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AUTUMN 1998

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Up Front

Why do so many people fear spiders? I can't remember ever having a conversation with someone who said they like them and I often end up talking to people about spiders when they find out I work at the Australian Museum.

In fact, my office is right next door to the spider department and every now and then I find it relaxing to take a break from my work and wonder in there to see what their resident arachnids are up to. I've been lucky enough to see the Funnel-webs having their mites removed, the tarantula shedding its skin and a big, beautiful golden orb-weaver spinning her egg sac. And lets not forget dinner time—the most exciting time of all.

STEVE WILSON

Spiders really are fascinating creatures and when you stop being afraid of them and take the time to learn a bit about them, then their behaviour is not as unpredictable and frightening. I say this from experience because for many years I suffered from arachnaphobia. I couldn't be in the same room as a spider. But not any more. By spending time in their company I have managed to overcome my fear.

I hope that all those people who have been coming to the Australian Museum's great spider exhibition have also started to see spiders in a new light and will not be so quick with the heel of their boots or the insect spray next time they meet one.

So, if you want to get to know spiders better, turn to page 40 and take a peak at their sometimes extreme mating behaviour.

But don't worry, if you can't manage to bring yourself to feel feel warm and friendly towards a spider just yet, this issue contains plenty of alternatives. Try one of the cutest little mammals in Australia—the Feathertail Glider, or how about a very interesting group of Western Australian frogs, or Australia's native miner birds. Then there's seahorses, pigeons, butterflies, bilbies and grasshoppers. It's a great issue—enjoy.

—Jennifer Saunders

AUSTRALIA
Nature

AUTUMN 1998 VOLUME 25 NUMBER 12

Published by
The Australian Museum Trust
6 College Street,
Sydney, NSW 2000.
Phone: (02) 9320 6000
Fax: (02) 9320 6073
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Web: http://www.austmus.gov.au
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Phone: (02) 9320 6178

SUBSCRIPTIONS
Phone: (02) 9320 6119
Toll-free (1800) 028 558
Fax: (02) 9320 6073

Annual subscription (4 issues)
Within Australia $A33 Other countries $A45
Two-year subscription (8 issues)
Within Australia $A63 Other countries $A83
Three-year subscription (12 issues)
Within Australia $A89 Other countries $A116

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 welcomes articles on the natural and cultural heritage of the Australian Region. Opinions expressed by the authors are their own and do not necessarily represent the policies or views of the Australian Museum. *NATURE AUSTRALIA* is printed on archival quality paper suitable for library collections.
Published 1998 ISSN–1324–2598

NATURE AUSTRALIA (as ANH) is proud winner of the 1987, '88, '89, '90 , '91, '92 & '93 Whitley Awards for Best Periodical, and the 1988 & '90 Australian Heritage Awards.

Front Cover
A Feathertail Glider at a banksia inflorescence. The two rows of stiff hairs projecting sideways from the tail give it a feather-like appearance. Photo by Wesley Tolhurst.

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LETTERS

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

Eyewitness Accounts

In Michael Archer's scoldings of those who dare think the Thylacine might exist (*Nature Aust.* Autumn 1997) I fear the value of eyewitness accounts was confused with the likelihood of the animal being extinct.

Eyewitness accounts alone are undoubtedly unreliable (just consider the variation in reporting of the same bank robbery) but not all reporters are wrong. Indeed, most science is based on eyewitness records of some sort and it is a bit rich of Archer to suggest that, because he and Dick Smith have made mistakes in identification, everyone else must do so all the time.

Not much in Archer's style supports his claim to be open-minded. I bet if he received an eyewitness report of a wombat in Tasmania he would accept it without question. You see, the presumption would be that they are there, whereas a report of a Thylacine would not be believed because they are presumed not to be there. I also wonder if Archer applied his scepticism to pre-1936 eyewitness reports of Thylacines. They could be just as unreliable as present-day ones. In reality, scepticism seems as subjective as any other approach to problems.

Although over half the recent reports indeed come from areas marked on large-scale maps as wet forest, in detail most of these places were drier habitat. So what, anyway? Thylacines were historically encountered in most Tasmanian habitats and many were caught in wet forest, the habitat Archer dismisses as unsuitable.

I don't know where all the spending is that Archer scoffs at. In the past decades by far the most effort has been by private searchers using their own resources that would in reality not be otherwise available. Sure, the Tasmanian Parks and Wildlife Service carried out a search in 1983 after one of their most experienced wildlife officers reported a clear sighting at close quarters in an area with a history of reports. Since then any budget has been in the low hundreds of dollars per year, barely enough to document reports. It seems the authorities are "damned if they do and damned if they don't".

I agree that the Thylacine is probably extinct, but can Michael Archer honestly say there is no chance for them at least in Tasmania? I deal with a wide variety of landowners and can assure him that science has a very tenuous grip on many rural Australians; just as much a case of city arrogance as country ignorance. Declarations by academics of what people must believe despite their own experience don't help. I bet searching for Thylacines could be just as much fun as digging up fossils and, in any case, how does one get proof without looking?

So dear sceptics, it seems as hard as you push the DELETE key the word 'but' will remain in discussions of the Thylacine; I think for much longer than Michael Archer can hold his breath.

—Tony Dwyer
Tasmania

AUSTRALIAN MUSEUM/NATURE FOCUS

Can accounts of current-day Thylacine sightings be trusted?

The Sightless Tiger

I've never seen a Thylacine,
That Tacit Tassie 'Devil',
And folk who might report a sight
Aren't strictly on the level.
Their appetite for sheep at night
Brought them into bad odour,
Then bounty-hunt spelt exeunt,
Thus to promote their coda.

There are some chaps with handicaps
Who spot a flying object,
Then write memoirs of men from Mars,
Or some similar project.

Beware of hoax or tasteless jokes,
Some painted striped deceivers
Will vandalise and scandalise
Your precious true believers.

Therefore abstain, you'll search in vain,
They are no more in situ.
To be succinct, they are extinct,
Won't be around to bite you.

—Len Green
Rose Bay, NSW

Why Do Native Stingless Bees Fight?

One of the biggest mysteries of the native stingless bees of Australia is the fascinating fighting swarm. Like Henry Drew (*Nature Aust.* Winter 1997) we have seen hundreds of *Trigona* workers emerge from a nest and begin attacking one another. They fall to the ground locked in twos or threes and wrestle each other to the death.

We at the Australian Native Bee Research Centre have observed fighting swarms in many different situations. Often they occur when nests are placed too close together. However we have also seen them where there appeared to be only one large, powerful nest in the area.

Fighting swarms might be

BILL RUDMAN/NATURE FOCUS

Swarms of this native stingless bee (*Trigona* sp.) will fight each other to the death.

caused by malfunctions of the bees' chemical signals or pheromones. In the multiple nest situation, one bee may encounter another from a different nest and release alarm pheromones. Neighbouring bees join in, emitting more alarm pheromone, until a chaotic mass fight occurs. In the single powerful nest situation, the queen may be unable to pass her marking pheromone on to all the bees in such a big nest. So bees at the nest extremities may smell like 'strangers' and an escalating fight could result.

It is important to understand this behaviour fully because it can cause problems when stingless bees are used for crop pollination. If you would like to 'bee involved' in our ongoing research on the fighting swarms, please write to me at the Australian Native Bee Research Centre, PO Box 74, North Richmond NSW 2754.

—Anne Dollin
Richmond, NSW

Wombats, Genetics and Politics

Professor Michael Archer writes of hairy-nosed wombats, genetics and politics (*Nature Aust.* Spring 1997). The wombat is clearly the odd one out here; the other two have often been combined (just think of the German Nazis and many other unsavoury characters).

Archer mentions a figure of 500 individuals as the threshold of genetic poverty. Does he not realise that Australia's population is in excess of 18 million? Further, the rate of genetic exchange among the world's five-billion-plus human population is probably greater now, due to modern means of travel, than it has ever been before. The lady from Oxley will have less effect on Australia's future genetic fitness than Canute had on the tide.

As for hybridisation 'giving the flick' to Ellis van Crevald Syndrome and other genetic disorders, nothing could be further from reality. Most such disorders are due to recessive genes. Hybridisation simply hides them in heterozygotes where they are immune from natural selection. We can be sure that they will re-emerge as 'founder effect' when the Afro-Amero-Austro-Eurasian invasion of Mars takes place.

The good Professor may well have something to contribute to my understanding of wombats, but when it comes to politics I don't need misapplied science to help me choose my set of prejudices.

—Robert W. Berry
Moorabbin, Vic.

I have just read "Worries about Withering Wombats" by Michael Archer (*Nature Aust.* Spring 1997). I find it deplorable that, to round off an otherwise excellent article on the need for genetic variation and after quoting some well-documented instances of inbreeding in small groups, Archer felt it necessary to beat his own particular political drum and to use, as a frightening example of a "possible" (?) scenario in Australia, the more usual media's misquotes and misconceptions of a politician who refuses to bow to politically correct views and is therefore continually denigrated.

I can find no other explanation than political, as this was after telling us in a previous paragraph that "Australian human populations are unlikely to confront problems [of lack of genetic diversity] for at least the next million years because we exist in such prodigious—probably excessive—numbers".

I am a follower of no politician and a subscriber to no political publication. I know you have a disclaimer regarding the views of your authors, but if *Nature Australia* is to become a vehicle to indoctrinate your readers, particularly young readers, with the political opinions of those whose articles we look to for accuracy and integrity, then I will no longer be a subscriber, and this will be with sincere regret after many, many years of outstanding reading.

—B. Kerryon
Monto, Qld

Pandanus Dieback Explained

In response to the letter by Merridy Cairn-Duff (*Nature Aust.* Winter 1997) about pandanus dieback in south-eastern Queensland, the following information should be useful.

For the past two years, researchers from the Queensland Department of Environment and the Queensland Department of Primary Industries have been working on this dieback problem. The dieback occurs on the Sunshine and Gold Coasts and has become prominent in the last five years.

The cause of the dieback is an insect, referred to as a planthopper in the family Flatidae. This planthopper builds up in large populations on the pandanus leaves, feeding on the sap. Heavy infestations produce excess moisture (honeydew), encouraging waterlogging and the growth of moulds in the pandanus heads. Pressure from enormous insect numbers, combined with rot (as well as secondary factors such as poor growing conditions), cause the growing points to die and eventually the death of the plant.

The planthopper is actually native to northern Queensland and it has been brought to south-eastern Queensland (presumably by humans) in the last ten years.

In the natural situation in northern Queensland, the planthopper is kept to low numbers by its main natural enemy—a tiny wasp that parasitises the eggs. This wasp is not naturally found in south-eastern Queensland. The planthopper has been moved south without its natural control (the wasp) and, as a result, its population has exploded.

Currently we are attempting to control the planthopper by introducing the host-specific wasp to restore the natural balance, while using a systematic insecticide as an interim measure (until the wasp is established). Steps are also being taken to prevent further spread of the insect into sensitive, uninfested pandanus populations. As well, stocks of pandanus are being grown from seed for future revegetation efforts.

If you have any further queries please contact Nat Smith at Queensland Department of Environment, Maroochydore on (07) 54438 944.

—Rob Hughes
Qld Dept Environment

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. The winner this issue is Len Green.**

Nature Strips

COMPILED BY
GEORGINA HICKEY

Cannibalism Before Sex

Who can deny a fascination with sexual cannibalism, in which the female attempts to consume her suitor during courtship, mating or shortly thereafter? While females obtain a nutritious copulation, the cannibalised male may benefit by increasing the number of eggs he fertilises, either by converting his body mass into eggs, or by ensuring the eggs are fertilised by his sperm and not those of a rival male (as appears to be the case for the Redback Spider; see *Nature Aust.* Winter 1997).

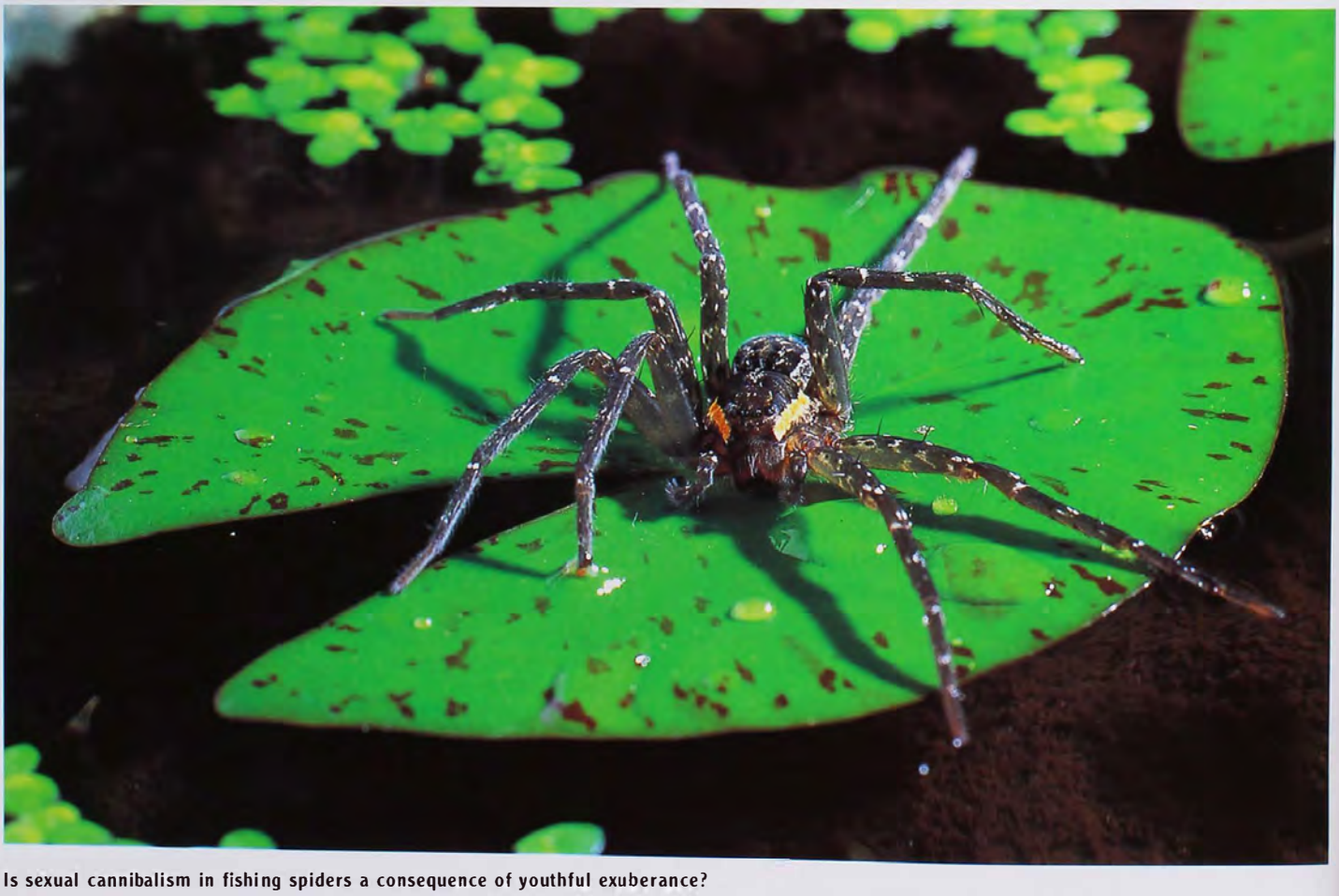
But these ideas cannot account for sexual cannibalsim before mating, which is more widespread, conveys nothing to the hapless male, and is curiously risky for virgin females that might remain that way. In a study of orb-weaving spiders, John Newman (State University of New York at Albany) and I suggested that virgins may benefit from eating rather than mating their partners when there are few prey or many males available. However, a recent study of the European Fishing Spider (*Dolomedes fimbriatus*) by Göran Arnqvist and Stefan Henriksson (University of Umeå, Sweden) provides little support for our ideas. They showed that sexual cannibalism was not influenced by female foraging history, mating status or the potential number of males. Surprisingly, many females failed to achieve complete inseminations, confirming the risk of eating a potential mate.

Why do female fishing spiders eat their suitors prior to mating, given the risk of failing to mate? Arnqvist and Henriksson believe the answer lies in the highly aggressive behaviour of juvenile spiders. Indiscriminate aggression in immature females is an advantage because it makes foraging more successful and thus they grow larger and lay more eggs. However, if this indiscriminate aggressive behaviour is not toned down following sexual maturity, it can lead to sexual cannibalism through mistaken identity. Thus sexual cannibalism in fishing spiders, rather than being adaptive for either the adult male or female, is an incidental by-product of aggressive juvenile behaviour. Provided the general increase in fecundity derived from immature aggressive behaviour outweighs the risk of some individuals remaining virgin, sexual cannibalism in fishing spiders will continue. One drawback to the 'aggressive juvenile' explanation for sexual cannibalism is that this aggressive behaviour may also be found in other species that are not sexually cannibalistic. Fascinating and mysterious behaviour indeed.

—Mark A. Elgar
University of Melbourne

Beaked Whales Suck

The mechanics of feeding in most whales are well understood; baleen whales (mysticetes) filter their



KATHIE ATKINSON

Is sexual cannibalism in fishing spiders a consequence of youthful exuberance?

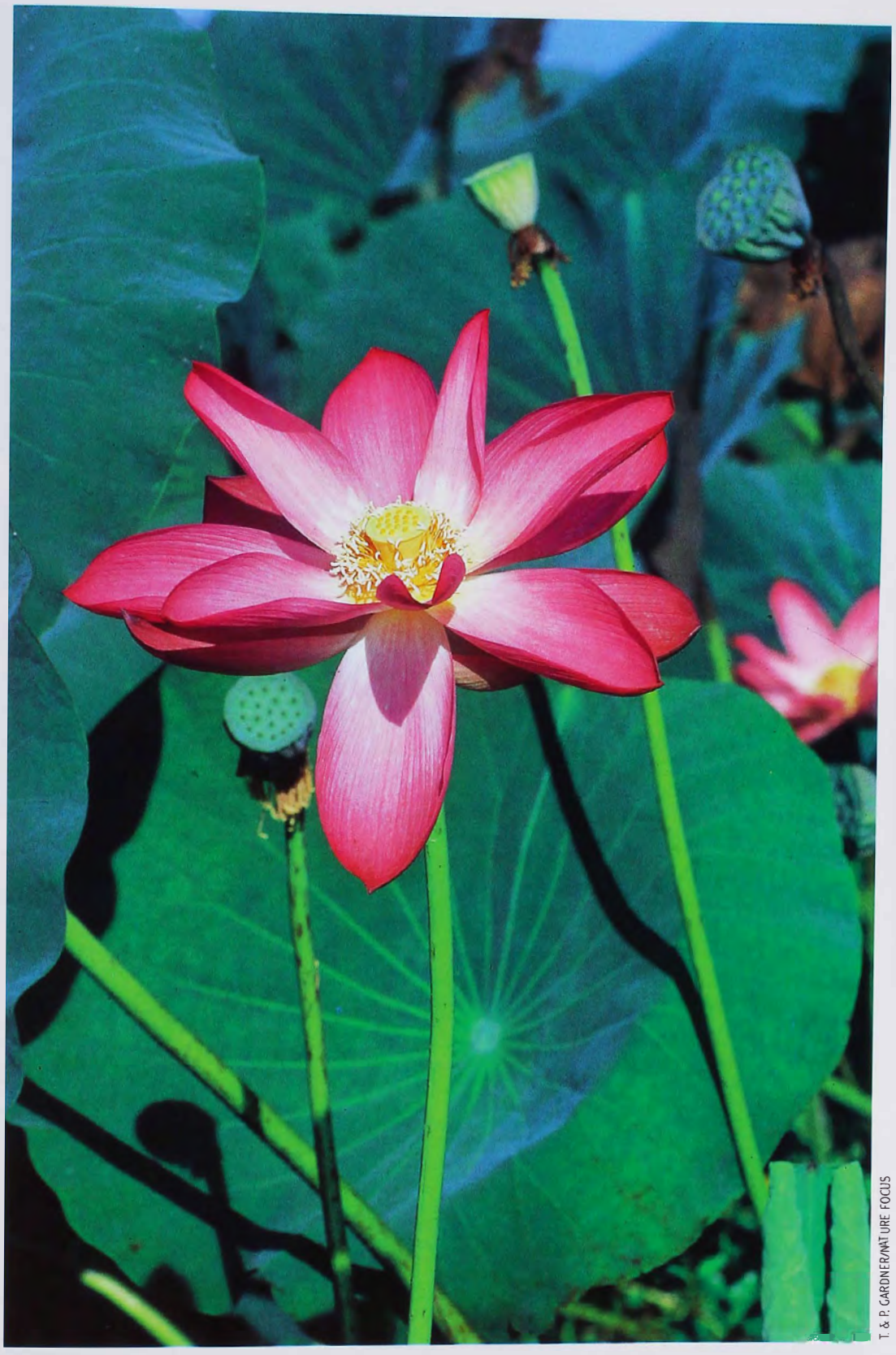
planktonic prey, while toothed whales (odontocetes) generally grasp their food with their teeth. But scientists have long been puzzled about how beaked whales—a group of virtually toothless 'toothed whales' with narrow snouts and small mouths—are able to catch and hold onto their prey. These whales (family Ziphiidae) have only one or two pairs of teeth, and often only in mature males, and are thought to be used mainly in aggressive encounters.

Investigating a long-held theory that beaked whales use suction to capture their prey—something common in fish, but previously unproved in whales—John Heyning (Natural History Museum of Los Angeles County) and James Mead (National Museum of Natural History, Washington DC) dissected numerous museum specimens. They found all ziphiids have a pair of grooves in the gular region, the part of the throat lying between the jaw bones, and suggest that, like a similar structure in baleen whales, these allow for expansion of the throat region. In addition, large muscles attached to the tongue enable it to move rapidly back in the mouth in a piston-like motion. The researchers believe that the combination of throat expansion and tongue retraction would lead to a sudden drop in pressure in the oral cavity, creating enough suction to draw in slippery prey like squid and fish.

They tested the theory on rescued Hubb's Beaked Whales (*Mesoplodon carlhubbsi*) recovering in aquariums. When one researcher placed a finger in the whale's mouth, it suckled strongly, and when presented with a fish, it was literally vacuumed up.

The findings have other implications too, say Heyning and Mead. Previously undamaged squid found in the stomachs of beaked whales (and also sperm whales) were taken as evidence that the whales used echolocation to stun their prey, but suction feeding may provide an alternative explanation as to why the squid were unmarked.

—R.S.



T. & P. GARDNER/NATURE FOCUS

Sacred Lotus flowers heat up and stay hot.

Hot Lotus

Legend has it that Buddha was born in the flower of a Sacred Lotus (*Nelumbo nucifera*). What truth there is in that, of course, is anyone's guess. As it turns out, however, the flower of the Sacred Lotus would be quite a cosy place for a mythological newborn.

Adelaide University zoologists Roger Seymour and Paul Schultze-Motel have discovered that the Sacred Lotus has a remarkable ability to significantly raise and tightly maintain the temperature of its flowers.

By inserting super thin metallic heat sensors into the plant's flowers, the researchers found that the plant could hold the temperatures within a range of 30–35° C for up to four days, even when the surrounding temperature dropped to as low as 10° C.

