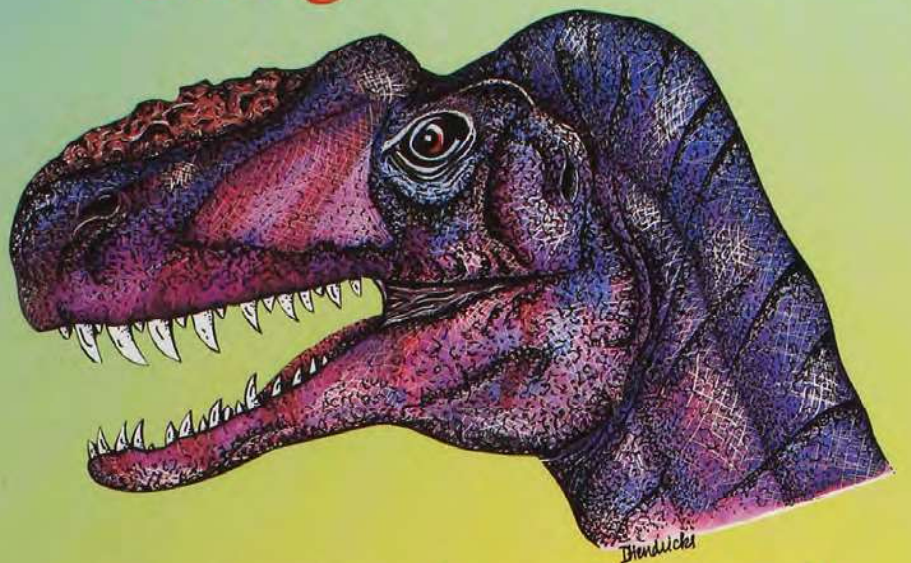

$7.95
AUSTRALIA
Nature
FORMERLY ANH MAGAZINE
SPRING 1995
CELEBRATING 75 YEARS OF PUBLICATION
OWLS ON NIGHT WATCH
PLATYPUS Pursuits
KOALAS' Toxic Diet
DINOSAUR Sex
Free Owl Poster
ISSN 0004-9840
03
9 770004 984002
AUSTRALIAN MUSEUM
AM

New predatory dinosaurs are being discovered every year



***Monosaurolophus jiangi*, a newly named carnivorous dinosaur from China**

Read all about this beast and other fascinating new discoveries in the latest issue of ***Dinonews*** *magaz*

THE DINOSAUR CLUB

Scientists at the Western Australian Museum formed ***THE DINOSAUR CLUB*** three years ago to provide information on dinosaurs and other prehistoric creatures in an easy to read, enjoyable format. Since then we have joined nearly 12,000 members, and through our popular magazine ***DINONEWS*** you can read about the latest discoveries from Australia and around the world, and help provide scientists with funds to continue researching our fascinating prehistoric past.

Simply copy and fill out the form and post with your cheque or credit card details (ring them first) to your local Dinosaur Club Branch.

INDIVIDUAL members (senior or junior) -receive ***DINONEWS*** magazine twice a year and a fun starter kit with information sheets, dinosaur games and activities, sticker and puzzle ($12 year).

GROUP membership includes everything from both junior and senior kits, *two* copies of each new ***DINONEWS*** issue ($20 year).

please copy and cut out

Name _____ Membership Type _____ $____

Address _____

_____

Credit card payments are preferred: VISA ☐ M/CARD ☐ B/CARD ☐

Credit Card Number _____ Expiry date _____

Signature _____

I would also like to receive all the back issues of ***Dinonews*** magazine (Issues 1-7) @ $2.50 each and enclose an additional $17.50. Total enclosed _____

WESTERN AUSTRALIA
(National Headquarters)
The Dinosaur Club
Western Australian Museum
Francis St, Perth, W.A. 6000
Ph: (09) 328 4411

SOUTH AUSTRALIA
The Dinosaur Club-
Dr. Fran Parker
Earth Sciences Resource
Centre for Schools
University of Adelaide
North Tce, Adelaide, S.A. 5000
Ph (08) 303 5959

NEW SOUTH WALES
The Dinosaur Club
c/-Margery Phair
The Australian Museum
PO Box A285, Sth Sydney
N.S.W. 2000 Ph: (02) 339 8111

CANBERRA
The Dinosaur Club
The National Dinosaur
Museum (Mike Durant)
Gungahlin A.C.T. 2912
Ph: (06) 230 2655

VICTORIA
The Dinosaur Club
c/- Dr. Pat Vickers-Rich
Dept. of Earth Sciences
Monash University, Clayton,
Vict. 3168 Ph: (03) 543 4061
(cheques to Monash Uni.)

SOUTH QUEENSLAND
The Dinosaur Club
c/-The Queensland Museum
PO Box 3300, Brisbane Sth,
Qld 4101 Ph: (07) 840 7555

NORTH QUEENSLAND & NORTHERN TERRITORY
The Dinosaur Club
c/- Greg McNamara
Geology Dept.
James Cook University
Townsville, Qld 4811
Ph (077) 81 4796

Up Front

One of the most enjoyable aspects of working on this magazine, is meeting the many interesting, dedicated people who devote so much of their lives to understanding and preserving nature.

By day, David Hollands is a medical doctor caring for the people of Orbost in rural eastern Victoria. By night, Dr Hollands indulges in a more unusual pursuit. Whenever he gets the opportunity, he can be found prowling around the Australian bush in search of our native owls. His nocturnal activities have enabled him to amass a unique collection of photos and experiences that make fascinating reading. As we were putting this article together, the good doctor was preparing for a trip to Scotland where he would spend the bitterly cold winter nights owl hunting—now *that's* dedication.

MARIE LOCHMAN/LOCHMAN TRANSPARENCIES

Despite appearances, Koalas do have to make some hard decisions.

Peter Larson is an American with a very different passion—the dead. For over 30 years he has collected, prepared and studied fossils. This fossil fascination led to his establishment of the Black Hills Institute of Geological Research in South Dakota. It was a volunteer from this organisation who unearthed the largest and most complete skeleton of *Tyrannosaurus rex* ever found. In his article for *Nature Australia,* Peter explains how sexing a dinosaur may be as simple as looking under its tail!

David Hollands captures a moment in the life of a family of Grass Owls.

Drs Melody Serena and Steven Cork are dedicated to the survival of two very special Australians—the Platypus and Koala. Despite the popularity of these animals, surprisingly little is known about their basic ecology. Melody has concentrated her study of Platypuses to individuals living along two tributaries of the Yarra River, 65 kilometres east of Melbourne. In order to study these animals, she had to first develop a method of catching and radio-tagging them. Since then, she has spent many hours tracking these elusive mammals. But it's all been worthwhile, as ongoing studies are now providing valuable information on Platypus movements and home ranges.

Steven has delved into the complicated world of Koalas and eucalypts. This is definitely a situation where all is not as it seems and Koalas live in a world where, if they're not careful, their next mouthful could be their last! Steven's research has serious implications with regards to the areas we put aside for Koala conservation.

This issue also finds Mike Archer risking life and limb in Borneo, while Tim Low takes us on a magical journey into the world of mushrooms. Lloyd Nielsen presents a unique portfolio of photos from tropical Queensland, and we take a very new look at a very old pine.

DAVID HOLLANDS

—Jennifer Saunders

Nature AUSTRALIA

SPRING 1995 VOLUME 25 NUMBER 2

Published by
The Australian Museum Trust
6 College Street,
Sydney, NSW 2000.
Phone: (02) 320 6000
Fax: (02) 320 6073
Trust President: Patricia Watson
Museum Director: Desmond Griffin

EDITOR
Jennifer Saunders, B.Sc.

SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.

PHOTO RESEARCHER
Kate Lowe

DESIGN AND PRODUCTION
Watch This! Design

PRINTING
Excel Printing Company

MARKETING AND SALES
Mike Field
Phone: (02) 320 6331

ADVERTISING
Sari Järvenpää
Phone: (02) 320 6179

SUBSCRIPTIONS
Mary Pollinger
Phone: (02) 320 6119
Toll-free (1800) 028 558
Fax: (02) 320 6073

Annual subscription (4 issues)
Within Australia $A30 Other countries $A42
Two-year subscription (8 issues)
Within Australia $A58 Other countries $A78
Three-year subscription (12 issues)
Within Australia $A81 Other countries $A108

New subscriptions can be made by credit card on the *NATURE AUSTRALIA* toll-free hotline (1800) 028 558 or use the form in this magazine. If it has been removed, send cheque, money order or credit card authorisation to the address above, made payable to the 'Australian Museum' in Australian currency. *NATURE AUSTRALIA* is printed on archival quality paper suitable for library collections.

Published 1995
ISSN–0004–9840

NATURE AUSTRALIA (as ANH) is proud winner of the 1987, '88, '89, '90, '91, '92 & '93 Whitley Awards for Best Periodical.

Front Cover
Highly specialised birds, Lesser Sooty Owls (*Tyto multipunctata*) occur only in the wet, dense forests of northern Queensland. Photo by Australian Picture Library/S. & R. Kendrick.

CONTENTS

Articles

Regular Features

Columns

LETTERS

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

Hopping-mice

I have just returned from a small gathering of The Royal Society of South Australia where we celebrated the birth of that indefatigable early explorer H.H. Finlayson, who perhaps knew more about the natural history of the Australian arid zone than anyone else of European descent. Being Sunday evening I flicked through my recent (Autumn 1995) copy of your magazine and have just read the article by Dave Wurst on the search for the Central Rock-rat. I see that, as we have feared for some time now, yet another medium-sized mammal may have disappeared forever as Dave was unable to locate any specimens despite setting over 4,000 traps. However, he does appear to have made a rediscovery that he seems to be unaware of. In his article he writes about Sweet Quandong seeds that are gnawed by Spinifex Hopping-mice, a phenomenon previously attributed to the Central Rock-rat and Lesser Stick-nest Rat. However, Finlayson in his 1940 paper in *The Transactions of the Royal Society of South Australia* writes under his species account of *Notomys alexis* (Spinifex Hopping-mouse) "According to The Blacks the large round woody seeds of the quandong (*Eucarya acuminata*), which have a rich fatty kernel, are also eaten by this species; the seed case is neatly drilled in one side only with a small hole, and the contents extracted. Under almost any quandong tree a proportion of such drilled and emptied seeds may be found, though the fact that so many are left untouched, suggests that it is an emergency food rather than a staple diet." Clearly, yet again, the first human settlers of this country knew about this interesting snippet of natural history before it was discovered by Europeans.

—Bill Breed
University of Adelaide

Invisible Parasites

In your Spring 1994 issue, the Northern Hairy-nosed Wombat was featured in an article by Chris Johnson titled "The Invisible Wombat". It has been pleasing to learn about the increasing 'visibility' or awareness of this rare Australian mammal over the past few years. For some reason wombats have failed to capture the interest of the media and the imagination of the Australian public in quite the same way as Koalas have.

So what chance is there for the animals that are invisible in 'the invisible wombat'? Thanks to Chris Johnson and his colleagues we are starting to learn quite a lot about the Northern Hairy-nosed Wombat, but we know nothing about their equally important (from a conservation perspective) parasites. 'Out of sight out of mind' is often the case when conservation strategies are being developed for our endangered species. However, their 'invisible' parasites may be having as much effect on their long-term survival as other more obvious ecological parameters.

Northern Hairy-nosed Wombats are now known to harbour at least two internal parasites, a cestode found in 1923 and a nematode *Oesophagostomoides eppingenis* found in 1992. The latter occurs only in the Northern Hairy-nosed Wombat and so is probably the rarest nematode of a mammalian host in the world.

Now that we are coming to realise the importance of maintaining biodiversity for a sustainable future, can we afford to ignore the largely invisible realm of the parasites that makes up about 50 per cent of our living world?

—Lesley Warner
Central Queensland University

Some interesting discoveries were made during the search for the Central Rock-rat.

ILLUSTRATION BY ANNE BOWMAN

AUSTRALIAN PICTURE LIBRARY/JOHN CARNEMOLLA

Turning coconut palm waste into paper makes good sense.

Palm Paper

Research called for by Peter and Jeanne Edwards (Letters, Autumn 1995), into the production of paper pulp from the refuse of coconut-oil palms, is well under way at a pilot plant in Indonesia. Here is a loose translation extracted from the now-banned *Tempo* magazine (18 December 1993): "Tree-hungry Indonesian paper makers, paying $US260 million a year for imported wood pulp to supplement domestic supplies, are looking to the palm-oil industry for help".

Only the stripped leaves of coconut palms are used for pressing oil. Stems and midribs, and the whole trunks of old trees that have to be replaced, go to waste. They are burnt, or dumped in rivers. The leaf stems alone amount to about three tonnes a year from each hectare of trees. Munched up, palm refuse makes a porridge like normal wood pulp. The fibre content is lower and the stem fibres are shorter, but palm pulp can be mixed with the real thing in proportions as high as 30 per cent to make heavier grades of paper—including high-quality writing paper. Technical feasibility has been proved.

Current production runs at an experimental plant at Deliserdang in northern Sumatra are establishing costings. Whatever price rural palm planters can earn will be a big improvement on what they receive now for the greatest tonnage of their crop. . .nothing.

—David Underhill
Palmerston, NT

Checking the Facts

I really appreciate your magazine and the work your regular writers do in bringing us information from all kinds of sources. However, I am disturbed that not only may they have little personal knowledge of their subject but that they do not check their sources against other references.

I refer to the short note on marigolds and mosquitoes in your Autumn 1995 issue. *Aedes* mosquitoes are the vectors in the spread of yellow fever and, more importantly for Australia, dengue fever, while it is the *Anopheles* that spread malaria.

I lead a busy life and rely on reputable journals such as yours to keep me informed. Like most of your readership I am disinclined to cross check every piece of information. While I do not propose you put each piece out for referees to scrutinise, you could pressure your contributors to lift their act.

—Alan J. Gillanders
Yungaburra, Qld

We pride ourselves in the fact that most of our authors do *have personal knowledge in their subject matter. In fact we go out of our way to get the experts to write the articles. The only area where we regularly get non-experts to write is in the Nature Strips (formerly Quips, Quotes & Curios) section—but when this happens the authors are still scientists or science-based. It would be impossible to get the authors of each paper to summarise their work for us.*

We do our utmost to ensure the accuracy of everything in the magazine. Every *article* is *refereed by at least one, usually two, experts. And this includes all the articles in Nature Strips, every one of which is sent to the cited authors for checking prior to publication. You will not find any other popular science magazine that does this.*

The inadvertent transposition of the mosquitoes and their respective diseases was an unfortunate error and one that was not picked up by the two scientists that refereed it.

—G.H.

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 Lesley Warner.**

Nature Strips

COMPILED BY
GEORGINA HICKEY

Animal Magnetism

We've known for some time that Honeybees (*Apis mellifera*) navigate using the direction of the sun and use 'dances' to communicate the direction of the best nectar sources to other workers. But it was less clear exactly how they aligned the parallel sheets of honeycomb in complete darkness inside hollow trees. Researchers suspected that they were using the Earth's magnetic field but couldn't find enough magnetite (a form of iron oxide) inside the bees. This substance is always found in other animals that navigate using the geomagnetic field, such as homing pigeons and marine turtles.

Recently though, Chin-Yuan Hsu and Chia-Wei Li of the National Tsing Hua University in Taiwan, solved the mystery. They found tiny crystals of magnetite inside iron granules, themselves contained within cells called trophocytes which surround the bee's abdominal segments. The trophocytes are linked to the bee's nervous system and the researchers speculate that the crystals actually expand and contract depending on the bee's position in the Earth's magnetic field.

—Geordie Torr
James Cook University

Sobering Herbs for Hamsters

Syrian Golden Hamsters (*Mesocricetus auratus*) are the party goers of the experimental animal world. Given a choice between water alone and water mixed with ethanol, Golden Hamsters go for the ethanol every time.

That's one reason why hamsters can help in studies of new drugs designed to combat alcohol abuse. Recently, hamsters have been used to trial a drug whose use was recorded in Chinese medical books up to 1,400 years ago.

The drug is an extract from the herb *Radix puerariae*. It is a traditional medicine still used by some Chinese herbalists to treat alcohol abuse.

Wing-Ming Keung and Bert Vallee of the Harvard Medical School studied extracts of the herb to see what may be responsible for its ability to control alcohol intake. They were able to iso-

ESTHER BEATON/TERRA AUSTRALIS PHOTO AGENCY

Honeybees use the Earth's magnetic field to align their sheets of honeycomb.

late and describe two chemicals, daidzin and daidzein, that they believed to be the active agents. But, just to be sure, some hamsters were brought in.

The hamsters were treated with either herb extract, daidzin, daidzein, or saline solution (the control), and were all given access to both pure water and an ethanol solution. Those treated with herb extract, daidzin or daidzein more than halved their ethanol intake. What's more, they suffered none of the toxic side effects associated with some other drugs used to treat alcoholism.

In further studies, daidzin and daidzein were shown to inhibit the activities of two enzymes, aldehyde dehydrogenase and alcohol dehydrogenase respectively. Whether or not this inhibitory effect suppresses alcohol intake is yet to be determined. It is the first time the effects of these two chemicals on drinking ethanol have been tested. Isolated from a herb that has been used in China for more than 1,000 years, daidzin and daidzein hold great promise for the future as safe and effective therapeutic agents for alcohol abuse.

—C.B.

AUSTRALIAN PICTURE LIBRARY/ZEFA

When given a choice between water and alcohol, Syrian Golden Hamsters will go for the alcohol every time.

Nursing Fathers Association?

Househusbands, paternity leave...these days men are sharing more of the responsibility for bringing up the kids. But they may just have been outdone by their mammal cousins, the bats.

In a game reserve in Malaysia recently, Charles Francis (now with the US Fish and Wildlife Service) and colleagues caught 13 male Dayak Fruit-bats (*Dyacopterus spadiceus*), and ten of them were lactating!

According to Thomas Kunz, of Boston University and co-author of the study, these bats aren't the first male mammals to produce milk. But they are the first known case of a lactating male mammal in the wild. Male humans and male domestic mammals, on the rare occasions when they have been found to lactate, have generally been suffering disease or hormonal imbalance. By contrast, these male Dayak Fruit-bats seemed normal and healthy.

The amount of milk the researchers were able to collect from the male bats was much less than the amount female bats produced. The tissue in the males' nipples was more like that of non-lactating females. The nipples were also smaller and less cornified, suggesting little or no suckling by young bats.

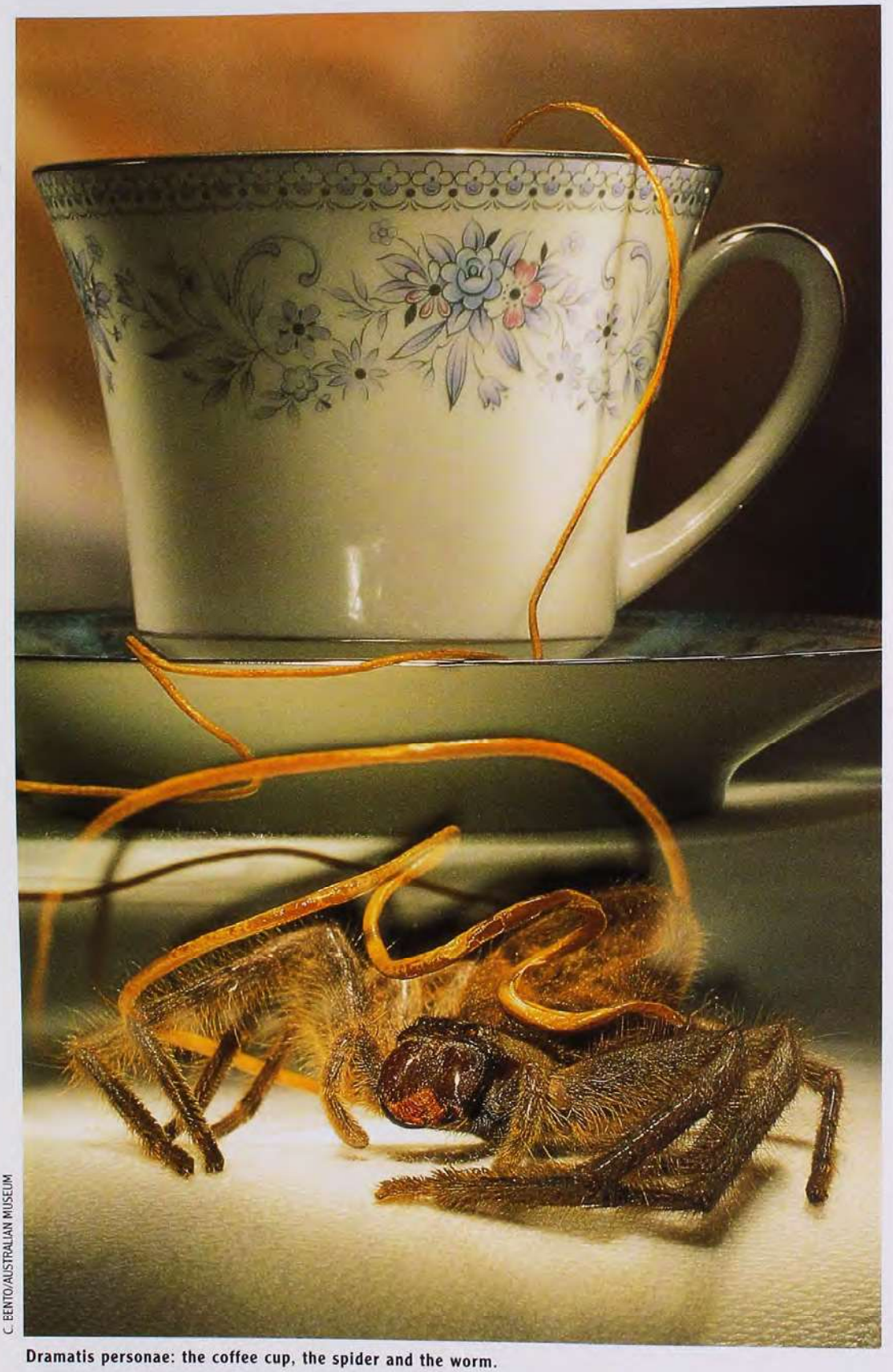
Why are the male bats lactating? At present no-one really knows. Physiological studies on circulating hormones should establish a chemical basis for the phenomenon, and studies of the social structure of Dayak Fruit-bat colonies will determine whether or not the males suckle their young. Francis and Kunz predict that male lactation is more likely to be found in monogamous species, where a particular male is more certain to be the father of his mate's offspring. From an evolutionary point of view, it makes making milk make sense.

—C.B.

The Worm, the Spider and the Coffee Cup

How would you explain the presence of a long writhing worm found in the cold remains of last night's cup of coffee? Something you narrowly missed drinking perhaps? But then you notice a large dead huntsman spider on the kitchen bench near the coffee cup...hmmm.

Poor old spiders! Their lives are full of tribulations, and some of the worst involve insidious attacks by a variety of lethal parasitic organisms. The worm in the coffee cup, probably a mermithid nematode, is one of these. Mermithid worms are internal parasites whose infective larvae enter spiders directly or via ingested food. Once inside the spider, the tiny worm obtains nourishment from its host's body fluids, digestive glands, gonads ('parasitic castration') and muscles. As a consequence, the spider becomes progressively more debilitated, but doesn't actually die. This is because the spider's vital organs usually remain intact, even though all of the abdomen, and occasionally part of the cephalothorax, may be filled with worm coils. Eventually, in a scene reminiscent of the movie "Alien", the gorged worm bursts out of the body of the debilitated spider, which finally dies during or soon after this macabre event.



C. EENTO/AUSTRALIAN MUSEUM

Dramatis personae: the coffee cup, the spider and the worm.

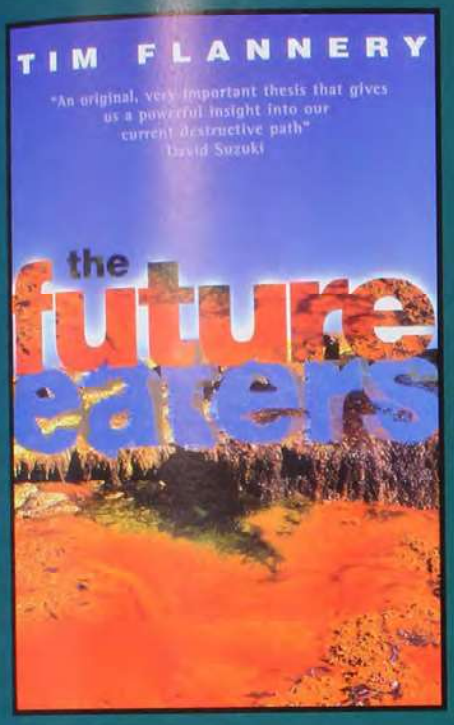
Before it dies, however, the spider often has to perform one more task for its deadly parasite. In some mermithids, the final free-living stage of the worm is aquatic, so that it is advantageous for the worm if its emergence can take place near a water body—a pond, creek or puddle. To increase this likelihood, such worms seem able to induce their hapless hosts to seek water, spiders sometimes actually walking into the water before the worm emerges. This behaviour may result from thirst-induced activity as the worm consumes the spider's body fluids. Whatever the reason, there is no doubt that the spider's water-seeking behaviour helps to ensure the parasite's survival and propagation.

So, what happened in the kitchen during the night? Perhaps the thirsty huntsman spider was carrying a water-dependent parasite and could find only one 'water body' in the kitchen—a cold cup of coffee left on a bench. The weakened spider climbed up the side of the cup and fell in. The tightly coiled worm then emerged from the spider's body into the liquid. The dying spider may then have managed to crawl out of the cup, only to succumb on the kitchen bench.

—Mike Gray
Australian Museum

ENVIRONMENT AND ECOLOGY TITLES FROM

REED BOOKS AUSTRALIA



THE FUTURE EATERS **DR TIM FLANNERY**

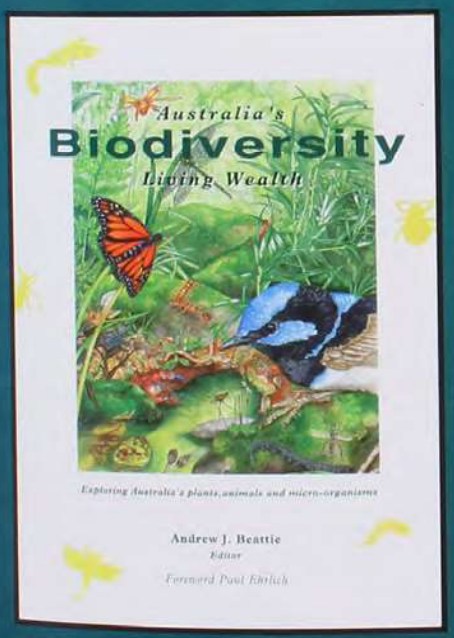
The future eaters (paperback edition)

Dr Tim Flannery, The Australian Museum

The first ecological history of Australasia, now available in paperback following the bestselling hardback edition. Challenging conventional wisdom on population growth, the impact of indigenous peoples, agriculture and wildlife conservation, Tim Flannery's narrative has the potential to change the way modern Australians perceive their continent and its unique life forms.

