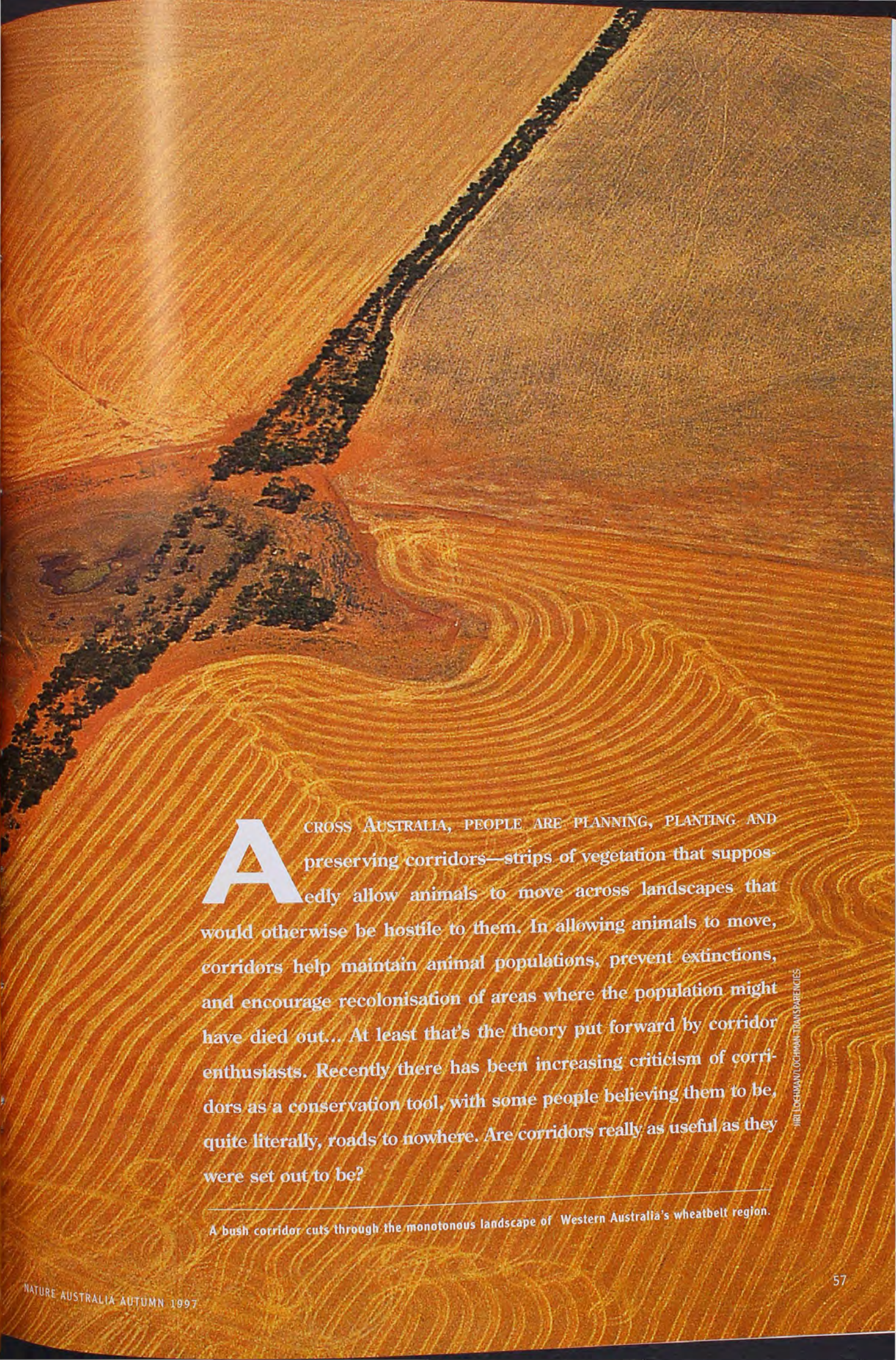
Dr Andrew Claridge is a Postdoctoral Research Fellow working jointly between the Centre for Resource and Environmental Studies at the Australian National University and the CSIRO Division of Wildlife and Ecology in Canberra. He has been studying the feeding habits of potoroos, bandicoots and other ground-dwelling mammals for the past ten years.

We are left with a conundrum. Not enough data are available to convince skeptics that wildlife corridors are useful, but acquiring the necessary data would be costly, if not impossible.

THE RIGHT PATH OR ROADS TO NOWHERE?

BY RICHARD J. HOBBS





ACROSS AUSTRALIA, PEOPLE ARE PLANNING, PLANTING AND preserving corridors—strips of vegetation that supposedly allow animals to move across landscapes that would otherwise be hostile to them. In allowing animals to move, corridors help maintain animal populations, prevent extinctions, and encourage recolonisation of areas where the population might have died out... At least that's the theory put forward by corridor enthusiasts. Recently there has been increasing criticism of corridors as a conservation tool, with some people believing them to be, quite literally, roads to nowhere. Are corridors really as useful as they were set out to be?

A bush corridor cuts through the monotonous landscape of Western Australia's wheatbelt region.

-IRIT LOCHMAN/T. LOCHMAN-TRANSPARENCIES

Several researchers in Australia have been examining the issue of corridors. Andrew Bennett (Deakin University) has been looking at mammal movements in corridors across the agricultural landscapes of Victoria; and David Lindenmayer (Australian National University) has been looking at the value of retaining corridors for Victoria's forest mammals. The longest-running study of corridors has been carried out in Western Australia. For the last 20 years Denis Saunders (CSIRO, Western Australia) has been studying how birds move around the agricultural landscape of the Western Australian wheatbelt.