Although it sounds like a feat more akin with the capabilities of a mammal, heat production in plants is quite a widespread phenomenon in the aroid family and has also been reported from a few species of waterlilies, palms, cycads and custard apples (see *Nature Aust.** Summer

**Previously ANH*

COURTESY DAVID M. DENNIS

How do 'earless' frogs, such as this Panamanian Golden Frog, manage to communicate with one another?

1994–95 and Spring 1991). No other plant, however, has been known to demonstrate such a precise ability to regulate temperature as the Sacred Lotus.

The mechanism by which Sacred Lotus flowers regulate temperature remains a mystery but the researchers speculate upon a reason for the phenomenon. They believe the heat acts as an energetic reward for the beetles that pollinate the flowers. Many insects must produce their own heat by shivering, before they can fly or compete for food and mates. By providing the insects with heat, the plant may enhance digestion, growth or reproduction of its pollinators and may prepare them for their flight to other lotus flowers.

—K.McG.

Who Said Earless Frogs Can't Hear?

For those of us kept awake at night by the incessant croaking of a pond-full of frogs it's fairly obvious that sound plays an important role in frog communication. Yet several frog species are 'earless', lacking an external tympanum, middle ear cavity and auditory ossicle. Paradoxically, these frogs often still vocalise, despite their apparent auditory impairment.

The Panamanian Golden Frog (*Atelopus zeteki*), found only in the lowlands of western-central Panama, is one such species. Erik Lindquist and Thomas Hetherington of Ohio State University studied these endangered frogs, to determine whether or not they can hear and what role their vocalisations play in communications.

The scientists searched for male frogs along rocky streams, placing a speaker near each one they came across and playing him a tape of another male calling. They then settled back and watched how the male frogs responded to the recording.

What they saw convinced them that the frogs could indeed hear the tape. Of the 15 frogs they tested, seven vocalised, ten turned towards the speaker and 11 signalled with their feet. During foot signalling, the males waved one of their front feet in a circular motion and occasionally stomped one of their hind limbs.

Panamanian Golden Frogs aren't content to let their call do the talking, beefing up their aggressive repertoire with an added visual display.

These responses gave the researchers some interesting insights into the frogs' social behaviour. By orienting towards the speaker, the frogs demonstrated that not only could they hear the tape but they were also capable of localising the sound source. And their foot signalling showed that male Panamanian Golden Frogs aren't content to let their call do the talking, beefing up their male–male aggressive repertoire with an added visual display. Similar behaviour has been observed in a number of frog species (see *Nature Aust.** Spring 1993), most commonly those inhabiting noisy mountain streams where a calling frog sometimes just can't make himself heard.

The mechanism by which 'earless' frogs manage to hear is still a mystery, although the researchers believe it is through a lung–inner ear pathway. Work currently under way on earless fire-bellied toads (genus *Bombina*) indicates that the lung is acting as a type of pressure transducer, like an eardrum or tympanum in other frogs.

—G.T.

*Previously *ANH*

Wingless Scorpion-fly

Australia's insect fauna contains many curiosities. The wingless scorpion-fly *Apteropanorpa tasmanica* is such an oddball that scientists have given it its own family, the Apteropanorpidae. *Apteropanorpa tasmanica* is only known from Tasmanian alpine shrubland, where adults spend their lives on the snow or in small alpine plants. A few other wingless scorpion-flies live in a similar environment in the northern hemisphere but scientists have always believed that they are only distantly related. We can only speculate as to why some scorpion-flies (order Mecoptera) lost their wings, but no doubt it has something to do with the combination of extremely stable, harsh and patchy environment in which they are found.

Apteropanorpa tasmanica was first collected in 1939 from Mt Wellington (near Hobart) and Mt Mawson (Mt Field National Park). Mt Wellington was subject to a devastating bushfire in February 1967, and no specimens had been collected from there since. Peter McQuillan (University of Tasmania) and I recently conducted a survey of *Apteropanorpa* with the intention of mapping its distribution and extracting its DNA to assess relationships with other scorpion-flies.

So far the survey has revealed healthy *Apteropanorpa* populations at Lake Augusta in the central highlands, Mt Mawson, and Mt Wellington. In an exciting development the specimens from Lake Augusta proved to belong to a new species, doubling the number of species in the family! And the specimens from Mt Wellington go to show that this small, flightless insect can survive severe bushfires. Its unusual life history probably contributed to its survival. *Apteropanorpa*, unlike most Tasmanian insects, spends the winter months as an adult, basking in small shrubs and apparently feeding on moribund insects on the snowfields. The larvae were spared from the bushfires because they probably spend summer deep in leaf litter and moss on the ground.

COURTESY DAVID YEATES

A six-millimetre-long wingless scorpion-fly (*Apteropanorpa tasmanica*): one of the first photographs ever to be taken of the species.

—David Yeates
University of Queensland

COURTESY KENTARO ARIKAWA

When it comes to mating, Japanese Yellow Swallowtail Butterflies are guided by the light.

Genital Eyes

Photoreceptive cells that function as simple eyes can be found on many unusual parts of the body in arthropods. Yet surely the most bizarre example is found in butterflies that have light-sensitive cells on their genitalia. The role of these 'genital eyes' has recently been under the spotlight of scientists at the Yokohama City University in Japan.

Kentaro Arikawa and his colleagues focused their study on the mating behaviour of the Japanese Yellow Swallowtail Butterfly (*Papilio xuthus*). By blacking out the male's photoreceptors with paint or destroying them with a heat probe, researchers could determine the function of the cells during mating. Only one in four males without their photoreceptors successfully copulated, compared with two-thirds of intact males. Arikawa *et al.* suggest that the change from light to dark detected by the genitals during intromission tells the male he is 'home' and signals for him to ejaculate. Without the photoreceptors the male cannot 'see' if he is properly inserted and will continue to search for her genital opening, even if he is already correctly aligned, until he eventually gives up.

Light-guided copulation may prevent crossbreeding as the lock-and-key relationship only exists between males and females of the same species. Any light leaking through the space of mismatched genitals would indicate an inappropriate mating of different species and prevent insemination.

For females, the function of photoreceptive genitals still remains 'in the dark'. One hypothesis suggests that females may use the cells in behavioural tasks such as egg laying.

—K.B.

New Zealand Rats

It has always been assumed that the Pacific Rat (*Rattus exulans*) arrived in New Zealand with the first human settlers about 850 years ago. Recently obtained dates of rat bone from both the North and South Islands, however, imply human contact at least 1,000 years before settlement.

Richard Holdaway from Palaecol Research in Christchurch obtained the dates by measuring the amount of carbon-14 in bone gelatin using

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The toilet habits of Collared Lemmings are dictated by their enemies.

accelerator mass spectrometry (AMS). The bones themselves were found mostly in deposits from the now-extinct predatory Laughing Owl (*Sceloglaux albifacies*). Most of the AMS dates were significantly older than the generally accepted date for human settlement of the country, and Holdaway suggests that the rats stowed away on the large canoes of early transient human visitors (or of those who quickly died out).

Holdaway has found additional evidence for the early arrival of New Zealand rats in the form of a jawbone from a Pacific Rat excavated from beneath the Taupo Tephra—a volcanic deposit on North Island known to be 1,850 years old. As well as its AMS date being consistent with that of the covering deposit, the bone's position beneath the undisturbed layer proves rats were established in New Zealand before the Taupo eruption.

—R.S.

Lemming Latrines

With the approach of summer, Collared Lemmings (*Dicrostonyx groenlandicus*) living in the Arctic undergo a strange shift in behaviour. They have spent the winter below the snows, but now with the thaw there is a new reason for going underground.

During the snow melt, these Arctic lemmings excavate special chambers from their burrows in which they defecate. But why would they install the indoor plumbing now, having spent the cold winter months going to the toilet above ground (but beneath the snow)?

According to Rudy Boonstra (University of Toronto) and colleagues, this seasonal shift in toilet habits may be related to predator avoidance, for once the snow has melted there is little cover available in the stunted tundra for a lemming, or its excreta. Concealing one's excreta is important for an Arctic lemming, because their faeces and urine stand out like a glowing beacon to birds of prey, which can 'see' the droppings in ultraviolet (UV) light. This ability allows raptors to scan a large area in a short time, concentrating their hunting to UV-signposted areas.

The researchers speculate that with intense predation on lemmings over summer, from hawks, jaegers and daylight-hunting owls, there is a strong selection pressure on lemmings to 'hide' their faeces and urine. By using underground latrines lemmings conceal their tell-tale waste and avoid alerting the watchful eye of airborne predators to their whereabouts.

—K.B.

Silk Gift Wrapping

The use of gifts in courtship is by no means restricted to human society. Just prior to copulation, males of many insect species present their mates with a prey item, which the females proceed to eat. The male hunting spider *Pisaura mirabilis* also presents prey items as 'nuptial gifts' (the only spider

COURTESY MARTIN BILFINGER

The male hunting spider *Pisaura mirabilis* prefers to wrap his nuptial gifts in silk before presenting them to the female.

so far known to do so), but *P. mirabilis* prefers to wrap his gifts in silk before presenting them.

Andreas Lang from Ludwig Maximilians University in Munich, Germany, was interested in the role that the silk 'wrapping paper' played in this copulatory transaction. In a series of laboratory experiments he initiated sexual excitement in male spiders by exposing them to the silk threads of females. He then gave them a fly to wrap, varying the size of the fly, the nutritional state of the male spider and the amount of time available to wrap the gift. He also gave females fly heads wrapped in varying amounts of silk and timed how long it took them to digest their gruesome gifts.

Lang found that, when males were given more time to wrap their prey, they produced more silk. Larger males produced more silk and hungry males took longer than satiated males to produce the same amount of silk. The size of the prey item generally had little effect on the amount of silk used to wrap it, although small spiders sometimes found large flies too tricky to handle and left these presents unwrapped.

The amount of silk produced by the males was generally small, suggesting that its nutritional value to the female is negligible. Instead, it seems to serve as a distraction: the more silk a male used to wrap his gift, the longer the female took to eat it, which would probably give him more time to copulate with her and increase his chances of fertilisation.

—G.T.

Blue Balls

It is quite common for the males of seasonally breeding primate species to intensify the colour of their genitals during the mating season.

COURTESY CAITLIN GABOR

Red-spotted Newts eat the eggs of other females but somehow manage to avoid their own.

This serves to advertise their readiness to mate and has been found to be associated with hormonal changes. However, male Patas Monkeys (*Erythrocebus patas*), even though they have a restricted breeding season, appear to have a bright blue scrotum year round.

To get to the bottom of the Patas Monkey's blueness, Fred Bercovitch from the Caribbean Primate Research Center at the University of Puerto Rico conducted a year-long study to determine whether there was, in fact, any variation in scrotal colour and whether this was seasonally correlated with testicular function.

Once a month Bercovitch measured the colour of the scrotum against a series of paint colour charts, as well as the size of the testicles and testosterone levels in each of six males. He found that seasonal fluctuations in testicular function were not reflected by colour changes. Even when testosterone levels had soared and the testicles had doubled in size, the colour of the scrotum remained virtually unchanged.

So why be blue in the first place? Bercovitch believes that for Patas Monkeys, even though their scrotal colour doesn't intensify during the mating season, the doubling in testicle size increases the area of blue and thus the contrast presented against the snow white fur of their rear end. This, coupled with the monkeys' acrobatic displays, leaves their competitors and prospective mates in no doubt about what's on their mind.

—R.S.

The doubling in testicle size increases the area of blue. This, coupled with the monkeys' acrobatic displays, leaves their competitors in no doubt about what's on their mind.

Newtritious Eggs?

In a restricted environment, such as a pond, cannibalistic behaviour can be a disadvantage—especially if your meals turn out to be your relatives. It is not surprising, then, that some amphibian species are able to discriminate kin from non-kin.

Caitlin Gabor, of the University of Southwestern Louisiana, conducted a comparative study between the females of two species of newt which lay hundreds of sticky eggs one by one and attach them to plant material. She found that, while female Red-spotted Newts (*Notophthalmus viridescens*) ate the eggs of other females and avoided their own, female Smooth Newts (*Triturus vulgaris*) tended not to eat any eggs at all but, when pressed, showed no preference for other females' eggs over their own.

The mechanism used by female Red-spotted Newts to detect the difference between the eggs was not established,

but the most likely explanation is that a chemical marker is present in the sticky substance that surrounds the eggs. In further tests, Gabor discovered that female Red-spotted Newts did not avoid eating their own hatchlings. Perhaps this is due to the fact that they no longer have any identifying chemical tagged to them. Protection from cannibalism may not be as necessary in hatchlings because, being mobile, they can escape predation to some extent.

Why some species and not others can discriminate between their own and other females' eggs is unclear. But for those that can't, the best option is to keep eggs off the menu altogether.

—P.R.

Blue Blood

We are all blue bloods. Or so it would seem when we look at the veins on the inside of our wrists. However, venous blood is deep red and, until now, no-one has understood quite why this optical illusion occurs.

Lothar Lilge (from the Ontario Laser and Lightwave Research Center at the University of Toronto) and colleagues immersed a clear tube of red venous blood in a white fatty solution whose optical properties are similar to the tissue that surrounds veins in our own bodies. They found that, while the amount of red and blue light reflected from the tube of blood was less than that reflected from the surrounding fatty solution, the blood absorbed relatively more red than blue, making the 'vein' appear blue when compared to its surrounds.

They also found that a typical 0.5-millimetre-wide vein looks red when it is 0.2 millimetre or less below the skin, but blue when it is 0.5 millimetre below. The deeper a vein is, the bluer it looks, until it is so deep we can't see it at all. This also explains why we blush red, not blue—the blood vessels that dilate when we blush are very close to the surface of the skin.

C.A. HENLEY

Besides providing the answer to an age-old mystery, the researchers' findings may have clinical applications. By using the colour of a vein, it may be possible to estimate the blood vessel's depth below the skin surface. Such information could be useful, for example, when treating vein malformations with laser therapy.

—C.B.

Sand-swimming Moles

Life is tough in the shifting sand dunes of the Namib Desert, south-western Africa. Such a barren and dry environment would not be expected to favour insectivores—mammals with typically high requirements for food and water. Yet the tiny (20-gram) blind Namib Desert Golden Mole (*Eremitalpa granti namibensis*) has a few tricks that enable it to survive where its main termite food is widely distributed in patches.

Unlike most other golden moles that typically search for food by burrowing, the Namib moles run over the surface of the sand at night. Their tracks are punctuated

COURTESY ROGER SEYMOUR

During the day, the Namib Desert Golden Mole rests beneath the surface and lets its body temperature drop to that of the surrounding sand.

by short dips every five metres or so, where they plunge beneath the sand, apparently listening for the sounds of buried insects. When they find a patch of food, they 'swim' through the sand in irregular paths while feeding.

Our recent measurements of the energetic cost of locomotion show that sand-swimming is more than 80 times more expensive than running the same distance over the surface. It is not surprising, therefore, that the Namib moles run on the surface between food sources rather than sand-swim. On an average night, they run 1,400 metres compared to only 16 metres of actual sand-swimming. Still, their foraging efforts yield only 2.7 grams of termites a night, which would be insufficient for most mammals their size. To cope with their low food availability and the high energetic cost of foraging, Namib moles let their body temperatures drop to sand temperature while resting beneath the surface during the day. This reduces their resting metabolic energy demand to one-fifth that of normal mammals and, overall, their daily energy requirement is about one-half. In this regard, the moles are more like lizards than mammals.

One might think that moles buried in the dunes would have difficulty breathing, because the loose sand presses on their body and there is no tunnel system to supply fresh air. However, they have several adaptations to deal with this problem: their nostril openings are sieve-like to exclude sand grains, their dense fur holds the sand away from their bodies so they can inhale, and their low metabolism demands little oxygen. Most importantly, the surprisingly large air reservoir that exists between uniform dry sand grains permits rapid diffusion of oxygen. Oxygen levels near the nose of resting moles turn out to be scarcely different from that in the above-ground atmosphere. Oxygen supply during sand-swimming is also not a problem, because as the moles move through the sand, the air supply between the sand grains is continually renewed.

—Roger S. Seymour
University of Adelaide

QUICK QUIZ

1. What does the H in pH stand for?
2. What do Barnacle Bill, Yogi, Flat Top and Bam-bam have in common?
3. Who was the Australian geologist and anti-Creationist at the heart of the 'Ark trial', held in Sydney last year?
4. What is the term for attributing human-like qualities to non-human things?
5. What does infection by the bacterium *Helicobacter pylori* cause?
6. Which chemical element is represented by the symbol Hg?
7. What is the name of the sheep claimed, by a Scottish research team, to be the first animal to have been successfully cloned from an adult cell?
8. Do Koalas have a forward- or rear-opening pouch?
9. What type of animals transmit Lyme Disease?
10. What do Honey Possums eat?

(Answers in Q&A)

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Like all those that make a killing among concrete and neons, pigeons are no fools.

CULTURE'S VULTURES

BY STEVE VAN DYCK

JUST ACROSS FROM THE CITY CENTRE, on the banks of the Brisbane River, lie four or five Sphinx-sized concrete blocks waiting, as it were, for a Herculean artisan to chip them into something memorable. To the cultured, the complex is the 'Cultural Centre'; to the cynical, the 'Cultural Bunker'. However, to the local pigeons the site represents a *coup de théâtre*, an unexpected gift of limestone and gravel flowing with caviar and chicko rolls.

Visitors looking for a seductive introduction to Brisbane culture are not disappointed if they dare to dine at one of the *unnetted* outdoor cafes. Almost the moment a scraping chair broadcasts the intention of a patron to leave, the sombre homing flock wheels in . . . more vultures than messengers of peace. Most of these take-away junkies are scrawny runts, with feet clubbed by pigeon pox, their rickets-twisted toes marking time until mercifully amputated by falling crockery, their feathers greasy and clotted. They slip and stumble over saucers and forks, knocking cream-streaked tumblers aside as they hammer their open beaks onto leftovers, packing scraps down their necks and plastering their faces with mud cake and cold chips.

Then, as sure as eggs, they'll make for the ground where, before an audience of Italian shoes and chipped cups, they'll deliberately copulate until the blushing diners at the next table turn their children toward home, scrape their plastic chairs back, and leave.

The attraction of pigeons to cement and stone has its origins in a genetic mortar that set hard in the rocky cliffs of the Middle East 120,000–310,000 years ago when Rock Doves (*Columba livia*) first appeared in the fossil history.

JOHN FIELDS/NATURE FOCUS

Pigeons can breed all year round. Here a male tries to convince a female that he is the best man for the job.

ROCK DOVE (FERAL PIGEON)

Columba livia

Classification
Family Columbidae (pigeons and doves), one of 303 spp. worldwide and 25 in Australia.

Identification
Light blue-grey with iridescent purple and green on neck. Usually two bold black bars across wings. Beak black, legs red, iris orange to red. Length 330 mm, weight 280 g. Sexes similar but female duller. Domestic varieties selectively bred for table, show and racing.

Distribution
Feral in Australasia, southern Africa, the Americas and Japan. Native to Arabia, India, Sri Lanka, Turkestan, Africa north of the equator, western Asia, Mediterranean region, eastern Europe, Shetland Islands, Faroes, Scotland and Ireland. (No-one knows if pigeons came with the First Fleet to Sydney, but by 1833 trap shooting was a well-established sport there.)

Food
Mostly spilled grain. One Canberra study (Frith 1982) revealed: grain 40%, bread 28%, garden and weed seeds 31%, miscellaneous (chewing gum, orange peel, one pearl button, rat droppings) 1%.

Reproduction
Breeds all months, but mostly Aug.–Dec. (Probably only one-third of urban population breeds.) Flimsy nest of sticks, roots, grass, rubbish in warehouses, bridges, roof ledges, towers, turrets, piers. Both sexes incubate 2 white eggs (35–43 mm long) for 17–19 days. Young leave nest at 31–35 days old. Pairs capable of raising 4 or 5 clutches annually.

That natural beginning has taken them on their own wings following Neolithic grain-growing humans grunting their way from India and Spain up to Scotland in the north and the Gulf of Guinea (Africa) in the south. And since their domestication for food around 4,500 BC they have piggy-backed their way to southern Africa, the Americas, Japan and Australasia to form home-and-away flocks, the constituents of which are a select feral cocktail distilled from fancy domestics that were bred from the basic Rock Dove prototype.

There has never really been a social, cultural or environmental conscience associated with releasing pigeons

around the world, whether it be from straw-lined wicker baskets or centre-stage at the Olympics. When exploited as message carriers, their homing ability and speed demanded they see their freedom frequently and, although these qualities were bred to perfection in the 19th century (Reuter's famous news agency was founded on news-carrying pigeons in the early 1850s), they were employed long before that. In 44 BC, when Mark Antony held the city of Modena under siege, Decimus Brutus sent messages out attached to pigeons, which he hoped could skirt the nets set up by the attackers to snare them.

If yesteryear's breeders of racers or fancy varieties could not bring themselves to eat their rejects, they could always abandon them to fend for themselves in the streets. Those street flocks now cost their indulgent provisioners plenty. For example, Trafalgar Square's famous flocks cost the British public £100,000 annually—the price of mopping up the tonnes of acidic marble-melting coo-poo, installing disincentives like electric zappers and needle beds on splattered statues and nest-clogged ledges, and hand-feeding them grain laced with contraceptives or strychnine.

The thing that strikes anyone who watches pigeons in the park, however, is that they, like all those that make a killing among concrete and neons, are no fools. People who have tried to frighten them off with loud noises, high-frequency whistles and artificial hawks are the first to testify that pigeons soon learn to give the greasy eyeball to bogus threats. Their capacity to watch and imitate what another pigeon does to obtain food means that waves of learning sweep rapidly through a flock, enabling the members to exploit new food resources and deal more efficiently with tucker. For example, the appalling ones in the Cultural Centre have taken almost no time to learn how to deliver a deft flick of the head under big yellow serviettes to check for discretely covered scraps lurking on plates underneath.

In 44 BC, when Mark Antony held the city of Modena under siege, Decimus Brutus sent messages out attached to pigeons.

And, contrary to their endearing reputation as birds of peace that peck away at food furiously instead of fighting, the Cultural vultures have learned that, by extending their wings over their backs like archangels, they can clobber a scrap-rival with the closest wing and drive it from a crust-littered table top. This is reminiscent of the sharp blows that were often dealt out to small thieving hands which, as kids, we slid under sitting pigeons to rob them of their eggs.

CA. HENLEY

Although pigeons can be a nightmare for council workers and outdoor diners, for many they represent an entertaining distraction from their otherwise sterile city existence.

Many pigeon studies have revealed that, in cities around the world, flocks stick to a certain beat and there is very little exchange (less than 25 per cent) between the individuals in those discrete bands. This may explain why a lunchtime walk away from the Cultural Centre and across Brisbane River's Victoria Bridge will reveal a flock in Anzac Square, the members of which are as glowing, lusty and proud as the brass Diggers whose heads and shoulders they poop all over.

To lunching city workers, shoppers and toddlers, pigeons provide a cherished distraction from the bleak sterility of the urban heart. And to a rich miscellany of residential eccentrics they provide a hungry family of recognisable individuals more grateful and far less complaining than any human flock of children.