"Tim Flannery is a scientist of astonishing enterprise and achievement. He reminds me of Indiana Jones - but with credibility to match the flair." ROBYN WILLIAMS

ISBN 0730104877 RRP $24.95



BIODIVERSITY **PROF ANDREW BEATTIE**

Biodiversity - Australia's Living Wealth

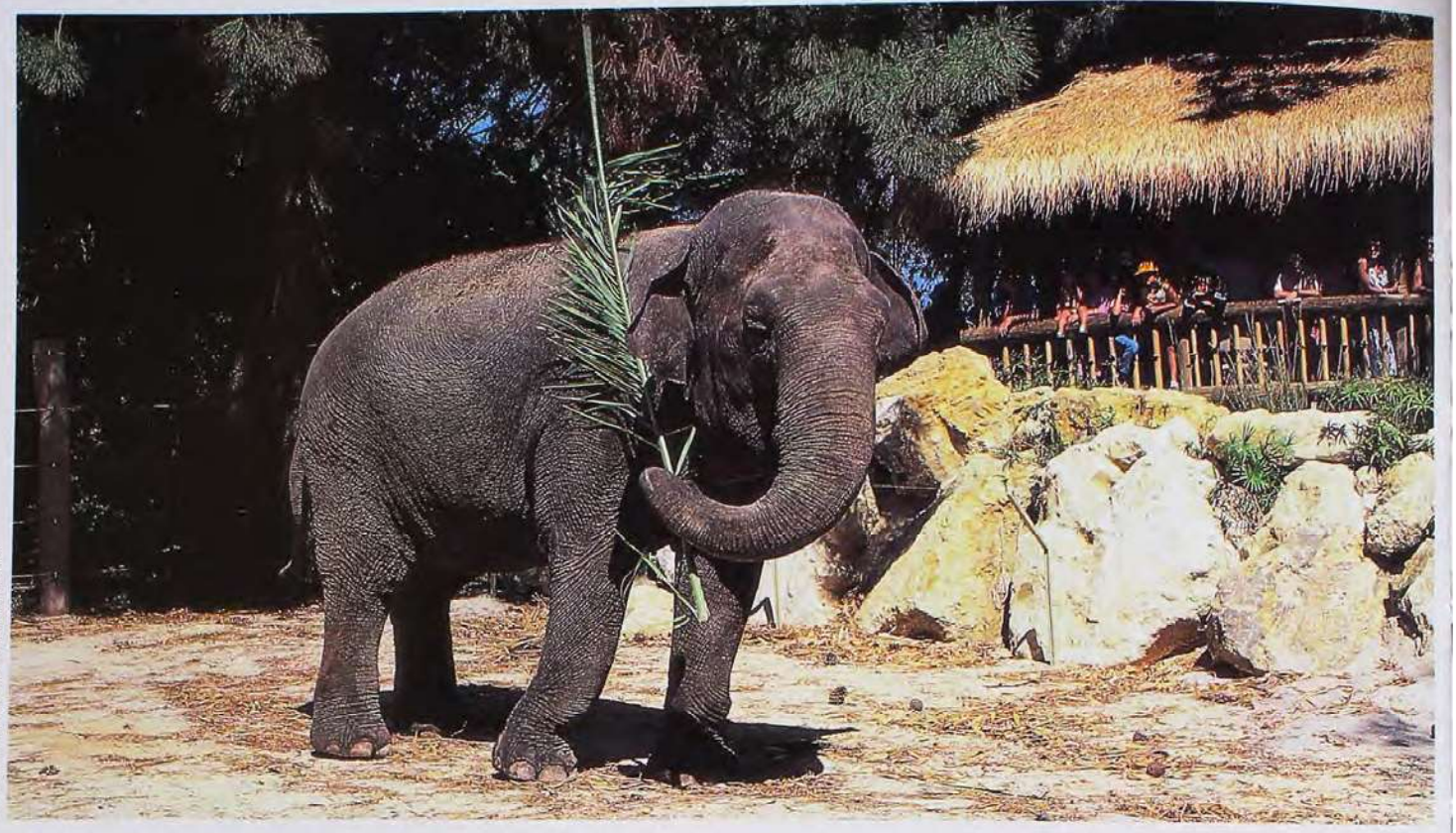
Prof. Andrew Beattie, Editor

"Today, it is a matter of urgency that everyone in Australia including those in government, business, biodiversity-based industries and education understands the meaning and importance of biodiversity," writes PAUL ERLICH in the foreword to this new book.

Biodiversity is THE environmental topic of the nineties, and this is the essential guide to exploring Australia's priceless, vast and unique biological diversity.

ISBN 0730104826 RRP $29.95

REED BOOKS



JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Itching for a Switch

Elephant skin is not as impervious as it seems. The huge creatures still suffer from the bites of flies and, when flies are thick, they require more than simple muscle twitches and flicking tails to deter the pesky insects.

It was noted over 100 years ago by Charles Darwin and others that Asian Elephants (*Elephus maximus*) in captivity break off branches with their trunks and use them as switches to presumably brush away flies. To confirm that this is what the branches were being used for (and not cooling aids or simply artefacts of captivity), animal behaviouralists Benjamin and Lynette Hart, from the University of California at Davis, recently studied the phenomenon in female working elephants in Nepal.

They found that the elephants increased the switching frequency of branches when more flies were around, and that the activity was indeed effective in deterring flies. In short, they confirmed that it complied with all the popular definitions of tool use. But the Harts observed something more than simple tool use which, after all, has been recorded in animals with as limited intelligence as wasps and birds. When vegetation was made available for feeding, an elephant would often 'save' a particular branch suitable for switching, putting it aside and eating the rest. And, on many occasions, the elephants were seen modifying the branches, making them more suitable for use as switches by removing small side branches or shortening stems without eating them.

This adds to the growing bank of evidence that the only thing thick about elephants is their hide.

—K.McG.

Keeping Your Meal Cool

If you were a wasp in Israel's Negev Desert, finding a meal for your parasitic offspring would be hard work; storing it so that it remained nutritious until they hatched, even harder.

COURTESY JOH R. HENSCHEL

Parasitic wasp larva and its spider host catching a breeze in the spider's nest entrance.

Asian Elephants fashion fly switches out of vegetation.

But while investigating the effects of temperature on the behaviour of a small nest-building spider (*Stegodyphus lineatus*), researchers David Ward and Joh Henschel from the Mitrani Center of Desert Ecology of the Negev noticed something unusual: some of the spiders had been attacked inside their nests by female parasitoid wasps (*Pseudopompilus humboldti*), and then their paralysed bodies were moved to the exposed entrance of the nest.

As most parasitoids go to great lengths to hide their victims (and their parasitic offspring), it seemed unlikely that the wasp would risk her larvae being eaten without a good reason. *Stegodyphus lineatus* builds a downwards-facing nest of dense silk reinforced and camouflaged with debris. However, previous observations of the spiders spending the hottest part of the day in the breeze-cooled nest entrance led the researchers to hypothesise that nest temperatures must be too extreme for the wasp to risk the zombie-like spider and larvae overheating.

When vegetation was made available for feeding, an elephant would often 'save' a particular branch suitable for switching, putting it aside and eating the rest.

To test their theory, paralysed spiders were deliberately moved by the researchers to positions either deep inside the nest or at its mouth, and a temperature probe used to monitor air temperature at each site. They found that both host and larvae left inside the nest were dead within a week, while those that were overlooked by predators at the nest edge survived. Ward and Henschel concluded that this host-storing behaviour appears to be an adaptive trade-off between predation risk and thermoregulatory requirements. They also believe it to be the only case of one species actively manipulating the body temperature of another.

—R.S.

The Dehorn of Africa

It makes for a tragic picture, a rhinoceros without a horn. Desperate times, however, have spawned desperate measures. During the

past 25 years, the world's Black Rhino (*Diceros bicornis*) population has fallen by 97 per cent, from 65,000 to 2,500. Blame for the decline is levelled squarely at poachers who slaughter the animals for their horns, prized in traditional Asian medicines and as ceremonial dagger handles in Yemen (Middle East). As the fight intensifies to save the species from extinction, African nations have developed radical protective strategies to deter poachers. One of the most controversial has been dehorning.

Namibia is just one country where wildlife teams are sanctioned to capture, tranquillise and saw off the horns of rhinos in the forlorn hope of making the animals worthless to poachers. Regrettably, the strategy seems extremely flawed. A study by husband and wife ecologists Joel Berger and Carol Cunningham, from the University of Nevada, has found the horns grow back at a combined rate of about nine centimetres a year. Only annual trimming would keep regrowth in check but, with each capture and dehorning costing up to $US1,400, the ongoing expense would be prohibitive.

Of greater concern, however, are the results of field studies by Berger and Cunningham to assess the dehorned rhino's vulnerability to predators. They found that calves of dehorned mothers died within a year of birth in areas with predators such as Spotted Hyenas. In contrast, all mothers with horns in the study successfully reared their calves.

Unfortunately, conflict with the Namibian Government over the results of their research has led to the untimely termination of Berger and Cunningham's work in Namibia. Dehorning continues and so too does the debate about its virtues.

—K.McG.

ANTHONY BANNISTER/ABPL

Dehorning Black Rhinos to prevent poaching remains a controversial issue.

NEW VISION

LEICA CAMERA GMBH, OSKAR-BARNACK-STRASSE 11, D-35606 SOLMS, TEL. +49 (06442) 208-403, FAX -410

MADE BY LEICA

LEICA BINOCULARS sharpen your view of the world, bringing alive fascinating details in amazing clarity and colour. Expand your vision while enjoying their compact size, light weight and high magnification. At your finger tips is an unlimited spectrum of use with Leica's top quality optics, award-winning exemplary design and ergonomics. Experience LEICA BINOCULARS and see what you've been missing – at your qualified Leica speciality dealer.

Leica

The freedom to see.

Fluffy-tailed Foot-tappers

When it comes to evading predators, many animals will try to look as inconspicuous as possible. But not phascogales. These small tree-dwelling marsupials, when faced with a hungry predator, tap their front feet so loudly it can be heard 20 metres away. They also fluff up the long hairs on their tail. This hardly seems the best way to avoid predation, but it works. After many nights watching these nocturnal animals in the wild, Todd Soderquist from Monash University believes he knows why.

Brush-tailed Phascogales (*Phascogale tapoatafa*) have dull grey, relatively camouflaged bodies with contrasting black and bushy tails. When a phascogale is threatened, it erects its tail hairs, distracting the predator's attention away from its body. An owl, for example, would be more likely to swoop on the conspicuous tail, allowing the phascogale (with a few less tail hairs) to escape.

A similar strategy has been shown to work for other species. In winter certain weasel species that forage in snow are all white except for a black tip on their tails. Experiments revealed that, when the tail tip was artificially coloured white, or a black dot was placed on the weasel's body, the weasel was taken more often by predators.

But what about the foot tapping? Phascogales appear to do this when a predator has already detected them some other way, such as by sound or smell. Soderquist believes that foot tapping tells the predator that it has been detected too: "I know you're there and I won't let you catch me, so you may as well try somewhere else!".

This is the first time that foot tapping and tail fluffing have been proposed as anti-predator mechanisms in phascogales. But they *are* last-ditch measures. By day phascogales try to avoid predators by sleeping in tree hollows with small entrances, and by night they can usually scramble up a tree out of danger.

—C.B.

Balding Birdos from Tasmania?

The collection of hair from unsuspecting mammalian bystanders is one of the more endearing behav-

When startled, Brush-tailed Phascogales erect the long hairs on their tail.

LEO MEIER/AUSTRALIAN PICTURE LIBRARY

COURTESY PENNY SLATER

In their pursuit of hair, fur or feathers, female Yellow-throated Honeyeaters are not shy.

iours of the Tasmanian endemic Yellow-throated Honeyeater (*Lichenostomus flavicollis*). While I was doing a field study of the species, nest-building females would visit my head several times a day, tugging at a hair at a time until one came free. Only once did a male alight on my head. The female is solely responsible for building the nest and, during the spring, gathers rabbit, possum, wallaby and other assorted varieties of fur and feathers to create a cosy lining for the young.

Locals told me how Yellow-throated Honeyeaters had landed on the back of dogs on their daily walks. One lady had left out hair brushed from her dog on a nearby tree, which the birds enthusiastically collected. Other reports of Yellow-throated Honeyeaters plucking hair from cattle, pigs, sheep, pets and humans are common. The birds share this behaviour with their close mainland relative, the White-eared Honeyeater (*L. leucotis*). Next time you visit Tasmania in the spring, perhaps you can arrange a *tête-à-tête* with the local wildlife.

—**Penny Slater**

Leaf the Fruit Alone

The defensive ploy known as 'self-mimicry' has been successfully adopted many times throughout the animal kingdom. Fish with eye-spots in their tails, for example, and butterflies with the same in their wings, use the strategy to confuse predators about the location of vital organs. Recently Philip Groom, Byron Lamont and Helen Duff from Western Australia's Curtin University of Technology recorded one of the few examples of the strategy in a plant.

Hakea trifurcata differs from other members of its large Australian genus by having two distinct adult leaf types, one broad and curved,

DENNIS SARSON/LOCHMAN TRANSPARENCIES

White-tailed Black Cockatoos are the major threats to the fruit of *Hakea trifurcata*.

the other needle-like. The broad leaves look very similar to the plant's mature fruits, which are unusual in that they remain green at maturity. When located next to fruits, the broad leaves are dense and very close to them in size; further away they are sparser and considerably larger.

Looking for explanations, Groom and his colleagues conducted feeding experiments with the White-tailed Black Cockatoo (*Calyptorhynchus funereus latirostris*), a seed eater known as the major threat to *H. trifurcata*'s fruit. They offered caged birds fruiting branches complete with broad leaves, and fruiting branches that had all the broad leaves removed. The amount of fruit taken by the birds from the branches with broad leaves removed was much higher than from normal branches.

Unlike many other *Hakea* species, *H. trifurcata* is unable to resprout after burning and, in its fire-prone habitat, population recovery is entirely dependent on seeds. Groom and his colleagues believe the broad leaves and fruit may have co-evolved to look like each other to confuse and discourage White-tailed Cockatoos from taking *H. trifurcata* seeds.

—K.McG.

Ostriches: Cheap Eats?

Myth has it that Ostriches will eat anything. Certainly their success in extreme conditions—the savannas and arid grasslands of Africa—would suggest so. This has led to a belief that Ostriches (*Struthio camelus*) are a very economical and adaptable animal to farm, and will thrive where sheep may not. Ostrich ranches are now appearing in poor-quality rangelands all over the world, including Australia.

To find out what it is that Ostriches really eat, Sue Milton and colleagues from the University of Cape Town observed the eating habits of live Ostriches and inspected the stomach contents of dead ones. Their results carry a warning for Ostrich farmers: far from eating anything and everything, Ostriches are very selective about what goes into their stomachs, preferring the tender leaves of annual herbs and grasses, and rarely eating woody material or dead grass. Only very young chicks eat insects because they lack the gut flora and gizzard stones required to break down fibrous plant material.

Farmers are making an expensive mistake by farming Ostriches in paddocks already overgrazed by sheep. When confined, these naturally nomadic birds will destroy the remaining vegetation on which they depend, leaving the paddock only suitable for a dust bath. The best ecological and economic answer is to keep the birds in well-watered lucerne feedlots—just like the sheep that they were intended to replace!

—R.S.

B. BERNARD/ANGELI/SYDNEY FREELANCE

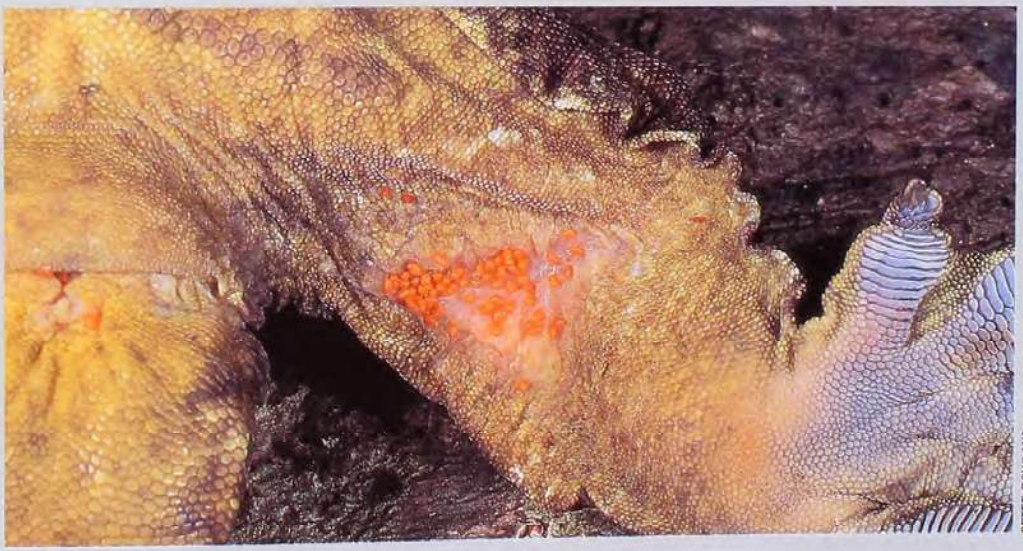
Contrary to the popular myth, Ostriches are fussy eaters.

When Boys Will Be Girls

A male of the parasitic wasp species *Cotesia rubecula* normally woos his mate with a predictable routine. But, as Scott Field and Michael Keller from the University of Adelaide have shown, when there's competition, tactics can take a spurious turn.

Once lured to a leaf by the female's sex pheromone, an unchallenged male fans his wings to produce a low-frequency buzz, then 'pulses' his abdomen upwards, sending a vibrational signal through the leaf. The female responds by tilting her head forwards, folding her wings and dropping her antennae flat on the leaf. But when there are two males competing for the same mate, one will short-circuit the foreplay routine and skip straight to sex.

And that's not all. After cop-



PETER ROWLAND

MITE POCKETS

Nature Australia spent months trying to locate a photograph of the mite pockets of a giant New Caledonian gecko to illustrate the story "Lizards with Mites in their Pockets" by Simon Blomberg in the Autumn 1995 issue. Although we were unable to locate one in time for that story, a photo has finally turned up that is just too good not to publish. Amateur natural history photographer and writer Peter Rowland, while working as a field assistant for Ross Sadlier (Herpetology, Australian Museum), managed to take this close-up shot of *Rhacodactylus leachianus*. It clearly shows the folds of skin under the back left leg that are home to the orange trombiculid mites. The evolution and function of these mite pockets is still very much debated.

—G.H.

C.B. & D.W. FRITH/FRITHFOTO

Azure Kingfisher.

QUICK QUIZ

1. What is the common name for a meteor?
2. Name the ship that spilt 38,000 tonnes of oil off Alaska in 1989.
3. In which Australian State would you find Cape Cuvier?
4. What is the longest time a funnel-web spider can survive fully immersed in water? Two, 12 or 30 hours?
5. How many people, to the nearest billion, are there in the world?
6. Which animal is depicted on the $1 coin?
7. In what year did Mt Vesuvius erupt and bury the city of Pompeii?
8. What is deoxyribonucleic acid more commonly known as?
9. The males of which species have testes that weigh up to a tonne?
10. What is an invertebrate?

(Answers in Q&A)

ulation, if the second male is still around, he too may attempt to mate with the female, putting his sperm in direct competition with that of the first male. The researchers found that the first male, in order to protect his sperm investment, mimics the posture of a receptive female. With the female's sex scent still lingering on his body, the second male is tricked into believing he is a she and may even attempt to copulate with him. Meanwhile the real female loses interest and flies away.

—K.McG.

The Platypus and The Kingfisher

On a trip to Eungella National Park, Queensland, Guy Troughton and Stephanie Wray (from Bristol Ecological Consultants) observed what they thought to be a feeding association between the Platypus (*Ornithorhynchus anatinus*) and two Azure Kingfishers (*Ceyx azurea*). While the Platypus dived, the birds watched from a convenient point on the river bank. After the Platypus surfaced, one of the birds would dive into the disturbed area and invariably come up with a fish. The Platypus did not seem to be perturbed by the birds. In fact, it barely noticed them. This happened seven times over a period of less than an hour and appears to represent a commensal relationship (where one of the species benefits and the other is unaffected).

As far as the biologists know, there have been no other reports of such feeding associations between birds and mammals. The closest to this would be the relationship between large grazing mammals such as cattle and Cattle Egrets (*Ardeola ibis*), which forage in the ground disturbed by the cattle's feeding activity. In this case the birds gain an advantage (compared with foraging in undisturbed ground), while the cattle remain unaffected.

—G.H.

Further Reading

Berger, J. & Cunningham, C., 1994. Active intervention and conservation: Africa's pachyderm problem. *Science* 263: 1241–1242.

Berger, J. & Cunningham, C., 1994: Black Rhino conservation. *Science* 264: 757.

Cunningham, C. & Berger, J., 1994. The de-horning dilemma. *Wildl. Conserv.* Jan./Feb. 1994: 15.

Field, S.A. & Keller, M.A. Alternative mating tactics and female mimicry as post-copulatory mate-guarding behaviour in the parasitic wasp *Cotesia rubecula*. *Anim. Behav.* 46: 1183–1189.

Francis, C.M., Anthony, E.L.P., Brunton, J.A. & Kunz, T.H., 1994. Lactation in male fruit bats. *Nature* 367: 691–692.

Groom, P.K., Lamont, B.B. & Duff, H.C., 1994. Self-crypsis in *Hakea trifurcata* as an avian granivore deterrent. *Functional Ecol.* 8: 110–117.

Hart, B.L. & Hart, L.A., 1994. Fly switching by Asian elephants: tool use to control parasites. *Anim. Behav.* 48: 35–45.

Hsu, C.-Y. & Li, C.-W., 1994. Magnetoreception in honeybees. *Science* 265: 95–97.

Keung, W.-M., 1993. Biochemical studies of a new class of alcohol dehydrogenase inhibitors from *Radix puerariae*. *Alcohol Clin. Exp. Res.* 17: 1254–1260.

Keung, W.-M. & Vallee, B.L., 1993. Daidzin: a potent and selective inhibitor of human mitochondrial aldehyde dehydrogenase. *Proc. Natl Acad. Sci. USA* 90: 1247–1251.

Keung, W.-M. & Vallee, B.L., 1993. Daidzin and daidzein suppress free-choice ethanol intake by Syrian Golden hamsters. *Proc. Natl Acad. Sci. USA* 90: 10008–10012.

Milton, S.J., Dean, W.R.J. & Siegfried, W.R., 1993. Ostriches eat anything: fact or fiction? *African Wildl.* 47: 205–208.

Milton, S.J., Dean, W.R.J. & Siegfried, W.R., 1994. Food selection by ostrich in southern Africa. *J. Wildl. Manage.* 58: 234–248.

Soderquist, T., 1994. Anti-predator behaviour of the Brush-tailed Phascogale (*Phascogale tapoatafa*). *Vic. Natur.* 111: 22–24.

Troughton, G.J. & Wray, S., 1994. An apparent feeding association between the Azure Kingfisher *Ceyx azurea* and the Platypus *Ornithorhynchus anatinus*. *Sunbird* 24: 45.

Ward, D. & Henschel, J.R., 1992. Experimental evidence that a desert parasitoid keeps its host cool. *Ethology* 92: 135–142.

Even if you have a fly-screened house, mud-daubers will still find 101 nooks around a verandah to satisfy their insatiable urge for plugging.

MUD-SLINGING SPIDER STINGERS

BY STEVE VAN DYCK

EVERY YEAR, COME SPRING WE get plagued by eccentric, owner-builder types dropping in. The men are only interested in chasing slim-waisted women and drinking, and the women are always in a tizz about spiders in their adobe houses and their swarms of growing children. The reason for all the visitors is crystal clear: our place hasn't got fly screens.

So, with never a wipe of their muddy feet, in they buzz through the open windows...squatters fit for swatters! The warm-weather guests are mud-dauber wasps (*Sceliphron* spp.) and each spring they come home to continue packing up where they left off last year.

They like to pack curtain folds and book spines, the backsides of cupboards and picture frames, and the insides of guitars, golf bags and fur-lined boots.

"This morning the soda syphon (which had not been used for a couple of days) refused duty, owing to a plug of terra-cotta-coloured clay. Upon the spout being probed the gush of gas expelled a quantity of clay and 35 small spiders...The spout had been converted into a nursery and larder by a carnivorous wasp, for in addition to the moribund spiders stored for the sustenance of future grubs were several unhatched eggs." (E.J. Banfield in *My tropic isle*, 1911.)

Even if you have a fly-screened house, mud-daubers will still find 101 nooks around a verandah to satisfy their insatiable urge for plugging. And most hair-tearingly, valve-blowingly frustrating is their proclivity for the sooty bowels of machinery exhaust pipes. At our place, many a long-awaited weekend has got off to a howling start when the mower or chainsaw muffler is found wadded up to the piston with a quarry of clay and a million paralytic spiders.

To the female mud-dauber goes the credit for this masterpiece of packaging, for while the males are preoccupied with sipping nectar from flowers, each frantic female is fussing under someone's garden tap, patting together balls of mud and flying off to a poorly sealed wardrobe or a work shed. There, among the long-johns or electric tools she builds her set of clay flasks, each an elegant, three-centimetre, thin-walled humidicrib into which a single egg will be laid. The mud-dauber stocks each pot with a pantry of provisions, enough to see her babies through the long dark nights of development.

Her choice of tucker might consist of small, orb-weaving garden spiders (family Araneidae) and her method of dispatching them is as calculated as it is ultimately lethal. While she grabs the spider in her jaws, being careful to avoid its fangs, she swings her tail under it and, with exact precision, stabs the spi-

The female mud-dauber wasp stocks each of her mud nursery flasks with a dozen or more paralysed spiders. A unique antiseptic in the wasp's venom keeps the paralytic spiders fresh until the developing young are ready to feed.

PHOTOS: JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

One precise stab from the sting at the end of the wasp's abdomen and the spider is doomed to the larder.

der right in the joint between the head and the abdomen—the spot where all the major nerves converge. It is the mud-dauber's characteristic 'wasp-waist' that enables it to perform such a sophisticated lunge. Few other wasps stretch out the classic hourglass figure to the extent seen in *Sceliphron*. Like a shot from an arrow dipped in curare, this leaves the spider free to breathe, but totally unable to respond to any form of stimulation (such as having its juices slowly sucked out!).

The mud-dauber deposits her egg on the first paralysed spider pushed into the crypt. Once a dozen or more spiders have been packed in, she caps the flask with mud, and moves on to the next construction. When the frantic female has constructed and packed up to 20 cigar-shaped tombs she may strengthen and consolidate the lot into a fist-sized glob, with decorations of blobs or ridges of clay (as in *Sceliphron laetum*), or alternatively the flasks may be left as simple unadorned cells (as in *S. formosum*). As soon as the eggs hatch, a week to ten days later, the grubs begin feeding on the paralytic spiders. A unique antiseptic substance in the wasp venom prevents the spiders decomposing while they are being slowly consumed, so all the lunch packages stay fresh right to the last mouthful.

The construction of mud nurseries is rooted in evolutionary tradition, not in understanding. From pottery to posterity the mud-dauber appreciates no connection between each step in the *modus operandi*. If you rob a newly provisioned larder of all its spiders, the wasp will still seal up the door to the empty vessel. Likewise, breaching a crypt does not result in repairs. The execution of each step in the sequence creates an appetite for the next. If all the cells are removed prior to the final application of stucco, the wasp senses nothing amiss and plasters the ravaged site with all the glug and fuss of a regular final touch-up.

It might take only three weeks for the wasp larva to 'suck the sap' from all the spiders in its crypt, but the metamorphosis from maggot to mason might be strung out for another ten months or more, by which time the air outside will probably be warm and moist and full of dangling fat spiders set to send the newly emerged wasp into a fizz of mud-lust.

With spring now upon us it won't be long before the apoplectic, stuck-in-a-bottle 'bizzzt bizzzzt bizzzzzzit' sound is with us again. And while I know the mud-dauber is a friendly wasp that never goes out of its way to sting humans, I can't say the prospect of its arrival fills me with great expectation. However I do know someone in my ceiling who will be overjoyed.

A few months ago I was up under the corrugated iron one night watching a young Black Rat (*Rattus rattus*) doing the rounds of the rafters. With the consummate ease of an oystercatcher, it located the rock-hard wasp nests cemented to the battens, then cracked the 'shells' open to extract the juicy white wasp larvae from within. So while we might despair the imminent appearance of mud-pods in October, at least that roof rat knows he'll be gathering his nuts in May. ■

Further Reading

McKeown, K., 1944. *Australian insects*. Royal Zoological Society of New South Wales: Sydney.

Naumann, I.D., 1991. Hymenoptera (wasps, bees, ants, sawflies). Pp. 916–1000 in *The insects of Australia*. Division of Entomology, CSIRO. Melbourne University Press: Melbourne.

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

MUD-DAUBER WASPS

Sceliphron spp.

Classification
Order Hymenoptera (wasps, bees, ants, sawflies), family Sphecidae (mainly solitary, predatory wasps), subfamily Sphecinae (mud-dauber and digger wasps). Three species: *S. laetum, S. formosum* and *S. caementarium*, an introduced species from the New World, now established in south-east Qld.

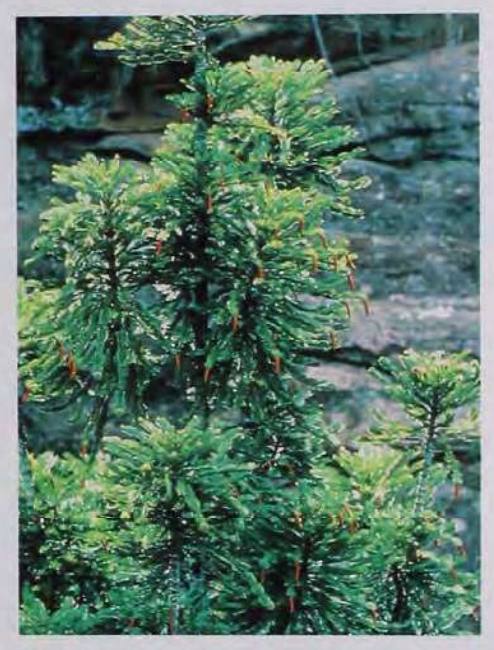
Identification
18–39-mm-long, slender, black-and-yellow wasps with long narrow waist.

