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AUSTRALIAN MUSEUM

NatureAustralia

SUMMER 2001–2002 Volume 27 Number 3

Published by the Australian Museum Trust
6 College Street,
Sydney. NSW 2010.
Phone: (02) 9320 6000
Fax: (02) 9320 6073
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WATCH THIS! DESIGN

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Fax: (02) 9320 6073
email: subscribe@austmus.gov.au

Annual subscription (4 issues)
Within Australia $A36.30 Other countries $A45
Two-year subscription (8 issues)
Within Australia $A69.30 Other countries $A83
Three-year subscription (12 issues)
Within Australia $A97.90 Other countries $A116
Prices include GST where applicable.

Proudly printed in Australia by Mockridge Bulmer

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. All articles in *NATURE AUSTRALIA* are peer-reviewed. *NATURE AUSTRALIA* is printed on archival-quality paper suitable for library collections.

Published 2001 ISSN–1324–2598

NATURE AUSTRALIA is proud winner of the 1987, '88, '89, '90 , '91, '92, '93, '99 & **2000 Whitley Awards** for Best Periodical, and the 1988 & '90 Australian Heritage Awards.

FRONT COVER
An adult male Yellow-footed Antechinus (*Antechinus flavipes*). Photo by C. Andrew Henley/Larus.

up front

I've always had a soft spot for wombats. I don't really know why, but I find them interesting and they definitely have the cute, furry factor working for them. But they also represent a bit of a conundrum. Why does such a large herbivore living a predominantly single life choose to live in a complex underground burrow system, and how can a wombat, living on such a poor diet, afford the energy to dig such a burrow system? In an attempt to answer these questions, a group of scientists decided to calculate whether the effort of building a burrow outweighed the energy saved by living in one. Answering this involved some Southern Hairy-nosed Wombats from South Australia, a lot of digging and crawling about in tunnels (and not just by the wombats), PVC piping and the use of a 'porthole' camera. For the inside story on what they discovered read "Life in a Wombat Burrow".


© ANDREW HENLEY/LARUS

A Southern Hairy-nosed Wombat at the entrance to its burrow.

Some scientists definitely like to get up close and personal with their study subjects. Chris Surman, author of "In Pursuit of the Gurge", has to wait in the dark on a wind-swept atoll for his seabirds to return to their nests with their stomachs full of food so that he get them to vomit. He admits it's a messy business, but it's worth it because his research may help save not only the seabirds but our fishing industries as well. On the other hand, Ingrid Visser has spent eight years studying and photographing Killer Whales off the coast of New Zealand. She can now recognise many of these whales on sight and one in particular seems to recognise her. Ingrid's research may prove vital in the conservation of Killer Whales and the oceans they inhabit.

When it came time to select the photos to accompany Alison Downing and Ron Oldfield's article on limestone mosses, Ron suggested it would be easier if we came to him. So with lupes in hand, we set off to Macquarie University not quite knowing what to expect. To our delight we were presented with an amazing array of material to look through because Ron is a prolific photographer with a passion for bryophytes. After sorting through hundreds of photos of hornworts, liverworts and mosses, we made our selection. Ron's work is so good we've decided to feature some of his best in a future Photoart.

We also take a look at why native plants can become pests, how the Nielsen Park She-oak was saved from extinction, what lurks beneath the most beautiful harbour in the world, and why sex is death to male antechinuses.

— JENNIFER SAUNDERS

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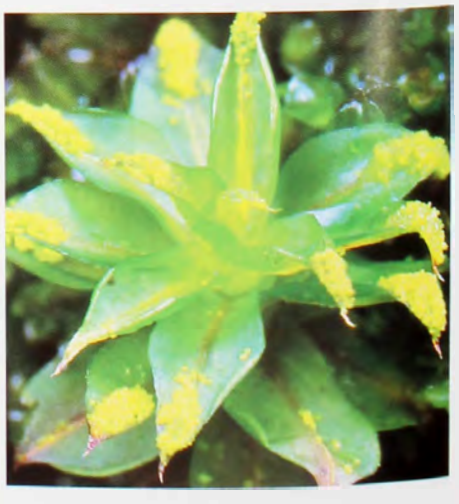

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Man-eating and Rinderpest

Bruce Patterson and Ellis Neiburger attributed the abandonment of the Ugandan railway construction in 1899 to man-eating Lions with sore teeth (*Nature Aust.* Autumn 2001). Surely Lions have always had sore teeth, so why then hasn't there been a record of continuous attacks on humans of the scale recorded at Tsavo River?

The more plausible reason for the fatal attacks was due to the introduction of rinderpest in 1895. This cattle disease caused catastrophic mortality among native and introduced hooved animals (ungulates), the main source of food for Lions.

The real story to be told is the changes the disease caused to the east African savanna landscape. Historically, the savanna had been open grassland with scattered Thorn Bush (*Acacia tortilis*) trees. By the 1920s, when the ungulates had developed resistance to rinderpest, the savanna had become a Thorn Bush woodland. During this time Europeans arrived and they wrote about these peculiar umbrella-shaped trees that dominated the landscape. This image of the African savanna became indelibly etched into our consciousness.

Today as national parks in these areas begin to revert to the more natural open grassland, managers are pressured to provide a landscape with more trees—similar to the one people had read about from earlier this century. But what the public and conservationists do not realise is that it was only a temporary environment created by a devastating disease.

—Robert Onfray
Penguin, Tas.

Rinderpest may well have had something to do with the attacks in Tsavo, but rinderpest first reached sub-Saharan Africa with a shipment of Indian cattle to the Italian army at Massawa (Eritrea) in 1887. It swept through Kenya in 1890–91, passed the Zambezi River by 1896, and destroyed up to 90 per cent of native cattle herds. However, there was another rinderpest epidemic in Kenya in 1898, more localised in its effects on the railroad line itself, that was triggered by infected cattle destined for Uganda. Although there are now vaccines that protect inoculated livestock from rinderpest, the disease continues to ravage herds of buffaloand kudu, including those in Tsavo. The last outbreak of this morbillivirus there was in 1993. But there was no corresponding increase in man-eating Lions.

'Bad teeth' and rinderpest are just two possible reasons for man-eating by the Tsavo Lions. Others include the proximity of the Tsavo camp to the slave caravan trail, unsafe camping and burial practices, and opportunity. All of these hypotheses are discussed in my book The lions of Tsavo: exploring the legacy of Africa's notorious man-eaters, which is scheduled for publication by McGraw-Hill (New York) in autumn 2002. The book also treats landscape change in Tsavo, in which Elephants play a major role, both historically as well as today.

—Bruce Patterson
Field Museum of
Natural History,
Chicago

COURTESY ROBERT ONFRAY

A thorn bush just after sunrise in Amboseli National Park, Kenya.

Native Pseudopets

It's people with views like Julie Murphy's (Letters, *Nature Aust.* Autumn 2001), about not keeping native wildlife in captivity, that will eventually lead to wildlife's downfall. Admittedly, many don't make good pets, especially hand-raised males of some species, but captive-bred, parent-raised species can. There are so many smaller species like bettongs, potoroos, bandicoots, possums, gliders, quolls and dunnarts that breed very readily in captivity, pose no threat to anybody and make very enjoyable animal companions.

One thing we should do is stop looking at them as pets in the conventional sense, but more like pseudopets from which we and others can watch and learn. The fact that most are active at night is also good. Most people work all day and don't spend enough time with their companion animals. That's where the problems start.

Many Australians wouldn't know half the animals we have in Australia, let alone have seen them. If we are to protect these animals, people have to realise they need protection. Conservation starts in our own backyard. If more people kept native animals, we would learn a lot more about them. And education is the greatest weapon against extinction.

—Dean Ewert
Johanna, Vic.

Conservation through Profit

David Horton's Last Word article "Not So Easy Being Green" (*Nature Aust.* Autumn 2001) is misleading. Australia has lost more mammal species in the past 200 years than the whole of the rest of the world has lost in the past 500 years. We can keep on arguing against sustainable use and in favour of the old ways, or we can try another strategy.

Horton postulates that placing a dollar value on wildlife "would quickly complete the devastation of the Australian environment begun in 1788". Unfortunately, he fails to note that this devastation has occurred under a system where natural resources have not been valued!

The statement "As the exploitation develops and numbers decrease..." implies an inevitable decline in numbers, even where sustainable use is the principal aim of enterprises utilising natural resources. The rest of the article is predicated on this fatal flaw.

Horton writes "Commercial imperatives don't encourage diversity of breeds". This ignores organisations like Earth Sanctuaries Ltd (ESL) whose aim is to save wildlife in the context of the entire biodiversity. ESL uses income from ecotourism to ensure both environmental and economic sustainability for its sanctuaries. The strategy of this approach involves educating people about Australia's environmental issues and offering them the opportunity to fund the solution through the purchase of shares in the company.

Actually saving the environment means achieving measurable outcomes. ESL was instrumental in the introduction of the new Australian accounting standard AASB1037, whereby the value of natural resources such as vegetation and endangered mammal species can be recorded as living assets in annual accounts. This system rewards enterprises that demonstrate an increase in natural resources.

Yes, ESL is a profit enterprise, but its core business is conservation, and it uses the marketplace as a tool to help reverse the destructive effects of a system that assumed people would do the right thing. In the view of many Australians, ESL and similar companies are providing leadership in the field of conservation, and hope for a better future.

—Cheryl McEgan
Stirling, SA

There are dozens, probably hundreds, of examples all over the world, of the dangers of commercially exploiting wildlife and the environment in general. The prognosis could be summarised in my three laws.

Horton's First Law: Wherever the environment is commercialised and there is a conflict between the needs of profit making and conservation, the demands for profit will prevail. Horton's Second Law: Wherever the environment is commercialised there will inevitably be a conflict between conservation needs and profit needs. Horton's Third Law: Wherever the environment is commercialised the commercial activity, no matter how small it is at the beginning, will grow rapidly and overwhelm the conservation interests.

The recent Fraser Island tragedy seems a classic example of Horton's Laws in operation, the spokesman for the business interests on the World Heritage island saying quite openly that the Dingoes should all go because there was too much money at stake in tourism. People concerned about the environment should engage in political action to stop tree clearing, protect wetlands, restore river flows, prevent woodchipping, and to establish more non-commercial national parks and wilderness areas. If they want to preserve particular bits of the environment, they could give money to non-profit Bush Heritage.

There are no quick fixes for the desperate environmental straits we find ourselves in.

—David Horton
Gundaroo, NSW

Thankyou Readers

On behalf of the Queensland Frog Society, I wish to thank *Nature Australia* magazine for inserting for free our Public Trust Fund brochure in the Autumn 2001 issue. The tax-deductible donations we have received so far are an indication of the concern the public and scientists have for our native amphibians. The Society wishes to publicly thank your readers for making our aim—funding further research into the decline in native frogs—a reality.

—Jenny Holdway
Qld Frog Society Inc.

Nature Australia **requests letters be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in this issue will receive a copy of** ***Believing Cassandra.*** **The winner this issue is Robert Onfrey.**

nature strips

COMPILED BY GEORGINA HICKEY

DANIELLE CLODE, RICHARD FULLAGAR, KARINA HOLDEN, MICHAEL LEE, JASON MAJOR, KAREN McGHEE, RACHEL SULLIVAN AND ABBIE THOMAS ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Blocked Noses for Sleepy Lizards

Sleepy or Shingleback Lizards (*Tiliqua rugosa*) maintain the same home ranges and pair bonds year after year, despite being active for only four months of each year. Given the sheer size of the range (up to six hectares) and the animal's lower-'n-a-lizard's-belly outlook, it was thought that they compensated for their low visual horizon by orienting themselves with a finely tuned chemoreception system (using their nose and/or their vomeronasal organ located in the roof of the mouth). Ido Zuri and Mike Bull from Flinders University decided to put this idea to the test.