Outside the city parks, pigeon-love culminates at events like the Royal Easter Show where genetic engineering bends over backwards to show off its achievements: White Fantails with ballooning chests so up front the birds stagger around unable to see the judge that prods them, Pouters long and top-heavy like albino toffee apples, huge edible Kings, as well as Dragoons, Scandaroons, Modenas, Jacobins, Tumblers, Red Antwerp Smerles, and Blondinettes with beaks so short they can't feed their own babies. Some fanciers in Bali and Lombok take pigeon appreciation a few steps further and slip little brass bells and bamboo flutes around their homers' necks to fill the sky with tinkling and panpipe whistling.

Feral Rock Doves are always going to be either a love or hate affair. While one person enjoys sitting on a park bench feeding their lunch to a pigeon, an hour later someone else sits rapt at an office window watching a Peregrine Falcon tear the same bird apart for its lunch. But, on the subject of pigeon lunches, if it's a Brisbane lunch with a garnish of Culture you are after, head for an unnetted cafe every time. The antics of the Rock Doves might be engrossing, but the pouting, posturing and preening of the cultured diners is a hard act for even the pigeons to follow! ■

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So brilliant is the grasshopper that in 1991 it was featured on a stamp and became familiar to many Australians.

LEICHHARDT'S GRASSHOPPER

BY PENELOPE GREENSLADE & LYN LOWE

LEICHHARDT'S GRASSHOPPER (*Petasida ephippigera*) was once to entomologists, as Lasseter's Reef was to a goldminer, the holy grail. One of the earliest collections of the species was made in 1845 by the explorer Ludwig Leichhardt in what is now Kakadu National Park. Leichhardt was no doubt drawn to the grasshopper because both males and females have spectacular orange and blue colouring. So brilliant is the grasshopper that in 1991 it was featured on a stamp and became familiar to many Australians. But because the region of the wet–dry tropics to which it is restricted was remote, further collecting trips to search for it were rare. As a result the absence of records after the mid 1850s suggested it might be extinct. It wasn't until 1971, after nearly 120 years, that the species was rediscovered.

Although also found in three other localities in the wet–dry tropics, the grasshopper is best known from Kakadu, where tour operators once halted at places where they knew it could be found to allow visitors to admire and photograph the insect. Sadly, however, the grasshopper has disappeared from most of these sites, due to inappropriate fire regimes.

A few years ago one of us (Lyn) became suspicious that the annual burning of Kakadu's vegetation, widely carried out in the region to reduce fuel loads, might be having a damaging effect on Leichhardt's Grasshopper. Lyn noticed that the flightless juveniles hatch at the end of the wet season in March. They climb the stems of the aromatic shrub *Pityrodia jamesii* to feed on its leaves, and grow slowly during the dry season, undergoing five moults before finally emerging as fully winged adults in December. After mating, the females lay their eggs and the whole cycle begins again. However this natural cycle, which is seasonally tuned, is being interrupted by the European method of managing fuel with fire.

So far Leichhardt's Grasshopper has no known predators; perhaps it assimilates chemicals from the plant that may make it distasteful or even toxic? Perhaps these chemicals contribute to the grasshopper's bold colouration?

Burning is normally carried out in May or June, when juvenile grasshoppers are most vulnerable, being unable to move quickly into shelter. Even if some do manage to find shelter from fire, the foliage on their host plant is burnt so they almost certainly starve to death. The current burning regime using fire bombs from the air is quite different to that practised by the original inhabitants who were on foot and probably only randomly burnt smaller patches of the lowlands.

It was obvious to Lyn that a change in the annual fire regime was vital for the species' survival in the Park but, without convincing data, management of the area could not be changed. So, in January 1992 Lyn selected five sites, all carrying populations of Leichhardt's Grasshopper, and monitored them carefully. Within two years fires had burnt into four of the sites, and the grasshoppers in them could no longer be found. To this day the grasshoppers still occur on only one of Lyn's original sites and this is the only one protected from fire by being surrounded by large expanses of bare sandstone.

So what now? Leichhardt's Grasshopper has been nominated for inclusion on the IUCN List of Threatened Animals and a recovery plan should now be prepared. This requires an accurate map of its total distribution, both within and outside the Park, to be drawn up. From this, sites with secure populations can be selected and given protection from fire. Additional attempts could also be made to breed the grasshoppers in captivity (previous attempts have failed) for possible reintroduction to sites with suitable habitat.

Apart from Lyn's studies, nothing else is known of the species' biology, although chemists Bill Kitching and Mary Fletcher from the University of Queensland are studying chemical aspects of its relationship to *Pityrodia* plants. They are especially interested in whether the grasshopper may retain in its body some of the chemicals contained in its aromatic food plant. So far Leichhardt's Grasshopper has no known predators; perhaps it assimilates chemicals from the plant that may make it distasteful or even toxic? Perhaps these chemicals contribute to the grasshopper's bold colouration?

Fortunately Leichhardt's Grasshopper is not yet lost and there is time to rectify the damaging effect that Europeans have had. But there are other species, some as yet unknown, that may also be gradually disappearing as a result of inappropriate fire regimes. What is vitally needed are fire regimes that are custom-designed for each vegetation type, locality, land use and so on, each of which has, as its aim, the protection of all the elements of biodiversity present. Until we have Australia covered by such fire regimes, we may continue to find that, no sooner do we make new discoveries, than we are destined to watch them slowly become extinct.■

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Penelope Greenslade is an entomologist working on soil animals in CSIRO, Canberra, and Lyn Lowe is a biologist with CSIRO's Tropical Ecosystems Research Centre in Darwin.

REG MORRISON

Because the fossil record is so meagre, we will never know the full extent of Australia's contribution to ecosystems overseas.

MADE IN AUSTRALIA

BY TIM LOW

AUSTRALIA LIES MORE THAN 7,000 kilometres from Hawaii, but it has managed to exert a profound influence on Hawaiian ecology. The mountain forests in Hawaii are dominated by wattles of Australian origin, and inhabited by birds that also originated here.

The common Hawaiian wattle tree, the Koa (*Acacia koa*), is very similar to Blackwood (*A. melanoxylon*), a tall wattle found in eastern Australia. The seed pods of Blackwood, or a close relative, were evidently borne to Hawaii long ago on ocean currents, there to evolve into Koa, and a second Hawaiian wattle (*A. kauiensis*). Honeyeaters and monarch flycatchers followed the same migratory path, island-hopping their way across the Pacific, evolving along the way into an array of colourful forms.

Few Australians are aware of the extent to which our plants and animals have colonised other parts of the world. There is a popular notion that Australia (defined here as including New Guinea) is an evolutionary backwater, where primitive lineages have survived in isolation without contributing to the richness of the rest of the globe. The wattles (genus *Acacia*, subgenus Heterophyllum) show how limited this view is. There are in fact 18 wattles with foreign distributions, found in such distant lands as Madagascar, Mauritius, the Philippines, Taiwan, Vanuatu, Fiji, Samoa and Hawaii. All of these plants have the leathery phyllodes (modified leaf stalks functioning as leaves) that characterise most Australian wattles, and they have all evolved from Australian ancestors that somehow dispersed overseas. Wattle seeds have very hard seedcoats (an adaptation to fire) and they probably survive well at sea.

Australian colonisers are most strongly represented on nearby islands to the north and east. Sulawesi, for example, one of the larger Indonesian islands, boasts eucalypts, grevilleas, macadamias, cuscuses and cockatoos, to name a few. New Zealand has hundreds of plants, birds and insects of Australian origin. They include Manuka (*Leptospermum scoparium*) and Kanuka (*Kunzea ericoides*), two shrubs that arrived in New Zealand so recently (probably hundreds of thousands of years ago) they have yet to evolve into separate species. Ironically, their Maori names have been adopted in Australia to describe the original Australian populations. Some of New Zealand's unique birds, such as the New Zealand Robin (*Petroica australis*), are obviously descended from very similar Australian ancestors, and Australian birds continue to colonise New Zealand—Silvereyes (*Zosterops lateralis*) flew across in the 1850s, Masked Lapwings (*Vanellus miles*) in the 1930s, and Welcome Swallows (*Hirundo neoxena*) in the 1950s. These colonisers may eventually evolve into unique New Zealand species. In New Caledonia a very common tree is the Broad-leaved Paperbark (*Melaleuca quinquenervia*), the same species that dominates swamps in eastern Australia. Its seeds may have blown across the sea.

PHOTOS: TIM LOW

Sea Fanflower, called Naupaka in Hawaii, has a wide distribution in the Indo-Pacific region. It has escaped from cultivation to become a weed in Florida and the Caribbean, and is likely to extend its distribution throughout the Atlantic tropics.

Sticky Hopbush is a characteristically Australian plant that can be seen throughout much of the world, as for example, here in the Everglades National Park.

A smaller, but still significant number of Australian plants and animals has spread much farther afield, into South-East Asia and the more distant islands of the Pacific. South-East Asia, for instance, is home to the Coast Sheoak (*Casuarina equisetifolia*), Cajuput Tree (*Melaleuca cajuputi*), Hairy Goodenia (*Goodenia pilosa*), and the White-breasted Woodswallow (*Artamus leucorhynchus*), which also occurs in Fiji.

But a couple of our plants have done much better than this, achieving spectacular distributions that girdle the globe. One of these is the Sticky Hopbush (*Dodonaea viscosa*). Hopbushes (*Dodonaea* species) are very characteristic Australian shrubs that the pioneers used as hop substitutes when brewing beer. Most of the 70-odd species are confined to Australia, but Sticky Hopbush has somehow managed to escape these bounds and has colonised every continent, except Antarctica, and many islands including Madagascar, New Zealand and Hawaii. In many countries it has been adopted as a folk medicine, and in Hawaii its leaves are used to make leis. To me it represents a little piece of Australia that I often encounter on travels overseas. I have seen it growing on sand dunes in India, on granite hills in South Africa, and in Slash Pine (*Pinus elliottii*) forests in Florida.

Another globe-trotter that presumably originated here is Devil's Twine (*Cassytha filiformis*). Of the 17 species of *Cassytha*, 15 occur in Australia, and 13 are only found here, so Australia is probably the original home of this plant. It is now a common creeper of beaches and woodlands in warmer regions of Australia, Africa, Asia and the Americas, and also grows on many islands including, once again, Hawaii. I have seen great thickets of it trailing over Water Pear (*Syzygium guineense*) trees on the banks of the Zambesi River in Zimbabwe, at a crossing point used by elephants. In Florida it often grows over stems of Sticky Hopbush, perhaps showing that expatriate Australians like to stick together.

Sea Fanflower (*Scaevola taccada*), found on tropical beaches as far west as Africa and as far east as Hawaii, is a third, very widespread plant that presumably originated here. It belongs in a family (Goodeniaceae) and genus that are overwhelmingly Australian and, while there are many fanflower species found overseas, nearly all of them grow on beaches or on islands in the Indo-Pacific region, suggesting descent from Australian ancestors with waterborne fruits. There can be little doubt that Sea Fanflower, like Devil's Twine and Coast Sheoak, owes its success to its habit of growing on beaches, and to development of seeds that survive lengthy immersion in salt water.

Because the fossil record is so meagre, we will never know the full extent of Australia's contribution to ecosystems overseas. Although it is easy to speculate about a few plants and birds that have dispersed recently, it is much more difficult to develop the larger picture, and to reconstruct dispersal events from many millions of years ago. Recent work on birds, however, suggests that Australia's contribution may be very much larger than any of us have expected. DNA studies in America indicate that several groups of related birds found around the world—the shrikes (Laniidae), crows and jays (Corvidae), orioles (Oriolidae) and others—evolved long ago from a lineage that arose in Australia. And the recent discovery in southern Queensland of the world's oldest known passerine fossils suggests that Australia may have been the evolutionary starting point for more than half the world's birds—the song birds (order Passeriformes).■

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Tim Low is an environmental consultant, natural historian and author of four books on wild foods and medicines.

Big eyes and a halo of whiskers help this Feathertail Glider see and feel its way around at night. Heart-shaped pads on the fingers and toes give it a firm grip on branches, but perhaps more importantly, a secure hold upon landing.

WESLEY TOLHURST

Feathertails are fearless in the trees, running along the flimsiest branches and leaping from branch to branch.

FEATHERTAIL GLIDERS

BY SIMON WARD

DO YOU REMEMBER WHICH animal featured on the Australian one-cent coin, before it was made redundant in 1991 (the one-cent coin, that is; not the animal)? Would you even recognise the animal in that one-cent portrait? Long whiskers and big eyes, and a strange-shaped tail. The tail, of course is the key. The animal is a Feathertail Glider (*Acrobates pygmaeus*) and its scientific name, meaning 'little acrobat', is very apt.

Feathertails are small (11–15 grams) possums that have two special adaptations for gliding from tree to tree. Like other gliding mammals, they have a gliding membrane or patagium, which in Feathertails extends from the wrist to the ankle. Unlike other gliders they have a flattened tail with a single row of long stiff hairs down each side, giving it a feather-like appearance and giving the animal its name. Armed with these adaptations, Feathertails are fearless in the trees, running along the flimsiest branches and leaping from branch to branch. They are 'extended leapers' more than 'gliders', but they are capable of long glides between trees (20 metres is not unusual). They have large heart-shaped pads on the ends of their fingers and toes that help them hold on, and these can provide enough grip for Feathertails to run across vertical panes of glass—a feat almost as tricky as holding on to trunks of wet gum trees.

The tail of a Feathertail is held out stiffly at a slightly upward angle as the animal glides, presumably acting as a rudder and brake. When moving along the branches, the animal drags its tail along leaves and branches, thus providing some support and security. It can also roll its tail up in a downward curl to carry leaves for nest-building. Feathertails are the only marsupial gliders to sport a feather-like tail. The only other animals that have similar tails are the non-gliding Feather-tailed Possum (*Distoechurus pennatus*) of New Guinea (the Feathertail's closest living relative), and the pygmy scaly-tailed squirrels of West and Central Africa (which are not marsupials).

The small size and nocturnal habits of Feathertail Gliders make them hard to observe, and they are rarely seen. They are most often encountered when cats bring them to their owners to show off, or when people find them when collecting firewood. However, they are actually fairly common in the tall forests of eastern and south-eastern mainland Australia, although less common in woodlands on the inland side of the Dividing Range. They do not occur in Tasmania; presumably there were never enough trees on the Pleistocene land bridges 15,000 years ago that linked Tasmania to the mainland for these and other forest-dependent animals to cross over.

JEAN-PAUL FERRERO/AUSCAPE

This Feathertail Glider is feeding on nectar and pollen of a Heath Banksia (*Banksia ericifolia*). After it finishes feeding at this inflorescence, it may carry pollen on its fur to another banksia, resulting in pollination.

FEATHERTAILS, LIKE MOST GLIDERS AND possums, are totally dependent on forests or woodlands. They need them to provide food to eat and places to live. Because they are small, very active mammals, Feathertails need high-energy foods like nectar and pollen, and invertebrates. They have been observed feeding at Yellow-bellied Glider (*Petaurus australis*) sap-sites, and they also eat some fruits and seeds. Eucalypt trees often flower profusely and are important sources for many of these foods, but other plants, like banksias,

C.A. HENLEY

By grooming themselves between bouts of foraging, Feathertail Gliders not only remain clean, but they also get a feed. They collect and eat any pollen that gets stuck to their fur.

which produce large quantities of nectar and pollen, can also be important. Because Feathertails visit many flowers each night, they are potentially important pollinators in Australian forests (see *Nature Aust.* Summer 1997–98).

In addition to providing Feathertails with foods, eucalypts are important for their hollows. Many Australian forest animals, including most of the possums and gliders, antechinuses, phascogales, bats, a variety of birds and also bees, use hollows in trees for raising young, or just as safe places in which to shelter. When they do find a suitable hollow, Feathertails build a nest in the form of a ball of eucalypt leaves (sometimes casuarina and/or acacia leaves) about the size of a softball, with a fist-sized internal cavity. Up to 16 Feathertails have been found nesting together, but groups are typically of three to five animals, and occasionally singletons. They don't form stable social groups, like Sugar Gliders (*Petaurus breviceps*) or Leadbeater's Possums (*Gymnobelideus leadbeateri*) do, and the only recurring social unit appears to be a mother and her adult daughters. Perhaps they help each other in raising young, but we don't really know. The best forests for Feathertails are probably mature ones where there are several eucalypt species that vary in their flowering seasons. This provides a year-round food supply and lots of hollows for potential nest sites.

Feathertails also make use of artificial cavities in their habitat. One popular provider of artificial cavities is the telephone company, Telstra. In bush areas on the edges of our cities, telephone lines are strung from pole to pole along the roadsides, and wherever there is a connection to a house there is a terminal box. These terminal boxes consist of a metal frame bolted to the pole, which supports both the thick inlet and outlet wires coming in from the bottom, and the fine-wire connections projecting upwards. Over the top of this

JEAN-PAUL FERRERO/AUSCAPE

With its gliding membrane, or patagium, from wrist to ankle on each side, a Feathertail Glider can glide 20 metres or more. The stiff tail-up posture is typical in a glide.

FEATHERTAIL GLIDER

Acrobates pygmaeus

Classification
Family Acrobatidae (which includes only 1 other species, from New Guinea).

Identification
The smallest gliding possum, about 15 cm total length (half of this is tail). Gliding membrane from wrist to ankle on each side of the body; distinctive tail with a flattened middle core and a single row of long stiff hairs down each side. Grey–brown above, white to cream below, very long whiskers.

Habitat and Distribution
Widespread in forests and woodlands of eastern and south-eastern mainland Australia. Found on both sides of Great Dividing Range, from near the top of Cape York through to the Grampians in Vic. and on into the east of SA.

Behaviour
Nocturnal and forest-dependent. Builds communal nests in tree hollows, emerging soon after dusk to forage, typically alone, but large numbers feeding together have been recorded. Feeds mostly on nectar, pollen and invertebrates.

Reproduction
In southern Australia, breeding strictly seasonal with births between July and January. Mothers typically produce 2 litters of 2–4 young within this season, and embryonic diapause occurs. The young have relatively slow growth and development, with pouch life lasting about 65 days, followed by about 40 days in the nest before young are weaned.

sits a moulded plastic cover, about 22 centimetres high and 9 x 7 centimetres in section. What better real estate could a homeless hollowless Feathertail find? Warm, dry and with a tight entrance hole that excludes most of the competition! Feathertails sometimes use the terminal boxes and build their nests in the space above the wires. They do not appear to cause any damage, apart from an occasional short circuit, so the contractors who maintain the wires for Telstra look on Feathertails as a nuisance to be tolerated, not as a pest.

The fact that Feathertails will use artificial nest boxes has proved to be very important to scientists like myself. It is important because Feathertails usually won't enter conventional small mammal live-traps, such as those used to study other forest mammals like pygmy-possums, antechinuses or rodents. We don't know why feathertails shun traps, but it means we have to rely on other ways of catching

Feathertail Gliders nest in tree hollows and one of the main ways people encounter them is when collecting firewood.

KATHIE ATKINSON

WESLEY TOLHURST

them. The best technique we have is to install nest boxes in areas of forest, and hope that Feathertails will use them. We then check the nest boxes during the day and catch any Feathertails that are nesting in them. Nest boxes seem to work best in middle-aged forests, where there aren't so many natural hollows, but the trees are mature enough to supply food for the Feathertails. However, even in these forests, only about ten per cent of nest boxes get used by Feathertails.

BECAUSE NEST BOXES ARE OUR ONLY reliable way of catching them, two areas of research on Feathertails have predominated. The first area is their reproduction, since when you catch a mother in a nest box, you also catch her young. In southern Victoria they have a strictly seasonal breeding pattern, but the season is probably longer in northern populations. Up to four (typically two or three) tiny young are born at a time. Each weighs about 18 milligrams and is smaller than a grain of rice. Their eyes and ears are only partially formed. The pouch young stay permanently attached to the teats for about 65 days, by which time they are about 1.7 grams and are getting too big for their mother's pouch. At this stage their eyes are still shut and they have only a fine covering of fur, but they are left in the nest while their mother goes out to feed, returning at intervals to suckle them. About 40 days later they weigh 8–8.5 grams and are weaned. The mother can then give birth, almost immediately, to another litter of young because of a remarkable series of events that occurred earlier in the cycle. Within a day of the previous litter being born, she mated again and a series of eggs were fertilised. These fertilised eggs developed normally for a few days, but then entered a period of delayed development called embryonic diapause (similar to that found in many kangaroos, and also in some rodents and shrews). This diapause is triggered by the sucking stimulus of the previous litter in the mother's pouch. As these young approach the stage of being weaned, the sucking stimulus becomes intermittent, and the embryos are reactivated, to be born soon after the previous litter is weaned. It is a remarkable system that ensures that the second litter of a season is born as early within a breeding season as is possible.

The second area of research is on patterns of torpor in Feathertails. When checking nest boxes on cold days (not just in winter), it is not unusual to find a ball of cold sluggish Feathertails that slowly turn into warm bundles of energy. These animals are in torpor, a strategy for conserving energy that involves lowering the body's internal thermostat, dropping the heart rate and becoming unresponsive. The body temperature typically drops to a couple of degrees above the outside temperature, but never drops below 2^{o} C. Such bouts of torpor may just be during the day, or may last for several days on end. Caroline Jones and Fritz Geiser from the University of New England recorded bouts lasting up to five-and-a-half days. However, Feathertails are not true hibernators.

A Feathertail Glider feeding on a eucalypt blossom. Note the expanded toe pads on the back foot.

Most recently, Lindsay Aitken and John Nelson from Monash University described the anatomy of the ear and the brain of Feathertails (and New Guinea's Feather-tailed Possum) and found them to be quite different to other marsupials. In their ear canal, just in front of the eardrum, there is a disk of bone that occludes most of the space, and this appears to reduce the hearing ability of Feathertails at most 'normal' frequencies, but possibly enhances their ability at low frequencies. In the brain, the lateral lobe is massively expanded where it connects with the nerves to the ear, possibly associated with the ear's filtering system. We don't know why Feathertails have such a filtering system. Perhaps these low frequencies are made by important natural predators of Feathertails, such as the wing-beats of owls. This is just one more intriguing area of research into Feathertail Gliders that beckons us.■

JEAN-PAUL FERRERO/AUSCAPE

Feathertails are fearless in the trees, running along the flimsiest branches at night in their hunt for insects, nectar and pollen. Truly a pygmy acrobat.