Life History
Female builds elongate, oval cells using moist clay. One wasp egg laid per cell. Cells stocked with spiders (usually *Araneus* spp.). before flask sealed. Up to 18 months later, young emerging wasp cuts a circular hole in the wall of the nest.

Scientists believe the Wollemi Pine survived from the age of dinosaurs by clinging on relentlessly to a pocket of uniformly moist surroundings.

WOLLEMI PINE

BY KAREN McGHEE



KEN HILL/ROYAL BOTANIC GARDENS

WOLLEMI NATIONAL Park is a wild and rugged place. Erosion and weathering of its predominantly sandstone landforms have produced a relentless network of reclusive valleys, dramatic cliff lines and remote canyons. Sydney lies less than 200 kilometres to the south-east, yet large tracts of Wollemi's 488,000 hectares remain pristine and unexplored.

It was these features that brought Dave Noble—a New South Wales National Parks and Wildlife Service (NPWS) ranger by profession and keen bushwalker by nature—to the edge of a sheer 600-metre drop in Wollemi. Impelled by the thought that he was entering unexplored territory, Noble abseiled down with his two trekking companions.

At the bottom, in a warm, wet, narrow sandstone cradle, was a rainforest that evoked a sense of the primeval. The dense but delicate understorey of ferns was shielded by Coachwoods (*Ceratopetalum apetalum*) and out of this main canopy emerged the crown of a tree of remarkable appearance. Unlike anything Noble had seen before, its leaves were waxy and fern-like and its trunk covered in chocolate-coloured bubbles of bark. It was just one of a stand of 23 adults and 16 juveniles, the largest (a fallen tree) 40 metres tall with a girth of three metres. Before climbing back out of the gorge, Noble took a small sample of leaves.

Back in civilisation, he showed it to Wyn Jones, a Senior Naturalist with the NPWS who didn't recognise it either but, suspecting Noble's find might be significant, forwarded it to Sydney's Royal Botanic Gardens. The sample, however, was only of juvenile leaves, which look markedly different from the adult foliage but appeared to have much in common with a primitive Chinese conifer. The Gardens' staff enquired whether the tree could have been introduced, but the remote location made this unlikely.

Noble led Jones and a small team back into Wollemi. As soon as Jones laid eyes upon the tree he knew it was something very special and collected a complete set of adult leaves, cones and bark for identification. Over the next few months Jones, Noble and a volunteer, Jan Allen, worked in secret as they searched through the scientific literature hoping to confirm what they suspected about the tree that had been dubbed the Wollemi Pine. When they were sure, they took their find to Ken Hill, a Senior Botanist at the Gardens. Hill was astounded. He is a leading expert on Australia's native conifers and agreed almost immediately that here was a major new find of international botanical significance.

The Wollemi Pine (*Wollemia nobilis*) is a living relic, thought to belong to a genus previously known only from the fossil records of Tasmania and New Zealand, more than 50 million years ago. It is a member of the ancient Gondwanan family Araucariaceae.

During the Mesozoic (250–65 million years ago), when the world's climate was uniformly warm and wet, the Araucariaceae was a dominating feature of the vegetation. But by the end of the Mesozoic, and with the break-up of the supercontinent Gondwana, the family became restricted to the Southern Hemisphere. As the climate became colder, drier and more seasonal, the distribution of the ancient Gondwanan plant families receded further and were replaced by much of the vegetation seen today. Until the Wollemi discovery, the family Araucariaceae was represented by only two living genera containing about 33 species, including the Kauri, Hoop, Bunya and Norfolk Island Pines. Scientists believe the Wollemi Pine survived from the age of the dinosaurs by clinging on relentlessly to a pocket of uniformly moist surroundings.

Since its announcement as "one of the botanical finds of the century", the Wollemi Pine has attracted huge overseas and local interest from the popular press, scientific fraternity and seed collectors. The priority for authorities has been to try to ensure the plant's survival. Only about a dozen people currently know of its whereabouts. Mature seed is being collected for research on its propagation and genetics, and for distribution to botanic gardens around the globe. At the moment, it is regarded as one of the world's rarest trees and the NPWS has begun a detailed search of Wollemi in the hope of finding more specimens.

Once genetic material has been distributed throughout the world, scientists say they will be reasonably confident the Wollemi Pine will survive in cultivation. They are, however, less optimistic about its chances in the wild. Rogue seed collectors, many of whom will destroy plants to get their booty, are the main concern. If just one of these people manages to locate the Wollemi gorge sheltering the only currently known stand of the pine, they could easily manage, with the whirr of a chainsaw, to erase what millions of years of natural disasters and climatic change have failed to do. ■

Further Reading

Jones, W.G., Hill, K.D. & Allen, J.M., 1995. *Wollemia nobilis*, a new Australian genus and species in the Araucariaceae. *Telopea* 6(2).

Karen McGhee is a freelance science writer living in Newcastle.

Although very few mushrooms can kill, they are a risky group to experiment with.

MUSHROOMS: SAMPLE WITH CARE

BY TIM LOW

IMAGINE A SCENE IN CHINA: A FAMILY of peasants is strolling through a forest of eucalypts gathering Australian mushrooms for dinner. That is the dream of Neale Bougher, a CSIRO Forestry scientist based in Perth.

Bougher is working on a project to introduce Australian fungi into Chinese eucalypt plantations to help the trees grow better. Eucalypts, like most trees, form symbiotic relationships with soil fungi. The fine, root-like hyphae of the fungi are adept at extracting soil nutrients, which they pass onto the eucalypt roots in exchange for other nutrients.

Most eucalypt plantations overseas lack a wide range of fungi, hence Bougher's project. His idea is that the Chinese could also use the fungi as foods. Mushrooms are delicacies and staples in China, and hundreds of different kinds are harvested. With loss of native forests, however, the wild supplies have declined.

On a tour of markets in Yunnan, Bougher saw peasants selling an Australian fungus—an earthball (*Scleroderma* species) evidently gathered from a nearby eucalypt plantation. He believes many more edible species could be brought in as part of plantation improvement.

This would not be the first time Australian fungi have gone to China. That honour goes to jew's ears (*Auricularia* species)—rubbery, ear-like fungi that were once exported from the forests of northern Queensland to China.

Fungi are one of the most poorly known groups of organisms in Australia. Very little is known about their edibility, and many species have not been named. Most biologists neglect them because they are furtive and difficult to preserve. Plants are studied in herbaria and animals in museums, but no institution has responsibility for classifying fungi. That task is left to a few scientists scattered through the CSIRO and other organisations.

The Aborigines of temperate Australia ate many kinds of mushrooms, but those who observed them could not give identifications. For example, George Grey in 1841 could only say: "The different kinds of fungus are very good. In certain seasons of the year they are abundant, and the natives eat them greedily."

A superintendent of the last Tasmanian Aborigines, Dr Milligan, was the most informative early observer. He saw Tasmanians eating Native Bread (*Polyporus mylittae*), Beech Fungus (*Cyttaria gunnii*; "a great favourite"), punk (probably *Piptoporus* species), and "Several mushrooms". Other fungi recorded in the past are native truffles (such as *Elderia arenivaga*) in central Australia, and Stonemaker Fungus (*Polyporus tumulosus*).

Native Bread created a stir in Tasmania because it is so odd. Pioneers ploughing new fields sometimes unearthed these huge "stones", weighing up to 20 kilograms, packed with what looked and tasted like compacted boiled rice. The "stones" are storage organs of the fungus that came to be known as Native Bread or Blackfellow's Bread.

Early writers such as Milligan give names for only about half a dozen edible fungi eaten by Aborigines across the whole continent. It's a pitiful total, showing that a vast body of knowledge was lost with the decimation of Aboriginal culture.

Fortunately, we can learn from else-

PHOTOS: TIM LOW

The most readily available edible mushroom in suburban Australian gardens is the Glistening Ink Cap. It has silky white stalks and tan-coloured caps that are often speckled.

Hairy Jew's Ear (*Auricularia polytricha*) grows on rotting wood in gardens and damp forests, both in Australia and in China, where it is harvested for food. Although lacking much flavour, it has a pleasant rubbery texture and readily absorbs the aromas of other foods.

Yellow Jelly Fungus (*Tremella* species) sprouts on rainforest trees after rain and has a pleasant jelly taste.

where. Most fungi found in gardens and paddocks are cosmopolitan species that have been eaten for hundreds of years in Europe, America or Asia. They include the Field Mushroom (*Agaricus campestris*), ink caps (*Coprinus* species), Giant Puffball (*Langermannia gigantea*) and Parasol Mushroom (*Macrolepiota procera*). The spores of some of these fungi may have blown to Australia in upper air currents, but others were probably brought in unintentionally in the soil of potted plants or in animal dung and feed. These should be considered exotic species in Australia.

The Field Mushroom is the best known of these, and one of the few fungi that was eaten by Australian pioneers. A small white mushroom that sprouts on lawns after rain, its gills are pink at first, turning dark chocolate brown. Nina Rawson's *Enquiry book* of 1894 gave recipes for broiling, stewing, baking and preserving the caps.

Other common suburban species are the Glistening Ink Cap (*Coprinus micaceus*), found in gardens and parks above rotting tree roots, and puffballs (*Lycoperdon* species), the small white 'blobs of putty' found on lawns after rain. Puffballs are eaten while still firm and white inside.

Despite what we know about edible mushrooms such as these, an enormous amount remains to be learned about the topic in Australia. Anyone with a strong sense of adventure (and a strong stomach) could make a pioneering contribution to this field. The problem, of course, is the spectre of poisoning. Although very few mushrooms can kill, they are a risky group to experiment with. Some of the poisonous species, including the deadly Death Cap (*Amanita phalloides*) and hallucinogenic Gold Top (*Psilocybe cubensis*), don't have any unpleasant warning taste. Others become poisonous if taken with alcohol. Although most mushrooms are probably safe to sample, anyone dabbling with this group is likely to come away with some bad experiences.

Perhaps the pioneering work on Australian fungi will be done overseas. It is curious that the Australian earthball sold in Yunnan is not known to be edible in Australia (although it was probably eaten by Aborigines long ago). Its value as food was presumably discovered by local experimentation. As Bougher's team introduces other Australian fungi to Chinese eucalypt plantations, we may soon learn more about our edible fungi from a most unlikely source—the People's Republic of China. ■

Further Reading

Bougher, N., 1993. Edible fungi in China. *Aust. Cent. Internatl Agric. Res. Forestry Newsl.* 16: 1.

Malajcuk, N., Grove, T.S., Bougher, N.L., Dell, B. & Mingqin, G., 1994. Ectomycorrhizas and nutrients: their importance to eucalypts in China. *Aust. Cent. Internatl Agric. Res. Proc.* No. 48.

Roth, H.L., 1890. *The Aborigines of Tasmania*. F. King & Sons: Halifax.

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

In front of us, the fleshy, keel-shaped comb, back-lit by the sun, glowed tomato red.

SIGNALS OF THE FLESH

BY NATALIE J. DEMONG & STEPHEN T. EMLEN

SITTING IN A SMALL MOTOR BOAT, in a bay choked with water lilies at Yellow Waters Billabong in Kakadu National Park, we saw our first-ever Comb-crested Jacana (*Irediparra gallinacea*), guarding and guiding four tiny chicks to food. From our knowledge of other species of these long-legged, spidery-toed 'lily-trotters', we knew that the adult in front of us was a male. In jacanas (family Jacanidae), females are normally larger and more aggressive, defending 'harems' of up to five mates, while males are more nurturing. In six of the seven species of jacanas, found worldwide in tropical regions, it is the males that, unaided by their female partners, perform all of the incubation and chick-tending duties. (In the seventh species, the parental obligations are shared equally.)

Both the male and female of the Australian species have the head adornment their name implies. In front of us, the fleshy, keel-shaped comb, back-lit by the sun, glowed tomato red. The male jacana, perhaps startled by some unseen, underwater danger, suddenly performed a hovering, dancing movement, with wings thrust skyward, legs dangling down, his voice raucous and repetitious in alarm. When the display ended as abruptly as it had begun, we noted that the comb colour had faded to a pale shade of corn-tassel yellow. A short time later, it had re-acquired its brilliant red. We were struck by the enormous differences in fleshy body parts between this species and the Wattled Jacana (*Jacana jacana*), which we, together with our colleague Peter Wrege, study in tropical Central America.

In the Wattled Jacana, the fleshy frontal shield is darker red and bi-lobed with several deep folds. Attached are two similarly coloured wattles that hang down on either side of the yellow bill. The colour of these soft structures varies little from month to month. Certainly there are no rapid changes in hue like those we had just witnessed in the Comb-crested Jacana at Yellow Waters.

The facial ornaments of the two species are visually striking, appearing like prominent billboards on birds that otherwise have fairly unremarkable plumage. What purpose do these fleshy decorations serve? If involved in advertising, what signals do they send?

We believe that the fleshy faces of jacanas function primarily as badges of status. Badges of status are bright patches of feathers or skin that are used in 'sizing up' or assessing the fighting strength of potential opponents. The black throats of male House Sparrows (*Passer domesticus*) are an example. By their size, badges signal relative dominance and fighting ability. Thus an individual with a small badge does not challenge a large-badged opponent, and those with larger badges gain preferential access to critical resources. In this way, competitive interactions are settled without actual fighting, and the inherent risks of physical injury are avoided. The 'honesty' of the badge size is maintained because, in their contests for resources or mates, most animals preferentially challenge other individuals that sport similar badge sizes to themselves. Those that might cheat (by wearing larger badges than they can genuinely defend) will be constantly tested, and they risk grave injury from much stronger opponents.

The facial ornaments of jacanas probably also serve as secondary sexual characters. Secondary sexual characters are morphological features that are used by

**Previously ANH*

When in a relaxed and submissive state, the comb of Australia's Comb-crested Jacana is a pale shade of corn-tassel yellow.

GLEN THRELFO

one sex to advertise itself and by the other sex as a basis for comparing and choosing mates. Familiar Australian examples include the specialised, elongate feathers of males in species such as birds of paradise and lyrebirds (see *Nature Aust.** Summer 1994–95). There are considerable energetic costs and survival risks associated with the growth and maintenance of exaggerated secondary sexual characters. Hence, their relative size and colourfulness are believed to honestly signal the bearer's genetic quality. Individuals of high genetic endowment can better afford the costs of producing larger and more colourful ornamentation.

Fleshy wattles and shields are particularly good indicators of an animal's ability to remain in good health—something that has long been known to poultry farmers. In addition, their degree of bilateral symmetry is thought to indicate the animal's genetic ability to cope with developmental stress. Thus individuals with large, colourful and symmetrical fleshy ornamentation around their faces may be advertising their genetic superiority.

Soft, fleshy ornamentation can have yet another function—that which we

COMB-CRESTED JACANA

Irediparra gallinacea

Classification
Family Jacanidae

Identification
Long toes that allow it to walk on floating vegetation; reddish comb on head; adults with boldly marked brown, black, buff and white plumage; females larger than males.\

Habitat and Distribution
Tropical wetlands, northern and north-eastern Australia; also Indonesia, New Guinea and Philippines.

Behaviour
Eats insects, and seeds and shoots of aquatic plants. Females defend harems of 1–5 males. Breeding variable but usually from January to May in the north, September to January in the east. Raft-like nest moored to submerged vegetation; 4 eggs per clutch. Male alone incubates and tends chicks.

In six of the seven jacana species, it is the males that are responsible for incubating and caring for the chicks. In order to move around the billabong quickly, this agitated male Comb-crested Jacana has tucked the chicks under his wing, leaving their spindly legs dangling.

GLEN THRELFO

N.J. DEMONG

Facial ornamentation is an excellent source of communication in jacanas. The size and colour of the fleshy red shield of this Wattled Jacana presumably advertises its fighting ability as well as its genetic quality.

witnessed in the Australian Comb-crested Jacana. By sudden and dramatic changes in shield colour, these birds communicate rapid changes in their motivational state. The hormones adrenalin and nor-adrenaline are presumably involved. As a bird comes into a state of heightened aggressiveness, the blood vessels in the vascularised shield dilate, causing the red colour to intensify. If the bird turns submissive, the same vessels, again under hormonal control, constrict, draining colour away. Thus the fleshy facial ornament reliably communicates an inner state of affairs: the individual's momentary likelihood of attacking, or of retaliating if attacked.

Although relatively uncommon in birds, communication mediated by rapid colour change allows two adversaries to more accurately assess the willingness of the other to fight. With this extra information, many would-be battles, which might otherwise occur, can be settled without escalating to the point of severe physical injury.

There is, then, variability in the amount of information communicated by the fleshy faces of the two species of jacanas. For both, facial ornamentation indicates an individual's relative health and vigour. This information is presumably useful both in assessing the probable fighting strength of a same-sex combatant, and in choosing a prospective mate. But when the comb colour of an Australian jacana changes, it signals the bird's current motivational state as well. This additional, up-to-the-minute information can further warn or inform a potential challenger of his or her chances for victory.

Why do female as well as male jacanas need to be so well endowed with advertising signals? In jacanas the sexual politics are dominated by females. In the Wattled Jacana, and we suspect in the Comb-crested Jacana as well, intruding females physically challenge resident females for ownership of both their territory and their male mates. The stakes are high. The intruder fights for the opportunity to reproduce, while the resident female battles for the privilege of continuing reproduction as well as for the survival of her current offspring. If the intruder is victorious, she destroys the eggs and kills any small chicks of the defeated female, thus terminating the parental duties of the fathers and making them available for her own reproductive benefit. Males, likewise, engage in territorial fights with other males, determining and defending their respective boundaries within the confines of a female's larger territory. Thus, in jacanas, where many of the behavioural roles typical of most birds are reversed, females as well as males benefit from the types of signals normally associated only with the males.

Facial wattles and shields are thus very effective as advertising billboards. They communicate valuable information to both would-be competitors and to prospective mates. So, the next time you encounter a bird with a fleshy face, admire the flash ornamentation but then consider the probable messages behind the medium. ■

Further Reading

Elgar, M.A. & Magrath, M.J.L., 1994. Dressed to impress. *Aust. Nat. Hist.* 24(11): 50–57.

Emlen, S.J., Demong, N.J. & Emlen, D.J., 1989. Experimental induction of infanticide in female Wattled Jacanas. *Auk* 105: 1–7.

Natalie J. Demong is a freelance writer and photographer with years of experience in avian field studies. Stephen T. Emlen is Professor of Animal Behaviour at Cornell University, Ithaca, New York. His ongoing study of the Wattled Jacana is conducted in cooperation with the Smithsonian Tropical Research Institute in the Republic of Panama. Together, this husband–wife team recently spent a six-month sabbatical in Australia, observing Comb-crested Jacanas and other wildlife.

A First from the National Wildlife Federation®

Individually numbered by hand with 24 carat gold.

Shown smaller than actual size of 20.3cm (8") in diameter.

The National Wildlife Federation® presents the first-ever collector plate by award-winning artist Peter Skirka.

Shrouded in twilight mist he watches and waits. Eyes aglow like luminous pearls set in shinning ebony. Alert to every sound, every movement. The black panther. Captured to perfection in the first-ever collector plate by award-winning artist Peter Skirka. Created in a special commission for the National Wildlife Federation.

"Silent Watch." A portrait of pure power. In the tradition of the most prized collectibles, this heirloom collector plate is crafted of fine porcelain and lavished with breathtaking colour. It is hand-numbered and bordered in *24 carat gold.* Each imported plate bears the artist's signature mark on its reverse side.

Priced at Just $39.50, this limited edition will be *closed forever* after just 45 firing days. Available *exclusively* from Franklin Mint.

SATISFACTION GUARANTEED.
If you wish to return any Franklin Mint purchase, you may do so within 30 days of your receipt of that purchase for replacement, credit or refund.

Franklin Mint Pty. Limited. (Incorporated in Victoria). ACN 005 086 591. 3 International Court. Caribbean Gardens. Scoresby. Vic. 3179. Telephone: (03) 9757 5600.

NA

A Limited Edition Collector Plate. Hand-Numbered and Bordered in 24 Carat Gold.

Please mail by 30th November, 1995.

Post to: Reply Paid 2000,
Franklin Mint,
Private Bag 20, South East Mail Centre. Victoria. 3176.
(No postage stamp required.)

Please enter my order for Silent Watch by Peter Skirka. I need send no payment now. I will be billed for $39.50 plus $2.95 postage and handling, when my plate is shipped. *Limit: One plate per collector.*

Signature _____
All orders must be signed and are subject to acceptance.

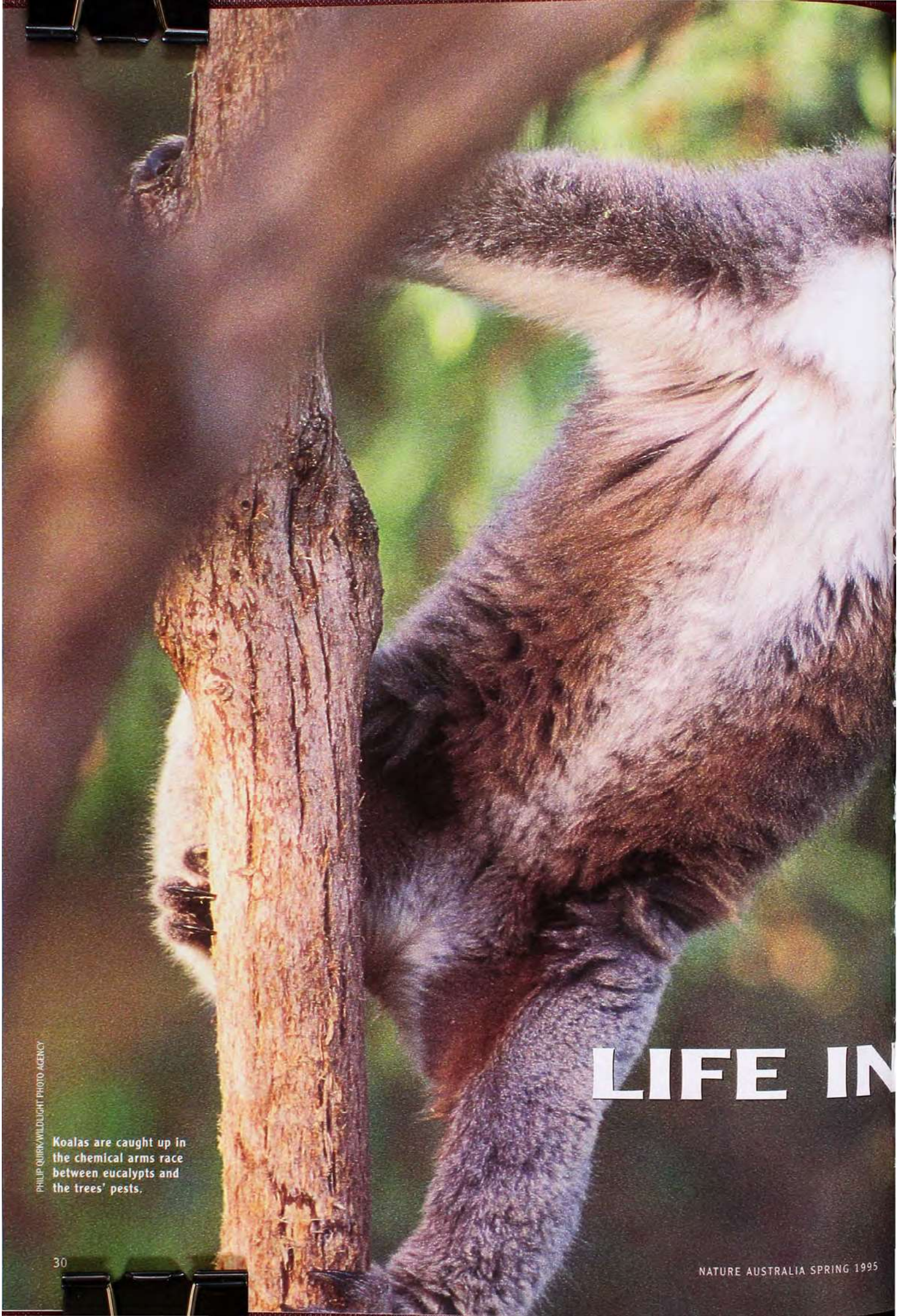
Mr/Mrs/Miss _____ Please print clearly

Address _____

Postcode _____

Telephone _____ Please include STD area code with your number. 00013 32133

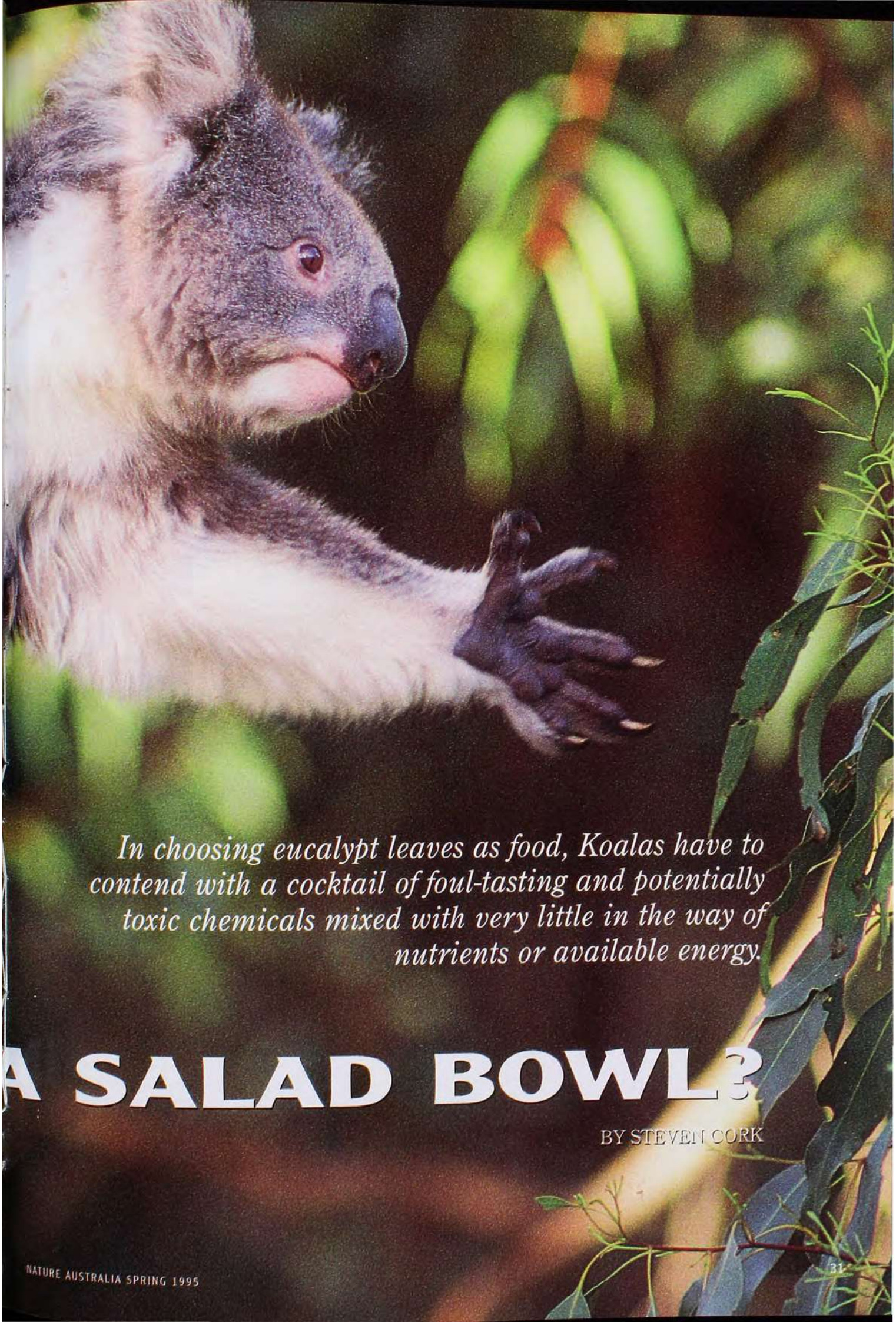
EXCLUSIVELY FROM FRANKLIN MINT



LIFE IN

PHILIP QUIRK/WILDLIGHT PHOTO AGENCY

Koalas are caught up in the chemical arms race between eucalypts and the trees' pests.



In choosing eucalypt leaves as food, Koalas have to contend with a cocktail of foul-tasting and potentially toxic chemicals mixed with very little in the way of nutrients or available energy.