Their study was made up of two parts. First they had to determine whether a nasal rinse with zinc sulphate, which is known to prevent the detection of chemical cues in other animals, works on Sleepy Lizards. Untreated lizards and lizards treated with saline solution were able to detect food hidden in perforated bags, showing increased tongue-flicking and gaping near the bags but ignoring bags filled with just water. Once treated with zinc sulphate, however, they spent equal time tongue-flicking over the water and food bags, indicating they could no longer smell the food. Clearly, chemoreception in Sleepy Lizards is inhibited by zinc sulphate, but it returns within 30 days without any ill effect.

For the next part of their study, the researchers monitored 50 Sleepy Lizards in the wild to determine their home ranges. They then treated them with zinc sulphate, saline solution or nothing, and released them back to where each had originally been caught. The researchers fully expected the lizards with 'blocked' noses to become disoriented and to wander away from home, but the treatment made little difference to the

How do Sleepy Lizards maintain the same home ranges year after year?

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

King Penguins have some clever parenting tricks to cope with unpredictable food supplies.

TUI DE ROY/AUSCAPE

lizards' performances. Zuri and Bull conclude that, while chemoreception is important for finding food and mates and for recognising offspring, it is not essential for home-range maintenance. Instead, the lizards must rely on visual recognition of permanent landmarks and other signals associated with home boundaries.

For Sleepy Lizards, the view may not be great, but there's no place like home.

—R.S.

Penguins Prepare for Parenting

Most penguin fathers are dutiful and attentive parents. King Penguin dads, however, give new meaning to the term 'parental devotion' according to new research by Michel Gauthier-Clerc (CNRS, France) and colleagues.

King Penguins (*Aptenodytes patagonica*) breed in colonies on the barren coasts of sub-Antarctic islands during summer. Each breeding pair produces a single egg, which the parents take turns in incubating. One holds it raised above the ground on the feet while the other takes off to the ocean to feed on fish, often travelling hundreds of kilometres in the process.

Usually the male is in charge of the egg just before hatching and when the female returns she regurgitates the chick's first feed. But, in such an unpredictable environment where long and perilous journeys are involved, things don't always run smoothly and the female can often return late. The researchers found, however, that the males aren't powerless to respond. Indeed, the father penguins seem to have a kind of internal clock that allows them to actually prepare for such a scenario.

In a study of birds breeding on the Crozet Archipelago, the researchers found that when a male King Penguin returns to his egg from a foraging trip any time between three weeks before and ten days after hatching is due, he will do so with food still in his belly. The closer to the due hatching date that he arrives, the more food he has retained in his stomach. Not only this, he'll hang onto this food in his belly while he fasts, just in case it's needed to feed the chick before the mother's return.

The King Penguin's ability to store food in the stomach without digesting it, and also to know when the chick is likely to hatch, the researchers suggest, is an adaptation to the unpredictable food supplies of the Southern Ocean.

—K.McG.

JEAN-PAUL FERRERO/AUSCAPE

Not amused? This Impala (*Aepyceros melampus*) may be providing more than just ticks to the Red-billed Oxpecker.

Ticked Off

Many species do things that seem to benefit themselves and another species at the same time. A classic example is the Red-billed Oxpecker (*Buphagus erythrorhynchus*), which picks ticks off large African mammals. Because ticks drain blood and cause infections, it has always been assumed the host benefits as much as the bird. But is this really so? Paul Weeks from Cambridge University decided to test this old assumption.

He studied two groups of Bonsmara Oxen over four weeks at a ranch in Zimbabwe. Both groups were equally exposed to normal tick infestations, but oxpeckers were kept away entirely from one group. Despite the birds, Weeks found there were no less ticks on the exposed oxen that those with no bird contact. He also found in two out of three field experiments that the wounds on oxen exposed to the birds were more likely to persist or recur. It turns out that the birds actually spent most of their time (85 per cent) drinking blood from wounds, not picking off ticks. Even when they did, they would generally go for fully engorged ticks, suggesting that the blood, rather than the insect, was the real attraction.

Weeks argues that a bird eating a tick full of blood hardly benefits the host—the tick has already taken the blood and passed on any disease it might have. He cautions that mutualistic relationships may be far more complex than they first appear. In climates where tick infestations are higher than in the area studied, the relationship may be more beneficial for the host. But for these Bonsmara Oxen, it's more a case of "You scratch my back, but I'd rather you didn't".

—A.T.

Fatal Attraction

Rats hate Cats; everyone knows that. They will scamper away at the slightest whiff of a feline predator. Yet every so often a fearless rat emerges, one so bold and daring it won't run away and hide. One that will actually play Tom and Jerry. What gives that rat pluck? The answer is *Toxoplasma gondii*.

Toxoplasma gondii is a protozoan commonly found in rat populations. It is capable of infecting all mammals, but its definitive host is the pussycat. That means that, in order to complete its life cycle and reproduce sexually, the parasite must be transmitted to the gut of a Cat.

Manuel Berdoy and colleagues from Oxford University have been examining the behavioural differences between healthy lab rats and those infected with *Toxoplasma gondii*. By marking separate corners of an enclosure with Eau de Rat, Cat, Rabbit and Fresh Air, the researchers could test the lab rats' preference for and avoidance of the different smells. The healthy rats showed a defensive reaction to Cat's Corner, but rats infected with *T. gondii* displayed a fatal attraction to Cat scent and none of the usual anxiety brought about by the enemy. There was no difference in the reactions to the other smells by healthy or uninfected rats.

How does the parasite turn a scaredy rat into a daredevil? The researchers suggest that the parasite is able to change the cognitive perceptions of its intermediate host. It makes its home on the brain of the animal, forming large cysts that seem to block the anxiety receptors so the rat becomes fearless of its predator. Although the parasite won't directly kill the rat, it will manipulate its behaviour until it falls victim to a Cat, ensuring the parasite's own survival.

—K.H.

The Skink Link

Life is tough on top of Hobart's Mount Wellington. Temperatures frequently drop below zero, bitter-cold winds blow year round, and snow can fall any time. It's

no wonder that one little resident plant known as the Honey Bush (*Richea scoparia*) carries its delicate reproductive organs inside secure capsules formed by fused petals (calyptra).

While that's great for protection against the elements, it has a couple of critical drawbacks: insects can't get in to pollinate the plant, and seeds can't get out. However, research by Mats Olsson, now at Sweden's University of Gothenburg, and colleagues has revealed how the Honey Bush ingeniously overcomes this problem with the aid of a small reptile, the Snow Skink (*Niveoscincus microlepidotus*).

Snow Skinks occur in large numbers on Mt Wellington where, for most of the year, they scavenge mainly insects. In summer, however, they feed almost exclusively on Honey Bush nectar, which they obtain by ripping open the calyptra along the plant's flower spikes. In so doing, the skinks expose the Honey Bush's reproductive organs to pollinating insects and provide an escape route for the seeds that later develop.

COURTESY RICHARD SHINE

The Tasmanian Honey Bush relies on the Snow Skink to expose its reproductive organs.

The researchers found that, by varying the amount of nectar offered, Honey Bushes have quite a degree of control over their relationship with Snow Skinks. To optimise pollination in a place with such severe and unpredictable weather, it's best for mature calyptra to be opened when conditions are mildest. That is exactly when lizards and insects, being 'cold-blooded' ectotherms, are out and about. And, not surprisingly, lizards overwhelmingly prefer mature calyptra (brown and laden with nectar) to those that are unripe (pinkish red in colour and offering much less of a reward).

—K.McG.

The Lazy Cannibal

The monstrous pincers and venomous sting of the scorpion can send terror coursing through the veins of people who suffer arachnophobia. Yet it may help these sufferers to know that scorpions have all the

COURTESY PHIL BROWNELL

Cannibalism is rife in scorpion society.

vigour of a zombie: their metabolic rate ticks over at only a quarter of the rate of other arthropods the same size. This means it's unlikely a scorpion will have the energy to scuttle after a nervous human to attack. Indeed, scorpions are sit-and-wait predators, and a reduced metabolism makes them extremely successful desert dwellers.

Because scorpions use very little energy to stay alive, they can invest more energy into producing young. Consequently scorpion populations can reach phenomenal densities of up to 50 kilograms of scorpion biomass over every hectare of desert dune. Bad news for arachnophobics planning a desert holiday. Bad news also for the smaller scorpions—for there's a sting in the tail of this story.

Cannibalism is rife in scorpion society and, what's more, much of the cannibalism is kept in the family, as the young don't scurry far from home. John Lighton (University of Nevada) and colleagues explain this unusual strategy as "transgenerational energy storage". That is, the young scorpions act as an energy storage organ for the population as a whole, in the same way Honeypot Ants store sugar in their bloated stomachs for nest mates to feed on. By producing excess young to eat at a later date, scorpions have found a unique life strategy that allows them to sit back and relax into desert life.

—K.H.

Becoming Human

In contrast with the early evidence of anatomically modern humans out of Africa by 100,000 years ago (and some would argue into Australia by 60,000 years ago), the first convincing and widespread trace of modern human behaviour out of Africa seems to arrive in an archaeological instant. About 40,000–50,000 years ago, an extraordinary burst of artistic activity and new tool kits flood the older and highly stable technologies of earlier human groups. In Europe, so rapid and dramatic were the changes that many scientists believe the older human groups, the Neanderthals, simply could not compete and became extinct. In a meticulous review of African archaeology, Sally McBrearty (University of Connecticut) and Alison Brooks (George Washington University) argue that the rapid changes in Europe, the Middle East and elsewhere obscure the very long and gradual history of modern human behaviour in Africa.

African archaeology challenges the idea of a modern "human revolution" (in the sense of behaviour) and suggests more gradual and episodic phases of technological and artistic development. For example, in a long list of modern behaviours, McBrearty and Brooks point out that production of stone blades, points, grindstones and use of ochre is older than 200,000 years; by 100,000 years ago there is evidence for fishing, exchange, delicate bone tools, barbed points and other decorative items; and microlithic tools, beads and artistic images appear between about 40,000 and 70,000 years ago.

Does the evidence indicate gradual behavioural evolution within Africa and more of a revolution outside? McBreaty and Brooks argue that the sudden changes that appear less than 50,000 years ago out of Africa did not emerge indigenously but are a consequence of rapid migrations. Therefore this cannot be called a revolution at all. The researchers suggest that the apparent time lag between anatomically and behaviourally modern humans in the Middle East and elsewhere is more a reflection of the discontinuous and limited nature of the archaeological record. For example, it is almost impossible to distinguish the stone tool kits of anatomically modern and archaic humans from 100,000-year-old sites in the Middle East, but there are in fact rare traces of modern human behaviour among the first earliest modern humans to escape from Africa. A recent study of the hand bones indicates that the modern human groups used hafted tools in more sophisticated ways than their contemporary archaic cousins (see "Getting a Grip on Early Human Tools".

page 14 this issue).

And what about the Australian evidence? An early human colonisation of Australia (a modern act in itself because it required sea crossing and language) by 60,000 years ago appears to be out of whack with the timing of modern human behaviour elsewhere (although perhaps consistent with the chronology of other modern anatomical data). Many are therefore cautiously sceptical of an early human arrival in Australia (see "A Matter of Time", *Nature Aust.* Spring 2000). Others argue for an earlier presence of apparently archaic humans (who may have been a lot smarter than previously thought). Still others believe that all of these contemporary archaic and modern human groups really formed a single widespread interbreeding population. The trouble is, until about 50,000 years ago, definitive evidence for the earliest of modern human behaviour out of Africa remains archaeologically elusive.

—R.F.

Confetti with a Punch

A Florida moth may have found the ultimate form of safe sex. Male Scarlet-bodied Wasp Moths (*Cosmosoma myrodora*) copulate for up to nine hours and lose a fifth of their body weight in the process. It's a big investment but these spectacular insects have evolved a way to assure safety from predators for both partners, and even for the offspring.