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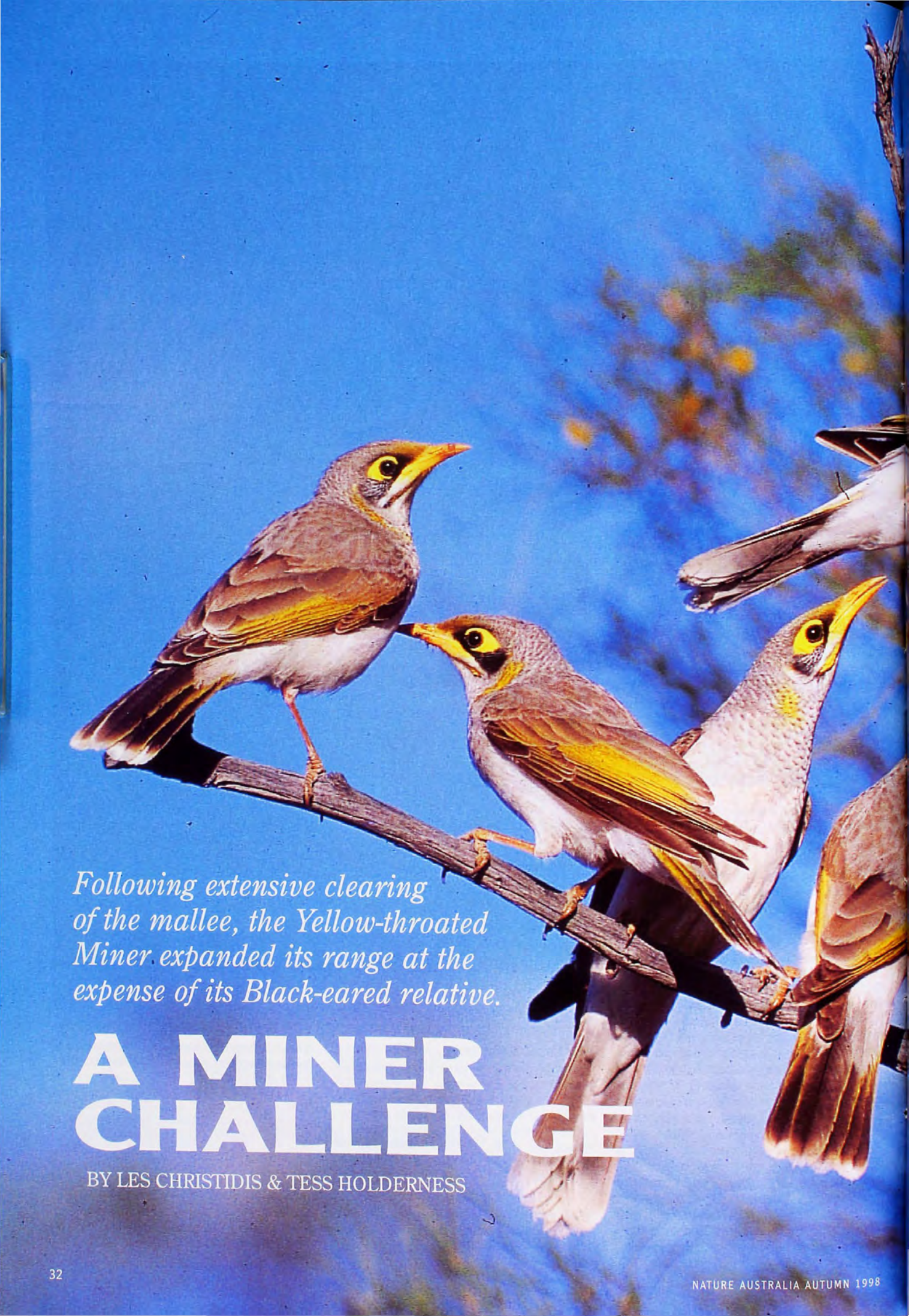
Dr Simon Ward is a lecturer in the Department of Zoology at the University of Melbourne. His research is mostly on the reproductive ecology of small marsupials, particularly possums, gliders and antechinuses, but also seabirds.



Following extensive clearing of the mallee, the Yellow-throated Miner expanded its range at the expense of its Black-eared relative.

A MINER CHALLENGE

BY LES CHRISTIDIS & TESS HOLDERNESS

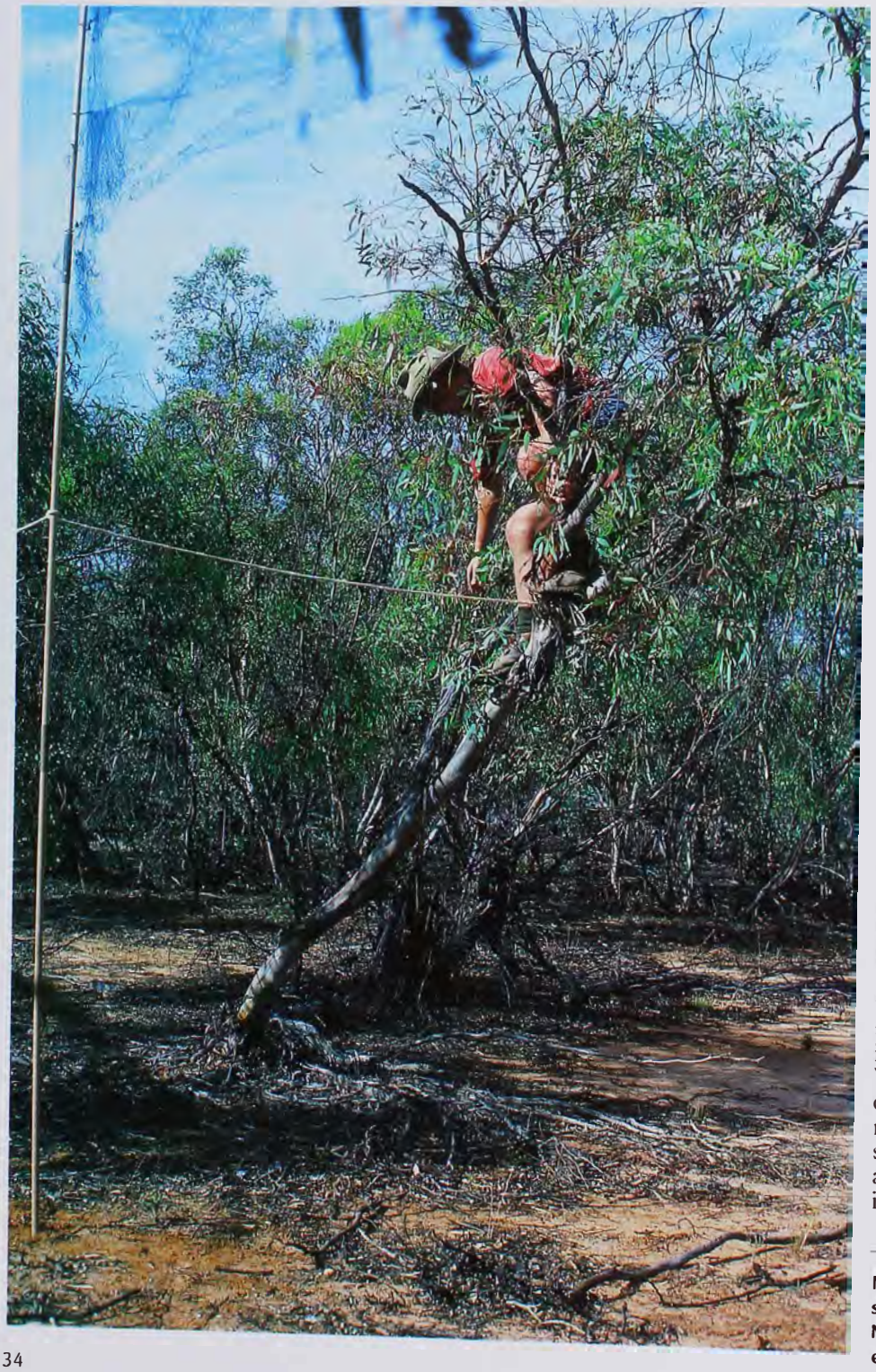
A corroboree of Yellow-throated Miners. The more dominant Yellow-throated Miner is genetically swamping the shyer Black-eared Miner in the wild.

GRAEME CHAPMAN

MENTION THE WORD MINER and many people automatically think of the introduced Indian or Common Myna (*Acridotheres tristis*). But this bird is totally unrelated to the Australian miners, which are honeyeaters in the genus *Manorina*. In a case of mistaken identity, early European settlers noted the bare patches of yellow skin around the native birds' eye and named them after the species they were familiar with.

There are four species of Australian miner, one of which—the Black-eared Miner (*Manorina melanotis*), from north-western Victoria and neighbouring regions in South Australia—is Australia's rarest bird. The combined effects of mallee clearing, wildfires, and hybridisation with the widespread Yellow-throated Miner (*M. flavigula*) have put the Black-eared Miner on the critically endangered list. Fewer than ten pure individuals are thought to remain in the wild.

The Bell Miner or Bellbird (*M. melanophrys*) is the most distinct of the four miners, with its attractive green plumage and recognisable 'clinking' call. It lives in the sclerophyll forests of south-eastern Australia. The Noisy Miner (*M. melanocephala*), which inhabits eucalypt woodlands in eastern Australia, is more similar in appearance to the Yellow-throated and Black-eared Miners, although it can be easily distinguished from these.



COURTESY HEALESVILLE SANCTUARY

While Bell, Noisy and Yellow-throated Miners are all relatively common in their respective habitats, populations of the Black-eared Miner started to decline just prior to World War 1, following the widespread clearing of its mallee home for wheat farms. Today, however, the species' greatest threat is loss of genetic identity through interbreeding with the Yellow-throated Miner. Indeed, some critics have raised the question of how much limited conservation funding should be allocated to a species that is already extensively contaminated genetically.

In the past, under natural conditions,

Michael Miller (from Healesville Sanctuary) setting up a mist net in the Wyperfeld National Park in order to catch hybrid Black-eared Miners for the breeding program.

GRAEME CHAPMAN

A hybrid Black-eared Miner feeds its young.

the Black-eared and Yellow-throated Miners were reproductively isolated. Their different habitat preferences formed a barrier to dispersal. The aggressive Yellow-throated Miner likes more open habitats whereas the shyer Black-eared Miner favours denser mallee. However, following extensive clearing of the mallee, the Yellow-throated Miner expanded its range at the expense of its Black-eared relative. This increased the number of points of contact between the two species, resulting in a genetic 'swamping' of the Black-eared Miner. Being behaviourally intermediate, hybrids were able to penetrate the thicker mallee habitat and become incorporated into the more secluded colonies of Black-eared Miners, further tainting the gene pool.

The various grades of hybridisation certainly complicate the positive field identification of pure birds. Generally, the Black-eared Miner is darker in colouration and smaller than the Yellow-throated Miner, with an extensive black face mask and little or no yellow colouration. Field guides differ as to the number of distinguishing features, although wildlife ecologist John McLaughlin (who has monitored the bird and its requirements for nearly a decade) has determined there are at least 17 plumage characters that separate the two species. Nevertheless, many are subtle and require careful examination in the hand.

Some critics have raised the question of how much limited conservation funding should be allocated to a species that is already extensively contaminated genetically.

Based on the similarities between the two miners, and the fact that they are able to produce fertile hybrids under natural conditions, some scientists suggested that the Black-eared Miner was simply a colour variation (or morph) of

LES O'ROURKE

Some of the differences between hybrid Black-eared Miners (left) and Yellow-throated Miners (right) are so subtle they require careful and close examination.

BLACK-EARED MINER

Manorina melanotis

Classification
Order Passeriformes, family Meliphagidae.

Identification
Av. length 25 cm, black face mask, grey crown, dark rump. Rapid and repeating scolding call.

Habitat
Mature mallee eucalypt woodlands, unburnt for more than 40 years. Tall chenopod or red-swale mallee preferred, with an understorey including *Acacia* and *Melaleuca* spp., small bushes, shrubs and hummock grassland (*Triodia* spp.).

Distribution
Formerly found throughout the Murray Mallee region. Current distribution centred around Murray–Sunset and Wyperfeld National Parks in north-western Vic. and Bookmark Biosphere Reserve in SA.

Behaviour and Breeding
Generally quiet and shy; does not rigorously defend territories. Breeds between Sept. and Dec., in cooperative colonies of less than 10 birds. Lays 3 eggs on average in bulky, cup-shaped nests 2–4 m above ground.

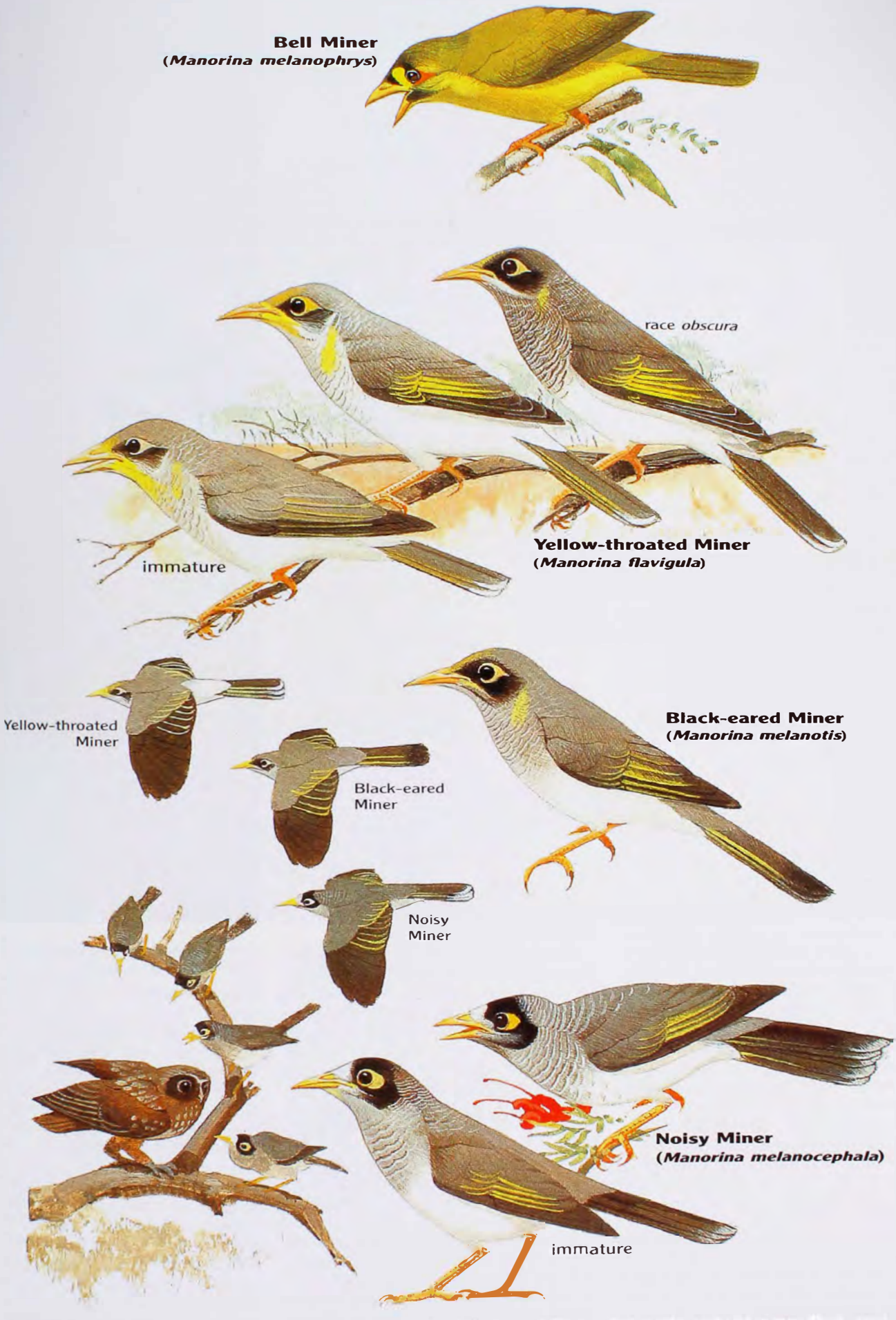
Diet
Invertebrates and nectar, mainly from eucalypts.

Status
Critically endangered.

the more common Yellow-throated Miner and did not even warrant subspecific status. However, there are problems with the application of this 'biological species concept'. Modern molecular techniques have revealed that natural hybridisation between otherwise distinct species occurs in numerous instances and therefore, by itself, cannot be viewed as sufficient evidence for combining two species as one.

According to proponents of the 'phylogenetic species concept', an understanding of evolutionary history is the critical factor in determining species limits. At the Museum of Victoria, Les Christidis and Janette Norman used a molecular approach to assess the Black-eared Miner's level of genetic differentiation in relation to other miners. In one of the first Australian cases to use DNA technology to address classification and conservation issues, they established beyond doubt its status as a distinct species.

USING A PROCESS CALLED 'POLYMERASE Chain Reaction Sequencing', differ-



As a result of extensive interbreeding between Yellow-throated and Black-eared Miners, photographic material of pure Black-eared Miners is extremely rare and an illustration is the only reliable way to clearly display the differences between the species. This illustration will help you to differentiate between Australia's four native species of miner.

Given the Black-eared Miner's dependence on mallee, unburnt for more than 40 years, a major management priority is fire protection.

ences between species are highlighted through measuring the sequence variation in their genes. In the case of hybrids, DNA from within the nuclei of cells is unsuitable as it is subject to recombination (the coming together of two different sets of genes during sexual reproduction), thus making it too difficult to identify which genes come from which species.

Situated outside the nucleus, mitochondria are tiny biochemical power plants that energise our cells and possess an independent, circular DNA molecule. This is passed on intact through the female line, which means all offspring possess their mother's mitochondrial DNA. A hybrid individual therefore contains only the mitochondrial DNA of the female parent—either the Black-eared or Yellow-throated Miner, but not both.

All living organisms carry the same four DNA building blocks (nucleotides or bases) within their genes. It is the precise ordering of these bases in a double helix that determines the genotype (genetic make-up) and phenotype (physical appearance and traits) of an organism. Closely related species share many common patterns and are differentiated by sequence variations.

The researchers extracted mitochondrial DNA from cells at the base of feathers and compared corresponding sections from the various miner samples. DNA sequences from the Noisy and Bell Miners, with their distinctive patterns, were easily recognised. Among the Yellow-throated Miner results, several DNA haplotypes (or genetic variations) were recorded, largely corresponding to the various subspecies (*M. f. flavigula, lutea, pallida* and *obscura*). When it came to the 17 available hybrid samples, using a process of elimination, the Yellow-throated Miner patterns were identified and what remained, in two of the samples, represented the genetic signature of the Black-eared Miner.

To further verify this as the correct code, the researchers examined feathers from the Museum's preserved specimens of pure Black-eared Miners, some more than 80 years old. Unfortunately, the extracted DNA was highly degraded and could only provide short stretches, which proved largely unsuitable for analysis. (New methods of replicating these smaller DNA fragments are currently being developed.)

Similarities across all the DNA results showed that the four miner species share a recent common ancestor. The Bell Miner displays the most variation, suggesting it was the first to diverge and become a separate species. This is understandable considering it is the most distinctive in appearance. The other three miners appear to have diverged from each other over a relatively short period of time.

The most interesting find is that, on a genetic level, the Black-eared Miner exhibits even more variation, in relation to the Yellow-throated Miner, than the Noisy Miner does. This is surprising and shows that appearances can be deceiving, given that the Noisy Miner is the easiest of the three to recognise and was therefore expected to exhibit the greatest genetic difference. As the Noisy and Yellow-throated Miners are universally recognised as separate species in their own right, the Black-eared Miner deservedly warrants species status.

THESE RESULTS QUALIFIED THE MINER for research funding to determine its conservation requirements. The Black-eared Miner Recovery Team, coordinated by the Victorian Department of Natural Resources and Environment, is managing the research and restoration effort. In Victoria at least, suitable habitat has already been identified and all known colonies are wholly or partly within conservation reserves or State forest. An action statement, under the Victorian Flora and Fauna Guarantee Act, will give special legislative protection to known and potential habitat in this State.

Given the Black-eared Miner's dependence on mallee, unburnt for more than 40 years, a major management priority is fire protection. Other species requiring mature-age mallee also stand to benefit from both the reservations and the suppression of wildfires. Current research is looking at Black-eared Miner threats, social organisation and breeding systems. The results will assist in the development of field techniques to curtail hybridisation, increase colony productivity and establish possible systems for the translocation and reintroduction of birds.

A captive breeding program is under way at Healesville Sanctuary in Victoria, with the aim of back-crossing and actively selecting towards the Black-eared Miner phenotype. According to the program's coordinator Michael Miller, this will help to maintain the genetic integrity of the species. It serves as insurance against total loss and hopefully will provide enough birds for the restoration of wild populations. This poses a challenge as cooperatively breeding birds have rarely been held and bred in captivity. However, after the first breeding season, two hybrid young successfully fledged and valuable nesting data are now being obtained.

A Yellow-throated Miner displays its distinctive throat markings.

The long-term aim is to de-list the species as endangered and achieve a self-sustaining wild population of at least 100 colonies of ten birds each (pure or at least close to the Black-eared Miner phenotype). They would need to be sufficiently dispersed so as not to be wiped out in a single natural disaster but in close enough proximity to allow for interbreeding between colonies.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

In a positive development in 1996, surveys in South Australia managed to locate many previously unknown hybrid colonies, primarily in the Bookmark Biosphere Reserve. The birds appear to be close to the Black-eared Miner phenotype and possibly include a handful of pure individuals. Four females from the population were captured in February 1997 and these have joined the nine hybrids, from Victoria's Wyperfeld gene pool, in the captive breeding program at Healesville. In a further protective measure, Birds Australia (formerly the Royal Australasian Ornithologists Union) recently purchased the pastoral lease of a property containing a significant number of the colonies, adjoining the reserve.

The preservation of the Black-eared Miner is very much a collaborative effort, involving birdwatchers, zoos, government departments, funding agencies (like Environment Australia Biodiversity Group) and land owners, among others. Members of the community are encouraged to report sightings and can also volunteer for field work. Interested parties can contact the Threatened Bird Network at Birds Australia*.