A SALAD BOWL?

BY STEVEN CORK

THE MOUNTAIN GORILLAS OF eastern Africa live life amidst a wide variety of juicy greenery that has prompted the description 'life in a salad bowl'. At first glance we might expect the same to be true for Koalas and other leaf eaters in the eucalypt forests of eastern Australia. It should be like us living in a house stocked to the ceiling with our favourite culinary delights. But the reality is much less appealing.

In choosing eucalypt leaves as food, Koalas (*Phascolarctos cinereus*) have to contend with a cocktail of foul-tasting and potentially toxic chemicals mixed with very little in the way of nutrients or available energy. The dietary fibre in eucalypt leaves makes them as tough as cardboard and even more difficult to digest. There is less protein than needed by most animals to survive. There are high concentrations of phenols, like those that were used in household cleaning products but have since been banned because they are poisonous and carcinogenic. And the characteristic scent of eucalypts comes from the same toxic essential oils used in disinfectants to kill bacteria. Its enough to give you indigestion just thinking about it! All of these problems are compounded by the Koala's small body size. Although necessary for mobility in the trees, theoretically it is far too small to allow for efficient use of tree foliage as food.

The dietary fibre in eucalypt leaves makes them as tough as cardboard and even more difficult to digest.

We can only speculate about how evolution has led any animal to be stuck with such a diet. It is not surprising that only two other species of marsupials—Greater Gliders (*Petauroides volans*) and Common Ringtail Possums (*Pseudocheirus peregrinus*)—specialise on eucalypt foliage and that leaf-eating is rare among tree-living mammals worldwide. Present-day Koalas appear to be descendants of a long line of leaf-eating Koala-like marsupials, some of which might have been evolving alongside eucalypts for 14 million years or so. Whatever forces guided this evolution, the 'pay-off' for Koalas is access to an abundant source of food and limited competition with other animals for it.

As a young researcher 19 years ago, I became interested in how Koalas deal with the nutritional challenges posed for them by eucalypt foliage. Since then, others have asked similar questions about Greater Gliders and Common Ringtail Possums. More recently, with colleagues at CSIRO and James Cook University, I've addressed the questions of how much these challenges vary within our forests, what environmental factors affect them, and what role the composition of leaves plays in determining where we find leaf-eating marsupials in eucalypt forests. These have become increasingly important questions as concern about loss of habitat, especially for Koalas, and debate over what type and how much forest should be conserved for these animals, has grown. With support from the Australian Koala Foundation and Australian National Parks and Wildlife Service (now Australian Nature Conservation Agency), we are seeing a story emerge of animals with extraordinary physiological abilities whose distribution within our forests is determined largely by the delicate balance between nutrients and toxins.

L.F. & O.G. SCHICK

Because eucalypt leaves are not very nutritious, Koalas have to eat large quantities to meet their nutrient and energy requirements.

THE ROLE OF CHEMICALS LIKE PHENOLS and essential oils in plants is a hotly debated topic. Many scientists believe these chemicals are part of a chemical 'arms race' between plants and animals. Plants grown and eaten by humans, such as lettuce, broccoli, spinach and peas, are the wimps of the plant world, selected because they cannot stand up for themselves. But most undomesticated plants do not just sit around waiting to be eaten. The theory is that, as animals have evolved ways to get around the defences of plants, the plants have

MARIE LOCHMAN/LOCHMAN TRANSPARENCIES

Koalas have a metabolic rate that is about half that of other mammals, and long periods of inactivity help compensate for the low energy and protein content of eucalyptus leaves.

PAVEL GERMAN

The Common Ringtail Possum is one of only three species of marsupial that specialises on eucalyptus leaves.

evolved even better defences; and so the arms race continues. For eucalypts, the arms race has mainly been with bacteria, fungi and insects; Koalas and other leaf-eating marsupials have been caught in the cross-fire.

Various ideas have been advanced to explain why some plant species defend themselves more than others. One that appears to apply particularly well to eucalypts proposes that the amount and type of defence a plant employs is determined by a kind of cost-benefit analysis on the nutritional resources available to it. Just as we use financial plans to maximise the benefits from the money we earn and spend, plants are thought to allocate their 'income' of nutrients and carbon to either growing or defending themselves in proportions that get the best return in terms of maintaining the energy-gaining functions of leaves. If the supply of nutrients to plants is low (for example, on low-nutrient soils like those on which many Australian eucalypt forests grow), then this limits a plant's ability to replace leaves eaten by animals. In this case, it pays to invest more in chemical defence than it would for plants growing on higher-nutrient soils. Sure enough, when we analyse leaves from a range of eucalypt forests we find very high concentrations of chemical defences in those growing on the old, weathered soils and lower concentrations in forests on younger soils with more nutrients, such as on the flood plains of large rivers.

The most efficient defensive compounds for plants growing on low-nutrient soils are ones that do not rob valuable nutrients from growth. In this respect, eucalypts are thrifty because the phenols and essential oils that they produce in prodigious amounts contain none of the nutrients like nitrogen or phosphorus that can limit growth of plants on Australian soils.

Plants that grow on nutrient-rich soils often produce small amounts of defensive compounds that contain nitrogen. Most of the drugs that we get from plants are from a group of nitrogen-containing compounds called 'alkaloids' (such as nicotine, codeine, morphine, strychnine, and many of the anti-cancer drugs currently in development). Although eucalypts do not produce alkaloids, some species do produce cyanide-containing carbohydrates that have a nitrogen component. These 'cyanogenic glycosides' are produced in small amounts but nevertheless enough to have killed unwary Koalas, at least in captivity. There are few data on production of cyanides by eucalypts, but it appears they are produced by only some individual trees in forests growing on the better soils. This might explain

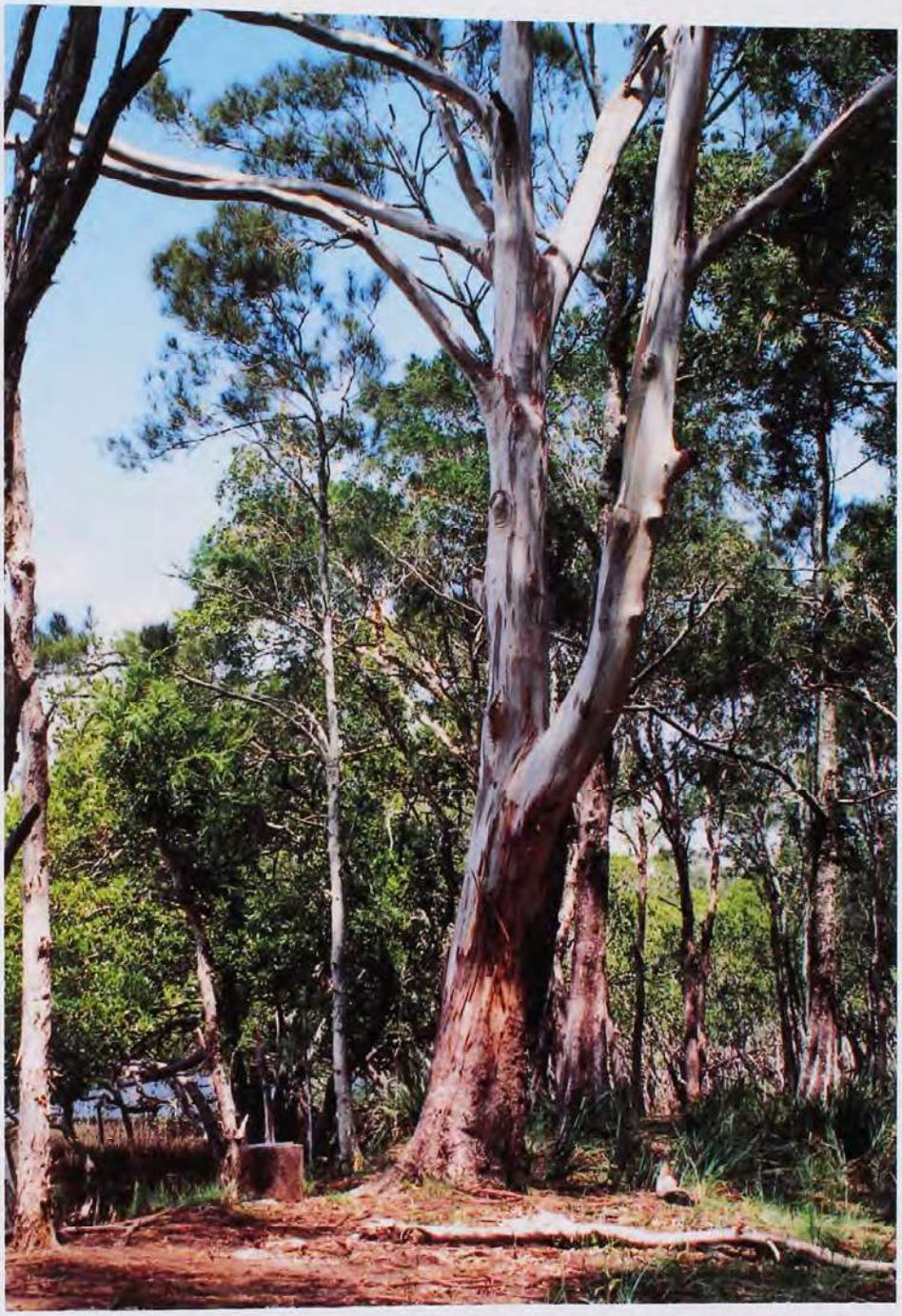
why Koalas eat some trees and not others even in their favoured forests.

We have considered the arsenal employed by eucalypts to defend themselves. But what tactics do Koalas employ in this chemical warfare and what costs do they pay? Koalas deal with the low nutritional quality of eucalypt foliage by having remarkable digestive adaptations, and low requirements for energy and nutrients. To understand the significance of these adaptations, we need to consider in more detail the nutritional problems facing a mammal that chooses to eat eucalypt leaves.

The high concentration of dietary fibre in eucalypt foliage poses two major problems, the first being that fibre itself is difficult to digest. Dietary fibre consists of sugars linked together in long, intertwined chains 'glued' together by a substance called lignin. In this form, the sugars cannot be digested by the enzymes that mammals (including Koalas and humans) produce. Mammals that eat a lot of fibre (like sheep, cows, horses, rabbits, kangaroos, Koalas) house bacteria and other micro-organisms in expanded parts of their gut and these can digest part of the fibre by a process called fermentation. (Incidentally, if you are thinking there might be an explanation here for the Koala's sometimes unsteady movements, you are not the first; unfortunately for that theory, however, the type of fermentation occurring in the Koala's gut does not produce alcohol!) Energy is released only slowly by microbial fermentation of fibre and eucalypt fibre ferments particularly slowly.

The second problem caused by dietary fibre is that it fills the gut, limiting the overall amount of leaves that can be eaten. We have all experienced that full feeling after a meal of muesli or wholemeal bread but eucalypt foliage contains three to six times that amount of fibre! This problem is far worse for small mammals because they have much higher energy needs for each gram of weight than do large animals but their gut is the same relative size. All in all, it would be much better for digesting eucalypt leaves if Koalas were the size of elephants; but then they would have problems climbing the trees to get to the leaves!

To solve these problems, the large intestine of Koalas sorts out the largest, least digestible particles of fibre and preferentially excretes them from the gut while retaining only small food particles and bacteria for digestion. This allows Koalas to eat more, compensating for the high fibre content. Similar functions of the large intestine are characteristic of the other small mammals that 'break the rules' and eat high-fibre diets (Greater Gliders, Common Ringtail Possums, certain lemurs, rabbits, lemmings and voles). In contrast, most marsupials living in the canopy of eucalypt forests and the majority of monkeys in tropical forests do not possess this special gut function as they eat low-fibre diets consisting of fruits, flowers, insects and sap.

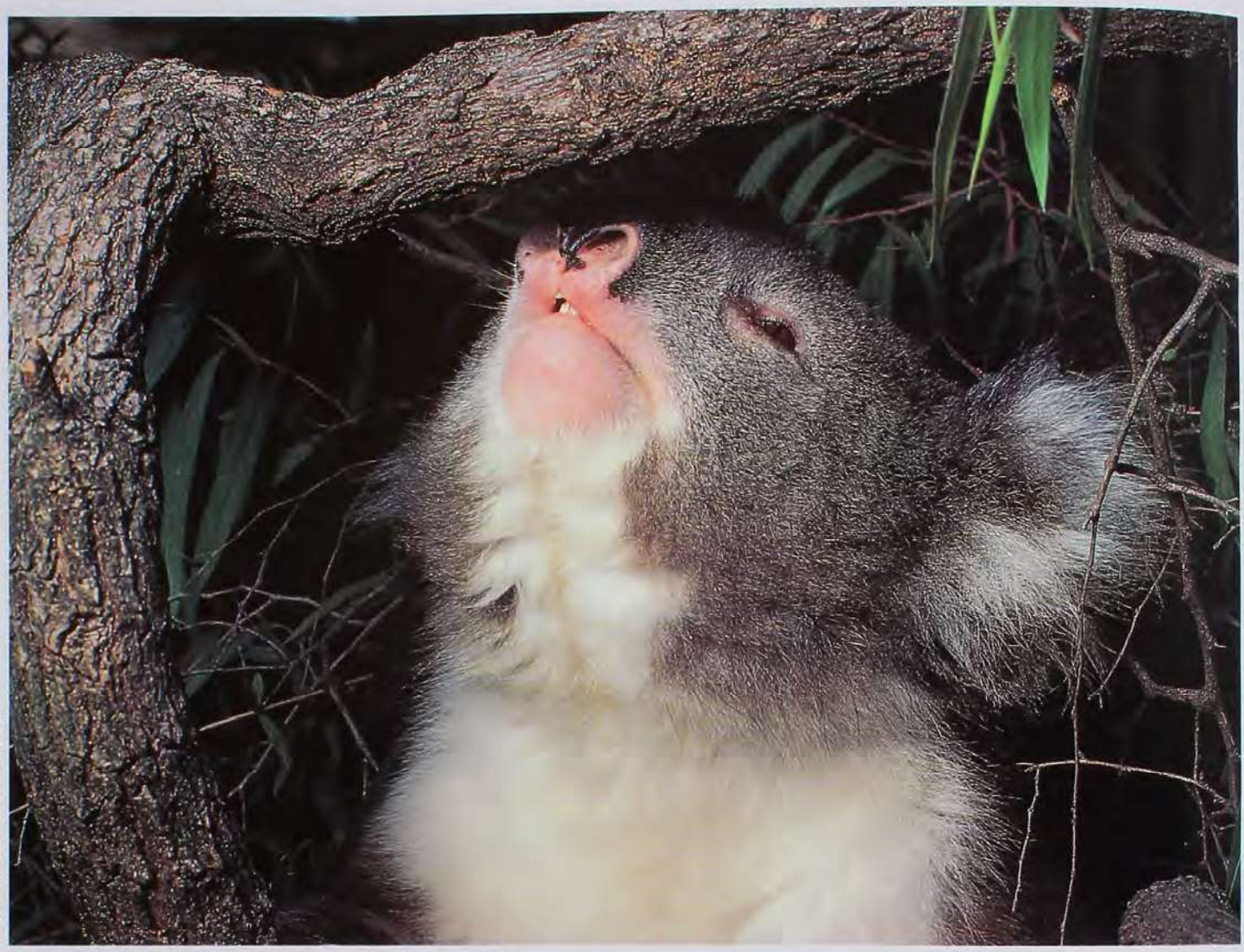


RAY LEGGETT

Prime Koala habitat. These eucalypts are growing on rich soil beside a creek in the Coffs Harbour area.

Koalas have a rate of metabolism about half that of other mammals, meaning their requirements for energy and protein are low. In addition, they save energy by being relatively inactive. Their sleepy demeanour helps compensate for the low protein and energy content of eucalypt leaves, and also means that limited gut capacity is not as big a problem as it would be for other mammals.

WHILE FIBRE PLAYS A LARGE PART IN determining the lifestyle of Koalas and other eucalypt-eating marsupials, protein and toxins appear to be more important in determining which forests these animals thrive in. As a general rule, Koalas and Greater Gliders are found in forests growing on the better-quality soils in eastern Australia. For example, the strongholds for Koalas in New South Wales are around Grafton, Coffs Harbour, Port Macquarie and Newcastle, where large rivers reach the coast and dump high-nutrient soils on their banks. Previous strongholds include the Bega Valley in south-eastern New South Wales, where the flood plains of the Bega River now provide high-nutrient soils for farming. This link between high-nutrient soils and Koalas is partly explained by the allocation of resources to chemical defence in eucalypts on these soils. The cost-benefit hypothesis discussed earlier predicts that trees growing on these soils should



JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Koalas prefer eucalypts that grow on rich soil. Unfortunately, this brings them into conflict with humans who also find these sites ideal for farming, timber harvesting and development.

allocate less carbon to chemical defence and more to growing new leaves, and in general we do find much lower concentrations of phenols on these soils than on the poorer ones away from the rivers.

But selection of the least defended forests is not in itself enough to guarantee survival for Koalas, for even these favoured forests produce formidable quantities of toxins. Koalas need a system of minimising the toxic effect of the plant's defences once they enter the body. As soon as the toxins leave the gut and enter the blood system, they are dealt with by a barrage of enzymes in the liver that attempt to immobilise or 'detoxify' them. This is done by chopping bits off the toxin molecule and attaching other components. New problems are created, however, because the detoxified compounds become acids and acidic blood is a major threat to any mammal. The work of Bill Foley at James Cook University shows that Koalas and other eucalypt-eating marsupials employ some metabolic tricks to neutralise the acidity but this ultimately means using large amounts of nitrogen and, perhaps, phosphorus. The nitrogen comes from the valuable protein that is in such low concentrations in eucalypt foliage. All of this means that it is not the absolute amount of chemical defence in eucalypt foliage that is of concern to Koalas but the amount relative to the concentrations of nitrogen and phosphorus. In other words, the higher the ratio of nutrients to phenols in eucalypt leaves, the better we expect Koalas and Greater Gliders to be able to cope with them.

In both southern and northern New South Wales, we have surveyed eucalypt forests growing under a wide range of environmental conditions and used a technique called Generalised Linear Modelling to tell us which components of the environment, leaf composition and forest structure are most closely related to the presence or absence of Koalas and Greater Gliders. At this stage, results for Greater Gliders are much more reliable than those for Koalas because it has been very difficult to get large numbers of Koala sightings and even more difficult to be sure they are really absent when they are not seen in an area.

Although these investigations are far from complete, two trends are apparent. First, there appears to be a critical ratio of nitrogen to phenols above which there is a much higher probability of finding Koalas and Greater Gliders. We suggest that below this threshold leaf-

eaters cannot persist as viable populations because toxicity is too high. Second, among forests above the threshold, leaf quality is just one of many factors that interact to determine habitat quality, others including the structure of the forest, the density of trees, the ages of trees, and the temperature of the site. Our ongoing work is aimed at defining which of these factors is most important in determining habitat quality for Koalas.

The first and most fundamental consequence of Koalas requiring forests with a high nutrient:phenol ratio is that this brings them into conflict with humans who also prefer sites on the better-quality soils, which are ideal for farming, timber harvesting and urban development. There is circumstantial evidence that, at least in some forms, these land uses are not necessarily incompatible with Koalas continuing to thrive. The big problem, however, is the dearth of objectively collected data that would allow confident planning for the coexistence of Koalas and humans. In the absence of these data, controversy and dispute continue to waste time and resources that could be better used in the interests of both humans and Koalas.

Understanding how changes to the environment affect habitat quality for Koalas and other leaf-eating marsupials is a step towards resolving these issues. For example, our research suggests that processes, natural or otherwise, that increase availability of nutrients for eucalypts (processes such as fire, tree-fall and some forms of logging) should reduce levels of chemical defences like phenols because the carbon previously used to synthesise defences is diverted to growing new leaves. In forests whose leaf composition is near our postulated threshold, this could mean the difference between viability or local extinction of populations of leaf-eaters. On the other hand, reducing the amount of shade, which would happen if some trees were removed, can increase production of carbon-based defences because more carbon becomes available from photosynthesis. This could also have implications for other factors that affect habitat suitability, such as size of trees and pattern of gaps in the forest. As indicated by our preliminary models, considerations of leaf quality must be weighed against the requirements of tree-living marsupials for structure and nest sites in their habitat.

There is a need to understand these processes much better than we do at present, but it is nonetheless encouraging that answers are emerging to what once seemed like hopelessly complex questions. What is clear is that eucalypt forests do not fit our image of a salad bowl. In fact, the more we learn, the more they appear like battlefields through which Koalas roam apparently oblivious to the chemical warfare being waged around them and unaware that there is anything tastier than a tough, fibrous, low-nutrient, potentially toxic eucalypt leaf. ■

Further Reading

Cork, S.J., 1992. Polyphenols and the distribution of arboreal, folivorous marsupials in *Eucalyptus* forests of Australia. Pp. 653–663 in *Plant polyphenols: synthesis, properties, significance*, ed. by R.W. Hemingway. Plenum Press: New York.

Cork, S.J. & Foley, W.J., 1991. Digestive and metabolic strategies of arboreal mammalian folivores in relation to chemical defenses in temperate and tropical forests. Pp. 133–166 in *Plant defenses against mammalian herbivory*, ed. by R.T. Palo and C.T. Robbins. CRC Press: Boca Raton.

Creagh, C., 1992. Soil clues to koala country. *Ecos* 73: 11–13.

Foley, W.J., 1992. Nitrogen and energy retention and acid-base status in the common ringtail possum (*Pseudocheirus peregrinus*). Evidence of the effects of absorbed allelochemicals. *Physiol. Zool.* 65: 403–421.

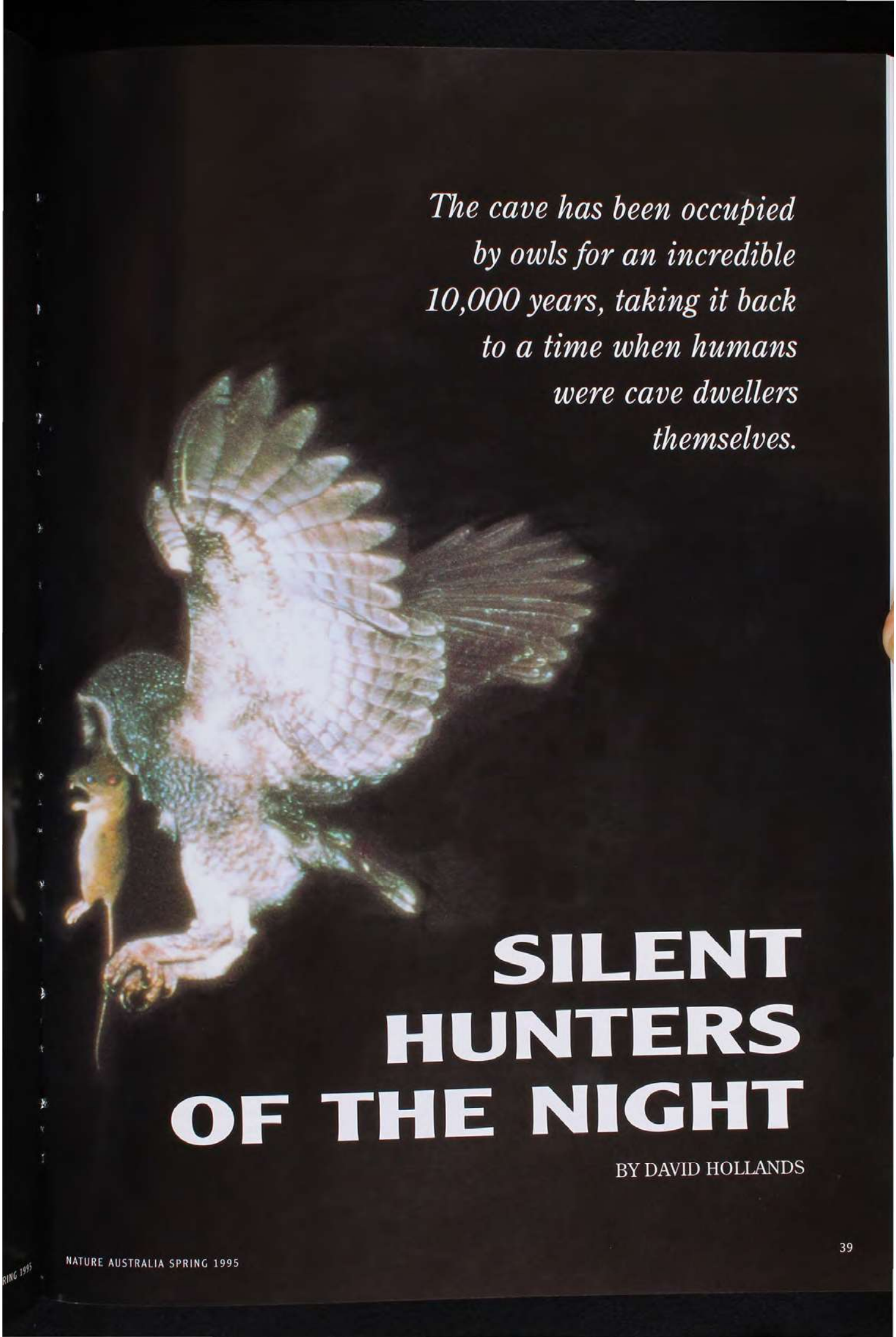
Dr Steven Cork is a Principal Research Scientist at CSIRO's Division of Wildlife and Ecology in Canberra. He has studied the nutrition and ecology of Koalas and other plant-eating mammals in Australian forests over the last 19 years. Currently, he leads a research group interested in how human activities can be harmonised with conservation of forest fauna.

KEN GRIFFITHS

Eucalypt leaves contain a cocktail of toxic compounds that are poisonous to all but a few animals.

DAVID HOLLANDS

A male Lesser Sooty Owl arrives at the nest with its prey—a Long-tailed Pygmy Possum (*Cercartetus caudatus*).



The cave has been occupied by owls for an incredible 10,000 years, taking it back to a time when humans were cave dwellers themselves.

SILENT HUNTERS OF THE NIGHT

BY DAVID HOLLANDS

DAVID HOLLANDS

SILVERED TRUNKS IN THE MOONlight. Feathered leaf patterns against the sky. Deep pools of darkness and shafts of moonshine. Stillness. Silence.

This is the Australian bush at night; a setting to fire the imagination and test the senses; accessible to all but known only to a few. It may be unfamiliar territory but it is home for many animals and birds, including the nine species of owl that occur in Australia. All of these owls belong to just two groups: the barn owls (*Tyto* spp.) and the hawk owls (*Ninox* spp.).

The world has about 140 species of owl and most of them are closely enough related to be grouped in the one family Strigidae. However, the 13 members of the genus *Tyto* differ considerably from all others and, together with the two little known bay owls (*Phodilus* spp.), have been placed in the separate family Tytonidae.

Among all the owls, *Tyto* species are the supreme night hunters, able to operate successfully on even the darkest of nights. Hearing is their great strength, so acute that they have almost no need for light to detect prey. The prominent heart-shaped area of feathers that forms the facial disc is a hearing aid, funnelling the sound into the bony ear openings in the skull. These openings are not only huge but placed asymmetrically, giving a directional quality to the impulses as they arrive at the brain.

The classic experiments of Roger Payne of Harvard University have demonstrated the ability of the Barn Owl (*T. alba*) to hunt in total darkness. Other members of the group are almost certainly just as gifted, and I can only add my own experiences with a Lesser Sooty Owl (*T. multipunctata*), which hunted successfully on a night of utter blackness while water was streaming noisily off the trees after a tropical downpour. *Tyto* species do also, of course, have excellent night vision, with the retina containing a preponderance of the rod cells that are found in all nocturnal animals. Interestingly, apart from the two sooty owls, the eyes are quite

The male Grass Owl has just delivered a rat to the female. Behind her, the young wait in one of the grass tunnels leading from the nest.

small, their size deceptively enhanced by a combination of dark colour and the radiating facial disc.

Silence of flight is characteristic of most owls but *Tyto* species appear to have the most silent flight of all. This is achieved by a combination of large wing area, soft feathering and an almost fluffy edging to the flight feathers, giving them slow flight with a minimum of turbulence.

THERE ARE FIVE SPECIES OF *TYTO* IN Australia. These make up a highly diverse group and occupy a variety of habitats, ranging from treeless plains to the densest rainforests.

Australia and the Grass Owl (*T. longimembris*) seem to be made for each other. The country has huge areas of grassland and, above all others, it is the Grass Owl that is adapted to live there. While other owls need hollow trees for roosting and nesting, and often use perches to hunt from, the Grass Owl requires none of these. It hunts exclusively on the wing, and roosts and nests in the grass, shaping chambers, tunnels and escape routes, all invisible from above.