Saunders spent many hours watching the endangered Short-billed Black Cockatoo (*Calyptorhynchus latirostris*), and became convinced that roadside corridors were important for these magnificent birds. They depend mainly on native vegetation for food, and feed along vegetated roadsides, and so are channeled between nesting sites and patches of suitable food. Indeed, the birds only persist in the areas of the wheatbelt where such connections remain, and are absent from areas where there is apparently still sufficient food and nest sites but no connections. Over the past ten years, Denis and many volunteers have followed the movements of an array of other bird species in the central wheatbelt. Again, it seemed that some species only moved from place to place if there was a link of roadside vegetation to follow. He also found that some species seem to use linear strips of vegetation as habitat. More recently, Jim Lynch from the Smithsonian Institution in Washington used radio-tracking to confirm that birds, such as the White-eared Honeyeater (*Lichenostomus leucotis*) and White-browed Babbler (*Pomatostomus superciliosus*), not only moved along the narrow strips of roadside vegetation, but actually lived in them.

The sum of this work led Saunders and others to conclude that the roadside corridors were a vital part of the conservation network in the wheatbelt. Andrew Bennett's work with mammals in Victorian agricultural landscapes led him to the same conclusion. But others have not been so convinced. Dan Simberloff, from the University of Florida, has been a long time critic of corridors, and claims that the work in Western Australia and Victoria does not provide conclusive evidence that corridors increase movement of animals across the landscape. In addition, he points out that corridors may have some bad points. For instance, they may encourage the spread of weeds and disease. But worst of all, devoting resources to purchasing, maintaining or creating corridors reduces the amount available for other conservation activities, such as purchasing or managing larger patches as nature reserves.

Dr David Lindenmayer radio-tracking at night for the endangered Leadbeater's Possum (*Gymnobelideus leadbeateri*). He is just one of the scientists currently investigating the role wildlife corridors may play in the survival of our native animals and plants.

ESTHER BEATON/TERRA AUSTRALIS PHOTO AGENCY

SO HOW CAN THESE RESEARCHERS COME to such different conclusions? A big part of the problem lies in the difficulty associated with obtaining good scientific evidence on the issue. Simberloff can argue that Saunders' and Bennett's data

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

The survival of the Short-billed Black Cockatoo in areas such as the wheatbelt region of Western Australia may be dependent upon the continuing existence of corridors, as they provide the birds with a vital channel between their nesting and feeding sites.

C.A. HENLEY

Recent research using radio-tracking has shown that birds such as this White-eared Honeyeater actually live in the narrow remnant strips of roadside vegetation.

do not show anything unequivocally because it was not collected in a rigorous experimental way. Even if cockatoos or other species are observed to move along corridors preferentially, that does not mean that they actually need corridors to move. They might be just as able to move across open paddocks. Without actually removing or inserting corridors and seeing what changes happen, we can't be sure that corridors are having the effect we think.

Designing and carrying out the kinds of experiment needed to provide conclusive proof one way or the other is an expensive and time-consuming proposition. In fact, Nick Nicholls and Chris Margules from CSIRO's Divison of Wildlife and Ecology in Canberra have demonstrated that such experiments are in fact impossible in the wheatbelt landscape. The complexity of the landscape is such that any effect of corridors would not be statistically detectable among all the other things that vary (such as remnant size, length and width of corridor).

So we are left with a conundrum. Not enough data are available to convince skeptics that corridors are useful, but acquiring the necessary data would be costly, if not impossible. Where does this leave us? Further studies may or may not help resolve the issue, but we really need to know now what to do about corridors. Clearly, we have to assess the usefulness of corridors on what we know already. The studies that have been conducted around Australia suggest some species, at least, use corridors either for movement or for habitat. But we don't know if they'd persist in the landscape if the corridors weren't there.

Increasingly in conservation the 'precautionary principle' is being invoked. This simply means that, if we do not know the outcome of an action, we should be cautious in what we do. In the case of corridors, therefore, where they already exist in the landscape, we should be careful to retain them. It is far easier to retain existing linkages than to replace them once they've disappeared. It may not be possible to ever completely re-establish suitable habitat for some species.

We must also recognise that the whole debate on corridors centres on only one aspect of their use: movement by animals. However, there is plenty of evidence to suggest that corridors have many other values too. The research by Saunders, Lynch and others has shown that roadside vegetation can act as linear strips of habitat for birds, whether or not they use them for movement too. We know next to nothing about how and if plants move along corridors (for instance, by dispersing seeds), but we do know that corridor vegetation is an important conservation resource in its own right. For instance, in the Western Australian wheatbelt, the same roadside vegetation that Short-billed Black Cockatoos fly up and down is also the repository of many populations of the State's rare and endangered flora, such as Merrick's Wattle (*Acacia merrickiae*) and the Matchstick Banksia (*Banksia cuneata*). In fact, some species are known only or predominantly from roadside populations.