William Conner (Wake Forest University) and colleagues found that, before mating, male moths forage on *Eupatorium capillifolium* and possibly other plants that contain high levels of alkaloids. Alkaloids as a group are generally nasty tasting (they include caffeine, nicotine and quinine) and are strong deterrents for spiders. As the moths feed, these bitter chemicals become concentrated in filaments in two modified pouches in the moth's abdomen. When the male is drawn to the irresistible pheromone of a receptive female, he flies about her then explodes the alkaloid-laden pouches over her, covering her in a bridal veil of poison and providing her with immediate protection from spiders. Alkaloid-laden males and females caught in a web are quickly cut free by the spider, far more often than moths that haven't eaten or been showered with alkaloids.

The moth's sperm also contains alkaloids and so the female gets an extra protective dose during copulation. This she leaves as a legacy for her offspring (see also "Moths & STDs", *Nature Aust.* Winter 2000). Analysis of moth eggs shows they too contain alkaloids passed on by the mother, conferring protection from marauding ants and other predators.

Experiments show males that didn't shower their bride with the poisonous confetti only got to mate about half as often as males that failed to shower them at all. However, other data seem to indicate that females cannot in fact discriminate between alkaloid-laden and alkaloid-free males and that it may be the act of showering that secures a mate.

—A.T.

What Makes a Wallaby Jump?

Kangaroo Island has been virtually free from mammalian predators since rising seas isolated it from the Australian mainland 9,500 years ago. Yet a new study has revealed that, despite living in such idyllic conditions for thousands of generations, the island's Tammar Wallabies (*Macropus eugenii*) can still distinguish friend from foe—but only on sight, not sound.

Daniel Blumstein and colleagues from Macquarie University were curious about the degree to which anti-predator behaviour persists over time in a predator-free environment. They tested the response of a captive population of Tammar Wallabies to the sight of a molded foam Thylacine (an historical predator), and to taxidermic

The male Scarlet-bodied Wasp Moth showers his 'bride' with bitter tufts.

COURTESY WILLIAM E. CONNER

JEAN PAUL FERRERO AUSCAPE

Predators of Tammar Wallabies are seen but not heard.

mounts of a Red Fox and Cat (evolutionarily novel predators). The wallabies reacted strongly to both the Fox and the Cat. They stopped foraging and became more watchful and, in the case of the Fox, thumped their feet much more when compared with control stimuli (which included the cart on which all mounts were presented). There was no real response to the model Thylacine, however, which made the researchers wonder about the importance of fur and other 'natural' features for predator recognition.

When played sound recordings of a Wedge-tailed Eagle (an historical and current predator) and the howl of a Dingo (an evolutionarily novel predator), the wallabies made no response, reacting only to the playback of wallaby foot thumps with reduced foraging and increased vigilance behaviours.

The researchers suggest that the foot thumps act as a generalised anti-predator alarm signal in Tammar Wallabies, and that the wallabies reacted to the mounts because of a general similarity in predator size, shape and forward-placement of the eyes. But while predator morphology is convergent, vocalisations are not, hence the wallabies' inability to recognise any predator's call, new or old.

—R.S.

Monkeys Make Medicine

The lush tropical jungle of South America may look like paradise, but pity the poor animals that have to live there. Unrelenting rainfall and suffocating humidity may be unpleasant to live with, but ferocious biting insects and tropical disease make life unbearable. Yet Wedge-capped Capuchin Monkeys (*Cebus olivaceus*) have found an ingenious way to deal with the discomforts of rainforest life. By rubbing the oozing discharge of certain millipedes (*Orthoporus dorsovittatus*) through their fur, the monkeys ward off the constant irritation of mosquitoes with a naturally derived insecticide.

A team of scientists led by anthropologist Ximena Valderrama (Columbia University) observed this behaviour in wild capuchin monkeys in Venezuela. The monkeys anointed themselves only during the rainy season when mosquitoes are abundant and the risk of bot-fly infection increases. Groups of capuchins would share millipedes they found during foraging outings, with each monkey taking turns to vigorously rub the live millipede through its coat before it was eventually thrown away.

The researchers were intrigued to learn more about the millipede's defensive compounds that the monkeys found so attractive.

They discovered that by tapping the body of a millipede they could milk copious quantities of the dark fluid from the animal's flanks. Chemical analysis revealed the millipede secretion to be a pure mixture of two benzoquinones, chemicals known to be both potent insect repellents and disinfectants.

There have been numerous anecdotal reports on the medicinal use of plants and animals by non-human species, even one of Madagascan Black Lemurs (*Eulemur macaco*) biting a millipede and then rubbing its wounded body through their fur. However, the capuchin study is the first to isolate the specific chemicals involved and, as such, is the best evidence yet of a non-human animal using organic material for medicinal purposes.

—K.H.

Chameleons Suck

Having a long prehensile tongue seems an effective way for some lizards to get lunch. The tongue's rough surface and sticky mucous coating are enough to snare small prey such as insects and other invertebrates up to five per cent of the lizard's body weight. But one group of lizards, the chameleons, have gone a step further. They can catch much larger prey, even small birds and other lizards, and they do this by adding some last-minute suction to their repertoire.

Anthony Herrel (University of Antwerp, Belgium) and colleagues unravelled the chameleon's secret with the aid of high-speed cinematography. Just before they strike their prey, chameleons contort the tip of their tongue into a cup-like shape resembling a bathroom or kitchen sink plunger. This produces a suction effect, with the cup engulfing the entire head of large prey, or the entire prey if it is small, and the tongue (with prey) is then pulled back into the mouth. The researchers estimate that suction accounts for more than two-thirds of the total force generated by the chameleon's tongue, enabling them to catch prey up to 15 per cent of their body weight.

The suction cap is controlled by a pair of muscles that run along either side of the tongue. By cutting the nerves that act on these muscles, the researchers showed that, while the chameleons could still project their tongue, they could not actually capture prey, instead only managing to knock it off its perch.

—J.M.

Marsupials and Mistletoes

Two things come to mind when I think of mistletoe: stolen kisses at Christmas and the birds that distribute their seeds. But just as kissing doesn't enjoy an exclusive relationship with mistletoe plants, birds aren't the only animals to disperse the seeds of these parasitic plants. In fact, the seeds of one South American species (*Tristerix corymbosus*) are dispersed exclusively by a marsupial, the first time such an association has been reported.

When Guillermo Amico and Marcelo Aizen (Universidad Nacional del Comahue, Argentina) discovered strings of mistletoe seeds clinging to the trunks of their host trees, they were intrigued because normally birds defecate the seeds onto the branches of trees while perching. Since deposition on a vertical tree trunk would require a feat of unlikely bird acrobatics, and the green colour of mature fruits would be more attractive to a mammal than a bird anyway, they looked instead for a mammal vector.

They found that the small, endemic, nocturnal Monito del Monte (*Dromiciops australis*) is a highly efficient disperser of mistletoe seeds. It consumes large quantities of fruit, then, shortly after, defecates 98 per cent of seeds, undamaged, on trunks and branches. Less than ten per cent fall to the ground, glued to the uneven surface of the tree by viscin, a sticky substance that holds the seed strings together. The

COURTESY ANTHONY HERREL

Chameleons, such as *Chameleo oustaleti*, suck for their supper.

marsupial's rapid digestion is also essential for the plant's germination: without passing through the animal's gut, the seeds fail to develop a holdfast, the disc-like swelling that helps the seed attach to its new host.

Amico and Aizen say, though, that this newly discovered relationship is actually old news. Both *Dromiciops australis* and *Tristerix corymbosus* are thought to have Gondwanan origins, so the marsupial's ancestors may have been helping the plant to find a mistletoe-hold for more than 70 million years.

—R.S.

Getting a Grip on Early Human Tools

Most of us could probably pick a robust Neanderthal out of a crowd of anatomically modern humans, but we would have more difficulty picking one on the basis of the garbage or tools left behind. In terms of the material culture that survives in the archaeological record 100,000 years ago, Neanderthals and early modern humans were practically the same. But Wesley Niewoehner from the University of New Mexico has found clues in the hand skeletons that uphold an argument for distinct behaviours in the two groups at this time.

Why are the stone tool kits of early humans so similar to those of Neanderthal populations?

Niewoehner created three-dimensional computer models of the hand joints of early modern humans excavated from the 100,000-year-old sites of Skhul and Qafzeh (both in Israel), and compared these with similar models of contemporary Neanderthals. Telltale signs of bone growth on the ends of the metacarpals (the bones in the palm of the hand) showed that the two groups tended to grip the same sorts of tools differently. Neanderthals used a powerful, palm-cupped, stabbing grip that transmitted force along a single main axis, whereas modern humans preferred using grips that transmitted force at an oblique angle. These grips are required for manipulating the different kinds of hafted tools (tools with handles) that are only common much later in the archaeological record. The hands of these early modern humans from Israel are indeed more like those of the later human populations of Upper Palaeolithic Europe (35,000 years ago) than their contemporary Neanderthal cousins. So, why are the stone tool kits of early humans so similar to those of Neanderthal populations?

Even though modern human behaviour (as indicated by stone tools) has now been traced beyond 100,000 years in the archaeological record of Africa (see "Becoming Human", page 10 this issue), emigrant human groups around that time appear to have adopted the local materials and foreign cultures. Under such conditions, the so-called 'modern humans' might have been wimps at many tasks and could have been at a real behavioural disadvantage for thousands of generations. Again, perhaps the artistic and technological skills of the European Upper Palaeolithic are a consequence of long-term interaction if not interbreeding between the different hominid populations.

—R.F.

COURTESY WESLEY NIEWOEHNER

Signs of early modern human behaviour can be found in the 100,000-year-old hand skeleton from Qafzeh, Israel (left) when compared with the similarly-aged Neanderthal hand (right).

Early Bird Catches the Warm

When to return north to their summer breeding grounds is an important decision for European Barn Swallows (*Hirundo rustica*). Arrive too early, and the birds risk being snap frozen by a lingering cold winter; arrive too late, and the prime breeding sites and partners will all be taken, and the chance to rear two broods in the one season disappears. A recent study has revealed that timing of migration is a calculated gamble based on both individual decision and genetic predisposition.

Anders Moller (Universite Pierre et Marie Curie, Paris) showed that male Barn Swallows tend to wait until they have accumulated sufficient energy reserves (as indicated by tail length, as only males in prime condition have a long tail) to enable them to survive the arduous flight and any unseasonably cold weather on arrival. However, he also showed that, regardless of condition, particular birds tended to fly at around the same time every year, and

close relatives (brothers, sons) tended to fly at similar times. A poorly fed male, therefore, can only delay migration for a short interval beyond its 'preprogrammed' time before its genes prompt him to fly away.

With summer starting earlier due to global warming, Moller notes that those birds genetically predisposed to arrive early will be at an increasing advantage, and will begin to outbreed and replace their late-arriving kin. Thus, by inducing changes in global weather patterns, humans are inadvertently altering the genetic makeup of Barn Swallows and, no doubt, many other animals and plants.

—M.L.