In light of the support network that is now in place, along with early captive breeding success and the location of additional hybrid colonies, the future of the Black-eared Miner, currently teetering on the brink of extinction, is looking a lot more promising. DNA technology played an important role in solving the taxonomic puzzle and determining that, as a species, the Black-eared Miner was in desperate need of preservation. Conservation genetics is a growing area of research and molecular techniques are revolutionising the field of taxonomy. They provide an additional and valuable tool, especially for addressing controversial cases like this one proved to be.■

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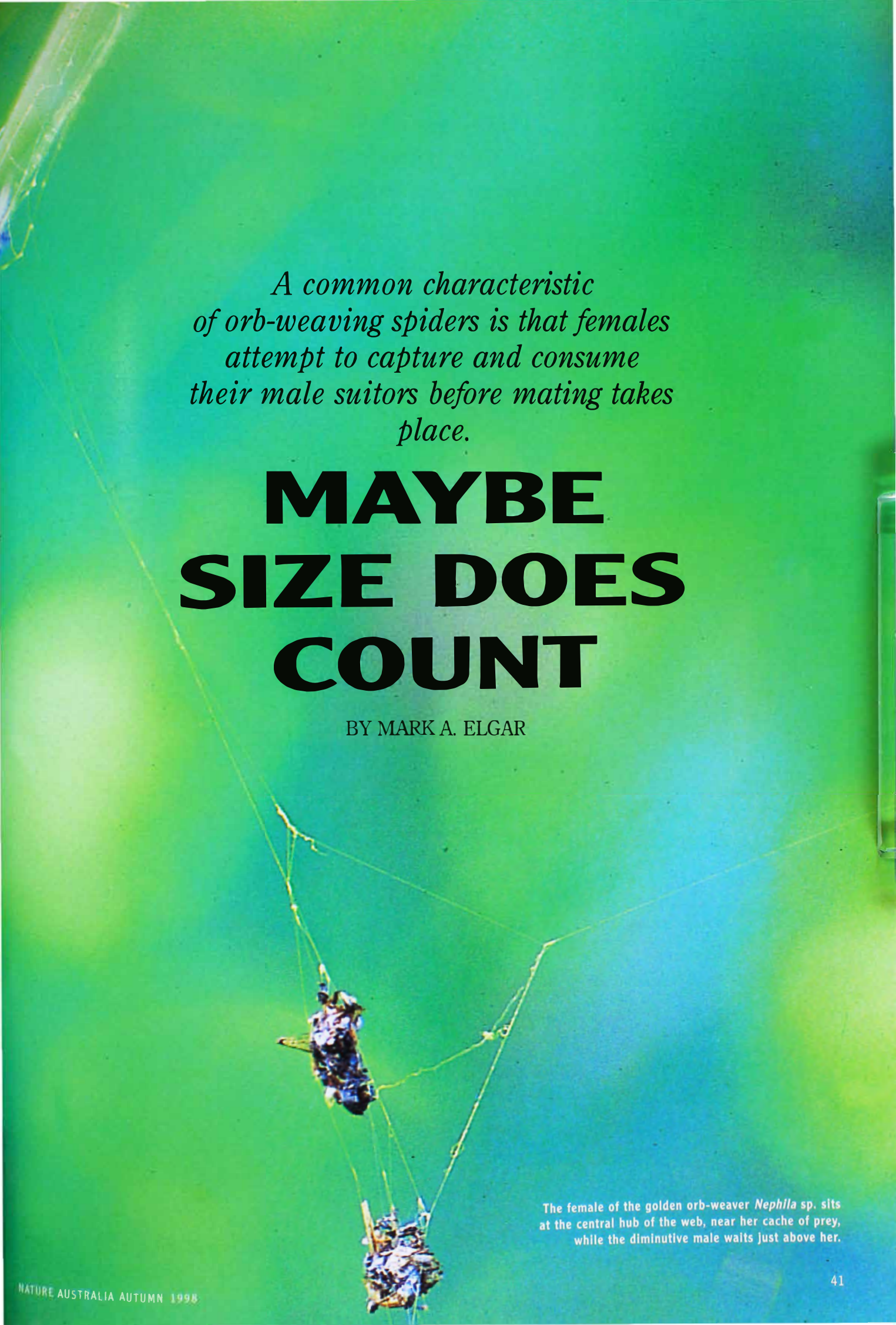
**Dr Les Christidis is a molecular biologist and Head Curator at the Museum of Victoria. He uses molecular techniques to trace the evolutionary relationships of Australasian birds and has an interest in conservation genetics. Tess Holderness is a science journalist and reporter based in Melbourne. Any sightings of Black-eared Miners may be reported to Birds Australia, 415 Riversdale Rd, East Hawthorn, Victoria 3123, ph: (03) 9882 2622.*

ESTHER BEATON

A common characteristic of orb-weaving spiders is that females attempt to capture and consume their male suitors before mating takes place.

MAYBE SIZE DOES COUNT

BY MARK A. ELGAR



The female of the golden orb-weaver *Nephila* sp. sits at the central hub of the web, near her cache of prey, while the diminutive male waits just above her.

MOST PEOPLE, AT ONE TIME or another, have bumbled into the vast webs of our large orb-weaving spiders. The lucky ones will have stopped short. But others may have had that unpleasant, and sometimes sticky, experience of a face-to-face encounter with the rather large resident spider. Whatever our reactions to these spiders, they are still very much smaller than us. Imagine then, the problems facing male golden orb-weavers (*Nephila* spp.) or banded orb-weavers (*Argiope* spp.), which can be as little as a tenth the size of the female.

Providing an explanation for the relatively diminutive size of the males of many tropical and subtropical orb-weaving spiders has fascinated naturalists and biologists for over a century. Male orb-weaving spiders are always smaller than their female counterparts; however, the difference in size between the sexes, or sexual size dimorphism, varies widely in this taxon. An extreme example is the golden orb-weaver *Nephila plumipes*, which is commonly found in the eastern coastal regions of Australia and is among the largest of our orb-weaving spiders. Females grow to a length of 35 millimetres, can weigh over 800 milligrams and spin webs that exceed one metre in diameter, while the males are considerably smaller, growing to little more than five millimetres and weighing a relatively modest 17 milligrams. In contrast, the 16-millimetre-long males of the nocturnal garden orb-weaver *Eriophora transmarina*, often found in suburban backyards, are not that much smaller than the 22-millimetre-long females.

Providing an explanation for the relatively diminutive size of the males of many orb-weaving spiders has fascinated biologists for over a century.

The golden orb-weaver *Nephila plumipes*.

How do we explain this difference in size between females and males? Natural selection may favour larger females because they can produce more eggs and therefore enjoy a greater reproductive success. On the other hand, males may improve their reproductive success by mating with many virgin females, which is most easily achieved by being among the first to achieve sexual maturity. And smaller males may mature earlier than larger males, thereby promoting greater sexual size dimorphism. While these arguments provide a general explanation for why male spiders are smaller than female spiders, it seems insufficient to account for the extraordinary sexual size dimorphism of some orb-weaving spiders. The answer may lie in their mating behaviour.

DENSEY CLYNE

STEVE WILSON

The male and female of the garden orb-weaver *Eriophora* sp. court on a mating thread that is spun by the male.

KATHIE ATKINSON

MARK A. ELGAR

The orb-weaver *Araneus diadematus* is a diurnal spider that is common in Europe and North America, and often occurs in relatively high densities.

A COMMON CHARACTERISTIC OF ORB-WEAVING spiders is that females attempt to capture and consume their male suitors before mating takes place. Why females behave this way is still not fully understood; the behaviour is curious because the female risks not having her eggs fertilised. But whatever the reason for why it occurs, pre-mating sexual cannibalism seems to have important implications for the size of males. Darwin was certainly convinced of this, quoting the observation by the Rev. O Pickard-Cambridge, an esteemed arachnologist of the day, that the male is ". . . so small as to be a sort of parasite upon the female, and either beneath her notice, or too agile and too small for her to catch without great difficulty".

Recently, my former student Babette Fahey (now at Harvard University) and I tested this idea by staging courtship encounters between females of the golden orb-weaver *Nephila plumipes*, and males of different sizes. Once a mature, diminutive male locates the web of a female, he moves along a support thread from the surrounding vegetation to the web, hesitating briefly before venturing onto the orb-web proper. The orb-web is where the female captures her prey and, not surprisingly, the male traverses very cautiously across it toward the central hub where she is waiting. If she responds to his movements, perhaps by orienting toward him, he pauses for several minutes. We discovered that females invariably responded to larger males, some of whom were subsequently eaten, but never reacted to smaller males. This result suggests that, for this species, natural selection (by sexual cannibalism) favours smaller males and hence supports Pickard-Cambridge's explanation for the extraordinary degree of sexual size dimorphism in this species.

However, this explanation is faced with a problem because sexual size dimorphism is not so great in other sexually cannibalistic orb-weavers, such as the larger nocturnal garden spider *Eriophora transmarina* or the small Enamelled Spider (*'Araneus' bradleyi*). The issue can be resolved by considering where on the web courtship and mating take place. Males of these spiders do not venture onto the orb-web, but instead construct a 'mating thread' that is suspended between the structural

The tiny male *Nephila* must traverse the orb-web to reach the female waiting at the central hub.

MARK A. ELGAR

The larger female *Araneus diadematus* (right) hangs from the mating thread that was spun by the male. He strums the thread with his third pair of legs and strokes the female with his relatively long, front legs.

threads of the web. The male attracts the attention of the female by hanging from the mating thread and strumming it like a harp. Eventually, she walks onto his mating thread, somewhat precariously, and the male strokes her with his long front legs. He then takes a final leap from the mating thread to the female and copulation occurs, providing she doesn't capture him 'mid-flight' and make a meal of him. My earlier experiments with the European orb-weaving spider *Araneus diadematus*, which also mates on a mating thread, revealed that females were better at capturing smaller males. For this species, larger males are more likely to mate and reproduce than smaller males, and hence sexual size dimorphism is not so great.

The results of these experiments suggest more general predictions about the patterns of sexual size dimorphism among species of orb-weaving spiders. Considerable sexual size dimorphism is expected in species that mate at the central hub because smaller males are less likely to be cannibalised by females. In contrast, it will be less pronounced in species that mate on a mating thread because smaller males are more likely to be cannibalised. This broad prediction can be examined by collating information on the size of males and females and the location of mating for many different species of orb-weaving spiders. The prediction seems to be upheld; sexual size dimorphism is more pronounced in species that mate at the hub than those that mate on a mating thread.

ALTHOUGH THESE STUDIES TELL US WHY the degree of sexual size dimorphism might differ between species of orb-weaving spiders, they can't tell us much about the evolutionary progression of these differences. Generally speaking, species of spiders with small females have small males and species

BRIAN CHUDLEIGH

Golden orb-weavers (*Nephila* spp.) form large aggregations. Each spider rests in its own web, which may sometimes be attached to other webs.

with large females also have large males. Thus, we can't be sure why, over evolutionary time, the difference in sexual size dimorphism arises between species. Is it because the size of females but not males has changed, or the size of males but not females has changed, or because both have changed?

The issue is controversial. Fritz Vollrath from the University of Aarhus in Denmark claims that the diminutive size of males of some species is the result of evolution toward smaller size. His explanation has nothing to do with sexual cannibalism, but rather that large size dimorphism is expected in species in which males suffer higher mortality than females, resulting in a population of more females than males. Consequently, there will be little competition between males for mating opportunities, which in spiders is usually won by the larger male. Thus large size is not important and smaller males that mature earlier may enjoy more reproductive success. The evidence for this argument is not particularly convincing, however, and a recent analysis of the phylogenetic relationships of spiders paints a rather different story. Jonathan Coddington, from the Smithsonian Institute in Washington, and colleagues have shown that, for golden orb-weavers, females tend to be much larger than their ancestors, while males are either the same size, or also larger. Thus the difference in sexual size dimorphism between species reflects a change in female, not male, size. Why females have increased in size, however, is not explained.

Where does this leave the sexual cannibalism story? In general males of species that mate on the hub are a similar size to those that mate on a mating thread. This too suggests that the difference in size dimorphism arises through changes in female size; as females have become larger (for whatever reason), selection through sexual cannibalism has simply suppressed any associated increase in male size for species that mate at the hub but not for those that use a mating thread. Of course, the explanation is only relevant for orb-weaving spiders that are sexually cannibalistic. But for these species, the question of size mainly becomes an issue of either discretion or brute force. ■

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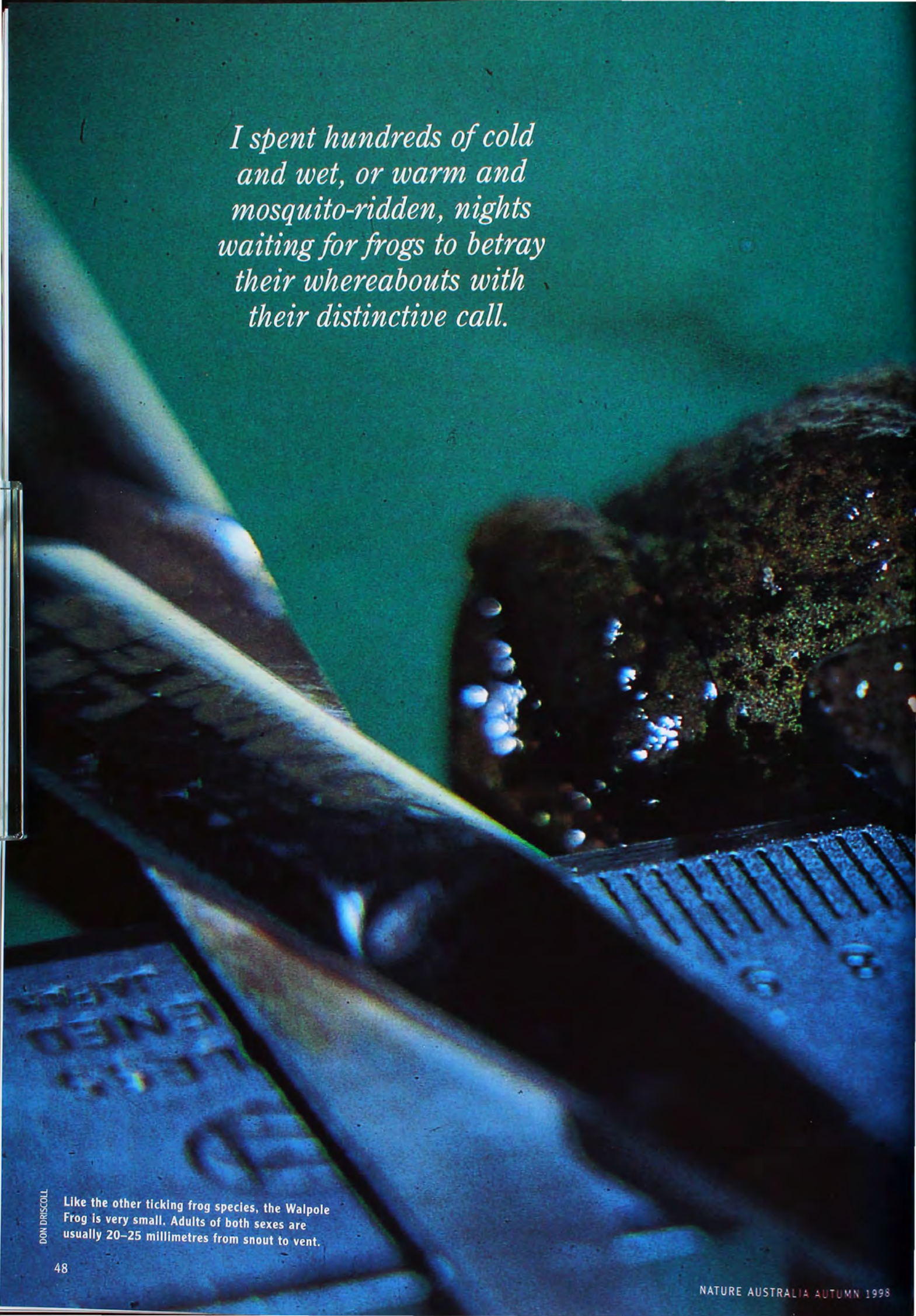
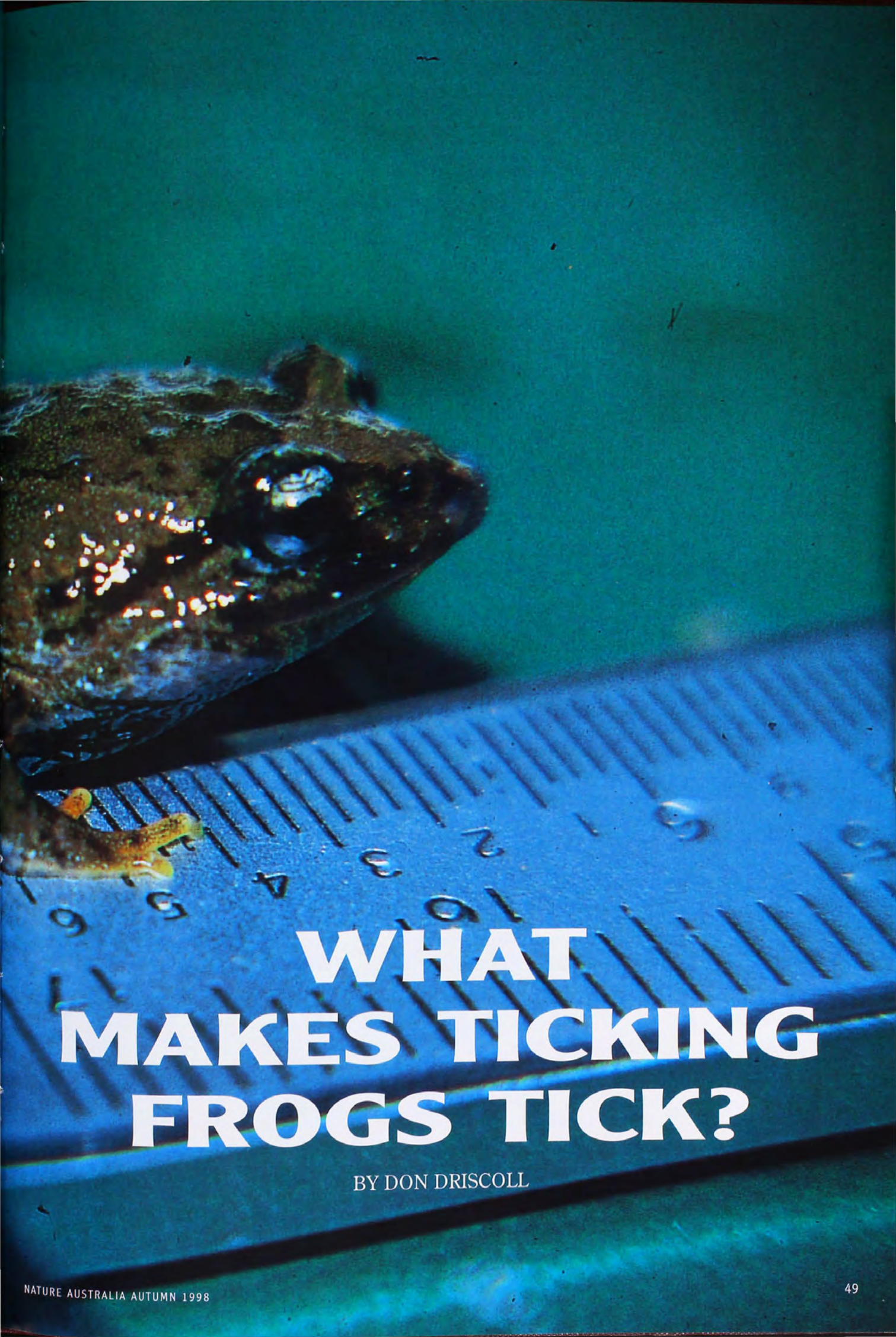
Dr Mark Elgar is a senior lecturer in the Department of Zoology at the University of Melbourne, where he teaches animal behaviour and evolutionary biology. He has a long-standing research interest in the mating behaviour of spiders and insects.

I spent hundreds of cold and wet, or warm and mosquito-ridden, nights waiting for frogs to betray their whereabouts with their distinctive call.



DON DRISCOLL

Like the other ticking frog species, the Walpole Frog is very small. Adults of both sexes are usually 20–25 millimetres from snout to vent.



WHAT MAKES TICKING FROGS TICK?

BY DON DRISCOLL

THERE ARE FOUR SPECIES OF 'TICKing frogs', in the genus *Geocrinia*, found in the rank swamps of south-western Australia. At first glance, all four species are small, brown and nondescript. However, when you flip them onto their backs, their true colours shine through. Their bellies have colours peculiar to each species, and these colours are the basis of their scientific names: *vitellina*, egg-yolk orange; *rosea*, rosy pink; *alba*, white; *lutea*, yellow.

Male ticking frogs call from shallow spherical burrows beneath leaf litter. They build their burrows in the damp soil beside streams or in soaks. Their call is a series of rapidly repeated clicks or ticks (hence the name 'ticking frog') and is used for attracting females. Female ticking frogs lay up to 30 eggs in the burrow and the larvae stay inside the burrow until they transform into frogs. The tadpoles don't eat anything and must survive to reach metamorphosis on the energy reserves provided in the egg yolk. This reproductive strategy, known as direct development, is quite different to most other frog species, many of which lay hundreds or thousands of eggs in water, and have free-swimming, feeding tadpoles.

Their unusual mode of reproduction renders ticking frogs particularly vulnerable to soil disturbance. Trampling by livestock or clearing of native vegetation churns up the soil, often with catastrophic effects on the resident frogs. Land clearance and grazing are the primary reasons that White-bellied Frogs (*G. alba*) are considered the most endangered of the four species. The Orange-bellied Frog (*G. vitellina*) is also an endangered species. Local catastrophes, such as disease, could at once wipe out this entire species because it has an extremely small distribution: it lives in only six creeks, within an area of six square kilometres.

I set out to examine genetic differences between populations within each ticking frog species. With this as my goal I leapt into the swamps.

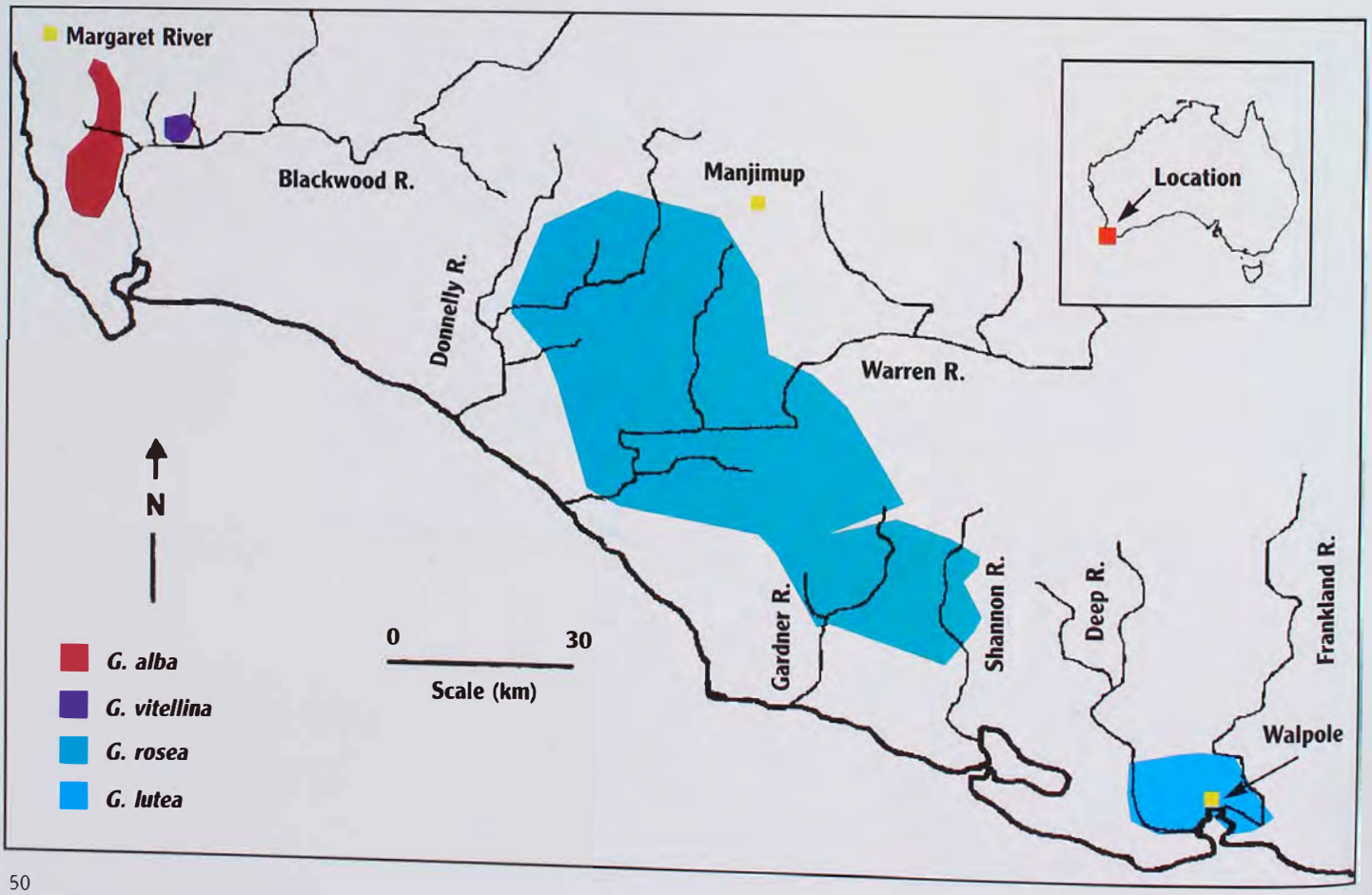
Tiny geographic distributions are characteristic of ticking frogs. All four species have separate ranges between the towns of Margaret River and Walpole, an area that spans only 200 kilometres. The domain of each species is minute, spanning from four to 70 kilometres. This is in stark contrast to most other frog species in the south-west, which live throughout huge areas, often spanning distances of more than 1,000 kilometres. So, why are ticking frogs different? How have four species of ticking frogs evolved within the same area that most other frog species range throughout?