The roadside vegetation also provides transects of the original vegetation across the landscape. In many areas, roadside corridors represent the largest remaining areas of native vegetation. For instance, in the Kellerberrin area of south-western Australia, there is more woodland on roadsides than in reserves and private remnants. This vegetation now provides a skeleton on which future restoration and revegetation can be based. From the point of view of the flora, therefore, corridors need to be maintained even if they don't foster

ESTHER BEATON/TERRA AUSTRALIS PHOTO AGENCY

The thin shape of wildlife corridors seems to make them more vulnerable to infestation by weeds, fertiliser and pesticide drift, and attack by pests such as Bag-shelter Moths. The caterpillars of these moths construct large bags of silk and leaves, and are more abundant and do more damage in corridors compared to larger nature reserves.

faunal movement.

Corridors provide other services as well. They form windbreaks and shelterbelts, and help keep rising water tables down. Vegetation strips along river banks can also maintain water quality by filtering out sediments and fertilisers carried in runoff. Again, these services are independent of any use by fauna. The idea of alley farming, or planting strips of native or other trees and shrubs across paddocks, is catching on because of the benefits for overall farm yields.

CORRIDORS ARE THUS USEFUL FROM A variety of perspectives. Their use for animal movement is only one of many possible reasons for retaining or establishing corridors. Having said that, however, it is also true that corridors can be difficult and costly to manage. Their long thin shape renders them susceptible to many influences from the surrounding landscape. These 'edge effects' include such things as weed invasion, and fertiliser and pesticide drift. Corridor vegetation may not respond to management actions in the same way as intact bush blocks will. For instance, weed invasion was not a problem following fire in a nature reserve in Western Australia, but was a huge problem in the adjacent corridor. Similarly,

DENIS SAUNDERS

A mist net is placed across a roadside corridor, to monitor bird use.

DENNIS SARSON/LOCHMAN TRANSPARENCIES

DENIS SAUNDERS

leaf-eating caterpillars of the Bag-shelter Moth (*Ochrogaster lunifer*) were much more abundant and did more damage in corridor woodlands than equivalent woodlands within large nature reserves.

Corridors on their own are also not an adequate response to the conservation problems in modified and managed landscapes. Instead, they have to take their place in an integrated strategy based on conservation networks with a core/buffer/corridor design. Existing nature reserves and remnants on private lands form the core areas for conservation, which need to be protected and managed. Protection of core areas can then be increased by establishing buffer

In an effort to learn more about the use of corridors by our native birds in the western Australian wheatbelt region, a radio-transmitter is attached to a female Rufous Whistler (*Pachycephala rufiventris*).

Corridors must not be seen to work alone. They will only be effective if they form part of an overall strategy to maintain and conserve the landscape as a whole.

zones around them which can help reduce 'edge effects' and also increase the amount of habitat available. Finally, the core areas can be connected by corridors.

In forest regions, where reserve networks and logging patterns are being planned, corridors can be left in place to connect reserved areas. However, David Lindenmayer's work has shown that corridor width is important, and simply retaining a narrow strip along streams, for example, may not be sufficient.

Where corridors already exist in fragmented landscapes (such as along roadsides), there is a good case for their retention, even though they are often difficult to manage. Revegetation programs can enhance and protect these natural linkages. Where natural connections no longer exist, the benefits of linear strips must be carefully weighed against other possibilities, such as enlarging existing remnant areas. Informed decisions about such choices require a detailed knowledge of the needs of individual species (for instance, whether they are currently being limited by lack of habitat, or by lack of connections in the landscape). The main problem is that we often do not have the necessary knowledge, and thus have to make best-bet decisions. These have to be based not only on the potential use of revegetated corridors by animals, but also the other possible benefits in terms of hydrology, shelter and so on.

In short, corridors are likely to be useful, but only in the context of an integrated conservation network. They are neither panacea nor problem, but only part of the answer. Conservation will be successful only if reserve networks are maintained (and often enhanced) and surrounding land uses are put on a sustainable footing. No conservation network can survive in a degrading landscape.

Planning, planting and maintaining corridors are worthwhile activities, but only in the context of a broader strategy aimed at maintaining and restoring the conservation and production values of the landscape as a whole. This entails more than whacking in a few lines of trees here and there. It involves developing a broad vision of what we want the landscape to look like and how we want it to work. But more than that, it involves a commitment from all concerned to implement the strategies needed to achieve that vision. Corridors are just one tool in a larger kit that needs to be fully explored and utilised.■

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Dr Richard Hobbs is a Senior Principal Research Scientist with the CSIRO Division of Wildlife and Ecology in Western Australia. His main research interests are the management and restoration of native vegetation in agricultural landscapes.

Rainbow Bee-eater
(*Merops ornatus*)

FEATHERED PORTRAITS

BY DAVE WATTS
NATURE FOCUS PHOTO LIBRARY

BIRDS... one of Australia's richest zoological assets. Their beauty and diversity is highlighted by this selection from the Australian Museum's Photo Agency — *Nature Focus*. All these photographs were taken by Dave Watts, a wildlife photographer from Tasmania.

Magpie Goose
(*Anseranas semipalmata*)

Osprey (*Pandion haliaetus*)

Beautiful Firetail
(***Stagonopleura bella***)

Shy Albatross
(*Diomedea cauta*)

FEATHERED PORTRAITS

Orange-bellied Parrot
(*Neophema chrysogaster*)

Pacific Gull
(*Larus pacificus*)

FEATHERED PORTRAITS

Brown Falcon
(*Falco berigora*)

The pattern of Thylacine sightings closely matched that for flying saucer sightings.