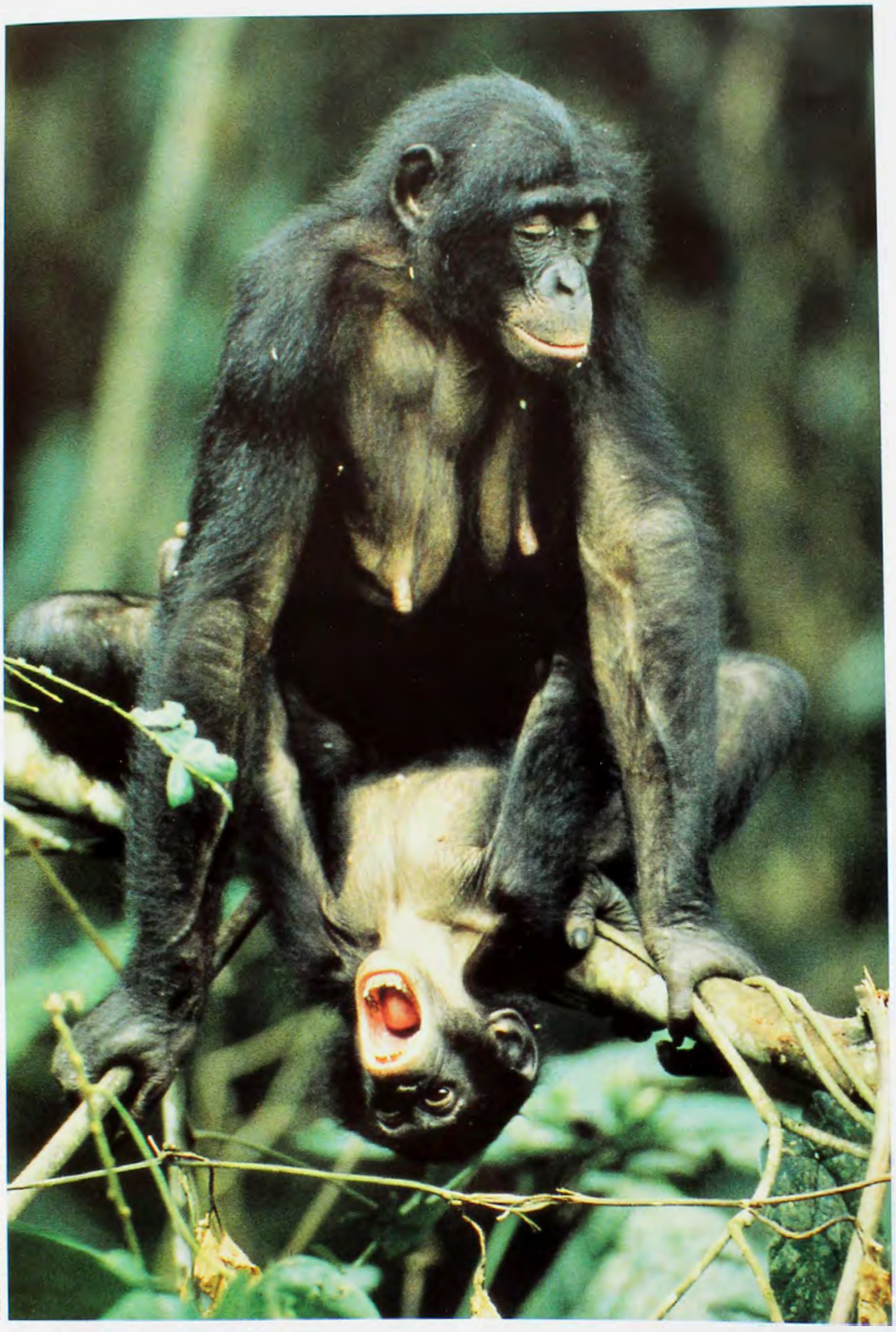
JAMES AMOS/PETER ARNOLD/AUSCAPE

Barn Swallows with 'early-migrating' genes will benefit with global warming.

Bonobo Back-flip

An amiable vegetarian that uses sex to nurture a harmonious existence is how science has come to regard the Bonobo (*Pan paniscus*), a rainforest-dwelling cousin of the Chimpanzee (*P. troglodytes*).

Studies of zoo populations during the past two decades suggest Bonobos live in a matriarchal society in which intercourse and genital fondling strengthen bonds and alleviate tensions between individuals. They have been observed engaging in sexual activities for the sheer pleasure of it and in just as many different positions and permutations as our own species. As a



MARTYN COLBECK-OXFORD SCIENTIFIC FILMS/AUSCAP

Are Bonobos really as peace-loving and sexually receptive as they are touted to be?

result, the Bonobo has become known as both the 'peaceful primate' and the 'sexy ape'.

In stark contrast, Chimpanzees are widely regarded among animal behaviouralists as 'brutal apes'—ruthless warmongers and aggressive predators with a patriarchal society structure in which females are subjugated and often brutalised by dominant males. Furthermore, sex for Chimps occurs only when females are 'on heat' and is limited to the same 'doggie' style adopted by most mammals.

Although our understanding of Chimpanzee behaviour and social strucure is probably accurate, our view of Bonobos is flawed, according to anthropologist Craig Stanford from the University of Southern California. The problem is that the popular picture of Bonobo society is based almost exclusively on zoo populations, while Chimpanzees have been extensively studied in the wild.

Results emerging from studies on wild Bonobos in the Congo indicate that Bonobos and Chimps are not as different as previously thought. The research suggests wild female Bonobos are no more hedonistic than their Chimp counterparts and that, like most other mammals, tend to be most sexually receptive when in oestrus (on heat). Bonobo societies also endure their fair share of aggression but more so from females towards males rather than the other way around.

—K.McG.

Little Boy Bass

Have you ever been disconcerted by the unexpected appearance of a throaty, deep-voiced radio announcer when you finally get to see him on TV? If you found your image of a tall, handsome, hirsute, older man displaced by a rather small, ordinary-looking bloke, don't be surprised—your mistake is a common one. Research by Sarah Collins from the Institute of Evolutionary and Ecological Sciences in the Netherlands has found that women consistently rated men with deeper voices to be older and heavier, more likely to have a hairy chest and be more attractive and muscular, than men with higher voices. Unfortunately, despite strong consensus between the women on these predictions, they were generally quite wrong.

While male body weight did correlate with some vocal characteristics, none of the other assumptions was correct. So why are women so certain that deep-voiced men are going to be more attractive, bigger and hairier than their higher-voiced colleagues? Collins suggests

that people might simply carry the rule they use to discriminate between men's and women's voices too far. Instead of just categorising deep and high voices into men and women respectively, we assume that the deeper a voice, the more 'male' its producer. It is also possible that males may be taking advantage of this incorrect assessment to enhance their reproductive potential. Producing thicker and longer vocal folds (and a deeper voice) may be easier (metabolically cheaper) than growing the extra couple of inches and working out at the gym, particularly if it makes them sound more attractive and masculine anyway.

So, women, don't close your eyes and believe all those whispered sweet nothings. Voices can be very deceptive.

—D.C.

Ozzie Kiwis

While Australia and New Zealand are close neighbours as the 'Russell Crowe' flies, they remain fierce rivals, with a well-developed sense of one-upmanship in many aspects of life. Australia has always been happy to 'steal' public figures from New Zealand and then claim them as its own, whether these be actors, racehorses or State premiers.

Although much less in the public eye, this practice extends to the biological realm. No doubt a blow to New Zealand pride, for example, was the discovery in Australia of fossils of the distinctive New Zealand ground-foraging bat *Mystacina*, implying that it evolved here and only later moved across the Tasman (see "Bizzare Bats of the Burrows", *Nature Aust.* Spring 1998). Now another, more ignominious possibility has been raised: that New Zealand kiwis are really Australian.

The southern continents each have one or more large flightless birds, the so-called ratites: Emu and cassowaries in Australasia, rheas in South America, the Ostrich in Africa. New Zealand has the most diminutive members, the kiwis (*Apteryx* spp.), as well as a vast array of now-extinct moas. It is generally considered that living ratites evolved from a single group that left representatives on each continent as these landmasses broke away from the southern continent Gondwana. But there is far less agreement about who is related to whom. Emus and cassowaries have always been considered each other's closest relatives. Likewise, a similarly close relationship has been accepted for the kiwis and moas, with their mutual ancestor assumed to be present on New Zealand when it floated away from Gondwana about 80 million years ago. After all, as flightless birds they had limited choices about how to get there.

A recent study, however, has turned much of this on its head. Alan Cooper (University of Oxford) and colleagues supplemented DNA sequences of the living ratites with some from subfossil moa remains. The findings confirm the Emu–cassowary connection, but not the kiwi–moa one. Whereas moas appear to have evolved on a breakaway New Zealand, kiwis are closest to the Emu–cassowary branch, apparently reaching the islands subsequently, after separation from Gondwana. If kiwis did not originate in New Zealand, they had to get there from somewhere else. Australia was the closest

Should kiwis, like this Brown Kiwi (*Apteryx australis*), call Australia home?

large landmass at the time and, having the closest living relatives, is an obvious candidate for the source. There is much more to be learnt before this can be accepted, including an explanation of how the kiwis' ancestor arrived in New Zealand. Nonetheless, the possibility that the national symbol of New Zealand is, in fact, an Australian should raise the stakes in the game of cross-Tasman bragging rights.

—Walter E. Boles
Australian Museum

Termites on the Menu

Tiny telltale scratches on the world's earliest bone tools were thought to have come from digging for tubers, which some anthropologists believe played a crucial role in human evolution (see "What's Cooking?", *Nature Aust.* Autumn 2000). However, a new look at these old tools suggests a different source for the scratches—termite mounds—and may provide the first known evidence of insectivory in early hominids.

Lucinda Backwell (University of Witwatersrand, South Africa) and Francesco d'Errico (CNRS, France) examined 85 bone points from the 1.8–1.0-million-year-old African sites of Swartkrans and Sterkfontein. Using computerised image analysis, they compared the markings on these tools with experimental bone tools that had been used to dig up tubers or break open termite mounds. Opening up a termite mound produced long, thin, parallel striations along the length of the tool, which the researchers explain came from the fine, even-sized sand grains (preselected by the termites) and the need for a vertical stabbing action to efficiently open the mound. By contrast, digging for tubers resulted in short, crisscross marks that varied in width, and arose from the mixed particle sizes in the ground and the need to attack the tuber from different angles. All the archaeological tools examined by Backwell and d'Errico showed wear patterns consistent with use in breaking open termite mounds. And the rewards for such behaviour would certainly have been worth the effort: there are nearly twice as many calories in 100 grams

Aborigines are known to consume termite mound for its mineral content.

PAVEL GERMAN/NATURE FOCUS

Did termite mounds provide a source of nutrition for early hominids?

of termites as there are in the same amount of steak.

As to who was using these tools, the remains of two hominid species have been found in the deposits: *Australopithecus robustus* and *Homo habilis*. Earlier analysis of the hominid bones had revealed the presence of a type of carbon obtained only from the consumption of grass-eating herbivores. This suggested a carnivorous diet but was harder to explain for *Australopithecus robustus*, which had been assumed to be strictly vegetarian. Backwell and d'Errico now argue that consumption of grass-eating termites could also have been responsible for this carbon signature, although more detailed studies are required to determine whether only one or both species were eating termites.

But is this the end of the story? Australian Aborigines are known to consume termite mound for its mineral content. Could the earliest bone tools have been used in a similar way (that is, to harvest the dirt, rather than the insects)? Also, work currently underway by Thomas Loy (University of Queensland) and colleagues on similar 1.8-million-year-old bone tools from the African site of Drimolen suggests that some of them were indeed used to process tubers (as indicated by traces of the plant tissue left behind). In these cases, the fine striations may simply have arisen through shaping of the tool tips with a stone artefact. The possibility that similar tools may have been used for different purposes highlights the complexity of early hominid behaviours.

—R.F.

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QUICK QUIZ

1. *What are the two most common forms of myriapods?*
2. *Do bluetongue lizards lay eggs?*
3. *What name is given to the suite of large animals that became extinct towards the end of the Pleistocene Period?*
4. *Where is Australia's largest population of pure-bred Dingoes found?*
5. *What do oologists study?*
6. *Which introduced animal was reported to have invaded Kakadu in early 2001?*
7. *Name an example of a pachyderm.*
8. *What is the title of Tim Flannery's recent book on the ecological history of North America?*
9. *Which sea mammal most likely gave rise to the mermaid myth?*
10. *What type of animals are the only ones to regularly tie themselves into a knot?*

(Answers on page 83)

Sex to die for

For a long time everybody pitied male antechinuses. Living, loving and dying, all within a year.

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Agile Antechinuses (*Antechinus agilis*) mate in a hollow log.

BY STEVE VAN DYCK

AT ONE TIME OR ANOTHER we all have had to sit through those cunning psychology tests where the interviewer says one word and you are expected to respond with the *very first* word that comes to your mind. Who, however, would admit to the number of times "sex" would have been the honest answer? Prompts coming from the world of vegetables and plumbing may make lying more palatable than qualifying as some sort of kinky misfit.