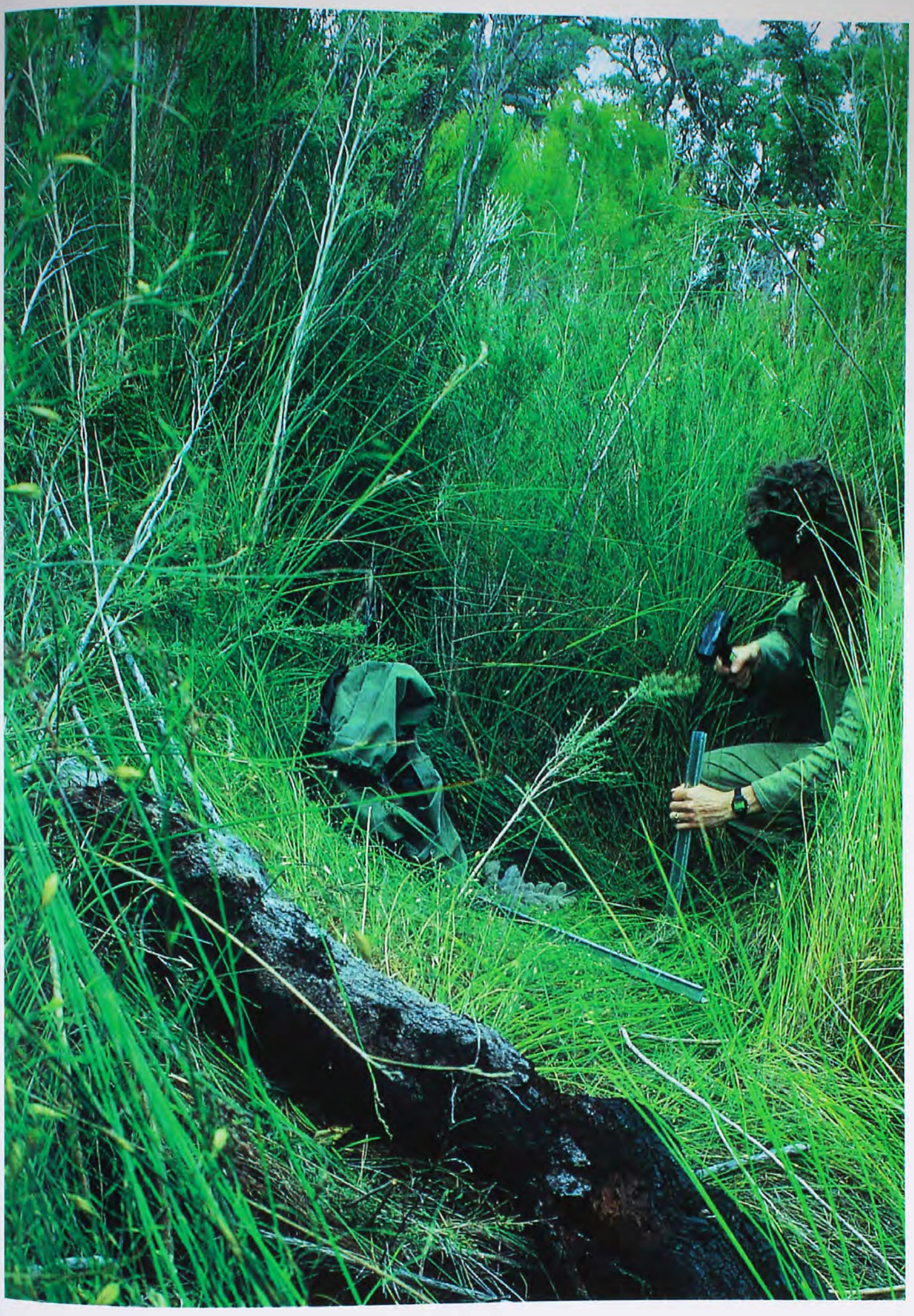
This is not a trivial question, nor is it purely of academic interest. The answers have practical applications in the fields of species management and conservation biology. Conservation of wild species involves more than just making sure that some individuals survive. Species are dynamic. They interact with one another and their environment. Species undergo genetic change; they diverge and evolve. Maintaining those dynamics is an important goal of conservation biology. Therefore, to conserve a species, the evolutionary processes of that species need to be maintained. To safeguard a species' ability to evolve, we need to know how it has evolved in the past. So, one of the questions I asked in my PhD research was how have ticking frogs evolved?

I SET OUT TO EXAMINE GENETIC differences between populations within each ticking frog species. A population is all of the frogs in a particular

COURTESY DON DRISCOLL

Ticking frogs breed in densely vegetated swamps with acidic, black soil. Here the author is shown marking the end of a survey transect to examine the impact of fire on the Karri Frog.





G. WARDELL-JOHNSON

PHOTOS: BRAD MARYAN

How to identify ticking frogs? Shown here are the ventral (belly) and dorsal (back) views of all four species of ticking frogs, which can be distinguished by their ventral colours: *Geocrinia alba* is white or pale yellow (first row); *G. vitellina* is egg-yolk orange (second row); *G. rosea* is usually pink or orange (third row); *G. lutea* is muddy-yellow or red (bottom row). Male *G. rosea* and *G. lutea* have black chins.

swamp, so each species consists of many local populations. I hoped this genetic approach would provide an evolutionary model that might apply at the broader geographic scale of the four species. With this as my goal I leapt into the swamps.

A typical ticking frog swamp is a broad creek line, sometimes with a distinct creek channel. The soil is usually black with peat, and supports a distinctive, almost impenetrable tangle of plants. These include Swamp Peppermint (*Agonis linearfolia*) and razor-edged sword sedges (*Lepidosperma* spp.), all bound together with entangling creepers and spiny wattles. I spent hundreds of cold and wet, or warm and mosquito-ridden, nights crouching behind a cone of yellow torch light, waiting for frogs to betray their whereabouts with their distinctive 'tk tk tk tk tk tk tk' call. The genetic technique I used required only a small tissue sample, so I was able to return all of the frogs to their swamps unharmed.

Later, in the lab, an incredible picture of diversification emerged. Within each species there were enormous genetic differences between the frogs from separate swamps, even for swamps less than one kilometre apart. I found some forms of genes only in a single population, while I found others in two or three populations in adjacent swamps. For such massive genetic differences to exist, the frogs in separate swamps must be almost completely isolated from each other. Dispersal among swamps would spread the genes, thereby preventing the build-up of genetic differences. Thus the big genetic differences told me that these frogs tend to reproduce in the same swamp as their parents and so, when new mutations arise, they are unable to spread to other populations.

Genetic estimates of movement can be problematic because there are usually alternative ways of interpreting the data. So I sought a more direct estimate of the dispersal tendencies of ticking frogs. I recaptured hundreds of individually marked White- and Orange-bellied Frogs and measured the distance between their capture site and their previous release site. It quickly became apparent that these frogs don't move very far at all. In many cases I knew which frog I was about to capture simply by its location in the swamp. I caught one frog within the same square metre of swamp in four successive years! The majority of frogs moved less than five metres between years.

Does this explain how four species of ticking frogs have managed to evolve in the south-west? By having stay-at-home dispositions, have these frogs simply been isolated in different areas and diverged to become different species? Perhaps. But if that were true, why haven't all of the populations in separate swamps become separate species? What holds species together? Patterns within the genetic data helped me answer this question.

Within each species there were a number of distinct groups, or clusters of populations. Populations within a cluster were more similar to each other than they were to populations in other clusters. What's more, these clusters of populations often abutted, creating very sharp genetic changes over very short distances. An analogy might be clusters of cities in European countries. Although the cities within the same country differ from one another, they are not as different from one another as they are from the cluster of cities in the adjacent country.

The most spectacular split within a ticking frog species was between the northern and southern populations of the Karri Frog (*G. rosea*). These two groups were so different that the taxonomic status of the Karri Frog is now being reconsidered: it may consist of two distinct species. The southern cluster of 'Karri Frog' populations all had a different form of one gene compared with all the populations in the north. This complete genetic change took place over a distance of only two kilometres. There were other remarkable genetic clusters within each of the ticking frog species. For example, nine populations of the Walpole Frog (*G. lutea*) from the lower reaches of the Frankland River had no genetic variation within the genes examined, and appeared identical. These made a bold contrast with Walpole Frog populations from farther upstream, and from the adjacent creek, which had variation for several genes. Why? How could these broad-scale groupings within species have formed?

TICKING FROGS

Classification
Family Myobatrachidae. 'Ticking frogs' include the four species in the *Geocrinia rosea* complex: Karri Frog (*G. rosea*), Walpole Frog (*G. lutea*), White-bellied Frog (*G. alba*), Orange-bellied Frog (*G. vitellina*). The taxonomy of *G. rosea* is currently being revised because this taxon may represent two distinct species.

Identification
Shorter legs, different breeding biology, and a simpler advertisement call than other frogs in the genus *Geocrinia*. *Geocrinia leai* is the only other *Geocrinia* sp. in south-west WA and it has a two-part 'RRRRit nik nik nik nik' call rather than a simple 'tk tk tk tk tk tk tk'. All ticking frogs have allopatric distributions (see map). Calls of *G. rosea* and *G. lutea* are difficult to distinguish, but have slower pulse rates, and are more continuous, than *G. vitellina* and *G. alba*. *Geocrinia vitellina* tends to have fewer ticks per call than *G. alba*.

Ventral Colouration
Geocrinia vitellina, egg-yolk orange; *G. alba*, white, or pale yellow wash; *G. rosea*, usually rosy pink, but also black, white, grey and orange; *G. lutea*, usually muddy yellow, but also black, white, grey and blood red. Males of *G. rosea* and *G. lutea* have a black chin. Inter- and intra-specific variation in ventral colours suggests this character may not be adaptive but, rather, a quirk of evolution.

Habitat
Broad drainage lines with dense Swamp Peppermint (*Agonis linearfolia*) and a variety of other human-inhibiting plants. Soils usually have a high organic content, and highest densities of all species can be found in water-seepage areas. *Geocrinia rosea* and *G. lutea* also occur in narrow, steep-sided creeks, or broad creeks where sword sedges (*Lepidosperma* spp.) are dominant. *Geocrinia rosea* breeds away from creek lines in high-rainfall areas, using rotting logs as burrow sites.

Biology
Call from July to Jan. Eggs of *G. alba* laid Aug.–Dec.; other species presumed similar. Direct development. Eggs laid in spherical burrow in moist soil, or rotting logs (*G. rosea* only). Average clutch sizes: *G. alba* 9.5, *G. vitellina* 11.8, *G. rosea* 24, *G. lutea* 13.2. No parental care. Metamorphosis in 28–98 days (*G. alba*), depending on temperature. In *G. alba* and *G. vitellina* majority reach sexual maturity 3 years after egg deposition; adults participate in 1.5 breeding seasons (average); max. longevity 6 years. Food unknown.

Status
Geocrinia alba—critically endangered due to habitat fragmentation and recent local population extinctions caused principally by habitat loss. Three small populations have died out in the absence of obvious causes, possibly indicating deteriorating climate. *Geocrinia vitellina*—vulnerable due to its small distribution and small number of populations. *Geocrinia rosea* and *G. lutea*—secure but local population extinctions of both species suggest ongoing monitoring is necessary.

G. WARDELL-JOHNSON

The answer to this question was critical to understanding how these species evolved.

Common ancestry was the most likely solution. All of the separate populations that have a similar genetic make-up do so because they stem from the same ancestral population. For this to happen there must have been an historic period of range contraction, leaving only a few refuge populations. These refuge populations formed the seeds that gave rise to many new populations when the range expanded. The offspring of the ancient refuge populations form the genetic clusters that are evident today. In North America, the genetic record of past distribution changes is well documented in amphibians, birds and mammals. In the northern hemisphere, range changes have generally been driven by the expansion and retraction of extremely cold conditions during past ice ages. In Australia, a lack of water may have had the same consequences as the overabundance of ice in the northern hemisphere. Cyclical changes in rainfall may expand or deplete available habitat, causing the frogs to spread out over the land, or to contract.

These frogs don't move very far at all. I caught one frog within the same square metre of swamp in four successive years!

The combined action of genetic change in isolated populations with long-term range changes can cause significant evolutionary shifts. So ticking frogs exist under highly potent conditions for evolutionary change. Consider the following hypothetical scenario. At some time in the past, there were three swamps, each with a population of ticking frogs. For one particular gene, say for eye colour, there were three alternative forms—black, brown and green. The climate was relatively wet, so the frogs were able to move between the three swamps. This dispersal continually mixed the three eye-colour genes among the populations. Then the climate began to dry out. The frogs could no longer traverse the dry bush between swamps, and so the three populations became isolated from each other. Some time later, a year of unusually dry conditions drastically reduced the number of frogs in each population. Through chance it happened that in one population only green-eyed frogs survived. As conditions continued to dry out, two of the populations became extinct, leaving only the population with the green-eyed frogs. This is a critical stage in this evolutionary scenario; the genetic difference between the refuge population (green eyes) and the original set of populations (black, brown and green eyes) will determine the magnitude of evolutionary change. The difference could be even greater if a mutation occurred in the refuge population to produce, say, red eyes.

Of the four ticking frog species, the White-bellied Frog is the most endangered.

When the climate did a back flip, and rainfall began to increase, the green-eyed frogs recolonised the other two swamps. When they did, they formed a cluster of three green-eyed populations. This range-expansion phase serves to magnify the genetic changes that occurred in the refuge population. Now, assume there was a second set of populations in the swamps next to the original three populations. During the drying, range-contraction phase, two of the three populations became extinct. The remaining population, by chance, lost all of the brown-eyed and green-eyed frogs, leaving only frogs with black eyes. When rainfall began to increase, the black-eyed frogs hopped back to the unoccupied swamps, forming a second genetic cluster of populations, with a sharp boundary between the black-eyed and green-eyed clusters.

It only takes a small leap of the imagination to understand how this process could operate at the larger geographic scale of the entire south-west of Western Australia. At some time in the past, possibly several million years ago, ancestral ticking frogs would have been spread throughout the south-west in much the same way that most other species are today. However, with an increasingly arid climate, their ranges would have contracted to the wetter areas with suitable refuges. The frogs in each of these refuges had vastly different characteristics (such as different belly colours, and slightly different ticking calls), giving rise to the species that we now recognise. Range changes since that time have produced substantial genetic divergence within all the ticking frogs, and may yet lead to the evolution of additional species.

THE CONSERVATION IMPLICATIONS OF this evolutionary process are profound. Connections of native vegetation between swamps are essential for range changes and divergence to continue. Even if ticking frogs are absent from particular swamps, those sites and the intervening habitat may be critical in their continuing ebb and flow. The range of the White-bellied Frog has been severely fragmented by clearing for grazing land. Fragmentation may have no immediate impact, since under the current climatic conditions most populations seem to be naturally isolated. What's more, during increasingly dry conditions, natural declines are expected as local populations die out. However, in the absence of connections between swamps, range expansion following contraction may be impossible. Without those connections, the next range retraction may be the last.

Scientists have reported inexplicable declines of many amphibian species from around the globe. Even taking into account obvious causes of extinction such as habitat destruction, there are still many declines that lack a satisfying explanation. Some researchers have propounded global warming, increases in ultraviolet radiation, or introduced diseases as possible causes. However, in every case, normal fluctuation in population size could account for apparent declines. Ticking frogs are a case in point. At some time in the past there have been massive, natural declines in this group of frogs. These have involved extinction of many local populations and probably lasted for many years; just as more recent declines have. However, we don't know how long it takes for these natural declines to occur. It would be surprising if declines were as rapid as those in northern Queensland, where several species have virtually disappeared in two or three years. Declines in ticking frogs are more likely to occur over decades or centuries. The debate that rages over the causes, and even the reality of amphibian declines, belies our lack of understanding of amphibian ecology. Continuing research into how frogs survive in both the long and short terms is gradually shedding light on why some species of amphibians have declined.

Each species of ticking frog incorporates many characteristics, and those features encompass far more than just their ticking calls and coloured bellies. They have an exciting and complex evolutionary history. It is a history of movement through an ancient landscape: geographic waxing and waning, combined with evolutionary change. My genetic study of ticking frogs emphasises the fascinating complexity of species in the wild. Species not only carry with them their body form, but also a deep evolutionary history. They are interwoven in dynamic and ongoing evolutionary processes. Those processes are inextricably tied to the land on which a particular species has evolved. Cut those links, and an important characteristic of that species would be lost, just as surely as taking the tick out of ticking frogs would render them impoverished shadows of their former selves. Therefore, to conserve a species, its links with the land from which it sprung must be retained. Although keeping a species in a zoo is better than its complete extinction, ticking frogs show that the entire essence of a species can only be retained in the wild.■

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Dr Don Driscoll completed his PhD on the population genetics of the Geocrinia rosea *complex of frogs in the Zoology Department at the University of Western Australia in 1996. He is now Senior Conservation Officer with the Threatened Species and Ecosystems Unit of the Queensland Department of Environment.*

CARY BELL

Nobody knew the scale or impact of the trade, and few people knew much about seahorses.

SEAHORSES UNDER SIEGE

BY AMANDA VINCENT

IT IS A SAD IRONY THAT THE SAME magical qualities drawing me to seahorses also threaten their survival. These quirkiest of fishes are now highly valued and heavily traded around the world for traditional medicines, aquarium pets and curiosities. Their charisma is problematic in another way, too; government officials and international agencies alike find it difficult to believe that such near-mythical fishes are seriously exploited and economically important. Luckily the public is proving more concerned about these well-loved animals, and this may make all the difference.

The seahorse *Hippocampus abdominalis*.

COURTESY A. VINCENT

Amanda Vincent travelling through fishing villages in the Philippines in order to collect information on the seahorse trade.

My own commitment to seahorses began in 1986, when I was doing my PhD on their behaviour and ecology. I was fascinated by seahorses, both for their own sake and for the possibility they offered to answer general questions about sex role reversal and the evolution of sex differences. You see, only the male seahorse becomes pregnant (see *Nature Aust.** Spring 1989). The female transfers eggs to the male's brood pouch, where they are fertilised. The father then protects the developing embryos, provides oxygen and nutrition, and controls the pouch environment. Pregnancy lasts ten days to six weeks, depending on the species and water temperature, after which the male goes into labour. He pumps and thrusts for hours to free the five to 1,500 young (again depending largely on species). They then swim away, never to return to dear old dad.

Most seahorse species are faithful to one site and to one partner. This fidelity has been best studied in the Australian species *Hippocampus whitei*. Each male has his own patch of seagrass, often only one square metre, where he spends all his time, pregnant for about half the year. The female swims in a much larger area but visits her pregnant mate each morning. Together they perform a ritualised greeting dance, promenading with linked tails and circling a seagrass shoot like maypole dancers. After the male has given birth, however, the dance is prolonged into full-scale courtship, lasting up to nine hours and culminating in remating. These seahorses will not even acknowledge non-partners.

The more I learnt about seahorses, the more I worried about their conservation status. As I travelled the world, I kept encountering piles of dead seahorses in medicine shops and in souvenir stalls, and I was constantly receiving letters from aquarists pleading for advice on how to keep their pet seahorses alive. Nobody knew the scale or impact of the trade, and few people knew much about seahorses. Thus, in 1993, I set off to wander through Asia with local interpreters, asking questions of everybody we met. The story began to unfurl as we visited fishing villages, dried fish traders, shell-craft exporters, aquarium dealers, and traditional medicine practitioners. Fisheries managers and government officials were often sceptical or dismissive, but by 1995 I had my unhappy answer.

THE TRADE IN SEAHORSES WAS HUGE and growing. It was very difficult to be certain of its absolute volume because the few published data that existed were full of gaps and discrepancies, and much of the field information I could glean was anecdotal and circumstantial. But from interviewing many people on different trade levels in many countries, I estimated that at least 20 million seahorses were sold dried for medicines and curios in 1995, with hundreds of thousands more sold live for aquariums. Assurance that this estimate is not too high comes from Taiwan's Customs data, which recorded net imports of about 11.3 tonnes of seahorses (more than three million animals) per year for that island alone in 1993 and 1994. Indeed, one Singapore merchant laughed at my underestimate, pointing out that it would be exceeded if even two per cent of mainland Chinese used one seahorse annually.

China's enormous economic growth is the key to the sudden increase in demand for seahorses and other medicinal products. These fishes (known as *hai ma*) are perceived as important for curing asthma, arteriosclerosis, impotence, incontinence, skin ailments and a host of other maladies. As disposable income grows, so

*Previously *ANH*

SEAHORSES

Classification
All classified as one genus (*Hippocampus*) in the family Syngnathidae, which also includes pipefishes and seadragons. Taxonomy in disarray, and under revision, but probably about 35 species. Australia probably has more seahorse species (at least 11) than any other country.

Distribution and Habitat
Found in most temperate and tropical seas, from Korea and Canada to Tasmania and Uruguay. Live in seagrasses, mangroves, coral reefs and estuaries. Commonly in depths of only a few metres. Usually seen grasping something with their tail.

Reproduction
Only the male becomes pregnant, providing protection, oxygen, nourishment and environmental regulation to developing young. Pregnancy lasts about 10 days to 6 weeks, depending on species and water temperature, after which the male goes into labour to release young. Produce 5 to 1,500 young per pregnancy, depending largely on adult size and latitude. Most species appear to form faithful long-term pairs. Male and female partners meet every morning to dance together. A widowed animal takes a while to repair.

Movement Patterns
Most are diurnal. Many species have very small home ranges. Males, for example, may move only within 1 m^2 for months during the breeding season, although females usually roam more. Short seasonal migrations are suspected for some species.

Diet
Voracious ambush predators that rely on immobility and camouflage to catch just about any live animal small enough to fit into their snouts (e.g. zooplankton, crustaceans, fishes).

demand for seahorses has increased by at least eight to ten per cent annually, according to merchants in China. Very high retail prices (particularly for the preferred large, smooth, bleached seahorses) only add to their allure in societies where conspicuous spending is valued, particularly for gifts.