TIGER, TIGER OUT OF SIGHT

BY MICHAEL ARCHER

IT HAD BEEN A LONG DAY EXCAVATING fossils from a cave near Margaret River, Western Australia. After dinner in the local cafeteria, I was driving back along the bush track that led to our camp. Suddenly a kelpie-sized, black-and-white animal loped out onto the road in front of me. I hit the brakes and the car skidded to a stop about ten metres from the creature. It turned to look directly at me and my heart stopped—it was a Tasmanian Devil (*Sarcophilus harrisii*), a living, breathing, beautiful creature everyone had thought—until now—had become extinct on the Australian mainland at least 100 years before Europeans arrived. I agonised over what to do. Should I jump on the accelerator and run it over as proof positive of its existence? Who otherwise would believe me? But what if it was the last pregnant female on the mainland? No, I decided I couldn't kill it. Not knowing what else to do, I edged the car closer to this phantom from the past, hoping for an even better look. It turned its head to shamble off and, as it moved, I stared in disbelief as it metamorphosed right before my eyes from an undoubted Devil into a small black-and-white pig that disappeared into the brush at the edge of the road. I sat there horrified and bitterly disappointed. I even felt cheated. Moments before absolutely nothing would have convinced me that it wasn't a Devil and if I hadn't gotten just that little bit closer, I would still be convinced to this day that I had seen a mainland Devil.

Aviator Dick Smith recalled a similar experience when searching for the wreckage of the Kookaburra in 1978 in the Tanami Desert. While flying his helicopter, he spotted the distinctive wreckage, beyond any doubt, noting even that the wheel stuck straight up just as it did in old photographs. Although he immediately turned around and went over the same spot many times, the wreckage seemed to have mysteriously disappeared. Later on the same expedition, he did find the wreckage—but more than ten kilometres to the north of where he thought he had first seen it. He too was stunned that something he was so positive he had seen could turn out to be a misconstruction of his mind.

Among the most famous and frequent 'sightees' in Australia are Thylacines, or Tasmanian Tigers (*Thylacinus cynocephalus*). What do we know for certain about these mysterious creatures? The 25–12-million-year-old fossil record from Riversleigh, north-western Queensland, has produced a wide variety of thylacinids from small, specialised cat-sized kinds (*Thylacinus macknessi*) to dog-sized predators (*Nimbacinus dicksoni*). By eight million years ago, only one kind, the Powerful Thylacine (*Thylacinus potens*), is known from Australia. The modern Thylacine made its appearance about four million years ago. It then disappeared from New Guinea around 10,000 years ago, and about 4,000 years ago, roughly the same time Dingoes were introduced to Australia, it disappeared from the Australian mainland surviving only in Tasmania, an island Dingoes didn't reach. On the basis of questionably dated bones and rock art, it is possible that Thylacines survived for a longer time in the rugged areas of north-western Australia. In 1936, the last individual for which there is tangible evidence (captured in 1933) died in the Hobart Zoo. The late, great David Fleay told me that, while in a cage photographing one of the Hobart Zoo Thylacines, it bit him on the rump—a final and certainly 'de-tailed' gesture for a naturalist who went on to become obsessed with finding Thylacines alive.

The International Union for the Conservation of Nature has declared that, if an animal hasn't been proven to exist for 50 years, it should be classified as 'extinct', a category Thylacines fell into in 1986. Some devotees, however, are unwilling to let the Thylacine go quietly into that last night. On a very regular basis I get letters from people who claim to have seen it, found its tracks, heard its cough or peered into the cold open chest of a blood-drained sheep or kangaroo—mostly from country areas of mainland Australia. I have followed up many of these reports, always hopeful, ever open-minded. One of the most intriguing was the 'Craignish Creature', claimed by many who had seen it near Maryborough, Queensland, to be a Thylacine. Immediately after a newspaper reported that it had been shot while raiding a chook yard in the town of Craignish, I contacted the person who held the carcass. It was delivered to me at the Queensland Museum—where, to my bitter disappointment, it turned out to be a very smelly but rather ordinary mangy Fox.

There have been many expeditions to Tasmania in search of the Thylacine since the 1930s including one by a Walt Disney film unit in 1958 and even one funded by the World Wildlife Fund. Most

MICHAEL SHARLAND/NATURE FOCUS

A rare 1930s photo of the Thylacine in Hobart Zoo.

have focused on remote areas of dense forest in Tasmania where reported sightings are frequent. But despite an embarrassing amount of money and the most clever hunting skills imaginable, all have failed to produce a photograph or even a single hair of a Thylacine.

On the basis of a sighting in Tasmania in 1982 by a Tasmanian National Parks and Wildlife Service officer, another long-term survey was undertaken in yet another area. Although no Thylacines were seen let along caught during the survey, population statistics for the presumed population were produced, including calculations of the estimated number of males and females.

In 1984, Ralph Molnar (Queensland Museum) compared Thylacine sightings with those for kangaroos (in early 18th-century Australia) on the one hand and flying saucers on the other. Flying saucer reports are judged even by UFO researchers to be largely (90–95 per cent) mistakes so they provide a standard for unreliable sightings. The pattern of Thylacine sightings closely matched that for flying saucer sightings rather than that for kangaroos. Three commonly shared features of the Thylacine and UFO sightings could be interpreted to contribute to their unreliability: very brief periods during which the sightings were made (less time for a good look); poor visibility at the time of the sightings (less opportunity for a good look); and very few observers made each sighting (fewer observers being arguably easier to fool than mobs of people).