One word that invariably elicits a great variety of responses is antechinus (pronounced 'anti-ky-nus'). Most people are probably going to respond with an "anti-what?" having never heard the word before. 'Antechinus' used as a common noun is a trendy use of a scientific name referring to a genus of lovable, chunky, carnivorous, rat-sized marsupials that are still sometimes reasonably common, although rarely seen. It is one of those Greek combo words from *anti* meaning like, sort of or pseudo and *echinos* a hedgehog (a myopic reference to antechinus fur texture).

To the initiated, the word antechinus might evoke the same "terror" a ferret generates in a Rabbit hole. Among the small birds of a backyard aviary, antechinuses can be lethal—not ruthlessly greedy like a Fox, but methodical, bowling over a bird-a-night until the lot is gone. Confused bird lovers who find their Canaries or finches neatly turned inside out like an Eskimo's parka can, almost certainly, attribute the delicate butchery to a fat nocturnal antechinus. And Murphy's Law (Subclause # 24: Antechinus *vis-à-vis* small birds), always applies— "the rarest and most valuable birds will always be eaten before those that are either diseased, infertile, palatable or easy to bag".

"Bodily discharge" might be another top-of-the-list knee-jerk reaction to the word antechinus. If you are fashionably tolerant and let antechinuses do the rounds of your home at night polishing off cockroaches and House Mice, then be prepared for a little 'something left on your plate'. Antechinus poo is generally gooey like tar, and comes in any shape depending on what they've just eaten. Mostly it's neither dry nor delivered in a tight capsule like a rat's dropping. This is why antechinuses love to nest in the linen drawer among the white tablecloths, because the cotton can suck up all the dark soupy liquid from the droppings making for a drier, cosier boudoir.

"Mental" is another common impression left by antechinuses. Apart from a two-legged dog on a trolley, there could be few funnier animals to have in your house. Antechinuses can run upside down along exposed beams, sideways across curtains and underneath floor rugs. To see one suddenly pop its head out from inside a shoe or a mixing bowl cannot fail to reduce the hardest soul to jelly. Their jerky, nervous movements and predisposition toward indecision have marked them as the clowns of the marsupial fraternity.

Such an inquisitive nature has its down side though, and it's not uncommon to find them floating face down in a fish tank or toilet bowl.

Conservationists might just shed a tear and say no more when they hear the word antechinus. Antechinuses represented just about our last chance with small urban marsupials. Without a doubt they would be happy to live with humans in cities, and probably better at dealing with cockroaches and House Mice than all the poisons we pump out in their control. But they are no match for Cats. Once eaten out from a suburb they can no longer re-enter or re-establish against that urban phalanx of pussies. Why is this, when rats and House Mice do it so well?

The reason probably lies largely in their physiological commitment to breeding just once a year. Where one female Black Rat or House Mouse might pump out 60 young a year (all the females of which will be sexually mature at the age of three months), an antechinus produces no more than 12 joeys (and usually only around six), none of which will breed until they are about 11 months old. The astonishing thing about their life cycle, though, is that after they mate, the males die! Because individuals in a population all mate at the same time, there is a period of months after breeding where the only male antechinuses around are pip-squeaks dangling from their poor mothers' teats.

What then, given the impossible, might a caring father antechinus say to his pubescent son to introduce him to the wonders of a changing body and the potential joys of intimacy? "Well, son, it's June already, and you've probably noticed your testicles are now as big as your head. Perhaps this shift in the decision-making geography of your body explains your diminishing interest in family picnics and cockroaches." If he were honest to the point of being abrupt, he might say, "My boy, as you know, an antechinus can spin the act of love out to about 12 hours on a cool, predator-free night, and keep this up for two glorious weeks. Enjoy it, because not long after doing it your plasma corticosteroid levels will reach flashpoint, you'll develop AIDS (Antechinus Immune Deficiency Syndrome) and bleeding stomach ulcers, and die within a week. Have you ever considered the priesthood?"

For a long time everybody pitied male antechinuses. Living, loving and dying, all within a year. But I think the pity was secretly couched in envy. Remember the 12-hour copulatory swan song repeated for a fortnight? A male of any species lasting 12 hours might be regarded as a treasure. Finding one in Australia might be regarded as a miracle! But it's more sensational than that. A few rough comparative calculations (*à la* one Dog-year = seven for humans) turn that tide of pathos on its head. Given the choice, what lifestyle would the average Norm choose to end his days? Gradual loss of teeth, eyesight and libido, cancerous prostate, aching bones and dribbling orifices? Or an antechinus-equivalent of three years of practically non-stop, unchallenged, promiscuous, unsafe sex, with each tumble lasting five weeks? Where is the *choice* in that?

So, what word were you supposed to think of as soon as you heard the prompt "antechinus"? The answer was, surprise, surprise, "sex". Sex...to die for.

Antechinuses

Antechinus spp.

Classification
Family Dasyuridae (carnivorous marsupials). Ten (look-alike) species in Aust.

Identification
Size of small rat but with Cat-like set of teeth. Jerky behaviour. Broad hind feet that stick out in Charlie Chaplin fashion. Pointy nose. Most species drab brown to grey but *A. flavipes* with grey head, light eye-rings, ginger rump and hind legs, black-tipped tail. Males bigger than females. Smallest species *A. agilis* (male head–body length 9.5 cm, tail 9.0 cm, 30 g), largest *A. godmani* (male head–body 14.5 cm, tail 12.5 cm, 95 g).

Distribution
Aust. wide, from rainforest to dry woodland. Most widespread species *A. flavipes* (WA, SA, Vic., NSW, Qld), most restricted *A. godmani* (highland rainforest of northern Qld).

Behaviour
Terrestrial, arboreal, semi-nocturnal. Eat mostly insects and arachnids, but supplemented with almost anything else (nectar, worms, small mammals, birds, reptiles).

Reproduction
All matings locally synchronised, but usually between midwinter and early spring. Males mate over two-week period then die. Gestation 28 days, young in the 'pouch' up to 50 days, then left in nest 2–3 months. Females may breed a second year.

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Nielsen Park She-oak

When discovered in 1986 there was a total population of only ten plants, two male and eight female.

THE SPARSELY BRANCHED AND drooping Nielsen Park She-oak (*Allocasuarina portuensis*) is an uninspiring survivor of eastern Sydney's foreshore bushland that nearly disappeared without anyone noticing. It is a slender shrub with dark green foliage, growing three to five metres in height. Like some of the other she-oaks (family Casuarinaceae), it is dioecious; that is, it has separate male and female plants.

When discovered by a National Parks and Wildlife Service Ranger in 1986 there was a total population of only ten plants, two male and eight female. All were located within 100 metres of each other at Nielsen Park, part of Sydney Harbour National Park.

The original distribution of this plant was probably more widespread around Sydney Harbour, but loss of habitat, due to extensive land clearing since European settlement, was a likely contributing factor in its decline. Another influence may have been an alteration in the vegetation community due to a changed fire regime. It is thought that more frequent fires in the past maintained a heath-dominated vegetation community. Now that there are fewer fires, larger species like pittosporums have become established, significantly reducing the level of light available to the she-oaks.

How could this species go undiscovered for so long within sight of the most densely populated part of Australia? First, no-one was really looking. Nielsen Park, which is only 20 hectares, did not become part of Sydney Harbour National Park until 1978, and the picnic and swimming areas did not previously attract as much botanical interest as other bushland areas. Second, at a casual glance most would have identified this plant as *Allocasuarina distyla*—a close relative that also grows throughout the area.

CRAIG SHEPHARD

However, there are several subtle morphological differences between the two species. Although the male flower heads of both species resemble a string of miniature beads (each 'bead' equalling one whorl of flowers surrounding the stem), in *Allocasuarina portuensis* the 'beads' are widely separated whereas in *A. distyla* there is no clear gap between the 'beads'. There are also differences in the leaves and branchlets. As in other members of the family, the leaves are highly modified. They are fused to the needle-like green branchlets, with only the leaf tips obvious as little teeth arranged in whorls around them. In the case of *A. portuensis*, there are seven or eight teeth in each whorl, but *A. distyla* usually has six to eight. The branchlets of *A. portuensis* also lack obvious hairs seen in many other she-oaks, including *A. distyla*, and the fruiting cones are smaller.

It is believed to be in risk of disappearing from the wild within 20 years.

As she-oaks are wind-pollinated and are able to hybridise with similar species, seedlings grown from seed collected from wild plants had to be treated with caution. It had been suspected that they could be hybrids with *Allocasuarina distyla* or *A. littoralis*, which also occurs in Nielsen Park. To address this important issue, staff at Mt Annan Botanic Garden performed preliminary genetic investigations, which involved comparing the DNA of some of the remaining wild *A. portuensis* specimens (and several cultivated plants) with *A. littoralis* and *A. distyla*. These studies suggested that *A. portuensis* was indeed capable of hybridising with other *Allocasuarina* species. But pure *A. portuensis* plants were distinguishable from hybrids by the morphological features described above. On the basis of these results, the number of pure *A. portuensis* in Sydney Harbour National Park was revised in 1997 to over 50, although most of these were planted from seed collected and grown in pots.

The Nielsen Park She-oak is listed as endangered in New South Wales and it is generally believed to be in serious risk of disappearing from the wild within ten to 20 years. As a consequence, the New South Wales National Parks and Wildlife Service has prepared a Recovery Plan for the species. The overall objective of the plan is to protect the species so that a viable population is maintained in the wild. Restoring the original habitat to open woodland/heath by the reintroduction of more frequent, low-temperature fires, and by controlling weeds to a minimal level, will help us to achieve this goal. In the meantime, you can see the Nielsen Park She-oak 'in captivity' at Mt Annan Botanic Garden, where it is flourishing, or as a single plant in the rare and threatened garden bed at the Royal Botanic Gardens Sydney.

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BY CRAIG SHEPHARD

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Growing native weeds

Wherever native plants are grown, they often 'walk' into nearby forests and become weeds.

PHOTOS: TIM LOW

Kurrajongs are now invading Perth bushland. One tree may shed 7,000 seeds, many of which are spread by birds.

I AM WANDERING THROUGH bushland with environmental consultant Rohan Cuming. As we wend our way through copse and thicket he keeps up a colourful banter: "This Sydney Blue Gum's a bloody good weed. And that's a real spready wattle. Here we've got a melaleuca, a big mongrel thing. I've seen it walking down roadsides. We've hand-pulled a lot of hakeas. These here are hakea seedlings. They walk too, they really do. And there's a Western Australian flowering gum."

I stumble along, wide-eyed in disbelief. In my darkest dreams I never imagined anything like this. We are in Mt Martha Park on the Mornington Peninsula near Melbourne, and it's Australiana gone haywire. Weeds are overrunning this place and the punchline is: most of them are Australian plants. A tangle of 38 species has claimed a hillside that once carried grassy she-oak woodland. All of this, in an important nature reserve.

Hundreds of Australian plants were planted on Mt Martha during the 1950s and 1980s to create an arboretum. Management lapsed and more than a third of the species 'walked'. The arboretum is now an 8.5-hectare eco-mess. Peppermint trees (*Agonis flexuosa*) from Western Australia jostle with South Australian Sugar Gums (*Eucalyptus cladocalyx*) and Lemon-scented Tea Trees (*Leptospermum petersonii*) from mountains in Queensland or northern New South Wales. "In the vernacular this is called a 'horror show', this level of weed invasion", Rohan told me. Mornington Council wants him to remove all the weeds. I suggested he drop napalm.

Mt Martha is an exaggerated example of a widespread and growing problem. Wherever native plants are grown, they often 'walk' into nearby forests and become weeds. Victoria, the worst affected State, has more than 200 Australian plants on her weed lists. They include more than 30 each of wattles (*Acacia* species) and eucalypts (*Eucalyptus* and *Corymbia* species), various tea trees and paperbarks (*Melaleuca* species) and a smattering of rainforest plants. Western Australia has almost 60 errant natives, including Scaly Tree Fern (*Cyathea cooperi*), Blue Gums (*Eucalyptus globulus*) and Kurrajongs (*Brachychiton populneus*).