So much of Australia appears to be Grass Owl country that it is strange to find that it is one of our rarest owls, a contradiction that has long puzzled me. Among the coastal grasslands of northern Queensland and the Northern Territory, it is rare but at least resident. Through the vast plains of the inland, however, its occurrence is both erratic and unpredictable. If insufficient prey was the answer, then this should also affect Barn Owls and Black-shouldered Kites (*Elanus notatus*), both of which have the same diet as the Grass Owl but thrive where it is rare. I believe the

ROGER BROWN

Barn Owls, like the other *Tyto* owls, are supreme night hunters and capable of hunting in total darkness.

FRITH FOTO

Sooty Owls are skilled hunters and can take a wide range of prey from the wet forests in which they live.

ground nest is the problem, being vulnerable to snakes, monitors and even the very rats on which the owls prey. I have known several nests where eggs or young have been plundered. The failure rate is clearly high.

Not so with the Barn Owl, which must surely be one of the world's most successful birds. It has thrived in Australia, where its nomadic habits allow it to take advantage of the periodic rodent plagues that are such a feature of Australian life. Historically the Long-haired Rat (*Rattus villosissimus*) was the species most commonly involved. Then the early European settlers arrived with their grain crops. With them came the House Mouse (*Mus musculus*), which multiplied so rapidly that it was soon the commonest plague rodent in Australia; a curse to wheat farmers but a boon to Barn Owls, which respond to the temporarily limitless supplies of food with prolific and continuous breeding.

I have camped along the Birdsville Track during a Long-haired Rat plague. Just about anything that could catch a rat was breeding. By day there were harriers, kites, falcons and eagles and then, as darkness came, the Letter-winged Kites (*E. scriptus*) and Barn Owls took over. Nesting sites were at a premium and I found Barn Owls breeding in hollow logs, down a dry well and even in the hide of a photographic tower that a friend had erected to photograph the kites.

Of course, rodent plagues do not last forever and, with the inevitable crash in numbers, the predators suddenly find themselves without food. It is the classic boom and bust cycle so beloved by economists but, for the Barn Owl, it usually means death. Many predators can turn to other food sources but the Barn Owl is a rodent specialist and is doomed without them. With food supplies failing, the Barn Owls disperse, often appearing along roads and in farm buildings, conspicuous in their starvation. And herein may lie the explanation for the species' early Australian name of Delicate Owl. Barn Owls are no more delicate than anything else, but they cannot live without food and frequently choose very public places to die.

The Masked Owl (*T. novaehollandiae*) is an intermediate species; in many ways a huge Barn Owl but with some of the characteristics of the two sooty owls. It hunts in the open like a Barn Owl but prefers the big hollows of forest trees to nest. It also occurs in two forms: pale and dark. Many pale birds are as white as Barn Owls and could easily be confused with them, but the deep chestnut dark form is much closer to the two sooties.

In Tasmania, where there are no other large owls, Masked Owls are the biggest and darkest of all. With no owl competitors, they occupy a wider variety of habitat and occur in greater numbers than anywhere in southern Australia. They seem very different from the pale and much smaller Masked Owls that hunt the northern Queensland cane fields. Perhaps they are separate species, but that is a matter for the taxonomists.

The two sooty owls are like no other birds on Earth; as dark as the forests where they live and with the biggest *Tyto* eyes of all. The Lesser Sooty is an Australian endemic, confined to the montane forests of northern Queensland, while the larger Sooty Owl (*T. tenebricosa*) occurs in wet forests in both south-eastern Australia and New

In their ground-level nests, Grass Owl chicks are vulnerable to attack from predators such as snakes, goannas and rats.

DAVID HOLLANDS

Guinea. They are elusive birds and, perhaps for this reason, I have spent more time trying to observe them than I have for any other owl.

IT IS OVER 20 YEARS SINCE I SAW MY FIRST Sooty Owl, roosting in the shade of a rainforest tree fern; sombre plumage, hunched shoulders, eyes narrowed to slits. There are times when primitive emotions can take over the logical mind, and the feeling then of something eerie and sinister was overwhelming; a feeling that was to be reinforced later that night when I heard its call, the so-called 'falling bomb whistle'. Whistle it may be when heard in the distance, but at close quarters it comes through as a demonic, downscale shriek; a terrifying sound when heard in the darkness of the forest.

I came closer and the owl flew away, looking awkward and uncertain, as out of its element by day as I would be when night came. Below the perch was a chalky mess of owl excreta and a number of pellets—the capsules of indigestible fur, feathers and bone that are regurgitated by all birds of prey. Skulls, mandibles, long bones and fur were all recognisable, most of which, with expert help, could be identified.

That Sooty Owl was my quarry and I went back time after time in my efforts to find its nest. Sometimes I heard the calls; occasionally I saw a bird, its eyes shining red in the torchlight like glowing coals. These were the good nights, but there were many others when Sooty Owls might not have existed at all; and I never did find that nest.

Sooty Owls are birds of deep rainforest gullies, so it came as a complete surprise when I was told of one living in a cave in the Blue Mountains of New South Wales. Cave breeding by Sooty Owls had never before been recorded, and it took only a short time to find the nest cavity, high on the wall of the limestone cave.

This was the beginning of a fascinating series of nights, watching from across the cave with my camera lashed onto the top of a stalagmite. I was there as the breeding cycle progressed from egg to chick and then to fully fledged owl. Throughout that time, I never saw the female leave the nest and suspect that she may have gone through the whole breeding cycle without flying. Each night, the male came to the nest at dusk, announcing his arrival in the cave with an ear-splitting shriek. Usually he brought prey and was clearly taking a heavy toll on the district's Sugar Gliders (*Petaurus breviceps*). Sometimes the female came to the cavity entrance to meet him but he always went inside, usually copulating with her before passing over the food. Afterwards, he would perch for long periods on one of the many stalagmites before flying off into the night, with the cave echoing his departing shriek.

This was compelling watching but equally interesting was the deep deposit of pellets that had fallen from the back of the nest cavity and onto the cave floor. In the forest, pellets quickly rot and disappear but, on the dry cave floor, they are preserved almost indefinitely. With help I was able to identify the remains of gliders, possums, antechinuses, rats and rabbits, testimony to the hunting skills of the owl. All of these animals still occur in the region today. What was most intriguing, however, was the discovery of the remains of the Rufous Bettong (*Aepyprymnus rufescens*), which has not been recorded in that part of New South Wales for over 100 years, and of the White-footed Rabbit-rat (*Conilurus albipes*), extinct since the latter part of last century. That was the extent of my research but the study has been continued by the University of New South Wales and it is now thought that the site has been occupied by owls for an incredible 10,000 years, taking it back to a time when humans were cave dwellers themselves.

The Lesser Sooty Owl is a bird of tropical montane rainforest; a miniature Sooty Owl that has evolved to live in that very special habitat. There are populations of Sooty Owls living both north of it in New Guinea, and south in Australia, a fact that probably delayed its recognition as a full species until as late as 1980. There are numerous differences between the two species in both structure and behaviour, but most of these differences are small. Perhaps this is a reflection of a species that has evolved only recently.

The world population of Lesser Sooties is concentrated in the wet, dense forests of northern Queensland from just north of Townsville to about

FRITH FOTO

The Lesser Sooty Owl is endemic to Australia and lives in the dense montane forests of the Atherton Tableland. In order to hunt ground-dwelling prey in this gloomy environment, these owls have to cling to vertical tree trunks.

Cooktown. Although a very small piece of Australia, it is one that contains a considerable number of owls. In this rich habitat they need only a very small territory and so it is quite common to find three or four pairs within calling distance of each other.

Apart from being rich, the habitat is also dense, black and tangled. How the birds find their way through it and catch prey is a source of amazement to me, and it is no surprise to find that Lesser Sooties have the biggest eyes of all the *Tyto* species.

For a human being, progress through this forest is a different story altogether and it is a tribute to John Young, a most remarkable Queensland owl man, that in 1987 he found 17 active nests, which is over five times as many as had ever been recorded before. Fourteen of these were along an eight-kilometre stretch of mountain track with no nest further than one kilometre from the track. I know of no other forest owl anywhere that achieves this sort of breeding density and it indicates the huge small mammal population that must have existed that year. Interestingly, there has not been a breeding season like it since, with owls breeding only sparsely or, in some years, probably not at all.

In order to be able to survive in these dense forests, the Lesser Sooty Owl has had to adapt. In contrast to the Sooty Owl, most of its prey lives on the ground, the very darkest part of this gloomy environment. The huge eyes are an obvious help but there is also the problem of the lack of low perches in the rainforest. The Lesser Sooty has solved this by learning to cling to the vertical tree trunks like a yellow robin, enabling it to bring the eyes into play at any height.

FRITZ PRENZEL/APL

Masked Owls hunt in open country but return to the forest to nest in tree hollows.

THESE THEN ARE AUSTRALIA'S MEMBERS of this very special family of owls; diverse, fascinating and, as a group, unique to Australia.

As predators, owls are at the top of the food chain and a thorough knowledge of them is vital to any understanding of environmental health. Recognising this fact, many countries have carried out extensive research and are well aware of the state of their owl populations. Sadly, the same cannot be said in Australia where our knowledge of such things is virtually non-existent. Perhaps the various *Tyto* species are doing very well, but perhaps they are not. In the present state of our knowledge there is no means of telling, but I feel there is some cause for concern.

In the cane-growing districts of northern Queensland, the recent introduction of a new anti-coagulant rat poison was quickly followed by the discovery of numerous dead Grass and Masked Owls. Autopsies revealed haemorrhages typical of this type of poisoning. This poison would appear to have a potential for harm rivalling that of DDT, yet it is freely available with no controls on its sale.

With the forest owls, urgent research is needed to determine the effects of clear-felling on owl populations. One such study is under way in New South Wales but, in other States, any urgency seems to be confined to the felling operations themselves. One State government has adopted the status of 'Minimum Viable Population'. This American concept attempts to identify the smallest population of a species that will be able to maintain its numbers indefinitely. It is a theory that is both unproven and academic. However, there is a grave risk that other governments will regard it as being both measurable and desirable, giving official countenance to lowering a population to the very brink without even the scientific knowledge for recognising when that brink has been reached.

These are only two examples but they are reason enough to worry. An Australia without owls would be both a poorer place and a less healthy one. We owe it to future generations of Australians to do the work now so that this will never happen. ■

Further Reading

Fleay, D., 1979. *Nightwatchmen of bush and plain.* Jacaranda: Brisbane.

Hollands, D., 1991. *Birds of the night. Owls, frogmouths and nightjars of Australia.* Reed Books: Sydney.

Payne, R.S., 1961. How the Barn Owl locates prey by hearing. *Living Bird* 1: 151–159.

Schodde, R. & Mason, I., 1980. *Nocturnal birds of Australia.* Lansdowne: Melbourne.

David Hollands is a rural doctor who lives at Orbost in eastern Victoria. His interest in owls goes back many years. He is author of two books, Eagles, hawks and falcons of Australia *(1984) and, most recently,* Birds of the night *(1991).*

If we could find a skeletal character defining the sex of an individual crocodile, we may be able to find this same character in dinosaurs.

TO SEX A *REX*

BY PETER L. LARSON

COURTESY OF MICHAEL W. SKREPNICK, ARTIST

IS IT POSSIBLE TO DETERMINE THE SEX OF A DINOSAUR SKELETON? Since dinosaurs and sex are my two favourite subjects, it is natural I would ask. While a straightforward question, the route to the answer may not be easy. Our first problem is that dinosaurs have been extinct for 65 million years. Because sexual organs are primarily comprised of soft tissue, and because it is exceedingly rare for soft tissue to be preserved in fossils, it seems we cannot simply use the method we use with live animals—that is, look under the tail.

The Lizard Queen's Final Day! This painting shows Sue on the alert because across the river another *Tyrannosaurus rex* poses a possible threat to her family. With Sue is her mate, one offspring resting by a tree and another practising its hunting skills on a turtle.

However, there are indirect means of studying soft tissue when all we have is a skeleton. Because of our intimate knowledge of our own anatomy, human remains provide the best example. Forensic detectives are able to reconstruct an individual, bit by bit, from a pile of bones. Their work has made it possible for us to recognise the differences in certain male and female human bones.

Palaeontologists also use forensic methods in resurrecting the past. We learn about a dinosaur's brain, nervous system, muscles and blood vessels through studying openings, pathways and scars preserved in its fossil bones. Why not look for skeletal evidence to help us separate males from females? The sex of a dog skeleton, for example, can be determined from the presence or absence of a baculum (penis bone). Although bacula are only present in certain mammal groups, there may well be other differences in the skeletons of dinosaurs that are the result of being either male or female. Such differentiation between males and females of the same species is known as sexual dimorphism.

But why should we care whether a particular dinosaur skeleton is male or female anyway? Knowing the sex of a dinosaur skeleton could help us unravel the classification of dinosaurs, which currently may separate male and female into different species. It could also help us to better understand dinosaur behaviour and social interaction, as well as the function of certain portions of dinosaur anatomy (if, for example, horns and head crests were possessed only by males, this would indicate their functions were primarily for sexual display and recognition).

We, as mammals, tend to assume the males of a species are larger than the females—a male-mammal-chauvinistic view.

I AM NOT THE FIRST PALAEONTOLOGIST TO be interested in sex. More than 30 researchers have explored the field of sexual dimorphism in dinosaurs. One of the earliest was O. Abel, who proposed in 1924 that the differences in cranial (head) crests of Canadian lambeosaurines (a group of duck-billed dinosaurs) might be accounted for by the sex of the individual. Also, Ralph Molnar from the Queensland Museum mentioned a possibility of sexual dimorphism in *Tyrannosaurus rex* in his 1991 paper on cranial osteology (the study of the bones of the skull). He suggested that the presence or absence of a rugosity (area of bone that is enlarged by wrinkles or ridges) on the postorbital (the bone above and behind the eye) could be a sexual difference. Neither Abel nor Molnar, however, assigned these characteristics to either sex.

Ceratopsians (horned dinosaurs) also have attracted the sexual interest of palaeontologists because these dinosaurs exhibit differences in body robustness and horn size. Scientists interpreted these differences by comparing ceratopsians to living horned mammals, and concluded that the more

PETER LARSON

A large theropod egg, shown in comparison to modern Domestic Fowl and Ostrich eggs. An expanded pelvis in female *Tyrannosaurus rex* would be an advantage to egg-laying.

BLACK HILLS INSTITUTE/ED GERKEN

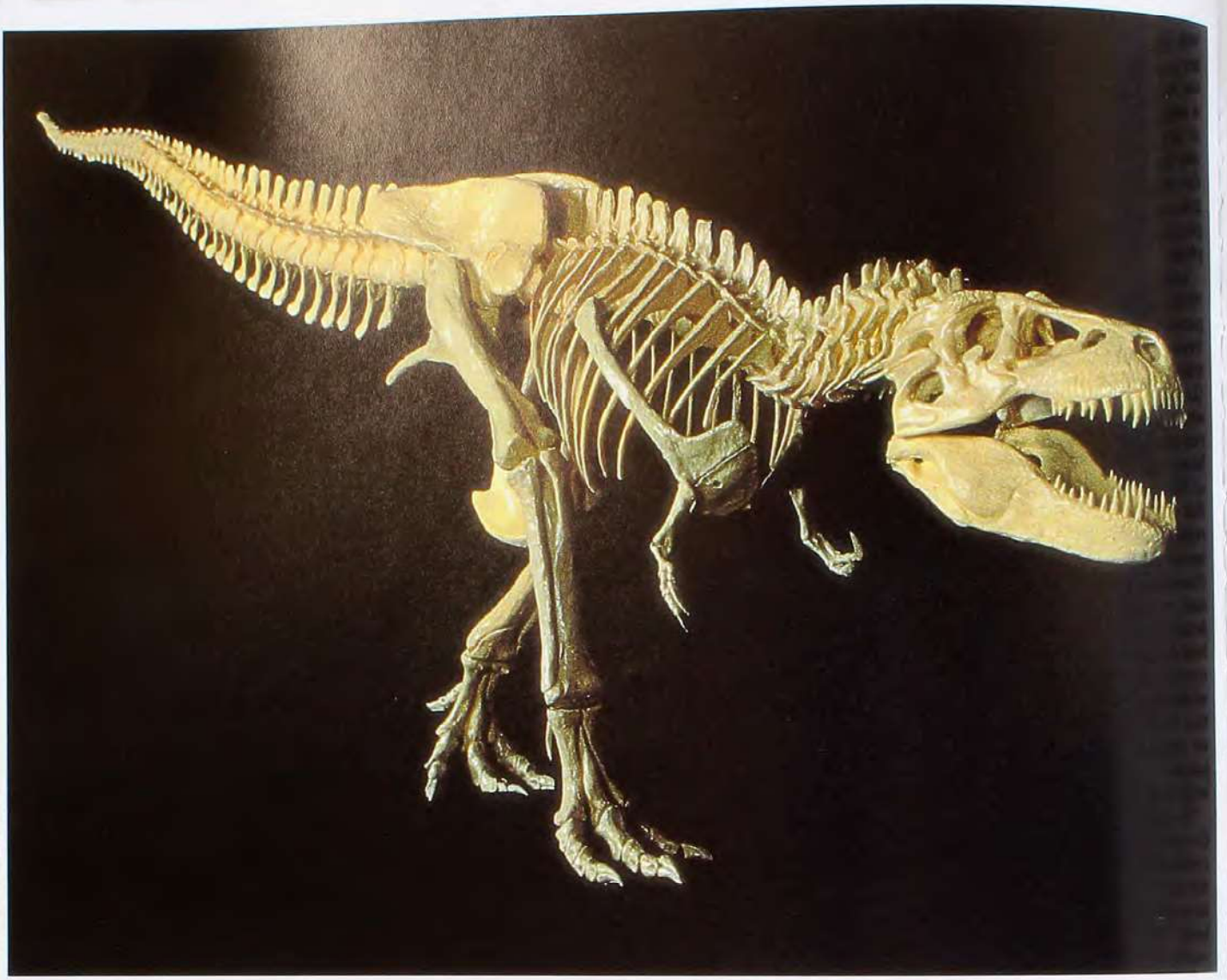
Peter Larson with Sue.

robust individuals with larger horns were males. I suppose that we, as mammals, tend to assume the males of a species are always (or at least usually) larger than the females—a male-mammal-chauvinistic view. That may explain why most palaeontologists who recognise sexual dimorphism automatically assign the larger, more robust, or 'hornier' individuals to the male gender.

More in-depth study of carnivorous dinosaurs, called theropods, yielded the first evidence challenging this chauvinistic viewpoint. Michael Raath, of the Port Elizabeth Museum in Humewood, South Africa, looked at a bone bed of *Syntarsus rhodesiensis*, a small Jurassic South African theropod. Studying the disarticulated remains of juveniles and adults, he found that, as these dinosaurs reached maturity, their skeletons developed into two forms, or 'morphotypes': a heavily built or 'robust' morphotype, and a lightly built or 'gracile' morphotype. Because these differences were seen only in mature individuals, they strongly suggest sexual dimorphism.

Raath found that robust individuals outnumbered gracile—but he concluded they must be *female*, reasoning that, in a sample containing a significant number of juveniles, the accompanying adults were more likely to be females, which would be more reluctant to leave their young if a dangerous situation presented itself. Supplementing Raath's argument is the fact that females normally have the larger investment in the young (this is true always in terms of the nutrients supplied with the egg, and usually in the care of the growing young) and therefore are most interested in their salvation. Raath also considered the possibility that the sexes might be geographically separated at certain times.

Ken Carpenter, a researcher from the Denver Museum of Science in Colorado, studies large theropods. He was one of the first to propose the existence of sexual morphotypes in *Tyrannosaurus rex*. Carpenter, looking at the North American *Tyrannosaurus rex* and *Tyrannosaurus* (*Tarbosaurus*) *baatar* from Mongolia, identified differences based upon the humerus (arm bone) and ischium (pelvic bone), as well as the more general robust and gracile appearances of other skeletal elements. Carpenter, like Raath, concluded that the robust morphotype was female. This conclusion was based, in part, upon the shape of the ischium in the robust form, which he believes



BLACK HILLS INSTITUTE/ED GERKEN

This detailed, anatomically correct sculpture of Sue was crafted by artist Joe Tippmann using measurements of the skeleton and its pathologies.

allows for a wider passage for laying eggs.

Despite this great interest in sex, no-one had identified a single anatomical character allowing us to assign a definite sex to an individual skeleton. This search became my focus in 1990, when we excavated and began preparation of the largest and best preserved *Tyrannosaurus rex* ever found. Her name was 'Sue' (see box), but was this huge beast really a girl, or simply 'a boy named Sue'?

In gathering data for this study, I searched the literature and visited institutions in North America housing collections from 68–65-million-year-old sediments. My intention was to locate specimens of *Tyrannosaurus rex* to see if differences could be identified, quantified and grouped. My results show that the 18 skulls or partial skeletons attributed to *Tyrannosaurus rex* may be divided into the same two groups, or morphotypes, discussed above: robust and gracile.

First I grouped these 18 specimens as generally robust or gracile. Then I observed that certain individual bones have recognisable differences, underscoring their robust or gracile natures. For example, in the skull, these bones include the postorbital (the focus of Molnar's studies), the lachrymal (the bone in front of the eye) and the quadratojugal (near the jaw hinge). In the body, they include the humerus, ischium and sacrum (fused vertebrae of the pelvis). Finding any one of these bones could provide an indication of the characteristics of an entire skeleton.

It seems reasonable to assume that these differences are based upon gender rather than the existence of two distinct species of extremely large carnivores living contemporaneously in the same region (the only other simple explanation). If these are indeed sexual differences, a mammalogist may have been tempted to assign the larger, robust morphotype to the male. However, other data—this time from living animals—suggested the opposite.

MOST PALAEONTOLOGISTS AGREE THAT crocodiles and birds are the dinosaurs' closest living relatives. Therefore, they seemed the best candidates for reconstructing the reproductive mechanisms of *Tyrannosaurus rex* and perhaps finding some skeletal basis for the sexing of dinosaurs.

However, I ran into the same preconceived gender notions when working

with the living animals. Ornithologists are prone to male-mammal-chauvinism, too. For example, they have always cast a suspicious eye toward raptors (birds of prey), since the females are invariably larger than the males. Assuming this situation is 'unnatural', ornithologists coined a chauvinistic term for this phenomenon: 'reversed sexual dimorphism'.

Looking at the animal kingdom as a whole, however, we see quite a different picture. Many species demonstrate this 'reversed sexual dimorphism'. In invertebrates, the female Redback Spider (*Latrodectus hasselti*), which eats her smaller mate after copulation, is the rule rather than the exception. In vertebrates we find that most living species of fishes and amphibians have females that outsize males. The same occurs in reptiles, with most turtle and snake species exhibiting 'reversed sexual dimorphism'. It is really only in mammals where males generally outsize females. But even here, the last stronghold of our prejudice, there are notable exceptions. Female mysticetes (baleen whales), for instance, are always larger than their male counterparts. Perhaps we should be careful about making a judgment as to what is 'normal' and what is 'reversed' sexual dimorphism.

The explanation for a larger female as the norm may lie in the very act of procreation. Male and female each bring to this union one half of the genetic material necessary for the creation of a new being. The male brings his half in a conveniently *tiny* package called a sperm cell. The female, however, not only contributes half of the genes, but also provides a very large bundle of nutrients encased in a *huge* package called an egg. This mandates that she invest more energy in nurturing these 'tickets to eternity', and also that the size of her body should, necessarily, be larger than her male counterpart's. (Female ovaries are substantially larger than male testes, especially when the ovaries contain mature eggs.)

Therefore, if it is 'normal' for the female to be the larger of the two sexes, then we must explain why sometimes males outsize females. It may be simply that a larger male has a distinct advantage when engaging in sexual competition among males for the right to impregnate multiple females. This condition is best displayed in herding mammals, like bison or even kangaroos.

Why don't we see this condition in birds of prey? Raptors, and other species of birds where females are larger than males, all have one thing in common: they are monogamous. Monogamy, and a one-to-one ratio between males and females, eliminates competition between males for the right to impregnate multiple females. Probably due to this lack of sexual competition, female birds of prey are larger than males.

Were female theropods larger than males? Certainly when we look at birds of prey it is logical to conclude that they *could* have been. After all, most dinosaur palaeontologists now believe that birds are the only surviving branch of a single class (Dinosauria) that includes theropods, sauropods, ornithischians and birds. If theropods were also monogamous, females probably were larger than males.

Crocodiles have often been used as models for dinosaur behaviour, because they have many shared characters with dinosaurs and presumably share a common ancestor. Thus, if we could find a skeletal character defining the sex of an individual crocodile, we may be able to find this same character in dinosaurs.

Despite this great interest in sex, no-one had identified a single anatomical character allowing us to assign a definite sex to an individual skeleton.

In crocodiles, sexual reproduction and removal of waste are all performed through one opening, called the cloaca. Male crocodiles have an intromittent organ as do snakes, turtles and some birds. This 'penis' apparatus has a slightly different construction than a mammalian penis, although its function is similar. Unlike most mammals, the crocodile 'penis' is retracted when not in use, past the cloaca and into the body. To retract and protect this organ, a 'penis-retractor muscle' is necessary.

Eberhard Frey, a colleague from Karlsruhe, Germany, has studied crocodiles. Through his dissections of the reproductive organs, he recorded a remarkable discovery: this male-only muscle attaches to the underside of the tail, anchoring the 'penis' to the first chevron, or haemal arch. Chevrons are the bony spines attached to the base of the caudal (tail) vertebrae. Frey also discovered that whereas the first chevron of female crocodiles is only half the size of the second, the first chevron in male crocodiles is approximately the same size as the second, presumably to provide more surface area for this male-muscle attachment.

Through my own examinations of crocodiles, I found that this first chevron is attached to the rear of the *second* caudal vertebra in male crocodiles and to the rear of the *third* caudal vertebra in female crocodiles. In other words, males have an extra chevron! Interestingly, Alfred Sherwin Romer

PETER LARSON

The cloaca of a male crocodile (with penis retracted within).

noted this dichotomy back in 1956 but, unfortunately, did not link it to sexual dimorphism. However, the presence or absence of this extra chevron in crocodiles is direct skeletal evidence of the type of sexual organ this animal possessed.

Can we use this same sex-related skeletal character in dinosaurs, particularly in crocodile relatives—theropods like *Tyrannosaurus rex*? When we look at mounted dinosaur skeletons, we note that the first chevron may appear as a different shape, or may occupy a different position in various mounts of the same species of dinosaur. Unfortunately, in most cases, we do not have detailed notes or photographs to assure us that what was mounted and restored represents the condition of the living dinosaur. Chevrons are only attached to the vertebrae by ligaments and are very easily disarticulated as the flesh is decomposed. So, we must concentrate our search on newly discovered, undisturbed or well-documented skeletons.

In the summer of 1993, Philip Currie from the Royal Tyrrell Museum in Drumheller, Alberta, located important new material. For several years, he had been preparing and examining species of *Saurornithoides* and other troodontids from China. Troodontids are closely related to *Tyrannosaurus*. Like *Tyrannosaurus*, *Saurornithoides* may be divided into robust and gracile morphotypes. Currie has prepared articulated specimens of each form. He found that in the gracile form, the first chevron is positioned on the *front* of the first caudal vertebra (on the *rear* of the last 'sacral', or pelvic, vertebra), and is approximately the same size and shape as the second. The first chevron on the robust form is positioned on the rear of the first caudal vertebra, and is more wedge-shaped and shorter than the second. In other words, the gracile morphotype has an extra chevron! Thus, these skeletons demonstrate that the robust and gracile morphotypes are indeed separable on the basis of skeletal characters defined by the sex of the individual. My conclusion is that, in this theropod, gracile morphotypes are male and robust morphotypes are female.

How could an eight-tonne, bipedal animal have managed to feed itself during convalescence? Was she fed by a mate?

An examination of *Tyrannosaurus rex* seems to yield the same result. In the gracile specimen at the Museum of the Rockies, the first and second chevrons are the same length and roughly the same shape. Although we cannot check Sue (see box), it is reasonable to assume that we may construct a parallel with *Saurornithoides*. This would place robust morphotypes, like Sue, into the female gender and gracile forms into the male. Although these results may

A DINOSAUR NAMED 'SUE'

On 12 August 1990, while exploring the badlands of the Hell Creek Formation in north-central South Dakota, Susan Hendrickson (a volunteer for the Black Hills Institute) came upon the remains of a large skeleton eroding from a 65-million-year-old stream bed. This was no ordinary fossil. It was, in fact, the beautifully preserved skeleton of the largest and most complete *Tyrannosaurus rex* found to date. The skeleton was named Sue in honour of its discoverer. Although Sue provided the spark that led to my study of sexual dimorphism in dinosaurs, her story is much more complex.