I raised a similar concern about Thylacine sightings in Tasmania (see *Nature Aust.** Spring 1984). The majority of 'good' reports of Thylacines were in areas of densely forested bush, not in the open forests and woodlands that were known to be their preferred habitat—and where they came to grief so quickly at the hands of the farmers and the Tasmanian Government because of their culinary interest in the sheep that had begun to infest their preferred hunting grounds. If Thylacines are now, as sighters suggested, hidden away in remote, dense bushland, why do they stay there? Why wouldn't they, like all other creatures that get hungry, be most frequently spotted within or on the margins of their preferred habitats, which are still filled with yummy sheep? They should be squashed on the roads throughout vast areas of the Apple Isle just like Tasmanian Devils and all other Tasmanian critters known. One Tasmanian Parks Officer explained that squashed Thylacines were not found on the roads because Tasmanian Devils ate them up before morning.

And then there are the hoaxers, mischievous folk who prey on those wanting to believe in live Thylacines. An organised beat by locals at Manjimup, Western Australia, in the late 1960s was intended to drive an often-sighted Thylacine from a copse of dense bush into the arms of waiting dignitaries and press. Instead, what fell over blinded by the flashbulbs was a sheep painted with black stripes and a sign on its neck saying "Tassie the Tiger". One recent hoax even caught the international journal *New Scientist*. In 1986 it published three photographs, taken by Western Australian Kevin Cameron, of what appeared to be the southern end of a Thylacine digging at the base of a termite mound at an undisclosed locality in south-western Western Australia. Cameron claimed that, before the Thylacine had heard him and run off, he had managed to take a series of photographs as he crept constantly closer to the distracted animal. Despite offers of $50,000 to allow the photographs to be carefully studied, Cameron refused. Matt Webster, an astute reader of *New Scientist*, noted in a subsequent issue that the shadow cast by a tree in the first photograph had shifted well to the left in the second, suggesting a long intervening period of time and, as Webster put it, that Kevin Cameron was "...either a very slow stalker or a very poor faker".

At the end of the day, surely it's time we accepted two ugly realities. First, the Thylacine is extinct—dead, gone, kaput. No more precious money, urgently needed for genuine conservation causes, should be spent on yet more futile searches. Second, we, the Europeans who bounty-hunted the Thylacine with the Tasmanian Government's blessing from 1830 to 1936, took it out. Clinging to Thylacine sightings is a true believer's way of refusing to face this unpleasant reality. If we are going to practise genocide on other species, we must accept the finality of the consequences and be prepared to live with the guilt. As someone intensely fascinated by everything to do with Thylacines, I would desperately love to be wrong—but I'm not holding my breath.■

*Previously ANH

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

REVIEWS

Frog Calls of the Greater Sydney Basin; Frog Calls of North-eastern New South Wales; Frog Calls of Brisbane and South-eastern Queensland.

Three audio cassettes produced in 1996 by David Stewart, Nature Sound, Wilsons Creek via Mullumbimby, NSW, 2482. $15.00 each (plus postage).

This series of three tapes covers 70 species of frogs found along the central eastern seaboard of Australia—an area rich in both frogs and people. Of these species, 20 are shared by two of the three areas covered, and 28 are shared by all three areas. Remarkably, the calls of only two species currently known from this area (one believed to be extinct) are unavailable.

For all but the enthusiast, most frogs are heard but rarely seen, so that the ability to record the presence of a species without having to locate, catch and identify an individual (a process that is actually illegal in the two States covered by these tapes) is not just a convenience but a critical aid to those with a need to record the diversity of these animals in any given area. Incidentally, the producer recommends that the tapes be used in conjunction with Martyn Robinson's excellent book *A field guide to the frogs of Australia.*

Although there are other recordings of frog calls from some of the areas encompassed by these three cassettes, David Stewart's tapes bridge a number of gaps and bring a comprehensiveness and recording quality not previously available to such a wide audience. Of the three tapes, the one covering the greater Sydney region has the edge, simply because the narration by Richard Morecroft is more lively. However, the information contained in all of the commentaries is excellent, each consisting of an introduction and conservation status. All three commentaries are available in hard copy in the leaflets that accompany the tapes, making the information very accessible.

Criticisms? My major gripe is the absence of localities (even in the most general terms) of where the recordings were made–a short coming analogous to the common failure of many otherwise outstanding natural history books to identify the geographic source of photographs of often highly variable species.

The use of different scientific names for the same species of mountain frogs on the different tapes (*Kyarranus* versus *Philoria*), while accurately reflecting different scientific opinions about relationships, could confuse an inexperienced user; why not present alternate usages? However, these are nit-picking criticisms that can easily be rectified in future versions.

David Stewart's cassettes will be of immense interest and value to those people living or working in the region who have a need or desire to identify the frogs in any given area, even their own backyards. They also have a wider potential as teaching tools in demonstrating both the enormous diversity of Australian frog calls and the significance of these differences in frog biology and ecology. But most importantly, they represent a major practical, scientific contribution to studies of biodiversity and conservation ecology in eastern Australia, helping to conserve those very species whose calls are represented on the tapes.

–Hal Cogger
Australian Museum

Frogs Tasmania

Audio cassette produced in 1996 by Deloraine Field Naturalist Group, Tasmania. Available from DFNG, RSD 491, Weegena, Tas. 7304. $10.00 plus $2.00 p&h.

This is an excellent addition to any Tasmanian naturalist's library or, indeed anyone else interested in Tasmanian fauna. It is well set out, easily understood, and even has different levels of text on its A and B sides. You pick your side as to whether you are an advanced (side B) or basic (side A) naturalist!