Native plants are taken very seriously as threats to reserves. In Arthur's Seat State Park (near Mt Martha), $95,000 has been spent attacking Bluebell Creeper (*Sollya heterophylla*) from Western Australia. In the Dandenong Ranges National Park near Melbourne, nine tree weeds are controlled and six of these are Australian—four wattles (acacias), Cape Wattle (*Paraserianthes lophantha*) and Sweet Pittosporum (*Pittosporum undulatum*). Around Sydney, where highways pass through reserves, managers are concerned by three wattles that tint the verges blue—Golden Wreath Wattle (*Acacia saligna*) from Western Australia, Cootamundra Wattle (*A. baileyana*) from southern New South Wales and Queensland Silver Wattle (*A. podalyriifolia*) from well to the north.

These weeds sometimes behave worse than any invader from abroad. In southern Australia, Sweet Pittosporum forms thickets in eucalypt forest so dark that eucalypt seedlings cannot sprout below and forest succession ends. In Adelaide's Belair National

BY TIM LOW

Global warming may help the Silky Oak spread south. Native to northern New South Wales and southern Queensland, it is now naturalising in Victoria.

Park it is shading out a rare greenhood orchid (*Pterostylis cucullata*). Around Brisbane, Umbrella Tree (*Schefflera actinophylla*) from tropical Queensland is shading the understorey in the same way. I have counted 80 seedlings in a square metre of eucalypt forest. Very few foreign weeds behave this badly.

Growing native plants is promoted as good for the environment, yet remarkable problems are emerging. Plants are popping up in the oddest places. No-one could expect that White Cedars (*Melia azedarach*) from coastal rainforests would sprout around Alice Springs, or that Silky Oaks (*Grevillea robusta*) from the Brisbane region could grow way down in Victoria.

So what should we do about all this? First, we should rethink what we mean by 'native'. In my dictionary (Concise Oxford) it means, in part, "Of one's birth, where one was born". Geraldton Wax (*Chamelaucium uncinatum*) is native to sandplains north of Perth, and to say "Geraldton Wax is native to Australia" fudges the facts. Australia is one of the world's largest countries, a whole continent, and Geraldton Wax occupies but little of it. Perth and Sydney stand as far apart as Portugal and Russia or Switzerland and Arabia. If explorer Nicholas Baudin had claimed Western Australia for France, Geraldton Wax in Sydney would now be an exotic species from Republique Westralia. When 'native' is used as a biological category it shouldn't be defined by political boundaries.

Australian plants that escape well outside their natural range are exotic invaders. The International Union for the Conservation of Nature (IUCN) defines an alien (or exotic) species as one that is "introduced outside its normal past or present distribution". All the plants mentioned here qualify.

The Association of Societies for Growing Australian Plants knows that a problem exists. It has a web page that goes like this: "Don't Grow Australian Plants! Now that we have your attention...Is an organisation whose objective is to encourage the cultivation of Australian plants really suggesting that people should NOT grow those plants? Well...yes! Under certain circumstances."

The Association lists some of the problem plants, emphasising it doesn't have a policy of 'Plant Australian at any cost'. It doesn't want to promote the spread of "ugly Australians". And it proposes some rules: grow indigenous plants (those native to your area); become familiar with weed lists and avoid problem species; check out unusual plants with experts. If growing something new, observe it closely and if it becomes rampant, pull it out. "If in any doubt...DON'T PLANT! It's not worth the risk!"

Sound advice.

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CHRIS SURMAN

TWO HUNDRED AND SEVENTY-FIVE YEARS LATER,
I TOO WAIT IN THE DARK FOR SEABIRDS TO RETURN.

IN PURSUIT *of the* GURGE

BY CHRISTOPHER SURMAN

BESIDE A ROTTING CANVAS TENT ON A WINDY NIGHT IN AUGUST, sailors, clustered around the feeble flame of an oil lantern, are startled as a large bat-like creature hits one of them in the back of the head. More whoosh by, wingtips shearing the tops of nearby shrubs. Eerie, mournful, cat-like sounds fill the air like the cries of drowning castaways. With little effort, the sailors pull the strange creatures from burrows they once thought belonged to long-departed Rabbits. "Muttonbirds!" they cry with joy*. Fattened up after many months foraging at sea, the birds provide welcome respite from the hard-tack diet of these shipwreck survivors. Within a few weeks, the nightly massacre ends as the birds fail to return.

**'Muttonbird' is a general term used to describe shearwaters, but particularly the commercially harvested Short-tailed Shearwater (Puffinus tenuirostris), which forms large breeding colonies on the islands of Bass Strait and Tasmania. They are so-named because their fatty flesh is supposed to taste like mutton, although the ones I have tried would be better named 'anchorybird'. Others believe the term comes from the fact that the birds replaced Sheep as a crop on hummock-grass islands, either for food or for their fat that was used in place of tallow from Sheep carcasses. Still others feel the name refers to the woolly down on the chicks. The derivation remains murky.*

CHRIS SURMAN

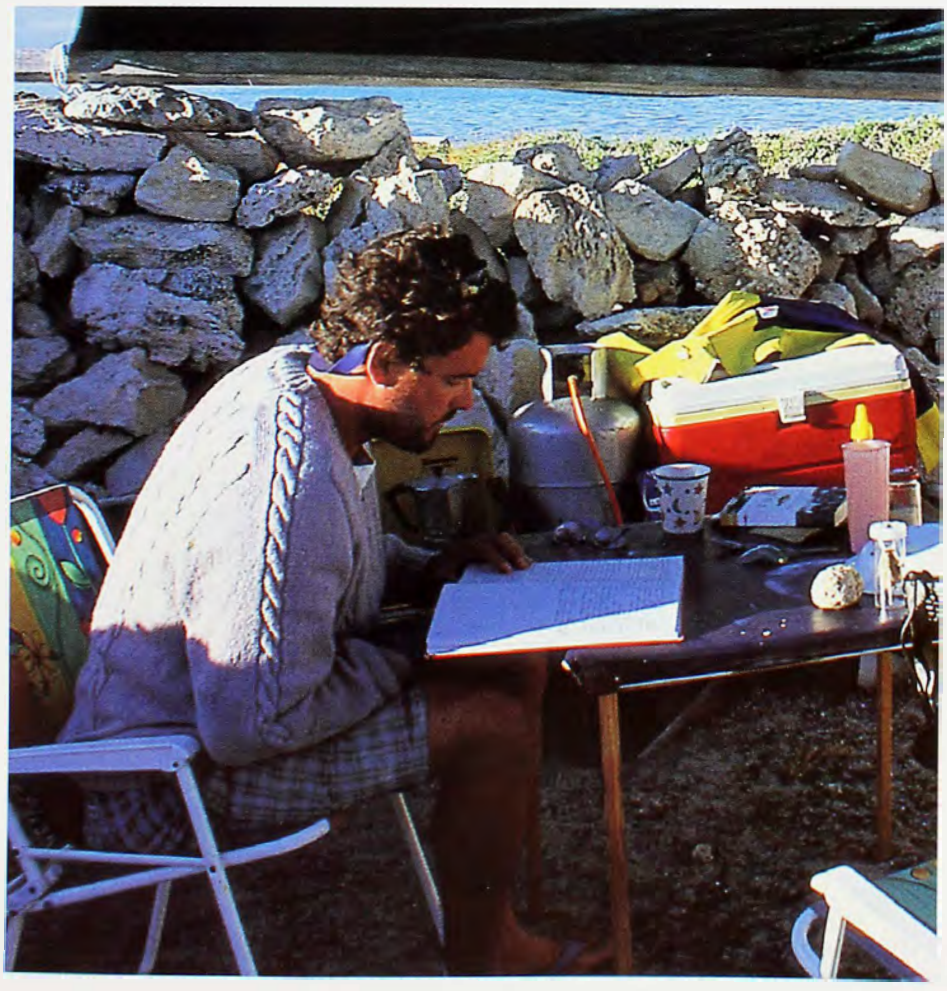
The author (in yellow jacket, above) and volunteers wade through mangrove swamp to collect regurgitates from Lesser Noddies. Regurgitates are placed in labelled jars for analysis. (Left) Lesser Noddies nest among the branches of the Grey Mangroves. They breed only on Pelsaert Island and two smaller islands to the north.

Two hundred and seventy-five years later on a nearby island in the Houtman Abrolhos, I too wait in the dark for seabirds to return. However, unlike the survivors of the *Zeewyk* shipwreck, I have no need to clobber them for food. Rather, it is the food that they carry in neat packages in their stomach that interests me. In pursuit of the 'gurge'. Regurgitated parcels of tightly packed fish tell us not only what these seabirds eat but where they may be foraging, how well they are doing, and how our fisheries may impact on their survival.

THE HOUTMAN ABROLHOS is made up of over 120 coral-covered rocky islands, 60 kilometres west of Geraldton on the mid-west coast of Australia. There are three main groups, each fringed by a reef that shelters the lagoons from the relentless swell of the Indian Ocean. The low-lying islands rarely protrude more than two metres above the high-water mark. Vegetation is sparse. The only trees are Grey Mangroves (*Avicennia marina*) and the rest of the vegetation is just scraggly, wind-blown, salt-tolerant shrubs.

One of the most notable features of the Houtman Abrolhos is its eclectic mixture of tropical marine creatures juxtaposed against a temperate environment. It is the northernmost extension of the breeding range of the Australian Sea-lion (*Neophoca cinerea*), but also the southernmost breeding location of the Green Turtle (*Chelonia mydas*). Seagrasses and cool-water kelps literally sway with the surge of breakers among huge expanses of brightly coloured staghorn and mushroom corals. Bread-and-butter fishes, such as Tommy Roughs (*Arripis georgianus*) and Tailors (*Pomatomous saltator*) caught by southern fishermen from Perth to Sydney, school over patches of reef patrolled by warm-water coral trouts (*Plectropomus* spp.) and parrotfishes (family Scaridae). Most spectacular are the three million tropical seabirds that return each spring from their Indian Ocean winter retreats to breed at the Houtman Abrolhos.

The explanation for the Houtman Abrolhos's unique wildlife is simple. Originating from the Indonesian Archipelago, a body of tropical water forms into a large coastal current on the north-west shelf of Australia. From here, as the Leeuwin Current, it begins its 2,500-kilometre meandering journey southwards, hugging the edge of the continental shelf all the way to Cape Leeuwin, from where it flows eastwards into the Great Australian Bight. Coastal communities see little influence of the Leeuwin Cur-



CHRIS SURMAN

The author filling out the log book at the field camp on Pelsaert Island. The rock shelter was constructed by visiting fishermen to escape the strong winds characteristic of the islands.

CHRIS SORMAN

Wedge-tailed Shearwaters foraging with a Bryde's Whale (*Balaenoptera edeni*). The small fishes are Slender Sprat (*Spratelloides gracilis*) and the throat pleats of the whale are clearly visible.

rent, but offshore islands like Rottnest Island off Fremantle, and the Houtman Abrolhos, lie directly in its path. It brings with it the larvae of corals and fishes from more tropical regions, and this may explain why so many tropical seabirds nest on the Houtman Abrolhos.

Pelsaert Island, the southernmost island in the chain, is the regular breeding place for 14 species of seabird. In terms of numbers and diversity, it surely rates as one of the most significant seabird sites in Australia. Over half a million Sooty Terns (*Sterna fuscata*), 260,000 Common Noddies (*Anous stolidus*), 150,000 Wedge-tailed Shearwaters (*Puffinus pacificus*) and 70,000 Lesser Noddies (*A. tenuirostris*) breed there each spring. Incredibly, this corresponds to 80 per cent of Sooty Terns, 50 per cent of Common Noddies, 20 per cent of Wedge-tailed Shearwaters and 75 per cent of Lesser Noddies nesting within Australia's territorial waters.