Traders in Hong Kong have commented that demand for seahorses is limitless. Certainly merchants in China complained in 1995 that they could not obtain enough dried seahorses, and asked us to arrange supplies of hundreds of thousands of extra animals. The main sources are apparently the Philippines, Thailand, Vietnam and India. Yet virtually all the fishers we interviewed in Asia told tales

As I travelled the world, I kept encountering piles of dead seahorses in medicine shops and souvenir stalls.

of recent dramatic decreases in seahorse numbers in their local populations, citing 25 to 50 per cent drops over five years or even 70 per cent losses over ten years in the central Philippines. Traditional Chinese medicine traders welcome the recent increase in sales of pre-packaged patent medicines because consumers cannot tell when these include the less preferred, damaged and juvenile seahorses that would be rejected if sold whole. Indonesia's traditional Jamu medicine also uses seahorses, both whole and pre-packaged.

As Asian seahorse numbers decline, Chinese merchants seek supplies elsewhere, even as far afield as Nigeria and Mozambique, Ecuador and Honduras. The main consumers are China, Hong Kong, Taiwan, Japan, Singapore and Korea, but ethnic Chinese in Western countries such as Australia also rely on dried seahorses. North America and Europe provide the main markets for live seahorses and for curios, with one Philippines company reportedly exporting at least 90,000 dried seahorses to Italy in one year. The

Seahorses of several species hanging in pairs (tied back-to-back at neck and tail) outside a curio or souvenir shop in Vietnam. Starfish, lobsters, shell-craft, and dried fish products are also sold in this harbour-front shop.

A. VINCENT

USA both buys and sells seahorses, with Florida landing at least 112,000 seahorses in 1994.

There are hints that Australia too is involved in the seahorse trade, with advertisements for dried seahorses appearing frequently in a fisheries trade journal for several years, and with one Tasmanian-based commodities company requesting 500 kilograms of dried seahorses from the Institute of Oceanography in Vietnam. Moreover, Australian trade in pipefishes, which are in the same family as seahorses, is well documented.

The largest pipefishes (*Solegnathus* spp.) are often called seadragons (*hai long*) in traditional Chinese medicine and are at least as valuable as seahorses. The stunning fishes that Australians call seadragons (*Phyllopteryx taeniolatus* and *Phycodurus eques*) are not used medicinally. Traders throughout Asia report purchases of *Solegnathus* pipefishes from Australia (also known as pipehorses, because of their curled finless tail similar to that of seahorses), and Taiwan's Customs data show imports of more than 1,000 kilograms from Australia in 1995. The little we know suggests that these are mostly a by-catch of trawling off Queensland, of little economic importance to the fisher. Recently, however, some fishers have been asking Queensland authorities to consider recognising the pipefish by-catch as a market commodity, suggesting its value may be increasing. We really do need studies to understand the impact of trawling on pipehorse populations and to consider ways to ensure their numbers are not reduced, perhaps by altering fishing gear or establishing strategically placed marine reserves.

Some seahorses are also a by-catch of trawling but in developing countries many are specifically sought by subsistence fishers, who catch them one by one. An experienced seahorse fisher finds it easy to penetrate their excellent camouflage and the seahorses facilitate capture by just gripping their holdfasts ever more tightly, rather than fleeing.

KATHIE ATKINSON

A 'non-pregnant' *Hippocampus abdominalis* male seahorse holding on with his tail.

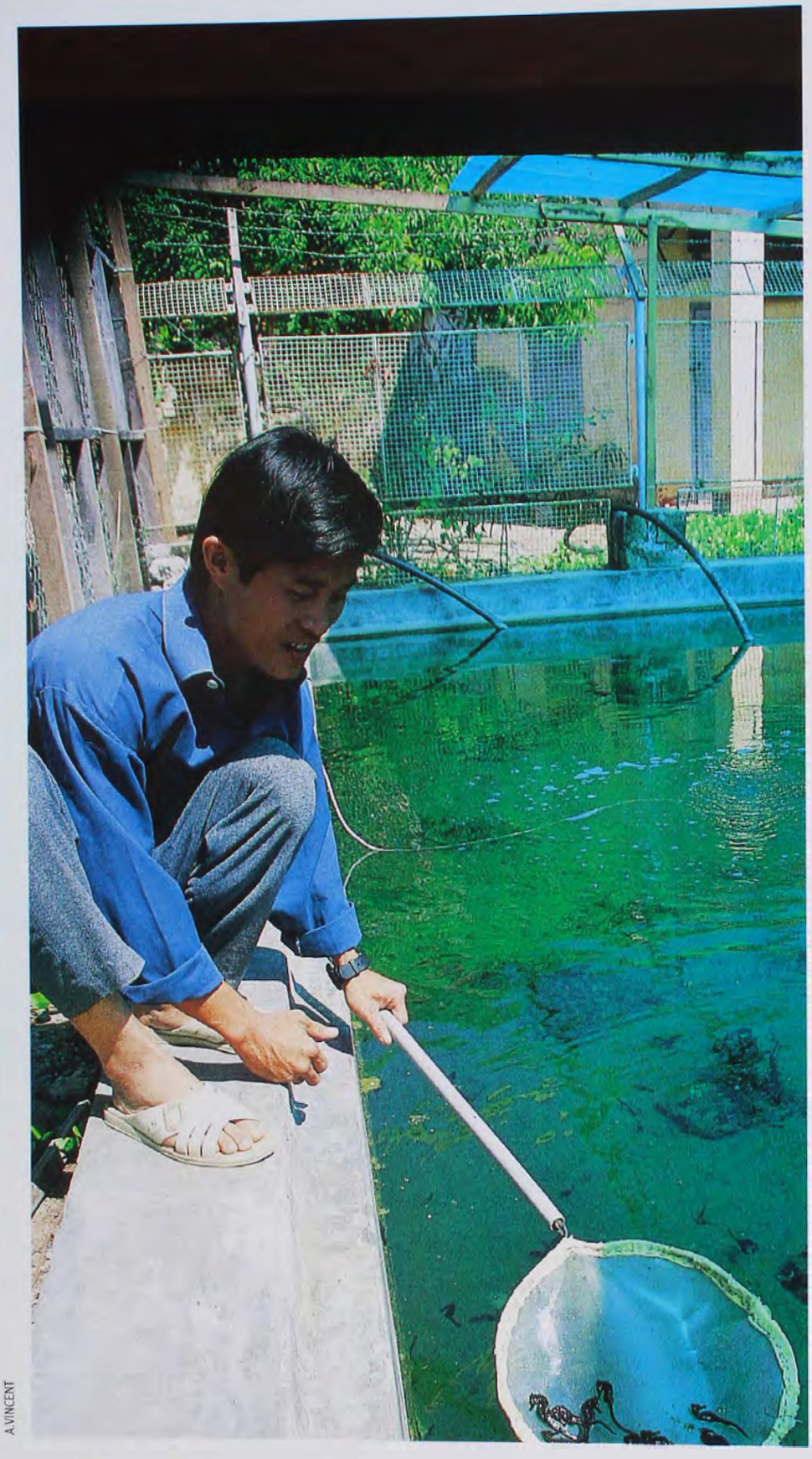
There are hints that Australia too is involved in the seahorse trade, with advertisements for dried seahorses appearing frequently in a fisheries trade journal.

RUDIE H. KUITER

A male *Hippocampus breviceps* gives birth.

Our earlier work on Australian and other species suggests that seahorses have many traits that make them particularly vulnerable to heavy fishing pressure. Brood carrying (pregnancy) means that the young will die if the adult dies, which is not the case in species without parental care and not necessarily the case in species that merely guard a brood; lengthy parental care and small brood size (other fishes may produce hundreds of thousands to millions of young at a time) mean that seahorses can't rapidly replenish depleted populations, no matter how favourable the conditions are for juvenile survival; their long-term fidelity means that catching one partner precludes reproduction by the other until it forms a new pair bond, which commonly takes weeks; and their slow swimming and small home ranges prevent them from moving rapidly into areas where seahorses have been fished down. In addition, adults are not usually exposed to heavy predation so they have not adapted to the heavy adult mortality imposed by fishing. Exploitation of temperate species, such as those in southern Australia, could be particularly serious as they have longer pregnancies and shorter reproductive seasons in which to recover from exploitation.

All in all, it's easy to realise that conservation measures are needed to stabilise and restore wild seahorse populations, although these are not so easy to accomplish. Seahorses are now



A.VINCENT

One of the seahorse culturing ponds at the Institute of Oceanography, Nha Trang, Vietnam. Vietnamese biologist Do Huu Hoang examines some of the seahorses he has reared since their birth in captivity. Skills are now being transferred to the local fishers to replace capture of wild seahorses.

contributing a vital portion of the annual income of many of the world's poorest fishers, and are considered an important staple for several types of traditional medicine. I worried a lot about how to reconcile the needs of animals and the needs of people before realising that the goals were the same: more seahorses. We must ensure sufficient seahorses in the wild so that some can be fished without jeopardising populations. This means adjusting both supply and demand.

OUR FIRST SEAHORSE CONSERVATION project is based in the village of Handumon in the central Philippines. This area is known for its innovative fishers and is largely responsible for the spread of seahorse fishing around the country. About one-fifth of the house holds in Handumon depend on seahorses, commonly for 40 per cent of their annual cash income. Fishers catch seahorses by hand, at night, while spearing other fish for the family food. So many other marine resources have already collapsed that this extremely poor village cannot imagine how it will compensate for the current tremendous decline in seahorse numbers. There is, therefore, widespread support for the community-based initiatives that I direct with a team of biologists and social workers from the Haribon Foundation, a Filipino conservation organisation.

We believe the best way to reduce exploitation of wild seahorses is by providing poor seahorse fishers with an alternative to the very hard work of seahorse fishing.

The Handumon village council has now set aside a 33-hectare marine reserve in good (but damaged) seahorse habitat, where fishing for all species is banned, and also enforces laws against illegal fishing in the rest of the village waters. Fishers, councillors and other villagers patrol and monitor their waters carefully with the result that within 18 months the number of fish species, and the numbers and sizes of fishes in the reserve have all increased. Moreover, fishing *around* the reserve has improved noticeably, thus providing hope to local people and encouraging other villages to establish their own marine reserves.

Fishers desperately need the money that comes from catching the large pregnant males and juvenile seahorses, otherwise best left in the sea, so we have developed a partial conservation solution. Fishers place newly caught pregnant males in sea cages, leaving them there until the young are born, whereupon the young escape to the reef

and the male is sold. Similarly, under a new initiative, freshly caught juvenile seahorses are now held in five-metre-wide corrals in the sea, built and run by groups of fishers, until the seahorses double in size and value. The seahorses start to reproduce during this period, with their young escaping to the sea. In both projects we advance loans so that fishers can pay themselves up-front, repaying the money when they eventually sell the seahorses. Because conservation problems don't arise in isolation, the project is also developing alternative livelihood options, running a range of education programs including conservation apprenticeships for high-school children, and promoting wise management of all marine resources.

Similar holistic approaches drive my other main field project, in Vietnam. A team of biologists from the Institute of Oceanography monitors the seahorse trade and studies seahorse biology, but concentrates on developing village-based aquaculture techniques for seahorses. We believe the best way to reduce exploitation of wild seahorses is by providing poor seahorse fishers with an alternative to the very hard work of seahorse fishing—seahorse aquaculture, for example. The process is far from perfected but we are getting closer.

Australian companies are also embarking on seahorse aquaculture. However, limitless demand for seahorses means that aquaculture in developed countries such as Australia is likely to be merely an economic activity, with little or no conservation benefit. It could even be damaging. First, problems with diet and disease currently hamper most attempts at seahorse aquaculture, such that they keep having to catch wild seahorses to renew their broodstock. Second, any growth in seahorse aquaculture is more likely to make legislative protection difficult if that becomes advisable.

Australia can be a potential buffer against extinction of at least some Indo-Pacific seahorse species. Seahorses can be caught legally in most places in the world. Few countries in the region could control the very diffuse and lucrative trade in seahorses even if laws were implemented. Australia is a rare exception: this country has the legal and legislative power to regulate fishing and to protect species, and Australian fishers do not depend on seahorses and pipefishes for their livelihoods. Indeed, Tasmania already has laws protecting seahorses and pipefishes, although permits have been granted to collect aquaculture broodstock. There is no doubt that pressure on Australian seahorses will increase as Asian seahorse populations decline, and that Australia will need to consider its response carefully.*

Seahorse numbers in some parts of the world are severely depleted but these fishes are probably not yet on the brink of extinction. With a lot of luck and hard work, and public support, we may be able to turn the tide enough to ensure that seahorse males can greet their partners and produce their young for many generations to come.■

**As of 1 January 1998, all seahorses, pipefishes and seadragons became subject to Australia's Wildlife Protection Act. Any exports of these fishes now require permits, which are only granted for animals derived from captive breeding programs or from approved management plans. This could be very good news for seahorses, provided the Australian Government administers these controls well, promotes necessary research on wild populations, and ensures that management initiatives support conservation goals.*

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Dr Amanda Vincent is Assistant Professor in Conservation Biology at McGill University, Montréal, Canada. She leads work on the reproductive ecology, trade, conservation and management of seahorses, pipefishes and pegasid fishes. Seahorses are both her passion and her excuse for involvement in many related marine conservation issues.

RUDIE H. KUITER

A female *Hippocampus breviceps* transfers her eggs to the male.

Yellow-banded Dart (*Ocybadistes walkeri sothis*) by M. Coupar

Mountain Spotted Skipper (*Oreisplanus perornatus*) by John P. Cooper

Red Lacewing (*Cethosia cydippe*) by Tom & Pam Gardener

FLUTTER-BYS

IMAGES FROM THE NATURE FOCUS PHOTO LIBRARY

A moth (*Agathia prasinaspis*) by H. & J. Beste

Common Brown Ringlet (*Hypocysta metirius*) by Pavel German

Orange Lacewing (*Cethosia penthesilea*) by Pavel German

Green Spotted Triangle Butterfly (*Graphium agamemnon*) by Pavel German

Common Silver Xenica (*Oreixenica lathoniella*) by John P. Cooper

Lemon Migrant (*Catopsilia pomona*) by H. & J. Beste

Reticulated Pythons are known to reach lengths of over ten metres—at which size adult humans become more of an hors d'oeuvre than a main meal.

FRIED AND FOOTLESS FOSSIL FANGERS

BY MICHAEL ARCHER

THERE IS A SMALL RESTAURANT in Kuching on the island of Borneo where for a price anything remotely edible from scorpions to monkeys can be added to the day's menu. Because the proprietress did a roaring trade in the finest fried all-python meat patties, a highly coveted local delicacy, we hoped to purchase the skeletal remnants of a large Reticulated Python (*Python reticulatus*) to compare with fossil pythons that looped through the Tertiary limestones of Riversleigh. An over-stuffed Reticulated Python wound its lumpy way around the ceiling of the dining room, shedding little showers of sawdust on the tables below. After we pointed to the python, the proprietress led us to a toilet behind the kitchen. The floor was covered with hessian bags seething with snakes of all kinds and sizes. She pointed out a pile of pythons destined for the pot and told us to help ourselves. After settling on a price, we swung the largest bag, snake unseen, into the boot of the taxi waiting outside, trying to ignore the horrified driver's protests.

Later that day I saw the snake on the preparation table of the Sarawak Museum. From the tip of its tail to its formidably long, curved, needle-sharp teeth (which had fanged one of the preparators), it measured a little under four metres long. Reticulated Pythons not much longer than this are capable of making a meal of teenage-size humans. Like several of the world's living pythons, Reticulated Pythons are known to reach lengths of over ten metres—at which size adult humans become more of an *hors d'oeuvre* than a main meal. At this length, these predatory sacks of muscle are near the maximum size for any snake, living or extinct.

Snakes big and small first wound their way around my own heart when, as an eight-year-old, I was emotionally dismembered by a Grimm's Fairy Tale about a tiny snake that befriended an innocent child. Every day it came to the back step where the child would give it a saucer of milk—until a horrid old woman who lived in the house killed it with a broom in front of the child. That was it; from the age of eight, snakes and I were an inseparable item. The only dent in the relationship occurred when I was 15. Having just taken delivery of a two-metre Boa Constrictor (*Boa constrictor*), I decided to offer it a drink of water at a friend's house. I remember well the rush of adrenalin when the unexpectedly large head emerged from that hessian sack—and that was the last thing I remembered. By holding the sack, I gave the powerful snake something to push against and it struck straight at my face, using its closed mouth like a fist to whack me between the eyes. I was flung across the room and knocked out cold. When I came to, the cranky reptile had my terrified friend clawing his way up the kitchen counter while his mother was trying, successfully, to drop the sack over its head from behind. Ah, sweet memories of childhood.

Although these worm-size wrigglers are only nightmares of the insects' world, one tiny Indian species evidently crawls inside the ears of people who sleep on the ground!

Although Australia doesn't have Boa Constrictors, it does have their close relatives, the pythons. Of these, the Amethystine Python (*Morelia amethistina*) has been recorded at lengths of eight metres. Australia's largest snake, however, may be an unnamed fossil python from the four-million-year-old Bluff Downs faunal assemblage of north-eastern Queensland. Brian Mackness and John Scanlon (University of New South Wales) suggest that this king squeeze of the Pliocene could have been, like Reticulated Pythons, over ten metres long.

John, whose doctoral thesis focused on the diversity and evolution of Australia's snakes, has been describing new kinds from the World Heritage fossil deposits of Riversleigh. Included are Australia's first extinct blind burrowing snakes (family Typhlopidae). Although these worm-size wrigglers are only nightmares of the insects' world, one tiny Indian species evidently crawls inside the ears of people who sleep on the ground!

Australia's, and possibly the world's, oldest elapids (family Elapidae) also come from Riversleigh. This widespread and diverse family includes toxic taxa ranging from Afro-Asian cobras and kraits to Australia's browns and the Fierce Snake (*Oxyuranus microlepidotus*)—far and away the most poisonous reptile in the world. One Australian branch of elapids even gave rise to venomous sea snakes (hydrophiids and laticaudids). Although it is possible that elapids evolved in Australia, it seems more likely that they entered Australia from the north not long before their first rare appearances in Riversleigh's early Miocene (25-million-year-old) rocks.

Pythons (family Pythonidae) occur throughout Riversleigh's 25-million-year sequence of rocks. Small ones are almost always present in bat-rich cave deposits like Gotham City Site, suggesting considerable antiquity for the python pastime of plucking bats out of thin air. Large ones are also common, including '*Montypythonoides*' (now *Morelia*) *riversleighensis* which may have been over five metres long, and an unnamed form that resembled the Reticulated Python.

Far more mysterious are the extinct madtsoiids (family Madtsoiidae). Because these massive, primitive snakes have been found in Australia, South America, Africa and Madagascar, they must have slithered throughout the once-united lands of Gondwana. The largest was *Madtsoia bai* from the Paleocene (about 60 million years ago) of Argentina, esti-

Australia's *Wonambi naracoortensis* was the last survivor of a mysterious group of Gondwanan giants.

mated to have also been ten metres in length. John Scanlon reported *Nanowana godthelpi*, a small (about one metre long) and very odd madtsoiid from 20-million-year-old deposits at Riversleigh whose teeth were hinged so they could fold backwards. Some large madtsoiids, John suggests, may have been aquatic, staring up at kangaroos which dipped their faces into pools to drink—for the last time.

Although madtsoiids vanished elsewhere just over 50 million years ago, in Australia they survived until the end of the Pleistocene (perhaps 100,000 years ago). Two partial skeletons of *Wonambi naracoortensis*, one of Australia's largest madtsoiids, were recovered from Henschke's Cave in south-eastern South Australia by local fossil enthusiast John Barrie. Although only six metres long, this sumo of the slitherers may have weighed in at 250 kilograms. How snakes this size, which normally require warm climates, survived in southern Australia is a mystery.

Until recently most evolutionists presumed that the first snakes evolved on land, from some unknown group of legless lizards. However research by Michael Caldwell (University of Alberta) and Michael Lee (University of Sydney) of *Pachyrachis problematicus*, an early Cretaceous (97-million-year-old) marine reptile from Israel, reveals it to be a perfect 'missing link' between the extinct mosasauroid lizards (which included ten-metre-long marine horrors) and the otherwise most primitive known snakes. Its snake-like, metre-long body was well-suited for swimming, despite its distinct but small hind limbs. If, as Caldwell and Lee conclude, the first snakes evolved and lived in the sea, the Father of all serpents who sweet-talked Eve must have worked his wicked wiles from a branch of coral in the ●cean of Eden.■

AUSTRALIAN MUSEUM/NATURE FOCUS

Further Reading

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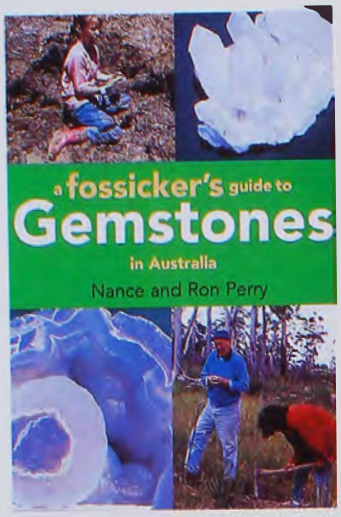
Professor Michael Archer lectures in biology and geology at the University of New South Wales. Most of his non-teaching hours are devoted to the study of the fossil faunas of Riversleigh, north-western Queensland.

REVIEWS



A Fossicker's Guide to Gemstones in Australia

By Nance and Ron Perry. Reed Books, Vic., 1997, 160pp. $24.95rrp.

Fossicking is an activity that many people long to try their hand at and this is a helpful little guide for beginners. The Perrys have written several books on the subject and this latest paperback edition was originally published as *A prospector's guide to gemstones* (1982).

The book starts from scratch, with a definition of fossicking, and gives basic information for the beginner about climate, maps, geology, gemology and equipment. Important matters such as legalities, etiquette and safety are touched upon. Ways of collecting and working deposits are explained in simple terms, for people with no prior experience.

How does one recognise a gemstone in the field? The Perrys provide a list of gems and their appearances that, although intended to be helpful, is sometimes couched in such vague terms that they would be little help in an identification. The description of diamond as "small crystals; oily appearance", for example, makes no mention of the unique lustre of diamond or its crystal shape.

The main sections of the book follow. There is an alphabetical list of gemstones with localities, where possible, in all States. These are not given precisely so it would be necessary to seek out more detail from other sources. Next is a State-by-State rundown on the main fossicking areas and occurrences, with some maps and information on access and accommodation.

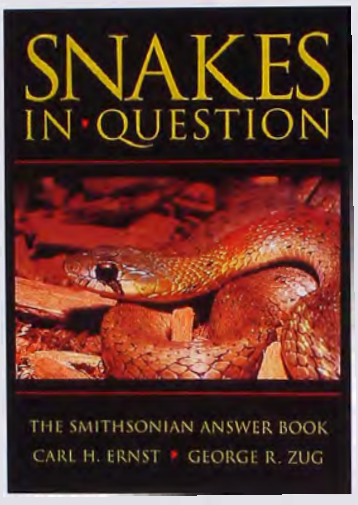
Poor quality of both black-and-white and colour photos, plus the absence of any size scale, diminish the usefulness of the guide. Some colour plates are inappropriate and have been wasted on items such as a white fossil crab, white gypsum crystals and an ironstone concretion, which are not gemstones and did not need colour treatment. There are no illustrations of diamond crystals, and yet "Is this a diamond crystal?" is a common Australian Museum public inquiry. Minerals such as crocoite and azurite/malachite are of interest to mineral collectors but are not gemstones. Six of the 23 colour plates are agate, when two would have been enough. Colour plates of the more commonly sought gems would have been much more helpful to beginners. There are no colour plates of blue or zoned sapphire crystals, garnet crystals, blue topaz, green beryl or peridot.