One shortcoming of the tape is that it is only of applied use in Tasmania. There are only 11 species of frog currently known from Tasmania. Of these, two are found nowhere else and two others have calls significantly different from those of the same species on the mainland. The result is a tape that is perfect for Tasmania but can't be applied elsewhere.

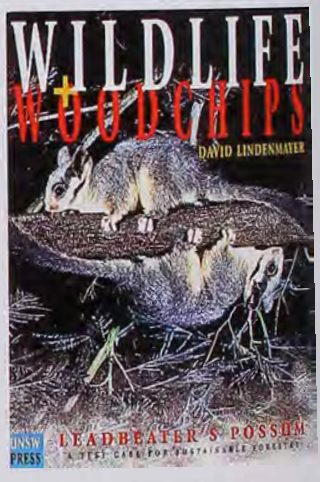
The small number of species could also have resulted in a very short tape, but the compilers have cleverly padded it out by adding details on natural history, biology, identification and habitat. Even so the calls of each species are recorded at least three times throughout the tape and again in combination choruses. You will be quite familiar with them by the end of the tape!

The information given is all useful and easily understood. I only had one slight problem with the toe pads of the Brown Tree Frog described as acting "like suction cups", as this implies they stick by suction, which they don't. They work using a combination of sticky mucous and textural surface to adhere to glass etc., but that is only a minor point.

On the plus side is the fact that this is the only regional tape I know of that has all the species of one State recorded on the one tape. This includes the call of the Moss Froglet (*Bryobatrachus nimbus*), a species that was only named in 1994. A rare recording indeed!

The tape is well priced at $10.00 and for an extra $2.00 can be posted to you. Well recommended.

—Martyn Robinson
Australian Museum



Wildlife & Woodchips: Leadbeater's Possum—A Test Case for Sustainable Forestry

By David Lindenmayer. UNSW Press, NSW, 1996, 168pp. $34.95rrp.

An interest in possums is certainly not a prerequisite for reading this delightful and highly illustrated book, which is relevant to a wide audience. The author is a leading expert on this species, and presents an easily readable

account of its biology, conservation management, and immediate threats to its survival from forestry operations. The quest to ensure the survival of this possum, Victoria's faunal emblem, is, as the title states, a test case for the ever elusive "ecologically sustainable forest management". It would be hard to find a better example of the challenge to society presented by the direct conflict between conservation of public forests for ecological values such as survival of this species, versus woodchip-driven timber harvesting. The possum's distribution has shrunk since European settlement to an area 60 x 80 kilometres, in the commercially valuable mountain forests just east of Melbourne. More than three-quarters of this falls within public forests destined for timber operations. Thus, the usual ploy that there are 'plenty more animals elsewhere', simply does not apply to this species. Leadbeater's Possum is critically dependent for shelter in hollows in the oldest trees, which are about 200–500 years old and which are rapidly being eliminated. The concluding chapter is "The Way Ahead: Conservation and Management". So what is the survival prognoses for Leadbeater's Possum? Read the book!

—H. Parnaby
Australian Museum

Rocks & Fossils
By Arthur B. Busbey III, Robert R. Coenraads, Paul Willis & David Roots. The Nature Company Guides, RD Press, NSW, 1996, 288pp. $40.00rrp.

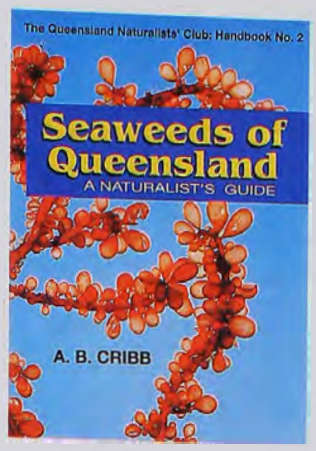
We have been waiting for a book like this for a long time. Anyone working in earth sciences at a museum will be well aware of the wide and diverse interest of the laymen in things geological. Rocks, minerals and fossils particularly fascinate the young and enhance the beautiful framework of our natural environment.

This unusual book allows us to browse the aesthetics of such wide-ranging topics as explosive volcanoes, rocks from outer space, processes of evolution, the birth of oceans, dinosaur eggs and frozen fossils. A friendly, non-technical approach challenges new understanding and unlocks fresh fields for investigation.

The science of geology has suffered from forced economic application. As a result minerals have been identified with mining. Fossils, particularly those of dinosaurs, have starred in the entertainment industry and our schools have largely dropped geological studies. We hope that this book will help a re-think towards the broader perception of our planet Earth and all the processes behind our evolution.

Source material is surprisingly diverse and has been sourced worldwide. Anyone keen on developing or enhancing a hobby collecting the ever-surprising range of minerals and fossils will find many practical hints concerning conservation and opportunities. There are many illustrations in this book that will be of great value for identification of specimens. These are excellently produced, considering that it is often very difficult to usefully portray rock and mineral specimens. It is, however, unfortunate that locality details have been omitted from many illustrations. This seems to be a common failing of much modern presentation, both in museums and in this book. Highly recommended for anyone and everyone interested in rocks, minerals and fossils. You will find them all, plus much more in this major work.

—Julian Hollis
Gold Hills Mining NL



Seaweeds of Queensland: A Naturalist's Guide
By A.B. Cribb. The Queensland Naturalists' Club, Qld, 1996, 130pp. Available from the Qld Naturalists' Club, c/- Dr Woodall, Dept Anatomical Sciences, University of Qld, 4072. $15.00 plus $3.00 p&h.