From the date of discovery, Sue began to yield information about her life, which ended so long ago. Between August 1990 and May 1992, many scientists and I were able to study the skeleton and the grave that yielded her bones. We were able to determine what killed this huge beast (the bite of another *Tyrannosaurus rex*), what happened to the body after Sue died (it fell into a stream and was rapidly buried), and even what Sue ate for her last meal (a duck-billed dinosaur).

During preparation of her skeleton, we also found the presence of an unusually large number of 'palaeopathologies', or ancient healed injuries. Pathologies can provide snapshots of an individual's daily life. These pathologies included evidence of multiple puncture wounds suffered, presumably, at the hands (or rather, mouths) of other tyrannosaurs. One wound to a rib apparently never healed. Inside the spongy swelling of extra bone growth we actually found the fragment of a broken *T. rex* tooth.

We also found two tail vertebrae that had been crushed so badly (perhaps stepped on during combat or copulation) that they had fused together. Probably the worst injury, however, was the smashed and healed left fibula (lower leg bone), broken so badly that almost half its surface had swollen to double its original diameter. How could an eight-tonne, bipedal animal have managed to feed itself during convalescence? Was she fed by a mate? Or perhaps she received this injury when she was small and under her parents' care.

Did *Tyrannosaurus rex* maintain and hunt in family units? Possible evidence was buried with Sue. We found the fragmentary remains of a smaller and more gracile (male) adult, and fragments of a juvenile and baby *T. rex*. The more we learned about this animal, the more questions we had.

PETER LARSON

Susan Hendrickson poses with her discovery, Sue the dinosaur.

Then on 14 May 1992, nearly two years after we began to study this remarkable beast, tragedy struck. Sue was seized by agents of the United States Government claiming that the Institute had illegally excavated Sue. In an early morning raid, armed agents entered the Institute and seized one of the greatest palaeontological treasures ever discovered, took her nearly 50 kilometres away and locked her in a metal container, next to a boiler room. Since that fateful day, no-one has seen or studied Sue.

Black Hills Institute brought legal action against the Federal Government seeking Sue's release. As a result, the Government finally admitted that we had not violated any laws when collecting her. The case, however, is still fraught with debate over the ownership of the fossil (regardless of the Institute's purchase of it from the landowner), and today, over three years after her abduction, Sue remains a prisoner. All the secrets she can share, all the answers she has to give are still locked away in that metal box with her skeleton. There is no way of knowing when, or if, she will ever be released. And because of the conditions of her storage, where humidity varies ten per cent and temperature five Celsius degrees each day, if the sun ever shines on Sue again, nothing may remain but dust.

(Note: 'Sue' is a registered trademark of the Black Hills Institute of Geological Research, Hill City, South Dakota.)

work for theropods, it would be presumptuous to automatically assume they work for all dinosaurs. In fact, preliminary surveys indicate the opposite assignment may be the case for plant-eating ornithischians, such as Australia's herd-dwelling *Muttaburrasaurus langdoni*, whose social behaviour may parallel mammalian harem habits.

SO, WHAT MAY WE CONCLUDE FROM ALL of this? By comparing *Tyrannosaurus rex* with its closest living relatives, and by identifying its robust and gracile skeletal elements, it seems clear that the two observed morphotypes represent sexual differentiation. Plus, the new significance attributed to the presence of particular chevrons indicates that male *Tyrannosaurus rex* (and other dinosaurs) had an intromittent organ or 'penis' similar to crocodiles and some birds. These results indicate that, for *Tyrannosaurus rex* and other theropods, the female is probably larger than the male. Identifying the sexes may even clarify our classification of dinosaurs. Not understanding these gender differences in the past, we may have misidentified sex-related differences as indicators of different species.

By drawing a parallel with predatory birds, I now believe that *Tyrannosaurus rex* was probably monogamous and maintained family groups. This possibility is supported by additional data. Sue was found with the fragmentary remains of an adult male (gracile morphotype), a juvenile and an infant *T. rex*. In addition, an adult male and a juvenile were discovered in the same excavation in Montana by the Los Angeles County Museum of Natural History in the 1960s.

Now that we have seemingly found a method of determining the gender of specific dinosaur skeletons, we should be able to attribute isolated robust or gracile skeletal elements to a specific sex. Knowledge of gender, combined with a reconstruction of the events that led to the animal's death and information on the ancient environment and geographic location, can bring to life the behaviour of animals extinct for 65 million years.

Australia is rich in fossils and many important dinosaur specimens have been found. Thus far, however, study of the sexual dimorphism of Australian dinosaur specimens has only just begun. I have discussed the subject with Australian palaeontologists, who will be watching for skeletal differences. With continued searching around the world, our understanding of sexual dimorphism in dinosaurs will be greatly enhanced.

However, my research seems to indicate that our first inclinations are usually our best. In determining the sex of a dinosaur, whatever its continent, a researcher need only duplicate the manoeuvres necessary in determining the sex of a live animal—simply look under its tail! ■

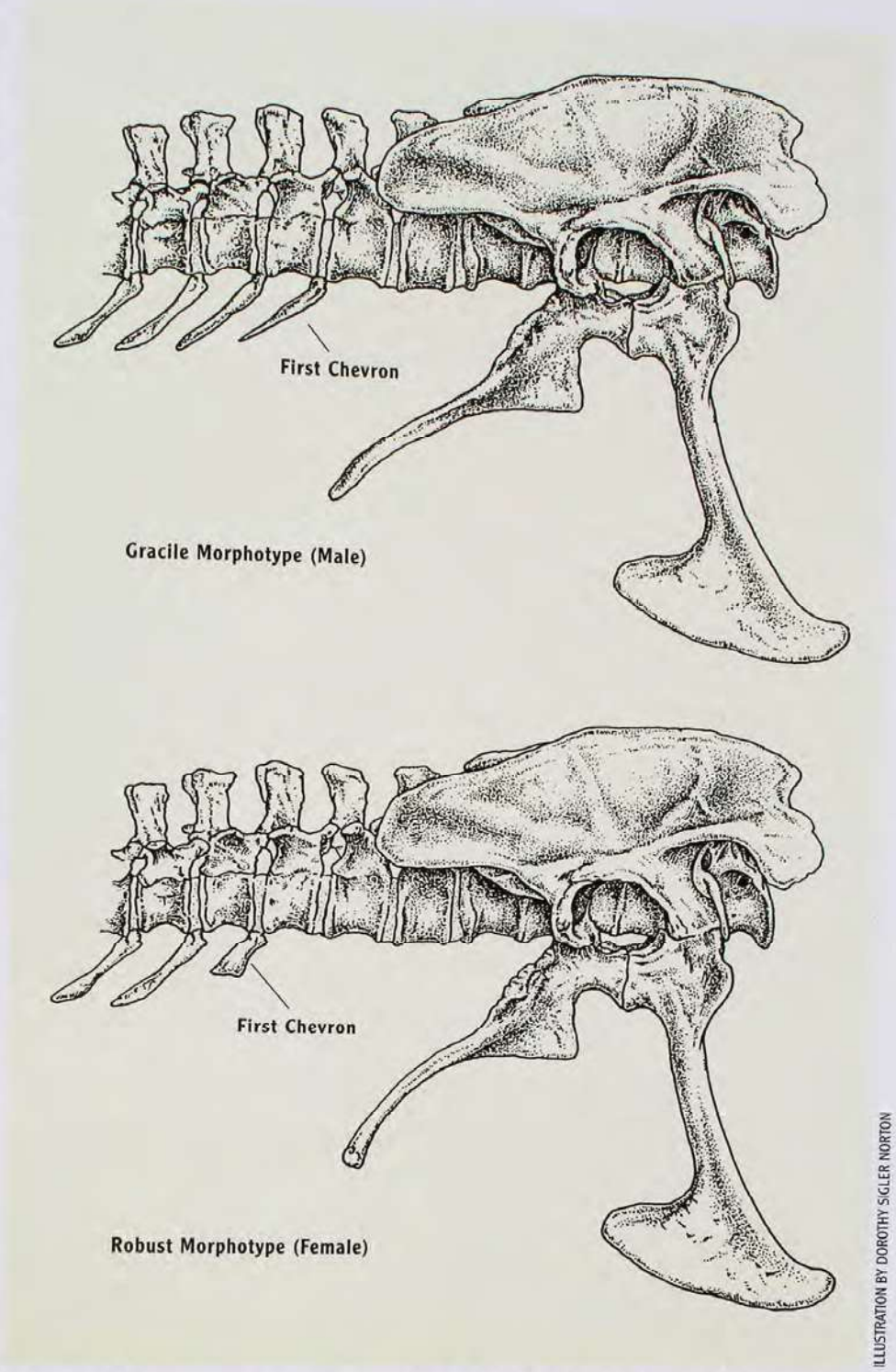


ILLUSTRATION BY DOROTHY SIGLER NORTON

It seems that *Tyrannosaurus rex* can be sexed on the basis of skeletal characteristics. The size and shape of the first chevron indicates whether it is a male (gracile morphotype) or female (robust morphotype). Illustrated here is the right lateral view of the pelvis and basal caudal (tail) vertebrae.

Further Reading

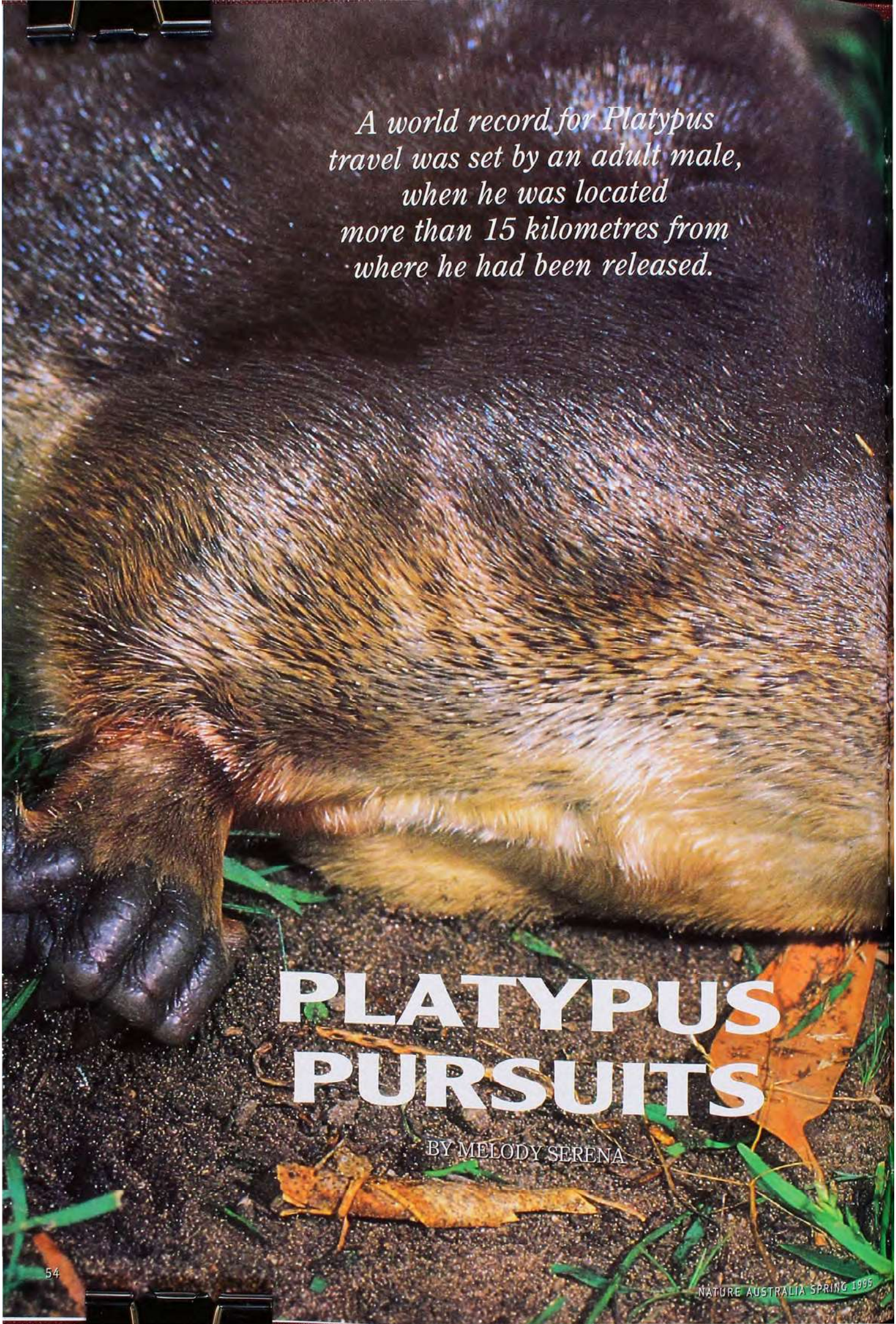
Amadon, D.L., 1975. Why are female birds of prey larger than males? *Raptor Research* 9: 1–11.

Carpenter, K. & Currie, P.I. (eds), 1990. *Dinosaur systematics, approaches and perspectives* (especially chapters by K. Carpenter and M.A. Raath). Cambridge University Press: New York, Port Chester, Melbourne, Sydney.

Molnar, R.E., 1991. The cranial morphology of *Tyrannosaurus rex*. *Paleontographica* 217: 137–176.

Weishampel, D.B., Dodson, P. & Osmolska, H., 1990. *The Dinosauria*. University of California Press: Berkeley and Los Angeles.

Peter L. Larson is Founder and President of the Black Hills Institute of Geological Research, Inc. and Vice President of the Black Hills Museum of Natural History in Hill City, South Dakota, USA. His research in palaeontology has spanned over 30 years, and he has collected, prepared and studied fossils in Asia, Europe and North and South America.



A world record for Platypus travel was set by an adult male, when he was located more than 15 kilometres from where he had been released.

PLATYPUS PURSUITS

BY MELODY SERENA

The Platypus embodies a curious mix of both mammalian and reptilian traits.

DAVE WATTS/NATURE FOCUS

IN THE MOON-DAPPLED WATERS OF THE creek, a small dark form bobs to the surface and momentarily floats in place, its duck-like bill grinding food inelegantly from side to side. Then, with a distinct double splash, it disappears under the rippled surface of the water, as unexpectedly as it arrived. One of the world's strangest mammals—the Platypus (*Ornithorhynchus anatinus*)—has made a brief appearance before returning to the shadowed depths of its watery universe.

The Platypus first came to the attention of Western science in 1799, when the English naturalist George Shaw published a description of the dried skin of a juvenile male. Shaw suspected that the specimen was a hoax, perhaps fabricated by the same clever Chinese taxidermists who created 'mermaids' by sewing together parts of the bodies of monkeys and carp. While Shaw's doubts regarding the authenticity of the Platypus abated when more specimens reached Europe, later scientific studies have shown that the Platypus is a highly unusual animal.

PLATYPUS

Ornithorhynchus anatinus

Identification

Uniformly dark brown above except for a small white patch just in front of eye; silvery-fawn below, sometimes with a central rufous tint; adult length 40–60 cm; mass 0.6–2.6 kg, with males weighing more than females. Most often seen floating or swimming quietly at the water surface. When alarmed, will 'splash-dive', making a loud single or double splashing sound as the animal dives abruptly.

Habitat and Distribution

Occupies permanent freshwater streams, rivers and lakes at all elevations in Tas., Vic., NSW and Qld south of about Cooktown. Also occurs on King Island and Kangaroo Island (introduced to latter), and occasionally in upper reaches of Murray River in SA. Will also make use of temporary or man-made water bodies, particularly when these are linked to natural streams or rivers.

Food

Feeds exclusively in the water on insects and their larvae, small snails and mussels, shrimps, yabbies, worms and occasionally small frogs.

Status

Common and widespread over most of its historical range. Has almost certainly declined in the Murray River downstream from about Echuca, and in the Melbourne and Sydney metropolitan areas.

Like the two other living species of monotremes—the Short-beaked Echidna (*Tachyglossus aculeatus*) and Long-beaked Echidna (*Zaglossus bruijnii*)—the Platypus embodies a curious mix of mammalian and reptilian traits. Like other mammals, it feeds its young with milk, is covered by fur and has a four-chambered heart. The size and structure of the Platypus brain is also typically mammalian. Like reptiles, however, the Platypus produces vitamin C in the kidney and not in the liver, lays shelled eggs (see Eggstraordinary Reproduction box), and has upper limbs extending horizontally from the body, giving the animals a shuffling, lizard-like gait. Other Platypus traits appear to be unique to the monotremes, such as the presence of a conspicuous, pointed spur on the male hind leg. Each spur is connected to a gland which, in the case of adults, secretes a powerful venom (see Earning their Spurs box). In addition, the Platypus bill is equipped with electroreceptors, which seem to be sensitive enough to detect tiny electric currents associated with movements of aquatic prey, such as shrimps and various insects (see *Nature Aust.** Autumn 1990).

The Platypus remains reasonably abundant throughout many of the wetter parts of eastern and south-eastern Australia, including Tasmania. Nevertheless, glimpses of this species tend to be rare because of its retiring and largely nocturnal habits. To enable such topics as social organisation and movement patterns to be studied in detail, it has been necessary to radio-tag the animals, so they can be consistently 'observed' in burrows and at night in the water.

A Platypus radio-tag consists of a miniature transmitter, battery and copper loop antenna, encased within a waterproof layer of epoxy resin. Once a radio-tag is activated, by removing a magnet taped to its surface, it emits pulsed signals at one-second intervals for up to 14 weeks. Each radio-tag broadcasts on a different channel, so animals can be individually identified at a distance with the help of a sensitive tracking receiver. From the strength and quality of a signal, it is also possible to tell whether an unseen Platypus is asleep in a burrow (the signal is fairly weak but very steady) or feeding actively in the water (the signal varies almost continuously as the animal turns and dives).

Before radio-tracking research could begin, a technical issue had to be solved: how best to attach radio-tags to the animals. For most mammals, the standard attachment technique is a collar. Unfortunately, the streamlined shape of a Platypus means that it lacks a well-defined neck! In earlier studies by Drs Tom Grant, Gordon Grigg and co-

workers in New South Wales, radio-tags were taped beneath the Platypus tail or implanted within the body cavity. These studies, using temperature-sensitive tags, successfully achieved their main goal of providing information on Platypus activity rhythms and body temperature (which is maintained at about 32°C when free-ranging animals are active and also when they are resting in burrows). However, both techniques have practical disadvantages. Even the stickiest tape falls off in water within a few days, and implantation requires surgery both to insert the tag and to recover it after the battery has failed.

Alternatively, when I began studying the patterns of habitat use and social organisation of the Platypus in 1989, I adapted a technique that has been used with great success on marine mammals—gluing the radio-tag to the outer fur of the rump, just in front of the tail. One advantage is that it is virtually impossible for tagged animals to get

* *Previously ANH*

PETER MARSACK/LOCHMAN TRANSPARENCIES

Platypuses are trapped using fyke (eel) nets. The nets are set in pairs to catch animals going both up- and downstream.

snagged on underwater objects. The tag is also elevated out of the water when a Platypus floats or swims on the surface, greatly improving signal reception. Finally, because a Platypus has extremely dense underfur, glue never actually comes in contact with the skin. The tags fall off spontaneously as fur is shed naturally, usually within about three months.

To radio-tag a Platypus, you first have to catch it. My research has relied on fyke (or eel) nets, comprising two net wings stretched across a stream or river, with a series of hoops supporting net funnels at the middle. The last funnel is shaped as a sleeve, so a Platypus can easily push its way into the end chamber of the net but has trouble determining how to get back out again. As an essential feature, the entire

PETER MARSACK

A section of the Watts River is set up for catching Platypuses. The whole length of the net must be suspended partially out of water so that the Platypuses can breathe.

length of the net is suspended partly out of the water, so a captured Platypus has access to air. The nets are set in pairs, to catch animals travelling in either direction, and checked every hour from the time they are set in late afternoon to early the next morning.

My studies have concentrated on the animals living along two tributaries of the Yarra River, about 65 kilometres east of Melbourne. Badger Creek and the Watts River were selected as study sites partly because of the high number of recent Platypus sightings by local residents. Both water bodies flow through a variety of land habitats, including forest, farmland and suburban development, with the Watts River actually passing through the township of Healesville. Another reason for choosing these sites was that both are fairly small streams, one to five metres wide. In theory, as the cross-sectional area of a channel shrinks, it should be increasingly easy for an animal to defend a segment of that channel as its own exclusive feeding or breeding territory. Hence, spacing patterns among Platypuses occupying small streams may be more clear-cut than in the case of larger water bodies.

To date, 25 animals have been fitted with radio-tags, some in more than one tracking period. Each radio-tagged Platypus is located regularly during daylight hours, when it is usually curled up asleep in a burrow. Active animals are tracked from the time they exit a burrow to when they return for the day. A hand-held compass is used to note the direction of the strongest radio signal as the animals move along a stream.

THE FIRST PLATYPUS I RADIO-TAGGED was a lactating mother, christened 'AA'. Her nesting burrow had three pos-

PETER MARSACK/LOCHMAN TRANSPARENCIES

sible entrances, only one of which showed signs of recent use. The point along the ground where AA's signal was strongest indicated that her nesting chamber was about three metres from the edge of the water, and five metres from the well-used entrance. By tracking AA carefully for the next five nights, I learned she left her burrow between 8.15 and 9.30 p.m. each evening to forage, and returned between 6 and 7 a.m. to care for her young. Then, on the sixth morning, AA failed to enter her nesting burrow as usual. What could have happened? After picking up a weak signal, I tracked her to a new burrow, 230 metres downstream from her original den, where she spent the entire day. Subsequent research along Badger Creek has shown that such behaviour is not unusual, with Platypus mothers leaving their offspring unattended for up to 38 hours at a time. A female Platypus may avoid returning to her nesting burrow more than is absolutely necessary, because of the effort required to dig through and then reshape the soil 'pugs' that are used to block the entrance tunnel when she is gone. Interestingly, female Short-beaked Echidnas also make a habit of leaving their dependent young unattended for lengthy periods, sometimes up to ten days.

Accomplished diggers, Platypuses can complete one metre of tunnel every two hours.

The Platypus has five sturdy claws on each front foot and is accomplished at digging. Based on observations in captivity, an animal can complete one metre of tunnel in about two hours. It should therefore come as no surprise that Platypus burrows do not appear to be in short supply along Badger Creek and the Watts River, with as many as 11 different burrows occupied by one adult female within a six-week period. The 'camping burrows' used by individuals without young appear to be simple structures, less than three metres long. The entrances to such burrows are usually hard to see, opening under water or just at the water's surface where they are often hidden by an undercut bank or log. Radio-tracking work has shown that Platypus burrows sometimes are occupied by two adults simultaneously, and may also be used by different individuals over time (for example, a burrow jointly occupied by an adult male and a subadult male for four days in January 1990 was later used by an adult female in June 1992).

Adult female Platypuses living along Badger Creek don't defend exclusive home range areas. Instead, neighbours overlap by about 50 per cent. This arrangement means that any point along a stream is usually shared by two females. It also means that females can limit the amount of time in which they come into contact, given that a Platypus can only be in the upstream or the downstream half of her home range at any point in time. An adult female home range along Badger Creek is up to 2.3 kilometres long, with animals moving as much as 1.9 kilometres in a single night.

The radio-tracking research undertaken along Badger Creek has confirmed that the Platypus lifestyle tends to be solitary, with females raising their offspring without any help from males. Therefore, to maximise his reproductive success, a male's optimum strategy consists of mating with as many females as possible. It follows that one would expect male home ranges to be larger than those of females, at least around the time of breeding in late winter and spring. For example, an adult male (K) tracked along Badger Creek at this time of year occupied nearly five kilometres of stream, overlapping with at least three grown females. Other females probably lived along an adjoining stretch of the Yarra River, 2.3 kilometres long, where he was also frequently found. When tracked overnight, K travelled a net distance of up to 6.2 kilometres, journeying back and forth along Badger Creek, from Badger Creek downstream into the Yarra, or back and forth along the Yarra past the mouth of Badger Creek. He also spent more time at the upstream and downstream ends of his home range than elsewhere, suggesting that he was patrolling these

EGGSTRAORDINARY REPRODUCTION

The Platypus breeds in late winter or spring, laying clutches of one to three eggs from August to October. Platypus eggs are only about 17 millimetres long and have a thin, white, leathery shell, like those of lizards. It is believed that the eggs are incubated between the female's curled-up tail and belly as she lies on her back or side in the underground nest. The length of incubation is probably about 10 to 11 days, similar to the incubation period of the Short-beaked Echidna.

It is unknown whether wild females leave the burrow to feed during incubation. In captivity, the Australian naturalist David Fleay observed that an incubating female first entered the water 5.5 days after retiring to her burrow. During her brief swim she defecated but did not feed. It was not until 11.5 days after incubation had begun that she was recorded actually eating something.

Platypus milk is rich in iron and contains only traces of lactose. A female Platypus does not have nipples. Instead, milk is secreted from two round patches of skin, about midway along the mother's belly. In captivity, a young orphan Platypus feeds by slurping up milk from a human palm with back-and-forth sweeps of its stubby bill. Under normal circumstances, such rhythmic pressure probably helps to stimulate lactation.

Juveniles first emerge from their nesting burrow in January to March. At this time they have grown to about 80 to 90 per cent of their adult length. Males and females are both believed to be capable of first breeding at the age of two years, although some females may not produce young until they are four years old or more. One female Platypus first caught as an adult along the Shoalhaven River by Dr Tom Grant in 1973 was found to be lactating 11 years later in 1984. The longest reliable age record for a Platypus is 17 years.

A Platypus radio-tag after being assembled but before being coated in epoxy resin. Once activated, this radio-tag can be used to track the Platypuses' movements for up to 14 weeks.

M. SERENA

areas in order to discourage neighbouring males from trespassing on 'his' property.

A world record for Platypus travel was set by another adult male (M), first radio-tagged along Badger Creek in May 1992. His signal could not be picked up along the stream on the following morning, and it was feared that the tag had failed. However, one month later his signal was located from a specially equipped aeroplane along a stream known as Woori Yallock Creek, more than 15 kilometres from where he had been released! M remained in this area for the next five weeks, and then again disappeared. This time, another aeroplane search found him back along Badger Creek, asleep in a burrow just a kilometre or so from where he had first been caught. No further information is available to help explain M's far-ranging behaviour. However, M's return does suggest that it may be difficult for a male like K to maintain an exclusive harem in the breeding season, no matter how hard he works at guarding a stretch of stream or river against rival males.

EARNING THEIR SPURS

From the time he first leaves the nesting burrow, a young male Platypus is equipped with a conspicuous, cone-shaped spur just above the heel of each hind leg. The juvenile spur is covered by a chalky white sheath, which chips away to reveal the amber-coloured spur by the age of one year. A young female Platypus has tiny whitish or brown 'spurs' (actually sheaths, one to two millimetres long) that are shed before her first birthday, leaving a small pit to mark each spot.

The spurs of adult males are 1.2–1.5 centimetres long and slightly curved, like a dog's canine tooth. Each hollow spur is connected to a venom gland in the upper thigh. The glands first become active when the male reaches maturity, and are largest during the breeding season. This suggests that spurs may be used as weapons when males compete for breeding territories or females. It is unknown whether such competition may lead to animals being killed in the wild. In captivity, a 15-year-old male Platypus died some days after being repeatedly spurred by a three-year-old male in December (after the breeding season), with the poison apparently responsible for major tissue damage. Platypus poison causes severe pain and swelling in humans, but is not considered to be life-threatening.

J. GARDNER

This adult male spur drips venom, which is produced by glands in the animal's upper thighs. Such spurs may be used as weapons by competing males.

WHILE THE PLATYPUS CAN STILL BE found over much of its historical range, the species has declined or disappeared in some areas. Various predators have been reported to kill Platypuses, including domestic dogs and cats, foxes, goannas, pythons, crocodiles, Murray Cod and birds of prey. However, the most significant modern threats to Platypus populations almost certainly stem from human activities. Although the species is fully protected by law, anecdotal evidence suggests that animals continue to drown regularly in completely submerged fish traps and nets (often those set illegally) or die after becoming entangled in rubbish, such as discarded loops of nylon fishing line. Chemical pollutants—such as paint thinner or used car engine oil that gets tipped down a storm drain—can harm Platypuses by fouling their fur or poisoning the aquatic invertebrates (such as insect larvae, small snails and mussels, shrimps, yabbies and worms) on which they mainly feed.