Lesser Noddies are of special concern as their only nesting places are Pelsaert and two other small islands 20 kilometres farther north, and on Bird Island in the Seychelles on the other side of the Indian Ocean. Other tropical seabirds such as Red-tailed Tropicbirds (*Phaethon rubricauda*), Bridled Terns (*Sterna anaethetus*) and Roseate Terns (*S. dougallii*) nest side by side with the more temperate, cool-water Pacific Gulls (*Larus pacificus*), Little Shearwaters (*Puffinus assimilis*) and White-faced Storm-Petrels (*Pelagodroma marina*).

Each year in spring my volunteers and I must transplant ourselves from the mainland to the research base. This is an old rock-lobster fisherman's hut, on tiny Fin Island, in the Pelsaert Group. The boat trip takes three hours from Geraldton, and we have to bring absolutely everything with us, from food, torch batteries and toilet paper to 60-litre drums of fuel for the generator and fridges.

Our home on the island, although comfortable enough, is made out of steel. This is not entirely practical in a marine environment—and rust has certainly claimed the camp, corroding

BY THE END OF THE NIGHT

I am covered by dark, fishy stains and bright streaks of poo. Blessings from the birds!

some of the main wall studs, and much of the join where the roof meets the gutters. Life here gets pretty exciting during big blows, which can get up to 65 knots (119 kilometres per hour). Old seamen have ways of judging wind speed. The first sign of whitecaps means 12 knots, while whistling rigging signifies 25 knots. We at the camp judge it another way. The lime-green carpet lifts two centimetres off the floor at about 20 knots, at 25–30 knots the windward walls start to pulse in and out, and at over 30 knots the polystyrene ceiling starts to move independently. Beyond that the camp begins to pump and roar to a symphony of wind. This past season has been particularly windy. Only the other evening, as I lay reading in bed, I noticed my clothes, piled on the floor, lifting up with the movement of the carpet. Interested to see just how windy it was, I placed my thongs on top of the shirt and shorts, and then the book I was reading, and finally the head torch. All this was still supported by the lifting carpet! A quick dash outside with an anemometer revealed the wind speed to be 38–42 knots!

SEABIRDS ARE ESSENTIALLY marine organisms, spending most of their time at sea. To understand what makes them tick we therefore need to consider how they relate to their marine habitat. We do this during the breeding season, when they are tied to the land, by collecting the stomach contents from adults when they return to their nest site after a day for-

Sooty Terns are the most numerous tropical seabird nesting on the Houtman Abrolhos. Over half a million nest on Pelsaert Island alone. Here a parent regurgitates a fish for its chick.

KATHIE ATKINSON

CHRIS SORMAN

A fisherman's shack on Fin Island. Visitors to the Houtman Abrolhos dream of palm-covered atolls but the reality is quite different.

aging at sea. As recently as the 1970s, seabirds were shot or poisoned to get at their gut contents. At the Houtman Abrolhos, however, I take advantage of the least intrusive method possible—the propensity of many seabirds to regurgitate (spew) when disturbed. Seabirds regurgitate their most recent meal as a nervous response to being captured, much like a skink drops its still-wriggling tail to distract a hungry predator. By visiting seabird colonies at a time when seabirds are most likely to be full, we are able to collect regurgitates with minimal disturbance to the population as a whole. On Pelsaert Island, where most of the breeding activity takes place, the best time is after dark.

To catch the terns and noddies that I study, I isolate a single bird on its nest with a narrow torch beam, and then I sneak up and pluck it from its nest. This is possible partly because these birds have had little experience of humans in the past and so remain quite unafraid, and partly because they are dazzled by the torch beam.

Once I have a bird in the hand it usually begins to regurgitate. If things go well, this ends up in my free hand where it is then scraped off and stored in a plastic vial. If the bird decides to shake its head at an inappropriate moment, the 'gurge' flies everywhere, covering my volunteers and me. The trick is not to unconsciously lick the corner of your mouth when you feel something there! As you can imagine, by the end of the night I am covered by dark, fishy stains and bright streaks of poo. Blessings from the birds!

Before release, I weigh and measure each bird to assess how healthy it is, and then place a small, numbered stainless steel ring around its ankle. Because I only sample from unbanded birds, this ensures that no bird loses more than one meal in a season.

After six hours in pursuit of the gurge, we return to our temporary campsite on Pelsaert with the wind at our back. On our return to nearby Fin Island the following morning we store the previous evening's 'catch' and begin to sort through gurges collected the previous week. Each gurge is an insight into a seabird's day. The types of marine prey found in the regurgitated contents give us a clue as to when and where that seabird had been feeding.

Eighty per cent of the diets of Less-

er and Common Noddies are made up of just three types of larval fishes—Beaked Salmon (*Gonorynchus greyi*), Blackspot Goatfish (*Parupeneus spilurus*) and Bellowsfish (*Macroramphosis scolopax*). From what we understand of the biology of these fishes, we can picture what the two noddies may have been up to out at sea. All three fishes are only available to the noddies during daylight, when the feeding action of predatory pelagic fishes such as tunas drives them to the surface in their desperate attempt at escape. It is then that the two noddies are able to hover and dip over the school, capturing fish in the top few centimetres of water or grabbing them in mid-air as the fish evade their watery predators. So we now know that Lesser and Common Noddies are diurnal feeders. We also know from plankton tows that their fish prey is only found west of the Houtman Abrolhos. Even though Lesser Noddies at around 100 grams are half the size of Common Noddies, I have recorded both species foraging over 150 kilometres from their nearest nesting site!

In contrast, the larger Sooty Terns (230 grams) eat mainly enope squids

FROM THE BIOLOGY

of these fishes, we can picture what the two noddies may have been up to out at sea.

(family Enoploteuthidae) and lantern fishes (family Myctophidae). Squids and lantern fishes spend the daylight hours at depths of about 50 metres and move to surface waters at night to feed. Both these prey are also characteristic of oceanic (off-shelf) waters, and so the presence of these prey in the guts of Sooty Terns suggest that these birds often feed at night, and many hundreds of kilometres from their breeding ground.

The plot thickens. Beaked Salmon are a temperate, bottom-dwelling fish, found as adults in coastal and estuarine regions of south-western Western Australia, and as larvae near the surface in offshore waters. Their predominance in the diet of the two tropical noddies poses interesting questions and reinforces the bizarre juxtaposition of marine organisms at the Houtman Abrolhos. Lesser Noddies also eat large volumes of Blackspot Goatfish, the larvae of which are known to be of a tropical origin and transported southwards by the Leeuwin Current. Goatfish are less common in the diet of Common Noddies. During years when the volume of Beaked Salmon in regurgitates dropped, Lesser Noddies still consumed many goatfish but Common Noddies did not. If Common Noddies share foraging grounds with Lesser Noddies, why do they tend to ignore schools of goatfish? Being a larger bird, the Common Noddy may not find it economical to feed on these reasonably small (less than 30 millimetres) fish. However the consequences of this discrimination can be catastrophic.

During the 1996 and 1997 breeding seasons there was an almost complete

Baitfish schools such as this one (Slender Sprat, *Spratelloides gracilis*) are pushed to the surface by tunas and then attacked from above by terns.

CHRIS SULLMAN

HANS & JUDY BESTE/OCHMAN TRANSPARENCIES

A Common Noddy with its chick. Common Noddies share feeding grounds with Lesser Noddies but appear to favour different fish.

CHRIS SURMAN

Detailed studies of Roseate Terns foraging over a school of baitfish. Roseate Terns are threatened globally by coastal development and diminishing food resources.

breeding failure of all those seabirds that foraged to the west of the Houtman Abrolhos. Apart from the two noddies and the Sooty Tern, this included Roseate Terns and Wedge-tailed Shearwaters. Interestingly, Crested Terns (*Sterna bergii*), Caspian Terns (*S. caspia*) and Pied Cormorants (*Phalacrocorax varius*), all of which feed either over the shallow reefs within the lagoons or towards the mainland, remained unaffected. Much of the breeding failure was attributed to a low supply of Beaked Salmon, and while Lesser Noddies also suffered heavy losses, their reproductive output was buffered by their ability to find and consume goatfish.

HOW CAN SEABIRDS help us? The response of seabirds to El Niño-related changes in the Leeuwin Current (lower sea levels and cooler temperatures) gives us an insight into the effects of short-term changes in sea level and sea temperature on fish stocks. With the ever-increasing threat from global warming, monitoring seabird behaviour may provide a natural indicator of changes in the marine environment. More importantly, although knowledge of seabird behaviour cannot save us from changes in ocean climate, it can help prevent us from overexploiting fish stocks to a point of no return. During the early 1970s, millions of Peruvian seabirds died after a dramatic El Niño event. The overexploitation of their favoured, cold-water-loving Anchoveta prey by local fishermen had already pushed the seabird population to the limit. With the onset of a warm-water intrusion associated with the El Niño, the Anchoveta were unable to breed, resulting in the collapse of the fishery and massive seabird mortality. Nearly 25 years later, those seabirds and the Anchoveta fishery have still not recovered to their former levels. Had fishing quotas been set at more realistic levels to account for seabird consumption and anomalous oceanographic events, the fishing industry and the massive seabird populations might still exist in their former state.

Dramatic fishery-related declines in seabirds are not uncommon. However, they do provide us with a valuable lesson, and one that we should heed. Monitoring the marine environment through seabirds provides not only a good and real-time indicator of the health of the marine environment and fish stocks, but also helps to conserve seabirds. Sounds like a win-win situation for all!

STEVEN DAVID MILLER/AUSCAPE

Crested Terns feed on adult pilchards and anchovies (such as this one) close to the Houtman Abrolhos, returning with a single item after each journey.

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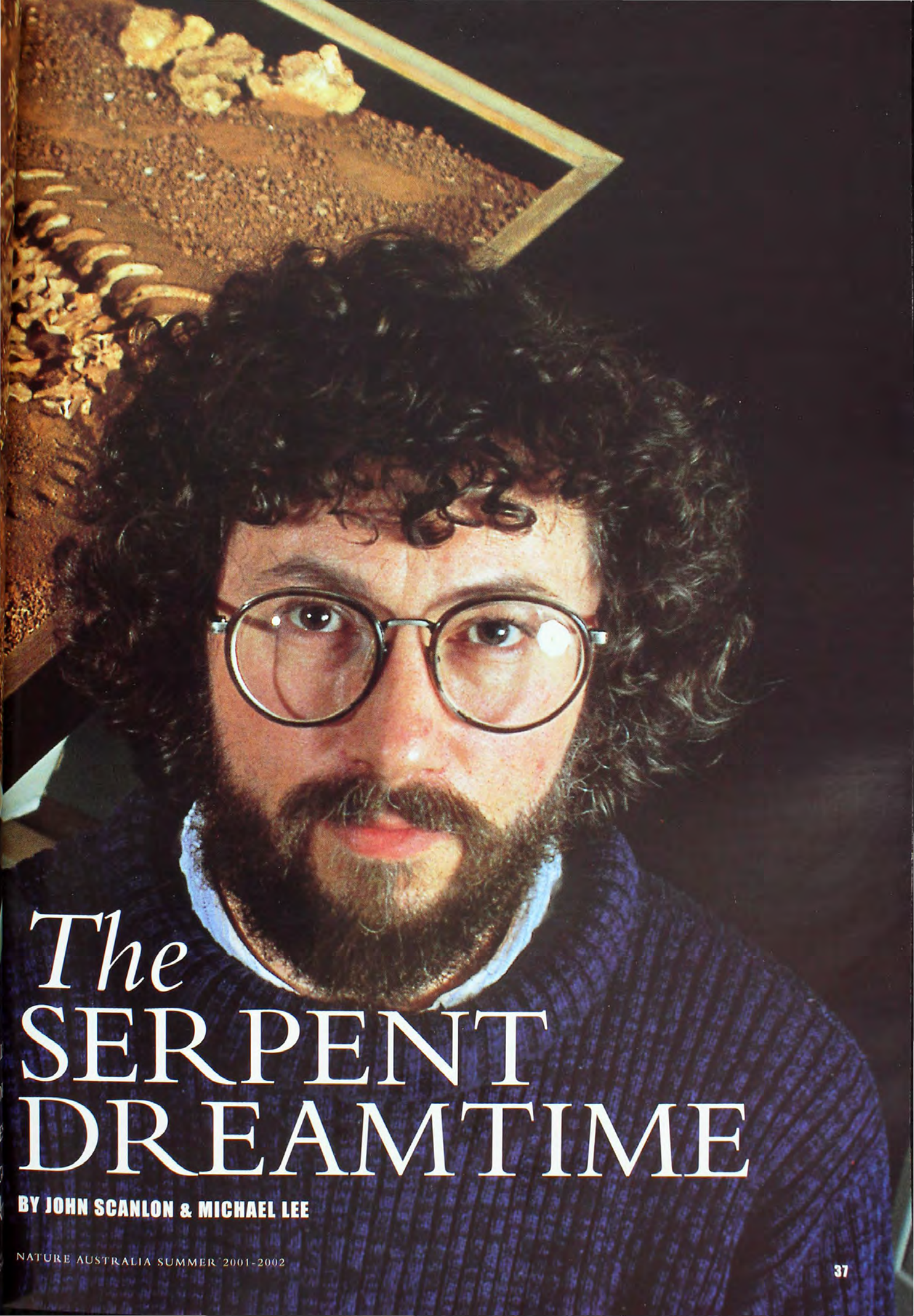
John Scanlon with the most complete skeleton of *Wonambi* donated to the South Australian Museum by its collectors John and Julie Barrie.