The section headed "Further Reading" could be much improved. Apart from various government publications, which can be difficult to obtain, there is no book listed with a publication date later than 1982. More recent books on gemology and gemstones include *Gemstones of the southern continents* (1991) by Lin Sutherland of the Australian Museum. Another section entitled "Helpful Information" gives a number of addresses to contact for more information, but could have mentioned museums with minerals and gemstone displays and expertise, so that people can get to see and know more about what they are actually looking for.

It should be possible to rectify these fairly glaring faults for the next presentation, thus providing a tighter, more informative guidebook.

However, these qualifications aside, if you have always intended to take the family fossicking or are planning to go on a field trip with friends, this is a good, compact little introductory guide to whet your appetite.

—Gayle Webb
Australian Museum



Snakes in Question

By C.H. Ernst and G.R. Zung. CSIRO Publishing, Vic., 1997, 220pp. $29.95rrp.

Snakes in question is one of a series originally produced by the Smithsonian Institution aiming to answer the most commonly asked questions about certain types of animals. Snakes have always been objects of fascination to humans, and the vast folklore that has built up around them warrants a book like this in reply. The majority of the book consists of clear, simple answers to 90 commonly asked questions about snakes, grouped into four broad themes, together with a section describing the biology of the largest snake species, both venomous and non-venomous, and several appendices of relevant statistics (classification, sizes, speeds and reproduction). The answers are liberally illustrated with drawings and clear black-and-white photographs, with a centre section of colour plates.

—Glen Shea
University of Sydney

The Graham Pizzey & Frank Knight Field Guide to the Birds of Australia

By Graham Pizzey and Frank Knight. HarperCollins, NSW, 1997, 576pp. $35.00rrp.

Australia has the luxury of three high-quality guides to bird identification. As these have evolved over the past two decades, each has garnered its own set of proponents. Graham Pizzey's original guide, published in 1980, has now been completely redone, with only a partial resemblance between it and the new version. The scale of the changes, completely rewritten and with brand new illustrations, is that of a new book rather than revision. In the new guide, the biggest shortcoming of its predecessor has been addressed while

maintaining the strengths.

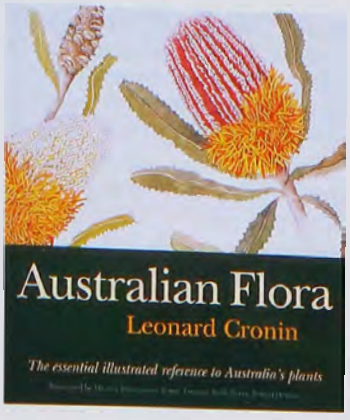
The original edition had an unwieldy and out-of-date format, which placed the text, illustrations and maps as separate sections. In the new version this has been rectified, with all the relevant information on a species available on facing pages. The first edition of this work contained by far the most extensive species accounts of the three guides. Although the level of detail has been trimmed somewhat, this book still offers the most in-depth information on individual species.

The illustrations are the most important component of any field guide and in this guide they succeed admirably. Frank Knight has produced plates that are attractive without compromising their usefulness. The number of species on a plate is generally fewer than in the other field guides and the individual figures are larger. It also gives space to show different plumages without overcrowding. The only real criticisms are occasional problems with proportion and shape.

There are a few errors, such as some maps with markedly erroneous distributions, but no doubt these will be rectified in subsequent editions. The cover and binding are made to withstand use in the field and maintain their integrity, definite pluses for a book intended as a working tool. Overall the standard of production is high.

The major complaint to make about this book is its size. At 24 x 15.5 centimetres and 1.1 kilograms, it is markedly larger and heavier than its competitors. This can be a significant disadvantage for a book intended to be carried in the field. Some people may find the inconvenience of transporting it sufficient to relegate it to the role of a desk reference rather than a field guide. This bothersome quibble aside, Graham Pizzey and Frank Knight have made an important contribution to the practical literature of Australian ornithology. This book will certainly receive a well-deserved audience.

—Walter E. Boles
Australian Museum



Australian Flora

By Leonard Cronin. Reed Books, Vic., 1997, 320pp. $45.00rrp.

This is a well-presented book, lavishly and beautifully illustrated by four talented artists. I could find the names of only two of the artists, Roslyn Devaux and Marion Westmacott, on the illustrations (with the majority by the latter artist), so I assume that the unnamed plates are by the other two. The work was first published in 1989 as *Concise Australian flora* and this edition is stated to have been revised. More on that later.

The format is designed so that native plants, from whichever part of Australia, are grouped under the broad categories of "Wildflowers", "Trees", "Palms", "Cycads and Pandanus", "Ferns" and "Fungi". It is good to see this last group included in such a book, even though recent research indicates that fungi are not plants. The inclusion of a few of the more common mosses, liverworts and lichens would have been useful.

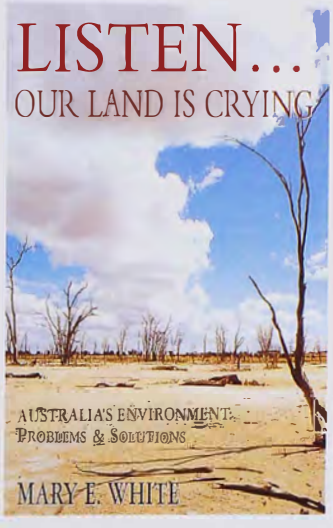
Keys are included under each of those major headings and they work well with some species. However the decision by the author to classify some of the common species as "Tree" or "Wildflower" is not very consistent. For example, *Acacia regens*, "a shrub to 4 metres" is included in "Wildflowers", whereas *Acacia longifolia*, "a bushy shrub or small tree, 2–10 metres" is included in "Trees". Other similar examples occur.

The selection of species is good and broad, and should assist the user in at least getting an idea of the genus or family of the plants they are interested in.

Now, to the greatest criticism of the book. It seems not to have been revised very well. The most recent reference in the bibliography is 1986 and there is none of the recent works on, for example, eucalypts and cycads. Some of the habitat and distribution information in the texts is incorrect, for example, for *Angophora hispida*, *Shefflera*, etc.

Despite its faults, this book should be very useful for a nature lover just starting to identify Australia's flora and I hope that another edition, better revised, will appear soon after this one sells out.

—Don F. Blaxell
Royal Botanic Gardens
Sydney



Listen... Our Land is Crying. Australia's Environment: Problems and Solutions

By Mary E. White. Simon & Schuster, NSW, 1997, 296pp. $59.95rrp.

This is Mary White's third major ground-breaking book, the other two being *The greening of Gondwana* and *The browning of Gondwana*. Again it is a superb-looking work, beautifully designed and illustrated predominantly with her own colour photos.

Ever since humans set foot on this continent they have been affecting the environment that over millions of years had reached an equilibrium. Early changes were slow and in many instances a new equilibrium was reached.

That is essentially how it was when Europeans arrived just over 200 years ago. Armed with their technology for growing crops, clearing land for grazing and the need for extractive industries, they began to change the environment far too fast for any new equilibrium to be established and the downhill slide of degradation of our natural resources such as soil and freshwater began.

This accelerated and reached the point many years ago where some people began to recognise that the environment could not sustain this abuse. In her book Mary brings all the problems to our attention again, but with renewed urgency for solutions to be applied or found before our greed leads us to a point of no return.

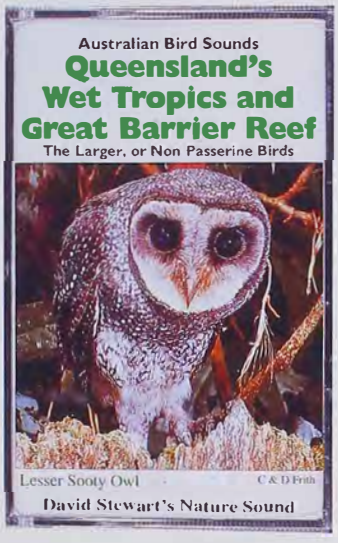
Of the 15 chapters, 13 are devoted to various problems brought about by the activities of humans. The extent of the problem is detailed and examples of solutions that have succeeded in overcoming the problem are documented. It becomes all too evident that the Australian environment is not capable of remaining in a healthy state and supporting European-style farming, grazing and the effects of feral animals. Australia is different to Europe and North America in many ways. It is the driest vegetated continent and problems related to water supply and usage are probably the biggest factors that will eventually, if they continue unchecked, lead to vast areas of land being laid to waste.

To some the book may give a frightening picture. Is it really as bad as White points out? The reader may come away with a feeling of doom and gloom and helplessness, especially if you live in a big city and feel that you have little influence over what happens in the bush where the majority of these problems seem to exist. But big cities and urbanised areas have their problems too. It is only by being made aware of the problems confronting us that we have any chance of influencing the politicians and those in power to ensure that governments take action. *Listen... Our land is crying* certainly makes the reader aware of the problems.

This book, along with Tim Flannery's *The future eaters*, should be essential reading for all politicians and indeed all Australians. The problems outlined are of such importance to the future survival of Australia that we need to seriously start working towards solving the problem of degradation of the environment without delay.

A great deal of research has obviously gone into the book and from the photos it is obvious that the author experienced many of the documented problem sites first hand, extending right across the continent. The quality of the production cannot be faulted as has always been the hallmark of White's books. The book is easily worth the $59.95 price, which has been kept to an affordable level by a grant from Fuji Xerox Australia.

—Robert Jones
Australian Museum



Australian Bird Sounds Audio Tapes

Queenland's Wet Tropics and Great Barrier Reef: The Larger, or Non-Passerine Birds

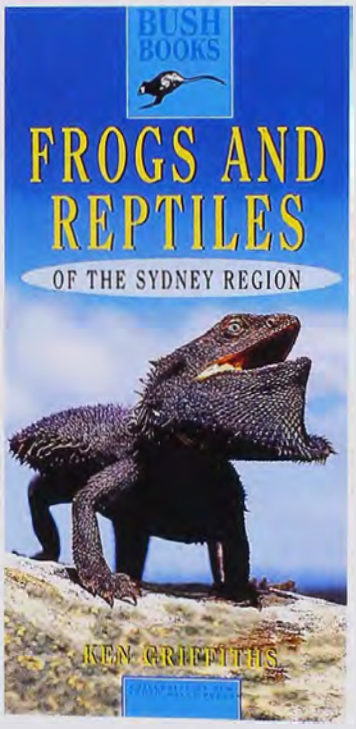
Queenland's Wet Tropics and Great Barrier Reef: The Smaller, or Passerine Birds

Lamington National Park: Rainforests of the Subtropics.

Produced by David Stewart, Nature Sound (PO Box 256, Mullumbimby NSW 2482), 1996, $15.00rrp each.

David Stewart, one of Australia's leading nature sound recordists, has added these cassettes of bird voices to his previous Australian Frog Call Series (three cassettes) and Voices of Subtropical Rainforests (CD). The first two form a set with a broad coverage of the birds of north-eastern Queensland and the neighbouring Great Barrier Reef (63 and 61 species respectively), with a high percentage of the endemic species. The third cassette offers 61 species from the vicinity of Lamington National Park in the Border Ranges, including a number of the endangered forms. The explanatory notes on the covers give the species name, duration of the track and a brief description of the vocalisation (but no locality information). These new productions maintain the high standards that Stewart has set in his earlier recordings and are warmly recommended.

—Walter E. Boles
Australian Museum



Frogs and Reptiles of the Sydney Region

By Ken Griffiths. UNSW Press, NSW, 1997, 128pp. $19.95rrp.

This is an excellent field guide for bush walkers, field naturalists, and anyone who feels a curiosity for the reptile and amphibian fauna they may encounter even in their Sydney backyards.

It is easy to use by flicking through Griffiths' superb photos to find a likely match and then comparing the descriptive notes with what you've found. This is aided by the various colour-coded sections: green for frogs (of course), blue for lizards, brown for snakes and turtles (often referred to as tortoises).

The descriptions are broken up into length (in centimetres), colour (including differences between sexes and juveniles), features (those that may aid in identification), reproduction (such as whether reptiles produce eggs or live young), similar species (those with which it could be confused and how to distinguish them), status (how common or rare it is), and then a section of biological notes including distribution, diet, call (in the case of frogs) and habitat.

The book also contains an informative introduction (enhanced by more colour photographs) on the habitats, identification methods, observation techniques, and a timely section on declining species and possible causes, including a detailed list of those Sydney species in decline. It also has a good overview description of each group (snakes, frogs etc.) at the beginning of the section dealing with them. The language and terminology used is simple and easily understood throughout.

There are a couple of minor niggles. The vocal sac of the Red-eyed Tree Frog (page 20) is referred to as a 'pouch'. While not necessarily wrong, this could be misleading (perhaps 'throat pouch' would have been better?). The Mosquito Fish (page 17) is now known as *Gambusia holbrooki* not *G. affinis*, although many books still refer to it as such. And the potentially very important last page on treating and preventing snake bite is separated from the rest of the text by two blank pages—it should really be given more prominence. But all in all these are minor problems.

To sum up, *Frogs and reptiles of the Sydney region* is a very useful book, both sized (11 x 22 centimetres) and priced nicely to make it become a well-used regional field guide.

—Martyn Robinson
Australian Museum

SOCIETY PAGE

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

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PMB 19,
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Q&A

Cocoon of Danger

Q: *At the beginning of the year I noticed a cocoon hidden among my honeysuckle vine. The cocoon was plump and healthy looking, and covered in what I assumed to be some sort of urticating hairs. Over the coming weeks I kept my eye on it, hoping to catch a glimpse of what would emerge. Unfortunately I never saw it and, because the cocoon did not split or break, I thought maybe something went wrong and the moth or whatever never emerged. Then I noticed a small hole in the side of the cocoon and when I looked through the hole, I could glimpse a shiny body inside. Can you tell me what created the cocoon and what could have happened?*

—Stephen Costello
Balmain, NSW

A: Your cocoon was made by the larva (caterpillar) of the White-stemmed Gum Moth (*Chelepteryx collesi*). These larvae are large, reaching over ten centimetres in length, and feed on eucalypt leaves. They are covered with numerous short spines that are woven into the cocoon wall by the larva as protection against predators. The spines not only make it difficult for parasites to attack the pupa within, but they also embed in the skin of any animal touching the cocoon. Be warned: don't touch these cocoons or you may be pulling out the spines for some time! The spines are not poisonous but will fester if not removed.

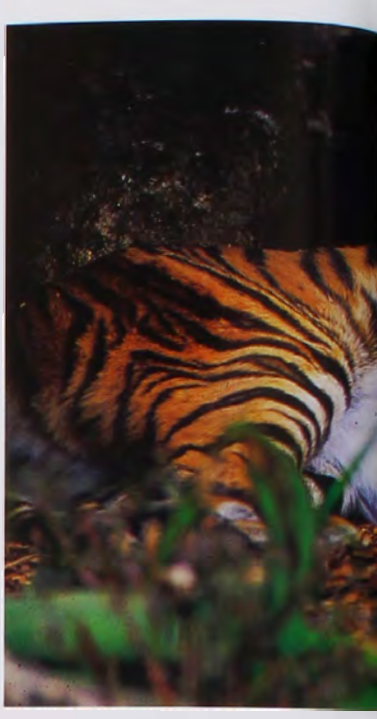
The hole you noticed in the side of the cocoon is the exit hole for the moth. The specimen you sent in had actually emerged and left the empty pupal skin behind, which often remains visible through the hole. The adult moths have a wing span of up to 16 centimetres. The colour of the female is soft browns and greys, while the male is darker with strongly contrasting markings. These moths are found from south-eastern Queensland to Victoria.

—Sally Cowan
Australian Museum

Mixed Signals

Q: *Several years ago we were persuaded by our youngest daughter to hand-rear a wild baby Rabbit. It was a male and it survived to become a much-loved pet. Because we felt he might be lonely, we gave him an elderly Guinea Pig for company. They became firm friends. Two years later, during the last few hours of the Guinea Pig's life, the Rabbit attempted to mate with it frequently, never having displayed such an interest before. We have witnessed the same behaviour in our Dogs. If one of them is dying from an age-related cause, the others in the small pack (male or female) will attempt to ride it for what we believe is the same reason. Perhaps a chemical odour sparks off this reaction and has nothing to do with the close bond between the animals.*

—Julie Peel
Sth Auckland, NZ



A: The sexual signals that exist between males and females in the wild are always adapted to the natural or preferred habitat in which speciation took place. If the habitat is changed, or if the animal is the product of many generations of captive breeding, as is the case for all domestic animals and many zoo and lab animals, then the sexual signals are maladapted and often indiscriminate; they're blurred, fuzzy and out of context, so to speak. It is interesting to note that most recorded hybrids (of both plants and animals) are related to habitat disturbance or human intervention.

Also, natural female rejection signals often require vigour. A moribund female may not be able to repel the advances of an 'unattractive suitor', or she may secrete excessively, or adopt unnatural postures. These may correspond to positive female signals when sensed by

PHOTOS: DENSEY CLYNE

The larva (left), cocoon (middle) and adult moth (right) of the White-stemmed Gum Moth.

DAVE WATTS/NATURE FOCUS

Do big cats like this Tiger purr?

nearby males, especially in zoos and domestic situations.

—Shane F. McEvey
Australian Museum

Big Happy Cats

Q: *I was recently nursing my Cat while watching a documentary on wild big cats like Lions, Tigers and Leopards. My own little Cat was purring away quite loudly and it made me wonder whether its larger relatives are also able to purr? If they can, what is the purpose of this form of communication?*

—Jane Powell
Rose Bay, NSW

A: Most of the small cats can purr, most of the large ones like Lions and Tigers cannot. Of the larger cats, the Cheetah is the exception; it can purr, quite loudly. Big cats occasionally make a purring sound but they have to take a breath in between purrs. Small cats purr continually and can in fact purr and miaow at the same time. Generally this form of communication is used to indicate contentment, however this is not always the case. Domestic Cats that have been badly injured might still purr, and some purr to indicate dominance over other Cats. Although kittens purr naturally when feeding, the reaction of purring when stroked by humans does not happen until they are a few weeks old.

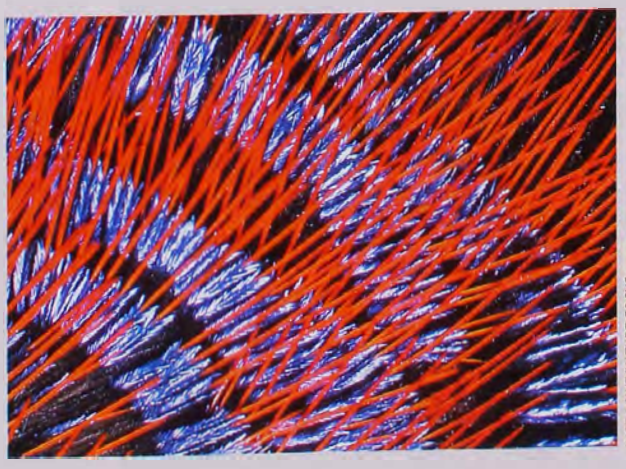
—Linda Gibson
Australian Museum

Answers to Quiz in Nature Strips (page 16)

1. Hydrogen ions
2. They are all names of Martian rocks.
3. Ian Plimer
4. Anthropomorphism
5. Ulcers
6. Mercury
7. Dolly
8. Rear-opening
9. Ticks
10. Nectar and pollen

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 Australian Museum Shop Gift Voucher. Summer's Pic Teaser was a thrips (*Idolothrips* sp.).



KATE LOWE/NATURE FOCUS

When I asked who would prefer a bilby over an Easter bunny, the vote was universally in favour of the marsupial.

THE TRIUMPH OF THE EASTER BILBY

BY TIM FLANNERY

EASTER IS NAMED AFTER THE European goddess Eostre who embodies the fertility of the boreal (northern) springtime and return of the Sun. It is one of the few Christian celebrations that still retains its pagan name. This might have something to do with Pope Gregory's instructions, given to the first missionaries in England in AD 601, suggesting they allow the English to celebrate their festivals in their pagan form but that they re-dedicate them to the Christian God.

The timing of Christ's death and resurrection fitted in quite nicely with Eostre's fertility festival. So did the link between the returning Sun and the life it brings, and the risen Son of God and his message of renewed life. Eggs and Rabbits, those splendid though pagan symbols of fertility, were thus accepted without demur into the newly Christianised festival of Easter.

Although the hybrid nature of the Easter festival rarely incites comment among the long-accustomed Europeans, it can cause confusion in cultures that are unfamiliar with it. Several years ago a newspaper article mentioned, for example, that a major Japanese department store, confused by the disparate elements of Easter symbolism, had displayed a gigantic Easter bunny nailed to a cross as part of their in-store celebrations.

Easter and its symbols are beginning to sit uneasily with Australians, too, but for quite different reasons. In Australia Easter is celebrated in autumn, making the links with returning fertility and renewed life rather strained. Worse, in a land dominated by the southern oscillation, Easter can coincide with gentle, life-giving autumn rains, or with the height of a death-dealing drought. It somehow seems perverse to celebrate the renewal of life when the land is dying for lack of water.

G. HAROLD

Even the seemingly innocent Rabbit is falling foul of Australia's unique ecology. A consummate symbol of fertility for our ancestors, it is widely regarded as a symbol of environmental destruction by Australians. It seemed a stroke of genius, then, when some confectioner hit on the idea of making chocolate bilbies. Bilbies are cute and present some superficial parallels with Rabbits. They are about the same size, have long ears, delightfully soft fur and they live in burrows. There, however, the similarities cease, for the omnivorous and carnivorous marsupial bilbies are very different ecologically from the herbivorous, placental Rabbits. Most inconveniently for the confectioners, bilbies are not good symbols of fertility. The Lesser Bilby (*Macrotis leucura*) is already extinct, while the Bilby or Greater Bilby (*M. lagotis*) is endangered.

Given the role that Rabbits may have played in the dramatic decline of both bilby species, there is poetic justice in the usurpation of the Easter bunny by the Easter bilby. Even better, a small percentage of the profits made from Easter bilby sales goes towards Bilby conservation.

Recently I visited my daughter's school to give a talk on deserts. I brought a few stuffed animals for the Year Five kids to examine, one of which was a Bilby. As they felt its deliciously soft fur, squeals of delight filled the room. I casually asked how many had received a chocolate bilby for Easter, and half the class put up their hands. When I asked who would prefer a bilby over an Easter bunny next year, the vote was universally in favour of the marsupial.

I suppose that I should just reconcile myself to the addition of the Easter bilby to our already confused cultural baggage. Still, I must admit to feeling a trifle uncomfortable at abandoning a fertility symbol that my European ancestors have celebrated for many thousands of years.

If we were to choose a fertile indigenous mammal as a more appropriate symbol for Easter, however, our choice would be limited, for most Australian mammals breed relatively slowly or are rare. There are exceptions among the native rodents, but I find it difficult to imagine even the most environmentally aware parent queuing to buy chocolate replicas of our most fecund mammal, the Long-haired or Plague Rat (*Rattus villosissimus*).■

Dr Tim Flannery is Senior Research Scientist in Mammalogy at the Australian Museum.

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

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Winter 1995–Autumn 1998

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Subject Matter

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