My research has shown that, while the Platypus is still reasonably widespread, the animals occur at low population densities in much of their habitat. For example, the average Platypus population density along Badger Creek and the Watts River is just one to two animals per kilometre of stream (excluding juveniles). The animals are capable of moving long distances, and have large home ranges relative to their body size. Thus, even in relatively big streams, Platypus populations are unlikely to be large enough to persist in isolation from others. Together, these traits underscore the importance of conserving adequate Platypus habitat *throughout* catchments in the species' range, including not only streams but also intervening sections of river. By working to improve stream and river corridors and water quality in their area, people can help to ensure that the Platypus, one of Australia's most fascinating mammals, remains secure into the future. ■

Further Reading

Grant, T., 1989. *The platypus: a unique mammal.* New South Wales University Press: Kensington.

Grant, T.R., Grigg, G.C., Beard., L.A. & Augee, M.L., 1992. Movements and burrow use by platypuses, *Ornithorhynchus anatinus*, in the Thredbo River, New South Wales. Pp. 263–267 in *Platypus and echidnas*, ed. by M.L. Augee. Royal Zoological Society of New

PETER MARSACK/LOCHMAN TRANSPARENCIES

Platypuses are solitary animals, limiting the amount of time they spend in contact with one another. This particular animal has a transmitter glued above the base of its tail.

South Wales: Mosman.

Griffiths, M., 1978. *The biology of the monotremes.* Academic Press: New York.

Serena, M., 1993. *Platypus—helping them in the wild.* Land for Wildlife Note No. 27. Department of Conservation and Natural Resources: East Melbourne.

Serena, M., 1994. Use of time and space by platypus (*Ornithorhynchus anatinus: Monotremata*) along a Victorian stream. *J. Zool. Lond.* 232: 117–131.

Dr Melody Serena is continuing her studies of Platypus ecology with the Melbourne-based conservation organisation, Species Survival Australia. Special thanks are due to Janet Gardner for her hard work on behalf of Platypus field studies along the Watts River and Badger Creek. The research described here has been funded by the Chicago Zoological Society, Sir Colin MacKenzie Trust, Winifred Violet Scott Trust, Zoological Board of Victoria, and Species Survival Australia.

PETER MARSACK

Radio-tracking Platypuses at Badger Creek. From the signals received, it is not only possible to pinpoint and identify an individual but also to tell whether it is feeding or asleep in its burrow.

QUINTESSENTIAL QUEENSLAND

BY LLOYD NIELSEN

My main interest in wildlife photography has been in lighting techniques. I prefer to use flash as the sole lighting source where possible, sometimes using up to five flash heads. However, photographing wild animals with this method can be very frustrating as you have to spend a lot of time gaining their confidence. With animals such as possums and gliders, it can take months to get them to a stage where I can set up the flashlights without disturbing them. And the frustration doesn't end there—subjects can be chased away by other individuals or a sudden downpour can mean hours spent setting up equipment are wasted. Thankfully I have found birds an easier subject but I now understand why some photographers concentrate on still-life subjects!

A male Victoria's Riflebird (*Ptiloris victoriae*) from upland tropical rainforest in Mount Spec National Park.

Common Nursery-frog (*Cophixalis ornatus*) at Paluma, northern Queensland.

Blue-tongue flower (*Melastona affine*) from Cape Tribulation.

Red-browed Finch (*Neochmia temporalis*) at Mount Barney, Queensland.

QUINTESSENTIAL QUEENSLAND

A male Australian King Parrot (*Alisterus scapularis*) at Bunya Range, Queensland.

Blue Quandong (*Elaeocarpus grandis*) fruit and fallen leaves, Cape Tribulation.

P H O T O A R T

Russet-tailed Thrush (*Zoothera heinei*) at its nest in Lamington National Park.

Fallen flowers of the Powderpuff Wattle (*Acacia flavescens*) on roots and rocks at Emmagen Creek, Northern Queensland.

A male Golden Bowerbird (*Prionodura newtoniana*) at Mount Lewis National Park.

PHOTOART

Grey Fantail (*Rhipidura fuliginosa*) nesting in Lamington National Park.

QUINTESSENTIAL QUEENSLAND

The 300,000 ravenous bats we had come to study were pouring out high over our heads, streaking for the night as they had done for millions of years.

BORNEO BATS AND SWEATY INSIGHTS

BY MICHAEL ARCHER

HENK GODTHELP WAS A DISembodied voice somewhere ahead in the constant rain of bat droppings and body-warm water. Only the barely visible glow of his torch indicated where, in this colossal 11-hectare cave, he had gone. Anxious to see what he had found, we closed up and labelled the sample bags filled with decomposing bat carcasses: "Rear Chamber, Niah Great Cave, Sarawak, Borneo". Suzanne Hand jumped nimbly off the remnants of the limestone floor we had been searching, to more ancient foundations below. In circular pools beneath its edge, older reddish-brown bat bones danced to the sound and fury of drops of water cascading from the 60-metre ceiling overhead. Clinging by their toes to the black dome far above us were colonies of many species of bats, including some with extinct cousins in the 20-million-year-old fossil deposits of Riversleigh, Queensland—the main reason we were here. Here, as in Riversleigh, diverse leaf-nosed bats lived with false vampires, free-tailed bats and common bats in limestone caves in lowland rainforests. By studying the modern situation of these Borneo bats, Sue hoped to better understand the prehistoric environments at Riversleigh. No similar situations exist in modern-day Australia or New Guinea.

When we reached Henk, only his quivering boots were visible. The rest of him was wedged head-first into a cleft beneath a vast limestone block. The 'tink, tink, whump' of his hammer and chisel indicated that something most curious had caught his eye. "Look at this" he huffed, as a dripping hand holding a black object jutted out from under the block. Expecting more bat bones, it was a shock to see the fossilised skull of a large turtle. Arthur White was later to conclude that it was a new species of pig-nosed turtle closely related to but different from *Carettochelys insculpta*, a freshwater species restricted to northern Australia and New Guinea. The turtle was a most unexpected Australian connection this far west of Wallace's Line.

Pleased with the day's finds, we prepared for the long return trek out of Niah Great Cave. The sounds of impatient bats stirring and swiftlets returning

As we climbed, thousands of pale, cicada-sized earwigs swarmed up the insides of our trousers and shirts, into our hair and down our backs.

increased as evening approached. We marched in single file along the narrow paths and wooden stairs that wove a slippery, drunken path around mountainous pillars and vast domes of dung-covered limestone. A waterfall that fell from the ceiling transformed to mist before it reached the floor below. By the time we reached the top of the colossal rubble pile in the entrance chamber, the 300,000 ravenous bats we had come to study were pouring out high over our heads, streaking for the night as they had done for millions of years.

We followed them into the rainforest as we headed towards the boat waiting to take us down river. Rain soon joined forces with sweat to wash the cave earth from our bodies. Millipedes 20 centimetres long and as thick as my thumb ambled along the walk beside us, while startled, narrow-headed snakes darted out of our way through the overhanging foliage. As we marched, the cacophony of frog and monkey calls was interrupted by unfamiliar cries and guttural coughs, making us think of Clouded Leopards and Sun Bears, as well as the dubious rumours that Sumatran Tigers might still prowl these forests. I turned on my mini tape-recorder so that the finders of our remains would at least

PHOTOS : M. ARCHER

The massive entrance chamber of Niah Great Cave. In rear chambers, suspended high over newly discovered fossil deposits, 300,000 hungry bats await the night.

Cave-riddled and bat-occupied limestone cliffs, leaning over pools in the lowland rainforests of Borneo: herein lies clues as to how some of the 20-million-year-old fossil deposits of Riversleigh, Queensland, may have accumulated.

know what well-fed beast had done the deed.

As we sloshed to the top of a set of fern-covered stairs, our torchlight was reflected by a huge limestone wall. Its cave- and fissure-riddled face leaned out over a shallow forest pool entirely surrounded by rainforest trees and vines. Little bats were darting everywhere, some even skimming the surface of the pool to catch an insect or scoop up a drink. We paused, excited by what we saw. This was very close to the situation we suspected was once common in the Riversleigh area of Queensland. Countless thousands of fossil bat bones in many of Riversleigh's limestone deposits appear to have accumulated in forest pools in similar, species-rich, lowland rainforest. It was tempting to think of the nocturnal scene in front of us as a kind of 'living fossil' micro-environment—one that suggested our scenarios for prehistoric Riversleigh were at least not impossible.

Four days later at Deer Cave, in the watershed of the mighty Baran River, our continuing search for Riversleigh-type situations found us clawing up the annoyingly mobile slopes of a vast pile of Naked Bat (*Cheiromeles torquatus*) poo. If skeletons persisted on this pile in 100 per cent humidity, that fact might have bearing on the conditions in which bones accumulated in Riversleigh's fossil caves. As we climbed, thousands of pale, cicada-sized earwigs swarmed up the insides of our trousers and shirts, into our hair and down our backs, perhaps thinking we were oversized bat carcasses in need of dismemberment. It was certainly a memorable experience and a learning one too. It supported another of Sue's hypotheses based on the study of Riversleigh fossil deposits: in conditions of this kind, bat bones are unlikely to survive unless they fall directly into water. On the poo piles themselves, high acidity and humidity and millions of hyperactive insects seem to obliterate the delicate bones before they can even think of becoming fossils.

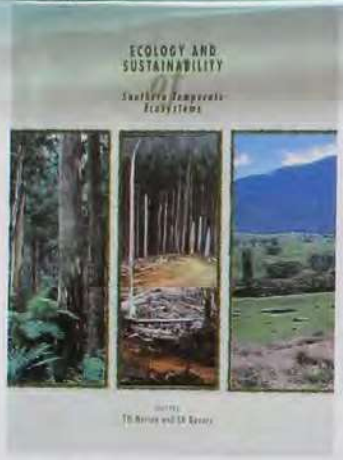
Since returning home, Sue has been exploring the mass of Borneo data to test hypotheses about Riversleigh's bat palaeoenvironments. But as she continues to develop new ideas for testing, more data from modern environments is required. A return trip to Borneo would be very useful. Arthur White also desperately wants more of his new prehistoric pig-nose, and Henk can't help wondering what other Australian-related beasts await discovery in that curious deposit. Yes, a return trip to Borneo would be very useful indeed. As for me, I sit here late at night in my annoyingly tame office in Sydney, marvelling at 'Fangaroo', the recently discovered Miocene tusked kangaroo from Riversleigh, while I let the tape-recording we made outside Niah Great Cave waft over the suburb of Maroubra (the calls to the police should be interesting!). Curiously, in many ways 'Fangaroo' is most similar to the Common Barking Deer (*Muntiacus muntjac*), one of the tusked muntjacs that inhabit the modern, lowland rainforests of Borneo. What a coincidence, eh? (Where's my suitcase?) ■

Further Reading

Payne, J., Francis, C.M. & Phillips, K., 1985. *A field guide to the mammals of Borneo.* The Sabah Society with World Wildlife Fund Malaysia: Kuala Lumpur.

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.

REVIEWS



Ecology and Sustainability of Southern Temperate Ecosystems

Ed. by T.W. Norton and S.R. Dovers. CSIRO Publications, Vic., 1994, 133pp. $39.95rrp.

Three main themes recur through this book: how much we know, how much we need to know and, sadly, how unsuccessfully our knowledge is incorporated into policy and our policy into practice. The solutions are not new, merely repackaged into what I find an unnecessarily academic format, particularly when the chief problem identified is that scientists are poor at communicating with a wider audience.

This is a book written for professional ecologists and prospective buyers should not be distracted by the title. It is mostly a collection of conference papers by some of Australia's leading forest ecologists, although it does give the impression that little forest ecology is done in places other than Canberra. The enthusiastic lay person will certainly learn from several chapters, but I would recommend the Resource Assessment Commission Report as a text that is both easier to read and of greater 'infodiversity'.

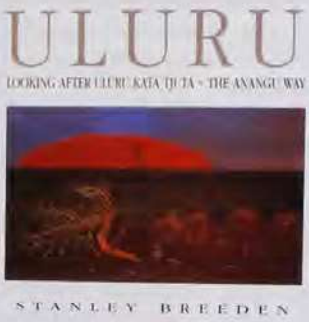
The book would have been more honestly titled "Ecology and Sustainability of Temperate Australian Forests", as other ecosystems do not get a look in. The highlight of the book is the synthetic review of timber-harvesting impacts on arboreal marsupials by Lindenmyer. There is also an excellent chapter on tree hollows by Gibbons that provides data on their abundance, use, formation and recruitment. For example, although cutting cycles are in the range of 30 to 150 years, *Eucalyptus pilularis* only starts to form hollows at around 150 years and peak hollow production in *Eucalyptus regnans* is at 570 years.

The chapter by Scotts presents an exciting framework for sustainable forest management at a regional level—it builds on the data chapters and produces something doable for planners and land managers. The remaining six chapters give coverage to other issues of forests and sustainability but they contain little in the way of new ideas or conceptualisation.

A book exposing the extent of forest mismanagement would have little credibility were it not printed on recycled paper. However, although green-printed text may discourage the enthusiastic photocopier, it makes it impossible to read the book in an old-growth forest—even the train was a challenge.

The papers are sufficiently well linked both in content and connective chapters to justify their publication as a book. However, it is not a friendly book and I am left with the feeling that the messages could have been conveyed, just as effectively, in more accessible professional journals. As the editors emphasise, well over half the available intellectual resources in the Australian conservation debate have been devoted to forests, perhaps at the expense of other ecosystems. The priority for future publications on forest sustainability should be to discuss the issues and the information in a way that is accessible to a broad public audience.

—Richard Major
Australian Museum



Uluru: Looking after Uluru-Kata Tjuta—the Anangu Way

By Stanley Breeden. Simon & Schuster, NSW, 1994, 210pp. $45.00rrp.

Tony Tjamiwa says in the foreword to *Uluru* that this book is an important one. He goes on to say that included in the book are "our ideas, our stories from the past, that Stanley has put down on paper here. By drawing them together and putting them down on paper, I hope that Stanley will help people to understand us and our history and law. I hope that understanding will draw all of us together as one people." Tony Tjamiwa, an Anangu owner of the land, is much better placed than me to judge the worth of this book.

The book is also a very personal account of Uluru for Stanley Breeden. The first chapter is written in the first person and the present tense. Reading the text gives you a glimpse of this fascinating area of Australia through the eyes of Breeden. He leads you through the physical area, the land and the fauna, and then into the distant past and the Anangu accounts of the origins of the land and the importance of this to the present.

One chapter in the book deals with the geology of the area, another with the amazing adaptations and interrelatedness of the plants and animals that have to survive in the harsh and often unpredictable conditions. These chapters are descriptions of the land through the eyes of Piranpa (an Anangu word meaning 'pale' that is used to describe white people).

Chapter 10, titled "Tracks", shows the deep understanding and knowledge of the land the Anangu have, through the eyes and words of tracker and ranger Edith Imantura Richards. Her intimate knowledge of the animals, their behavioural characteristics and tracks enable us to view the landscape and the animals through her eyes. Links are made where appropriate to her custodial and educational role, and to Anangu history and law. A nice connection is made with the painting done by Kunbry Pei Pei and the story of Uluru. This section works well because we are now steeped in the physical aspects of the land, we have walked through the area, we understand the geological history and the Anangu history, and we have the present landowners explaining it to us.

The introduction of rabbits and other introduced animals, such as foxes and cats, has had a devastating effect on the land and wildlife, especially the small to medium-sized mammals. The role of drought, fire, hunting, feral species and the interactions between these factors form the basis of land management practices of both the Anangu landowners and the Piranpa agencies today.

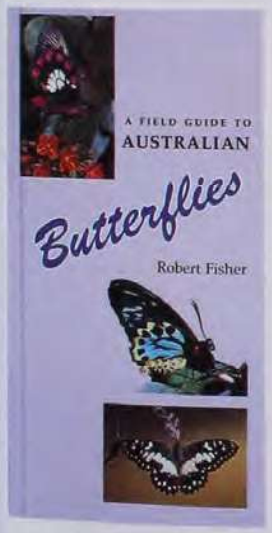
The intrusion in time of Piranpa into this land is a mere few hundred years of its long history. The effect will be long lasting and something that the original landowners could never have guessed at in their early encounters. The drought in the 1930s, the incursions into Anangu land by white explor-

ers, police, anthropologists, missionaries, government officials, farmers, and the introduction of sheep and cattle caused hardships and changed Anangu life irrevocably.

At one level *Uluru* makes a perfect coffee-table book in the best sense. You can come back to it again and again. The photographs are wonderful and, as you flick through the pages, the informative captions are satisfying and give the reader an insight into the life, the land and the law of this part of the Centre. Because many of the chapters are set in particular seasons, the book would be useful pre-reading if you were planning a trip to coincide with sightings of reptiles or a flush of flowers after spring rains, or to gain an insight into the land as the Anangu know it.

I enjoyed this book very much, however, as with all books of this genre, I did baulk a little at the price tag. Perhaps a hint before your next birthday?

—Anne Skates
Australian Museum



A Field Guide to Australian Butterflies
By Robert Fisher. Surrey Beatty & Sons, NSW, 1995, 254pp. $29.95rrp.

The author has done well in selecting more than 200 of Australia's nearly 400 species for inclusion in his field guide. A little practice and careful use of his, mostly good, coloured plates should enable you to recognise common species.

Some illustrations are larger than life. I would have preferred them to be nearer natural size, but wing span is given for each species in the text. Most illustrations are of 'set' specimens, these being more useful for identification than those of live specimens with wings in a natural position. It is refreshing, however, to see many illustrated in a more natural stance. This gives a 'lift' to the book. On the page opposite the illustration of each species is general information on its distribution in Australia and beyond, with brief comments on immature stages and food plants.

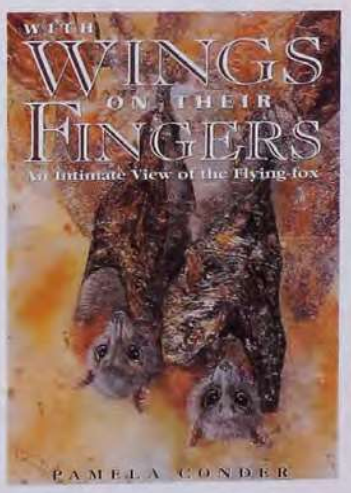
A few statements in the book are a little out of date. This is mostly the result of recent research rather than any fault on the part of the author. However I do suspect that the illustration (upper side) of the female *Candalides consimilis* is, in fact, of a female of the very similar *Candalides absimilis*. In *C. consimilis* there is more purplish suffusion over the white patch in the hind wing. Also, Australia's most spectacular butterfly is referred to as *Troides euphorion* and given the common name of Cooktown Birdwing. To most butterfly collectors it would be known as *Ornithoptera priamus euphorion*, one of the subspecies of the Cairns Birdwing.

It is impossible to illustrate the eggs, caterpillars and pupae of all the species in a small field guide but a fairly useful compromise has been devised by giving typical examples at the beginning of the section dealing with each family. There is a useful, short glossary of terms near the back of the book, but it should be noted that "metamorphosis" refers to the series of changes of form through which an insect passes from egg to adult, not just the change from pupa to adult.

In only a book such as this would you find phrases such as "Roger was copulating like a professional" to drive home an important point (so to speak) about mating systems!

This book has all the features of a good field guide and is reasonably priced. The print is big and clear, the headings and names stand out, the sections of text for each species are clearly separated from each other, and the page shape is convenient for taking into the field. Most importantly, the cover is thick and the binding is strong so it should stand the wear and tear of field use.

—C.N. Smithers
Australian Museum



With Wings on their Fingers: An Intimate View of the Flying-fox
By Pamela Conder. Angus & Robertson, NSW, 1994, 168pp. $29.95rrp.

If you like flying-foxes, then you're going to love this book. If you don't like these animals, read the book any-

way and you'll understand why these bats now have such a big following.

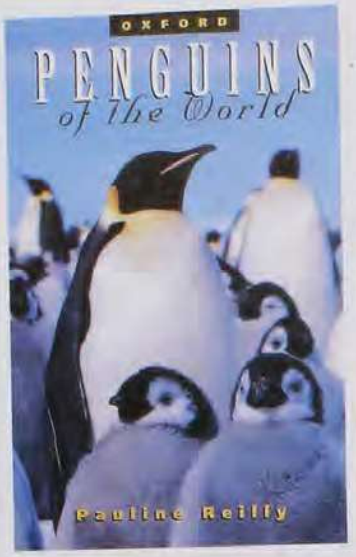
For nearly 25 years I've been in the small army of people trying to convince the broader community that bats are the good guys, not only to the lay public but other wildlife scientists as well. I wish that at the onset I had this book in my armoury. Scientists can sometimes get stale when trying to get the message across. They use the same set of verified facts, amusing snippets and on occasion a little bit of calculated guesswork. As an author, Pamela Conder is quite the opposite: she still uses the verified facts but cleverly embellishes them with a vast array of natural history observations and a few good yarns.

Pamela's other talents include a bent for history, and this book will provide a good resource for people (particularly taxonomists) who need a reference and a synopsis of the much muddled rearrangements that have occurred in the systematics of *Pteropus*. For example, Pamela's extensive investigations into the provenance of the now-extinct Dusky Flying-fox (*P. brunneus*) are well summarised, and exemplify well the dilemmas that we have in properly classifying some of our bat fauna.

With wings on their fingers isn't just a good natural history text, it is also a very good read because it is interspersed with humorous anecdotes and some interesting ways to emphasise an element of behaviour. In only a book such as this would you find phrases such as "Roger was copulating like a professional" to drive home an important point (so to speak) about mating systems!

If you are a critical scientist, then please ignore some of the non-standard methods that would worry some editors: this book offers so much that these quirks soon go unnoticed. *With wings on their fingers* is a 168-page potpourri of good science and natural history, enriched with summaries of major issues and topics (such as phylogeny, taxonomy, behaviour, reproduction), topped off with good humour and anecdotes, and elegantly adorned with colour plates and sketches that attest to the author's standing as a well-recognised artist.

—Greg Richards
CSIRO Wildlife & Ecology, Canberra



Penguins of the World

By Pauline Reilly. Oxford University Press, Vic., 1994, 164pp. $19.95rrp.

This book comprises an introduction on the diversity of penguins, a chapter on each of the six main groups of penguins (in which are discussed such topics as description, dispersal, populations at sea and on land, behaviour and breeding), and a final chapter on threats, conservation and the future.

Pauline Reilly has studied the Little Penguin intensively and had the opportunity to study the Gentoo Penguin on Macquarie Island. She has also had the opportunity to observe several of the other 17 species of penguins in the field. Thus, she speaks with an appreciation of how they live, and to this she has added the accumulated knowledge of the last 40 years. Furthermore, she has been able to incorporate the latest information from the Second Penguin Symposium held in 1992, and colour plates from the *Handbook of Australian, New Zealand and Antarctic birds* (1992). There is also a good selection of black-and-white photographs and illustrations.

The style is one that can be easily read by anyone wanting to know more about penguins. There is a large amount of good information in each of the chapters, which altogether give an excellent account of this highly specialised group of birds. I recommend this book to the student at school who needs information for a project, to the naturalist wishing to increase their knowledge of this group, and to the scientist who simply would like to gain a rapid 'feel' for the group. It is not often that a book can satisfy the needs of all these readers. I hope that there will be additional books of this type to cover other specialised groups of birds.

—M.D. Murray

Butterflies of Tasmania

By Julie Virtue and Peter McQuillan. Tasmanian Field Naturalists Club, Hobart, 1994, 104pp. $24.95rrp.

This excellent book is probably best described as a field guide to Tasmanian butterflies. It illustrates all species (except two based on old single records) in colour. In fact, it is the illustrations that make the book so attractive. Artist Julie Virtue has captured the true 'essence' of each species in meticulously executed watercolour portraits. There is just one butterfly per plate and these are presented in a variety of interesting and unusual formats, sometimes as live individuals, sometimes as museum specimens artistically dissected so that both the upper and underside of the wings can be viewed, but most often they are portrayed with wings spread flat so that they appear neither dead nor alive but just a delight to look at. Frequently a sprig of the larval food plant is also incorporated into the paintings, giving a useful extra dimension to the information the book provides.

The text has been written by Peter McQuillan, a well-known and highly regarded entomologist with a remarkable local knowledge of Tasmanian insects. All known facts on biology, flight period, food plants and distribution are summarised for each species, and occasional additional snippets from the author's own observations have been added. I was particularly impressed with the distribution maps, which plot localities from which a species has been recorded on a 10 x 10-kilometre grid; these maps exceed in accuracy and detail any previously published for Tasmanian butterflies.

The introductory section of the text provides an excellent brief overview of butterfly biology, diet, conservation and classification. McQuillan's views on conservation make interesting reading and good sense.

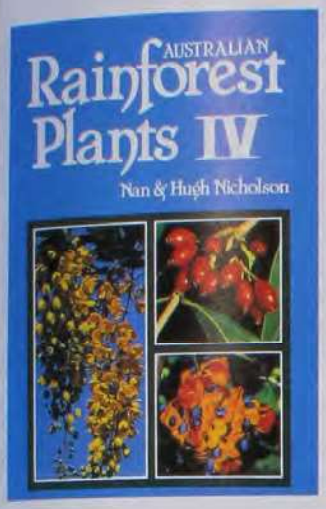
The text is remarkably free from errors; I could find just one slip (page 66) where *Nesoxenica leprea leprea* is erroneously recorded from eastern (rather than western) Tasmania and just one minor typographical error. The text for *N. leprea* also should have mentioned that the male is figured at the end of the Introduction; only the female appears opposite the text and the reader may be unaware that the male appears elsewhere.

There is no doubt that this book fills an important gap in Tasmanian natural history publications, and it fills it exceedingly well. The book will be invaluable for anyone wishing to identify butterflies in the field and is small enough to conveniently carry in a backpack.

If you have any kind of interest in Tasmanian butterflies, this book should be on your shelf, whether you are a professional biologist, a weekend naturalist or just a bushwalker with a love of nature. I congratulate the artist, the author and the

Tasmanian Field Naturalists Club, which published the book, on an outstanding effort.

—M.S. Moulds
Australian Museum



Australian Rainforest Plants IV
By Nan and Hugh Nicholson. Terania Rainforest Publishing, NSW, 1994, 72pp. $14.95.

I don't know about other gardeners, but I find rainforests both fascinating and frustrating—a bit like this book in some ways. Fascinating because of the immense range of beautiful and unexpected plants that inhabit Australia's rainforests, and the pages of this book. Frustrating because no one gardener can hope to cultivate them all, despite the fervent desire to do so, which this book engenders. But despite wanting to curse the authors for whetting what may amount to an unquenchable appetite, I can't really do that. Nan and Hugh Nicholson's Rainforest Plants series is just too good to justify that kind of petulance.

As the title implies, this is the fourth book in the series and it deals with Australian rainforest plants in the context of both their natural rainforest home and their cultivation in gardens. This book follows the series' format of a separate paragraph of general text about each species, along with a brief description on cultivation and propagation. Accompanying the text for each species is a colour photo usually depicting foliage, flowers and perhaps fruits. The 114 species dealt with in this volume are presented alphabetically by scientific name and indexed by common name. A brief discussion on the role of disturbance in rainforest ecology concludes the book.

And that's it! No long dissertations on the aesthetics of rainforests. No dry botanically correct descriptions. No quotes. A damn good thing too. Nothing more is really needed to achieve the authors' aims of exposing us to some of Australia's rainforest plants and giving us some information on how to grow them. Modest but worthy aims that result in modest but worthy books. In fact, the small physical size of the books in this series might tempt you to dismiss them at first sight. Especially when displayed alongside the plethora of larger coffee-table books dealing with rainforests. But don't be fooled. The text is excellent and the photographs superb.

One thing that is always a problem with any series that grows bit by bit, is the lack of coordination between volumes. This could have presented a serious practical difficulty in utilising this series in that each volume deals with a different suite of rainforest plants. How does one find a particular plant in the series without remembering which volume it is in, or going through each volume's index? A cumulative index of course. The authors have wisely included a coupon in this volume that may be used to obtain a free cumulative index of common and scientific names for books I to IV. Problem solved.

So really there is not much else to say. If you are interested in rainforest plants, or are a gardener of Australian natives, or are simply curious about what the fuss over rainforests is all about, then this book (or any of the others in the series) will get you started. Or should I say hooked? (I'm sure we can fit another strangler fig in the backyard.)