For people who enjoy seaside strolls, a snorkel in the shallows, or students who need a quick reference, this is a good field guide to the common marine algae (seaweeds) of Queensland. Its price ($15.00 plus $3.00 for postage) will also ensure that everyone can afford it. When Alan and Joan Cribb published their book on the plant life of the Great Barrier Reef (1985, University of Queensland Press), they included a chapter covering 67 colour photos of marine algae. The present book easily surpasses that guide with its 168 species and photos of mostly green, brown and red seaweeds. The photographs are excellent; sharp and clear, and are accurate images of what the plants really look like. Good identifications, using this book, will therefore be assured. Where possible, Cribb has also listed the common name alongside the scientific name and, although these names are mostly arbitrary, they may be more easily remembered by the novice. Except for three instances, the accuracy and currency of the species names are good. For the pedants, *Jania crassa* is now *J. verrucosa*, *Gracilaria verrucosa* is now *G. gracilis* and *Scytosiphon lomentaria* is now *S. simplicissimus*.

—Alan Millar
Royal Botanic Gardens Sydney

SOCIETY PAGE

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

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Contact: Glenys Oogjes

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Fauna Rescue of South Australia Inc.
7 Ormsby Ave,
Modbury North, SA 5092
Ph: (08) 8264 4958
Contact: Mrs Sheila Burbidge

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Contact: Alan Leishman

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Ph: 1800 032 501
Contact: Madeline Townsend

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100 Currie St,
Adelaide, SA 5000
Ph: (08) 231 0016
Contact: Helen Jaensh

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Ph: (02) 9233 4670
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Contact: Ms Alison Miller

Membership fee: $30.00 (ordinary member); $40.00 (ordinary member outside Aust. & NZ); $5.00 (extra family member); $5.00 (junior member); $45.00 (corporate member, $50.00 outside Aust.); $30.00 (affiliate member)

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Ph: (03) 9363 6841;
F: (03) 9360 5704
Contact: Brian Barnett

Membership fee: $28.00 plus optional extras

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SA 5000
Ph: (08) 271 6860
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Q&A

Practice Makes Perfect

Q: *To human ears the lyrebird seems to be extremely accurate in its mimicry. Do lyrebirds have some kind of organ enhancement that gives them a vocal edge over other avian mimics? How often does a lyrebird need to hear a sound in order to be able to reproduce it?*

—Jane Correy
North Sydney, NSW

A: Avian mimics occur on most continents, but they are particularly well represented in Australia. Although many Australian species have been reported exhibiting some degree of mimicry, none is as well known for this practice as the lyrebirds. However, there appears to be no special development of the syrinx (voice box) in species that mimic compared to those that don't. In fact, the voice box of lyrebirds is less complex than that of most other mimicking species.

Many birds are hatched already knowing their species-specific calls; no learning is required. Other birds, particularly the songbirds (including lyrebirds), must learn their songs from their parents or other older members of the species. Only after listening and practising do they become proficient in producing their correct song. Likewise, the acquisition by lyrebirds of songs of other species requires a period of learning, both from the mimicked repertoire of their father and from the neighbouring members of the species being mimicked, and fine-tuning through practice. The learning of a call of a lyrebird from an adjacent lyrebird, and subsequent spread of this call through a local population, are well known.

—Walter Boles
Australian Museum

A male Superb Lyrebird (*Menura novaehollandiae*) displaying.

H.& J. BESTE/NATURE FOCUS

A *Rhizophora apiculata* mangrove seedling growing in northern Queensland.

H.& J. BESTE/NATURE FOCUS

Means of Survival

Q: *How do mangrove seedlings survive under water with no carbon dioxide?*

—Lindsay Wu
Kentlyn, NSW

A: Mangroves are viviparous, that is, the seed germinates while it is still on the parent plant. When it reaches a certain stage of development, the seedling drops into the water and floats in the sea until it is washed up on the muddy shore, usually at the mid- to high-tide water mark. Here the plant is not always fully submerged, and so it can obtain carbon dioxide from the atmosphere. Although there is a high level of soluble carbon dioxide in the water, it is not easily accessible.

—Royal Botanic Gardens
Sydney

Seamoths

Q: *Sometimes when I buy a parcel of king prawns at the fish market I find some bony little creatures amongst them (specimen enclosed). They look like sea horses or miniature saw sharks. What are they?*

—R. Heine
Annandale, NSW

A: These small fish are Slender Seamoths (*Pegasus volitans*). You were correct in identifying a likeness to seahorses as seamoths, seahorses and pipefishes all belong to the same order of fishes. Other

RUDIE KUITER

Slender Seamoths often end up being trawled with prawns.

fishes in the group have similarly evocative names like snipefishes, flutemouths and trumpetfishes.

Seamoths are covered in hard bony plates and their bodies are flattened from top to bottom. Their name derives from the broad rounded pectoral fins, which are spread sideways like wings. Seamoths can crawl along the bottom using movable spines on their pectoral and ventral fins. Compared with many of their relatives, they have a rather short snout and an underhung jaw, but the mouth forms an efficient suction tube to extract worms and other invertebrates from burrows.

Seamoths live on the sea bed in warm and temperate shallow coastal waters. In 1958 they were noted to occur in association with the movements of commercial prawns, so it is not surprising that your free-loaders were trawled as by-catch with the prawns.