—Greg Gowing
Australian Museum

The Guide

Welcome to The Guide, ***Nature Australia's*** **marketplace for over 100,000 people who now read every issue of the magazine. As a *Nature Australia* reader you are part of a very special group – a large and growing band of enthusiasts with a real interest in Australia's nature. *Nature Australia* is read in homes, universities, colleges, schools, libraries and other institutions across Australia and overseas.** ***Advertisers can reach this very special group for a surprisingly low cost in* The Guide.**

Call Sari Järvenpää on (02) 320 6179 for full details.

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:

CONSERVATION

Australian Trust for Conservation Volunteers
PO Box 423, Ballarat, Vic. 3353.
Ph: (008) 032 501
Contact: Sandy Squire, Membership Enquiries

Membership fee: $25.00 (single); $30.00 (family)

National Parks Foundation of SA Inc.
GPO Box 759, Adelaide, SA 5001.
Ph: (08) 231 0016
Contact: Helen Jaensch, Secretary of Council

Membership fee: Donation

EDUCATION

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

Membership fee: $19.50

ENVIRONMENTAL

Port Sorell Landcare Group Inc.
PO Box 48, Port Sorell, Tas. 7307.
Ph: (004) 28 6507
Contact: David J. Lane, Coordinator

Membership fee: $15.00

GEOGRAPHIC

The Royal Geographical Society of Qld Inc.
112 Brookes St, Fortitude Valley, Qld 4006. Ph:(07) 252 3856
Contact: Kath Berg, Administrator

Membership fee: $30.00

INSECTS

The Australian Entomological Society Inc.
c/- Dept of Crop Protection, Waite Campus, Univ. of Adelaide, PO Glen Osmond, SA 5064.
Ph: (08) 370 2987
Contact: Dr Paul Madge, Hon. Secretary

Membership fee: $50.00

The Society for Insect Studies
11 Melrose Parade, Clovelly, NSW 2031. Ph: (02) 665 2169
Contact: Mr B.L. Brunet, Hon. Secretary

Membership fee: $10.00

MOLLUSCS

The Malacological Society of Australia Ltd
c/- Australian Museum, Division of Invertebrate Zoology, 6 College St, Sydney, NSW 2000.
Ph: (02) 339 8275
Contact: Alison Miller, Secretary

Membership fee: $30.00 (Aust.)

MUSEUMS

Friends of the Qld Museum
PO Box 3300, Sth Brisbane, Qld 4101. Ph: (07) 840 7641
Contact: Sandra Mann, Exec. Officer

Membership fee: $25.00 (single); $30.00 (family); $20.00 (conc./country)

The Waterhouse Club
SA Museum, North Terrace, Adelaide, SA 5000.
Ph: (08) 207 7389
Contact: Mary Lou Simpson, Exec. Coordinator

Membership fee: $50.00 (single); $70.00 (family)

TAMS, The Australian Museum Society
Australian Museum, 6 College St, Sydney, NSW 2000.
Ph: (02) 339 8225 F:(02) 360 3073
Contact: Megan Alsop

Membership fee: $50.00 (single); $65.00 (family/joint); $40.00 (conc.)

NATURAL HISTORY

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

Membership fee: $20.00

Royal Society of SA Inc.
c/- SA Museum, North Terrace, Adelaide, SA 5000.
Ph: (08) 223 5360
Contact: Mr J.F. Wallman, Hon. Secretary

Membership fee: $30.00

Linnean Society of NSW
PO Box 457, Milsons Point, NSW 2061. Ph: (02) 929 0253
Contact: Mrs B.J. Stoddard, Secretary

Membership fee: $50.00; $28.00 (students)

The Postal Microscopical Club of Aust.
28 Valley Rd, Hazelbrook, NSW 2779. Ph: (047) 58 7128
Contact: Michael Dingley, Secretary

Membership fee: $30.00 - $13.00 (depending on category)

REPTILES

Hawkesbury Herpetological Society
PO Box 2, Whalan, NSW 2770.
Ph: (02) 832 8714
Contact: Sharon O'Brien, Secretary

Membership fee: $5.00 (single); $20.00 (family)

SA Herpetology Group
c/- SA Museum, North Terrace, Adelaide, SA 5000.
Ph: (08) 201 2805(w) 272 2730(h)
Contact: Tim Milne, President

Membership fee: $20.00 (adult)

Tasmanian Herpetological Society
Queen Victoria Museum & Art Gallery, Wellington St, Launceston, Tas. 7250.
Ph: (003) 40 1340
Contact: Dr Rodney Geelan, Acting Secretary

Membership fee: 10.00 (single); $20.00 (family)

Victoria Herpetological Society Inc.
16 Suspension St, Ardeer, Vic. 3022. Ph: (03) 363 6841
Contact: Brian Barnett, President

Membership fee: $38.00 - $25.00

SCIENTIFIC RESEARCH

ASSAB, Australasian Society for the Study of Animal Behaviour
c/- Dept of Zoology, Univ. of Qld, St. Lucia, Qld 4072.
Ph: (07) 365 2979/2491
Contact: Dr Kevin Warburton, Secretary

Membership fee: $25.00; $15.00 (conc.)

ANZSES, Australian & New Zealand Scientific Exploration Society Inc.
PO Box 174, Albert Park, Vic. 3206. Ph: (03) 866 8699
Contact: Colleen Lazenby, Director

Membership fee: $30.00; 50.00 (incl. NATURE AUSTRALIA); $35.00 (overseas)

EARTHWATCH Australia
Level One, 453-457 Elizabeth St, Melbourne, Vic. 3000.
Ph: (03) 600 9100
Contact: Matilda Leone, Operations Manager

Membership fee: $45.00

ZOOS

ASZK, Australasian Society of Zoo Keeping
PO Box 248, Healesville, Vic. 3777. Phone: (059) 62 2744
Contact: Carla Srb, Membership Officer

Membership fee: $35.00 (Australasian); $45.00 (o/seas); $60.00 (Australasian corporate)

Are you a Club Secretary?

The Society Scheme is designed to help your club or society with free publicity, funds and member benefits. Contact Mary Pollinger at *NATURE AUSTRALIA* for more details.

Newsletter/Journal, Monthly meeting, Bi-monthly meeting, Annual meeting/conference, Weekly meeting, Quarterly meeting, Field outings/Tours, Conservation/Working programs, Discounted Goods or services, Magazine, Social/Education Activities, *Nature Australia* magazine, Seminars

WARNING!

THESE MEDICINES HAVE A DEADLY SIDE-EFFECT.

If the killing of tigers for medical remedies continues at its present rate, within 5 years there will be no tigers left alive in the wild.

If that shocks you, so will this. Products like those on this page, which purport to contain parts of tigers, have been purchased in Australia by WWF investigators.

Incredibly, none of the store owners selling these substances are likely to be prosecuted. Because although it's illegal to import products made from tigers, it's virtually impossible to bring a case against those selling them due to inadequate laws controlling domestic sale.

It's a legal loophole which is fuelling the demand for tiger products in Australia and helping to ensure the tiger's extinction.

WWF will soon be lobbying government to change the law and this horrible hypocrisy. We need your support to do this.

Write to WWF at GPO Box 528, Sydney, 2001 and we'll send you information on how you can help us stop the illegal trade in tigers and other endangered species.

Before it really is too late.

WWF

YES, I'LL JOIN WWF IN FIGHTING ILLEGAL TIGER TRADE.

☐ I will support WWF. I enclose $35 by cheque / money order / credit card.
☐ Please accept my donation of $_____ ($100, $75, $50 – other)
Or charge my ☐ Amex ☐ Visa ☐ Mastercard ☐ Bankcard

Card number _____

Signature _____ Expiry Date ___/___/___

Name _____

Address _____

_____ Postcode _____

Telephone: Home _____ Work _____

Please return to WWF Australia, GPO Box 528, Sydney NSW 2001

Q&A

Glaucus atlanticus is able to remove the stinging cells from its bluebottle prey and store them for use in its own defence.

Common *Glaucus*

Q: *Having just recently become a subscriber to your wonderful magazine, I was hoping if you could help me by identifying the small creature in the enclosed photo. It was taken on a beach at Magnetic Island where these small blue pieces of plastic-like material were washed up on the beach. On placing them in sea water they unfolded into small (10–15 millimetres) creatures.*

—J.M. Douglas
Lower Templestowe, Vic.

A: The small blue animal you photographed at Magnetic Island is far more common than most people suspect. It is an opisthobranch sea-slug, *Glaucus atlanticus*, beautifully adapted for floating upside down on the surface of the world's oceans. It feeds on floating cnidarians, in particular *Physalia* species, including the Portuguese Man-o'-war (*P. physalis*) and our familiar form of bluebottle, *P. utriculus*.

Glaucus is able to remove the stinging cells from bluebottles and store them in sacs at the tip of each of the tube-like structures (cerata) that form fan-like structures on each side of the body. Because *Glaucus* can concentrate the stinging cells, a sting from the slug can often be more painful than a bluebottle sting.

Like a number of animals that live at the surface of the world's oceans, *Glaucus* is blue. Its distinct silvery underside and dark blue top serve as a means of camouflage, disguising it from the fish below and birds above.

Glaucus floats with the aid of a bubble of gas in its stomach, and is often found washed up on shore along with stranded bluebottles, especially after a few days of onshore winds.

—Phil Colman
Australian Museum

Living with Butchers

Q: *A couple of years ago two black-and-white butcher birds became regular visitors to our verandah to eat mince meat. After nesting time they brought along one brown offspring. The three of them have remained regular visitors, the younger one remaining brown. This week they have brought along two new little brown birds, which both seem to be fed by the three adult birds. We would like to know more about butcher bird family structure, and also if it is necessary to add any vitamins to the mince meat.*

—Tony Stone
Nerang, Qld

Young Pied Butcherbirds may delay getting their black-and-white plumage so they can remain unchallenged in their parents' territory.

A: Like many Australian birds, Pied Butcherbirds (*Cracticus nigrogularis*) frequently live in family groups. Unlike the situation in Laughing Kookaburras (*Dacelo novaeguineae*), this family structure is not obligatory, and adult pairs can successfully rear young without the assistance of non-breeding individuals. Unfortunately the Pied Butcherbird is one of the more common Australian birds that is still awaiting a good study of its natural history. It is not known what percentage of breeding pairs is augmented

by young birds, nor do we know how long these offspring remain with the parents. The black-and-white plumage appears to develop at the end of the first year. In your birds, however, the helping offspring seems to have retained brown immature feathers. This may be a result of developmental inhibition by the presence of adults. As long as the young bird stays brown, it will not be perceived as competition to the adults and can thus remain in the territory without attracting an aggressive response. Similar situations are known in other species, such as the Satin Bowerbird (*Ptilonorhynchus violaceus*), but remains speculative for the Pied Butcherbird.

Mince meat by itself, although a favourite with butcherbirds and other species, is lacking in some necessary vitamins and minerals. This can be corrected by adding a few drops of baby vitamins and calcium powder. A preferred approach may be to provide dried dog or cat food, perhaps the single best food you can offer. It contains a good balance of vitamins, minerals, protein and other necessary ingredients. The required amount can be moistened until the pellets are soft, and then the excess water gently squeezed out. A mixture of mince and the pellets might be initially needed to convert the butcherbirds to the new food.

—Walter E. Boles
Australian Museum

Answers to Quiz in Nature Strips (page 18)

1. **Shooting star**
2. ***Exxon Valdez***
3. **Western Australia**
4. **30 hours**
5. **Six billion**
6. **Red Kangaroo**
7. **AD 79**
8. **DNA**
9. **Southern Right Whale**
10. **An animal without a backbone**

P I C T E A S E R

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* magazine. Please don't forget to include your name and address. The first correct entry will win a $20 gift voucher from the Museum catalogue. Winter's Pic Teaser was a leaf mantis *Deroplatys desicatta* from Borneo which, when threatened, produces a flash of colour and a sudden change of shape.

THE LAST WORD

Of Australia's 18 worst environmental weeds, all but one or two were deliberately introduced as pasture or fodder plants or ornamentals.

AUSTRALIA'S WEED SCANDAL

BY TIM LOW

QUARANTINE IN AUSTRALIA is a farce. Our quarantine protocols impose strict curbs on animal imports, but freely welcome in weeds, in the guise of new pasture and ornamental plants.

The statistics are alarming. According to a recent survey 60 of Australia's weeds originated as pasture legumes or grasses released into northern Australia between 1947 and 1985. Thirteen of these deliberate introductions are now major weeds. Of almost 500 exotic pasture species trialled during that time, only 21 proved useful—yet most of these are also weeds. Of the 60 weeds, 21 are problems in crop lands, 20 are environmental weeds (weeds of natural habitats), and another 19 are weeds in both situations.

A study by Dane Panetta showed that half of Australia's declared noxious weeds were brought in deliberately (mostly as ornamental garden plants). An example is Kochia (*Kochia scoparia*), introduced as recently as 1990 from North America for revegetating degraded land, despite its status as a major crop weed throughout the world, and its reputation for poisoning stock. It is now declared noxious in most States.

Of Australia's 18 worst environmental weeds, identified in a major report from the Australian National Parks and Wildlife Service (ANPWS, now called Australian Nature Conservation Agency), all but one or two were deliberately introduced as pasture or fodder plants or ornamentals. One of the worst is Mission Grass (*Pennisetum polystachion*), a useless pasture introduction that is now a declared noxious weed in the Northern Territory. A major threat to tropical woodlands, it burns hotter than native grasses, leading to deaths of trees and animals.

It is a national scandal that so many of our worst weeds were deliberately brought in. We may wonder why governments did not act long ago to stop the damage. The sad truth is that vested interests in government and industry oppose a tightening of the quarantine net. Indeed the Quarantine Service is hamstrung by funding cuts, and many of its functions have been privatised—which is like handing over the nation's defence to mercenaries.

In 1991 the Commonwealth and States agreed to develop a National Weeds Strategy (NWS) to address the growing weed problem. The report released the following year ("Towards a National Weeds Strategy") was a huge disappointment. Despite input from the ANPWS it made only one oblique reference to pasture plants, and did not address the role of nurseries in introducing ornamental weeds. The strategy did recommend that quarantine be tightened with a screening system to weed out risky imports. Plants would be rejected if, for example, they were poisonous, spiny, twining, or closely related to known weeds. The proposed screening system had too few criteria to keep out most weeds, but it was a start.

In September 1994 the draft NWS was produced, and fortunately it is a great improvement and does acknowledge the problems. In another important step, the Australian Weeds Committee commissioned the development of an improved screening system. Whether this system is adopted, along with the recommendations of the NWS, will depend upon endorsement by government committees, some of them representing traditional agricultural interests, and likely to be hostile. A screening system would also need to be properly funded.

A good screening system is essential, but on its own does not go far enough. It assumes we can predict which plants will become weeds. This is not always so. Much depends upon the predators that control a plant in its native home. A plant that is benign in Africa or South America may run riot in Australia in the absence of controlling beetles or caterpillars.

What we also need is a cost-benefit analysis for proposed imports. Those wanting to release a new plant should be forced to argue before a panel of government and conservation agencies that the benefits to the nation would significantly exceed the possible costs of weed control and degradation. This idea is only common sense, but it is likely to meet very strong resistance from importers.

Consider the problem of ornamental plants. New species and varieties continue to flood into the country and routinely become weeds. For example Singapore Daisy (*Wedelia trilobata*), introduced in the 1970s, had become a weed all over coastal Queensland by the late 1980s. Given the scale of problems like this, common sense dictates that we should close the door on ornamental imports. It is difficult to argue that we need new garden plants, when a bewildering choice is already available from nurseries. Enough is enough.

The need for new pasture plants is also questionable. Mark Lonsdale, who conducted the pasture weeds survey mentioned at the start, argues that pastoralism in the Northern Territory can be just as profitable using native pastures. He found that the Northern Territory cattle industry only generates $1.48 per hectare, whereas the control of weeds, many of which were introduced as pasture or fodder plants, costs about $30 per hectare for annual weeds and $120 for woody weeds.

Importers have never had to justify themselves, for there is no public scrutiny of plant imports. The conservation movement has never taken up the issue in a serious way. The public is complacent, assuming (quite reasonably) that Australia learned from its past blunders—from the disastrous introduction of rabbits, Cane Toads and prickly pears. The reality, that we are still committing the same blunders in the 1990s, is profoundly depressing.

Whether we are capable of learning from the past and acting sensibly in the future now depends upon closed-door negotiations between government agencies. The public and especially the conservation movement should urgently become involved. After all, weeds cost Australia $3 billion each year, and represent one of the major conservation problems of the 20th century. ■

Tim Low is an environmental consultant, author and conservationist. He submitted recommendations on a draft of the National Weeds Strategy on behalf of the Queensland conservation movement.

CORAL SPAWNING SWEEPSTAKES

GUESS THE TIME OF THIS YEARS CORAL SPAWNING AT LIZARD ISLAND

WIN A FABULOUS 4 NIGHT CRUISE FOR TWO

On one night every year, the Great Barrier Reef begins a breathtaking ritual. Masses of tiny coral polyps release their egg and sperm bundles into the water creating a "snow storm" of spawn.

Guess the day and time of this years coral spawning near the Lizard Island Research Station and you could win a 4 night Captain Cook cruise for two on the luxurious *Reef Endeavour*.

■ **Visit Cooktown and Lizard Island** ■ **Go snorkelling** ■ **View the coral reef from a glass bottomed boat** ■ **Enjoy 5 star cuisine** ■ **Fly Business Class from Sydney or Brisbane with Qantas**

Prizes courtesy: ■ **Captain Cook Cruises** ■ **Qantas** ■ **Coles Myer** ■ **Suncorp Group**

■ **The Coral Spawning Sweepstakes is an initiative of The Lizard Island Reef Research Foundation, a registered Charity** ■ **The Foundation supports the work of the Lizard Island Research Station** ■ **The Lizard Island Research Station is dedicated to research into all aspects of the Great Barrier Reef** ■ **The Research Station is a facility of the Australian Museum**

HOW TO ENTER

HINTS

1 **Spawning normally occurs a few days after the full moon in early Summer, and within 1-5 hours of sunset**

2 **Full moons in late 1995 will occur on the following dates:**
■ **November 7th** ■ **December 7th**

3 **Sunset will occur at the following times respectively:**
■ **6.25 pm** ■ **6.41 pm**

■ **Guess the day and time to the nearest hour of the peak coral spawning near the Lizard Island Research Station, as determined by the Station's Directors** ■ **The Sweepstakes time is in Lizard Island Time,1 hour behind Eastern Summer Time** ■ **Each guess costs $10** ■ **Each entry form has a provision for up to 5 guesses** ■ **The winner will be the person who guesses the correct date and time** ■ **In the event of more than one correct entry, the winner will be drawn by ballot** ■ **If there are no correct entries, the closest entry will be declared the winner** ■ **Closing date for the competition is 31 October 1995** ■ **The winner will be notified by mail and name published in Nature Australia and MUSE** ■ **The prize is transferable but not cash redeemable** ■ **The prize is valid for 12 months**

I submit the following entries in the Lizard Island Reef Research Foundation Coral Spawning Sweepstakes for 1995.

Estimate the time to the nearest hour-

1 **The spawning will occur on,** *Date*_____ **at,** *Time*_____

2 **The spawning will occur on,** *Date*_____ **at,** *Time*_____

3 **The spawning will occur on,** *Date*_____ **at,** *Time*_____

4 **The spawning will occur on,** *Date*_____ **at,** *Time*_____

5 **The spawning will occur on,** *Date*_____ **at,** *Time*_____

No. of guesses_____ **@ $10 ea = $**_____ *(Maximum of 5 guesses per entry form)*

Send your entry by post or fax to (02) 320 6074.

Name:

Address:

City: St/State: P/C:

☐ Cheque enclosed *(please make payable to: The Lizard Island Reef Research Foundation)*

☐ Please charge my Credit Card

☐ Bankcard ☐ Visa ☐ Mastercard ☐ Expiry Date:

Card Number:

Cardholder's Name:

Signature: Date:

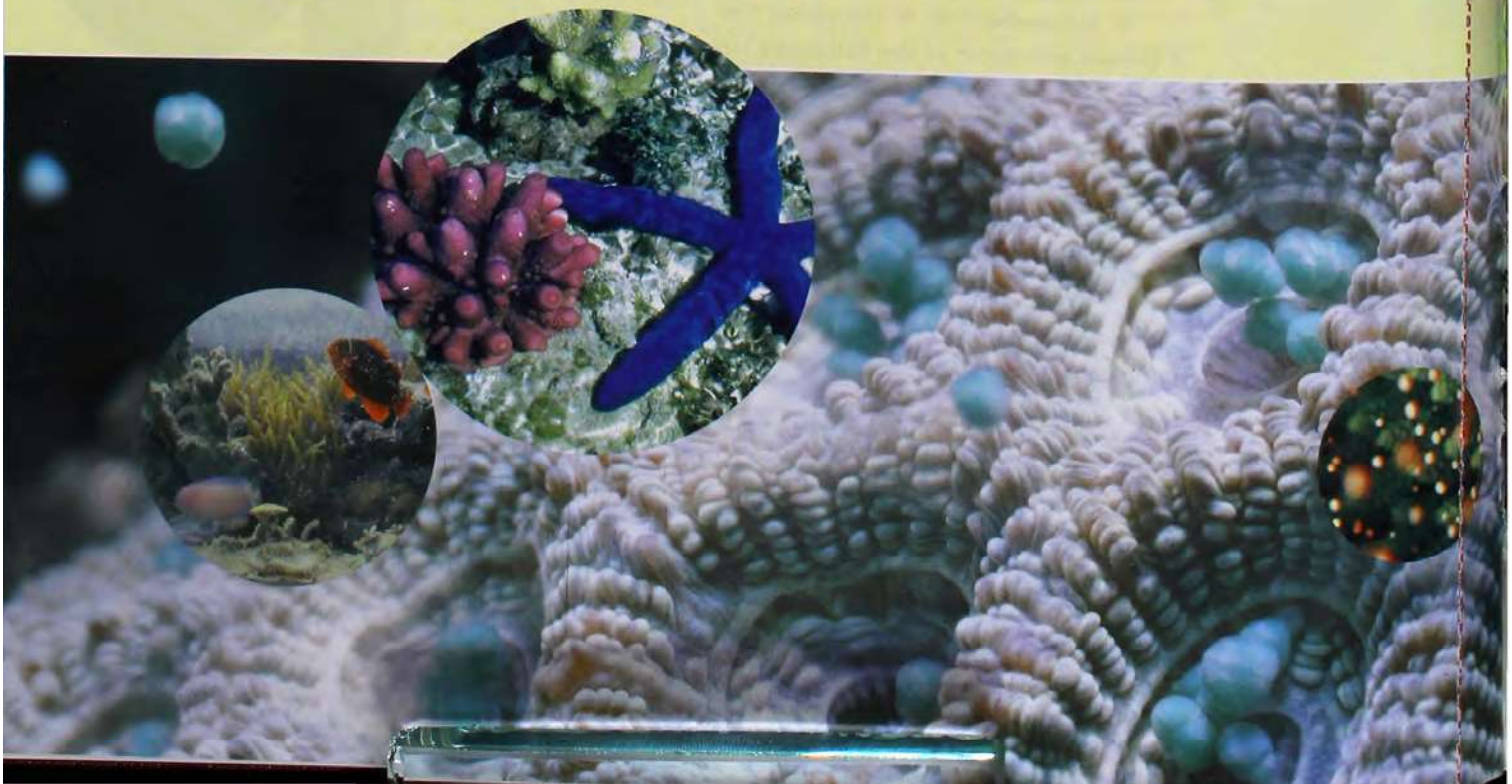
I wish to make an additional donation to the Lizard Island Reef Research Foundation of $

ENQUIRIES

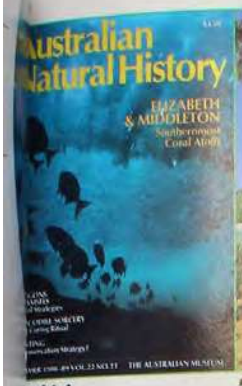
If you would like more information about the activities of the Foundation, including information about Membership, then please tick this box ☐
or contact: **Miss Gail McCarthy, The Lizard Island Reef Research Foundation, The Australian Museum, 6 College Street, Sydney, NSW, 2000,** *Tel: (02) 320 6277.*

AFFIX STAMP HERE

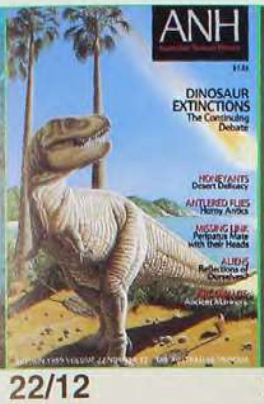
The Coral Spawning Sweepstakes
The Lizard Island Reef Research Foundation
The Australian Museum,
6 College Street, Sydney
NSW, 2000



BACK ISSUES & SUPPLEMENTS



2/11



22/12

23/5

23/6

23/7

23/8

3/9

23/10

23/11

23/12

24/1

24/2

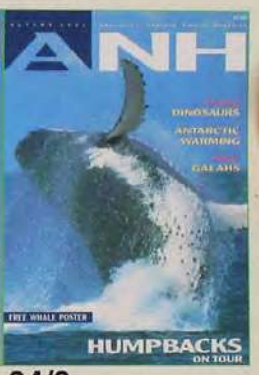
24/3

24/4

24/5

24/6

24/7

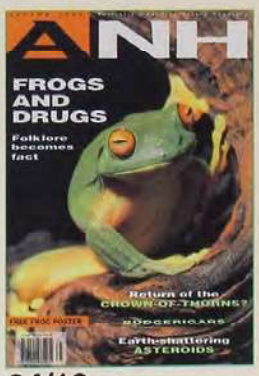


24/8

24/9

24/10

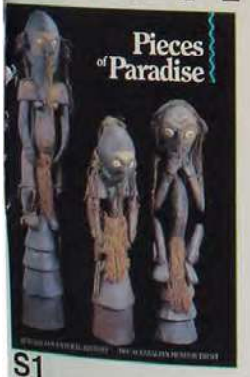
24/11



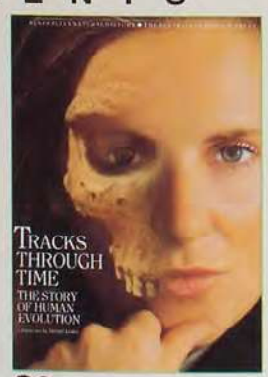
24/12

25/1

SUPPLEMENTS



S1
Pieces of Paradise

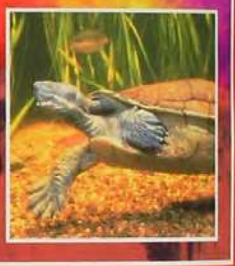


S2
Tracks Through Time

Library box holds 12 issues of the magazine. Finished in durable, dark green PVC. It will ensure your copies remain in mint condition.

To order use the form opposite

DISCOVER A WORLD OF INTERACTIVE MULTIMEDIA...



- Thousands of pages of text and images
- Over 40 minutes of video
- Covers every known Reptile and Frog in Australia

AUSTRALIAN REPTILES & FROGS

The Multimedia Experience

These CD-ROM products require a Windows-based MPC compliant computer

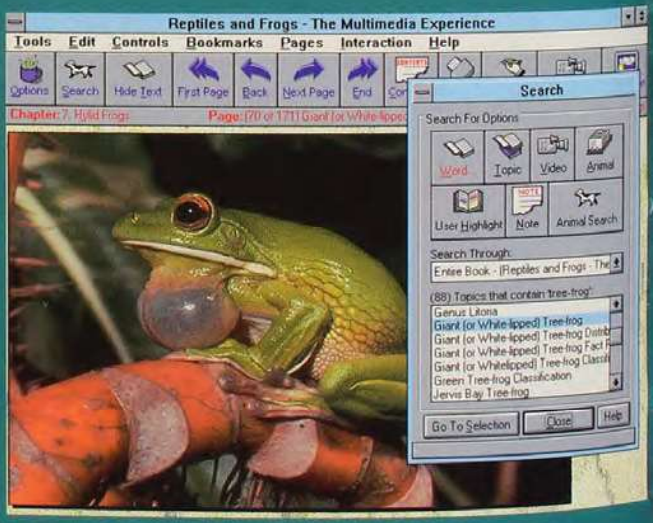
Other Available Titles:

Australia

Barrier Reef

Australian Mammals

New Car Buyers Guide



Titles Available Soon Include:

Australian Birds, Australian Fishing, 100 Years of Australian Film, Waltzing Matilda, and many more!

Available from major bookshops and computer stores

Webster Multimedia

Webster Publishing

A.C.N. 001 648 180

Unit 2, 25 Frenchs Forest Road Frenchs Forest NSW, 2086 Ph: (02) 975 1466 Fax: (02) 452 3493

AUSTRALIAN MADE