—Liz Cameron
Australian Museum

Answers to Quiz in Nature Strips (page 16)

1. South Australia
2. Mad Cow Disease
3. Venus
4. Helmeted (or Yellow-tufted) Honeyeater
5. Female
6. Ozone
7. Blue Whale
8. Mauritius
9. Triassic
10. The study of fossils

PIC TEASER

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a $20 gift voucher for the Museum Shop Catalogue. Summer's Pic Teaser was the larva of the emperor moth *Opodiphthera helena* seen from the rear end.

DENSEY CLYNE/MANTIS WILDLIFE

Our oceans should not have to pay the price of providing a cure for cancer or treatment for skin wrinkles.

MARINE RESOURCES: CURE-ALL OR LOSE ALL?

BY MARY GARSON

MOST PEOPLE HAVE, AT one time or another, combed the beaches and shores for shells, bits of driftwood, or even oysters. And "why not?" you may ask. We all take for granted our rights to remove potential food, bait or tools from our surroundings. Human civilisation would not have gone far on this planet had it not been for our hunting and gathering instincts. But did you know that Australia's precious marine resources are being 'combed' on a much larger scale by scientists eager to find new products and commercial uses for them? What is the environmental cost of this activity?

Bioprospecting is the search for novel chemicals from natural ecosystems, in the hope that they may provide leads towards commercial products as diverse as pharmaceuticals, cosmetics and paints. Drugs developed from natural sources, representing 25 per cent of the world's medicines, include treatments for leukaemia, heart disease, malaria, cancer and products that suppress the immune system or kill harmful bacteria or parasites. Multinational pharmaceutical houses have much to learn from nature, which in essence has been running an efficient, cheap and chemically ingenious drug development program for millions of years.

Bioprospecting the oceans began over 20 years ago. Marine bioprospectors start by removing small samples from a wide range of plants and animals. After screening, only a handful of the chemical extracts prepared will show useful activity and warrant larger-scale recollection. Unfortunately, a nasty fate awaits organisms that do provide a drug lead, particularly if the active ingredient is present in only tiny amounts. Recollection sometimes means several thousand kilograms of the animal or plant are removed, and often without any environmental impact study! One bioprospecting organisation based in the United States isolated just one milligram of an anti-cancer compound from 450 kilograms of marine worms, each only three to five millimetres long. Luckily harvesting of marine invertebrates has not yet occurred on this scale within Australian waters, there so far being no major candidate for drug development. Six marine candidates are currently in American clinical trials, including chemicals isolated from sponges, tunicates and molluscs.

One bioprospecting organisation isolated just one milligram of an anti-cancer compound from 450 kilograms of marine worms.

Globally we know next to nothing on how to protect and conserve our marine biodiversity. The difficulties currently faced by our fishing industry well illustrate the problems, but we know significantly less about the biology of sponges or tunicates, for example, than we do about fishes. In the past, the policy of the bioprospecting industry was to collect, period. However now, against the backdrop of the Convention on Biological Diversity, bioprospectors are becoming more sensitive to environmental and harvesting issues. Even so, large-scale harvesting of Australia's marine resources should only be approved if an environmental impact study is also carried out.

There is a future for the marine bioprospecting industry, but only if it can become sustainable. A New Zealand group working on anti-cancer chemicals from a marine sponge (*Lissodendoryx* sp.) has made remarkable progress in the technique of sponge-farming in Wellington Harbour. Other scientists are learning how to grow marine animals in the laboratory or to culture symbiotic micro-organisms isolated from within the animals' tissue. One high-tech solution is to transfer genetic information from a sponge into a microbe. Then, by growing the microbe in the laboratory, it is possible to obtain the 'sponge' chemical from it. These experimental advances may help make the industry more sustainable.

Compared to neighbouring South-East Asian countries, which currently lack regulations to protect their biodiversity, Australia is fortunate to have instigated federal legislation since 1982 to protect against the removal of our native flora and fauna overseas. However, this legislation was developed before the word 'bioprospecting' had been invented. It may now be time to amend the law to accommodate this quickly developing industry, encouraging and ensuring that collectors demonstrate a responsible attitude to assessing and ameliorating potential environmental impacts. Restricted access or proscriptive collecting conditions should be placed on areas of high endemism; more marine reserves should be created to provide areas of minimum disturbance and maximum beauty; and research into the identification of our marine floral and faunal resources, together with assessment of key habitats and reproductive strategies of key organisms, should be funded by the bioprospecting companies. After all, we live in a user-pays society.

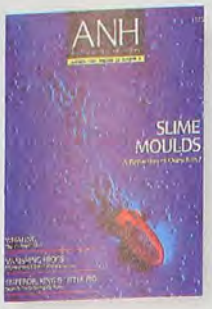
Our oceans should not have to pay the price of providing a cure for cancer or treatment for skin wrinkles. Marine biodiversity may represent a potential benefit to sick people and is a valuable economic resource but, more importantly, it is part of our biological heritage and should be appreciated for its own sake. So next time you go beachcombing, think about how we ought to be protecting marine plants and animals from their own chemical wealth.■

Dr Mary Garson is a senior lecturer in the Chemistry Department at the University of Queensland who researches the chemistry of marine invertebrates.

BACK ISSUES AND SUPPLEMENTS

23/6

23/7



23/8

23/9

23/10

24/1

24/2

24/4

24/5

24/6

24/7

24/8

24/9

24/10

24/11

24/12

25/1

25/2

25/3

25/4

25/5

25/6

SUPPLEMENTS

25/7

S1
Pieces of Paradise

S2
Tracks through Time

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