TREVOR PEARCE, SOUTH AUSTRALIAN MUSEUM

AUSTRALIA IS NOTORIOUS FOR ITS VENOMOUS SNAKES, BUT 20 MILLION YEARS AGO THINGS WERE VERY DIFFERENT.



The SERPENT DREAMTIME

BY JOHN SCANLON & MICHAEL LEE

AUSTRALIA IS NOTORIOUS for its venomous snakes, being home today to scores of species including nine of the 'top ten' deadliest in the world. But 20 million years ago, in the early Miocene Epoch, things were very different. Venomous snakes had only just arrived here after island-hopping from Asia, and only a few rare, small species had evolved from the first colonisers. There were also non-venomous, constricting pythons, similar to our living carpet snakes, and worm-like, burrowing 'blind snakes', which are also still with us. However, most of the snakes in Australia at that time were completely different and are now totally extinct, being known only from tantalising fossil remains.

The first clues to the existence of these archaic snakes came from the fossil beds at Naracoorte Caves in South Australia. From about 500,000 to 200,000 years ago, during the Pleistocene, the ceilings of these underground caves were intermittently open to the world above. These sinkholes formed diabolical pitfall traps into which unsuspecting animals would plummet. Large mammals such as marsupial lions would be unlikely to survive the drop, but snakes, lizards and various small mammals may have spent their last days at the bottom of the shaft, feeding on each other or scavenging the flesh of other victims.

STEVEN DAVID MILLER/AUSCAPE

Pleistocene mega-predators in conflict: skeletal reconstruction of *Wonambi* and *Thylacoleo*, based on skeletons from the Naracoorte caves.

While examining fragmentary bony remains from one of the Naracoorte caves (Victoria Fossil Cave), Meredith Smith at the University of Adelaide identified some isolated vertebrae from a very large snake, possibly around five metres long. In 1976 she christened it *Wonambi naracoortensis*, borrowing the genus name from the Pitjantjatjara peo-

BRIAN CHOO

Southern Australia, about 100,000 years ago. A Giant Tasmanian Devil (*Sarcophilus laniarius*) has returned from a night on the prowl only to find *Wonambi* blocking the entrance to its lair.

ple of central Australia, who used the name for giant serpents believed to inhabit sacred local water holes and rock hollows (see box). This was the first species of extinct snake from Australia to be described. Smith noticed that the vertebrae were very similar to those of much older, and even larger, extinct snakes called madtsoiids, which had been described from equally fragmentary remains in South America and Africa.

Since then, additional (but still fragmentary) remains of madtsoiid snakes have been found elsewhere around Australia, most notably at Riversleigh in north-western Queensland. The freshwater limestone deposits there preserve skeletal remains of a huge diversity of late-Oligocene to mid-Miocene animals (roughly 25 to 15 million years old). They inhabited a complex landscape of lakes and pools shaded by rainforest, out of which emerged cave-riddled, rocky hills. Rather than thick, continuous layers of fossil-rich sediment, the treasures of Riversleigh are usually concentrated in patches only a few metres across, resulting from local transient accumulations of bones in small pools, fissures and caves. Searching for new sites, and quarrying them for vertebrate fossils, is a strenuous but frequently thrilling experience. It's quite rare to see snake fossils in the field, especially small ones, which are

usually only later revealed in the lab by sieving sediment or dissolving the rocks in acetic acid. However, in some places at Riversleigh, where the limestone rock has eroded under slightly acidic rain, snake vertebrae several centimetres across project from the weathered surface of boulders. Most impressive are the occasional, partly articulated skeletons, in one case a large python entwined with a medium-sized crocodile.

Many madtsoiids inhabited the Riversleigh landscape. Among these were a smaller version of the South Australian *Wonambi* (*W. barriei*, only about three metres long and possibly arboreal) and two terrestrial 'dwarf' species (*Nanowana*) less than a metre long, whose jaws and teeth suggest they specialised in feeding on hard-scaled lizards such as skinks. Also present was the giant *Yurlunggur* (a species similar to *Y. camfieldensis* from Bullock Creek in the Northern Territory), which may have been semi-aquatic like the South American Anaconda (*Eunectes murinus*).

THE SNAKES WERE *huge, as long as a station wagon and as thick as a telegraph pole—more massive than any python in Australia today.*

Madtsoiids are more abundant and diverse in the Miocene of Riversleigh than at any other place or time in the world. In most of the other sites, the madtsoiids are a very minor component of the fauna, represented by only a few bones.

Both Naracoorte and Riversleigh provide exceptional windows into prehistoric Australia, and have been granted World Heritage status. While most of the palaeontological attention at these sites has centred on the mammals, which are stupendously diverse, the reptile discoveries are also important. However, until recently, the material consisted almost entirely of isolated vertebrae and ribs. Consequently, the true nature of madtsoiids, and their relationships to other snakes, remained almost totally obscure. Then, John Barrie and his family from Adelaide found and excavated a pair of partial skeletons of *Wonambi* from Henschke's Quarry Cave at Naracoorte. When all the parts were painstakingly

ANNA GILLESPIE

BRIAN CHOO

A nine-metre-long subadult mosasaur (*Moanasaurus mangahouangae*) in full underwater flight.

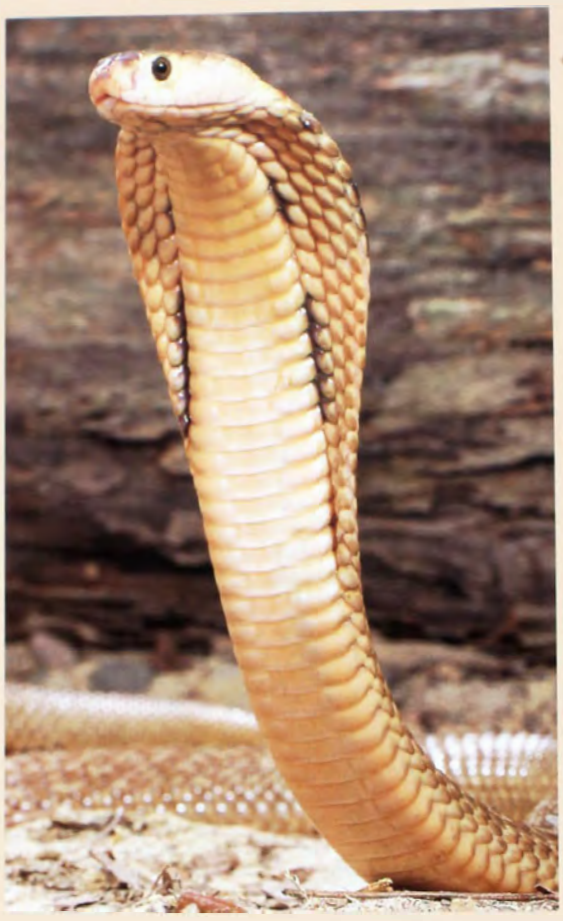
sorted out and assembled, the reconstruction revealed that the snakes were huge, as long as a station wagon and as thick as a telegraph pole—more massive (although possibly not longer) than any python in Australia today. *Wonambi* had a wide, flat skull and huge distensible jaws with long recurved teeth, allowing it to engulf wallaby-size marsupials and other animals that shared its habitat.

THE RECENT DISCOVERIES of madtsoiid snakes in Australia have proved intriguing on two counts. Previously madtsoiids had only been found in South America, Africa and Madagascar, so the geographic range extension into Australasia showed them to have occupied nearly all of the southern lands formerly joined as the supercontinent Gondwana (they have also now been found in south-western Europe). But while madtsoiids went extinct on all the other continents around 55 million years ago, only ten million years after the dinosaurs, in Australia they remained successful and diverse for at least another 40 million years. They began to decline only during the mid-Miocene, 15 million years ago, and by the early Pliocene, about five million years ago, most of them were gone, their ecological places taken up by an increasing diversity of pythons and venomous snakes, both invaders from the north. Only two giant species were left: *Wonambi* in the south, and *Yurlunggur* in the north-east of the continent. Both

This split limestone block, photographed in the field at Riversleigh, exposes a rare series of articulated vertebrae of the large Miocene madtsoiid *Yurlunggur*. Dissolving the rock with acetic acid will reveal more of the skeleton, possibly even the skull.

Rainbow Serpents

In Aboriginal traditions throughout northern Australia and in much of the southern inland, giant rainbow-coloured serpents with long hair or plumes, beards and sometimes legs (up to six of them!) guard sacred pools, control storms and floods, and teach and enforce the sacred law, punishing transgressors by swallowing them and sometimes their whole tribes. Rainbow Serpents were among the most important creator spirits during the Dreamtime, when all the people, animals and features of the landscape came into being. Some clans (especially in Arnhem Land) claim these mythical serpents as ancestors, supreme creators or the mother of the whole world, while others accept them as being just part of the landscape, one of the more powerful and exotic species of wildlife with which they share their country.



JOE MCDONALD/AUSCAPE

A Chinese Spitting cobra (*Naja atra*) in threatening posture. The expanded hood of cobras could be the source of the winged serpent legends.

Rainbow Serpents are common in rock art, occasionally depicted in great detail but more often as stylised, almost abstract images. Recent studies by Paul Taçon (Australian Museum) and colleagues have supported the idea that some of them are based on a small marine fish related to seahorses (the Ribboned Pipefish, *Haliichthys taeniophorus*), while rock-art enthusiast Percy Trezise suggests that Rainbow Serpents are representations of comets. Whatever the complicated history of the pictorial traditions, it is clear that Aboriginal art and legend distinguish between Rainbow Serpents and other kinds of snakes living today that are associated with water, such as pythons and file snakes. This suggests a possible historical association of Rainbow Serpent myths with recently extinct, and perhaps rather odd-looking, giant snakes in Australia, and has led to the idea that the Wonambi (giant mythic serpent) of the Pitjantjatjara people might also be the *Wonambi* of Australian palaeontologists.

However, similar giant, bearded or plumed serpents occur in mythological traditions all over the world, from the dragons of China and Europe, to Quetzalcouatl in Mexico. They presumably can't all be based on Pleistocene madtsoiids, because these existed only in Australia. Either there were many separate origins of similar myths in different parts of the world, or they can be traced back to a smaller number of origins early in human history.

Perhaps the simplest way to account for these similar stories—the most parsimonious hypothesis, as scientists like to say—is to suggest that they arose only once very long ago in human history and have been handed down with slight modifications across various cultures. Thus the 'wings' and 'beards' of these mythical serpents, as well as their lethal power, might reflect features of a real animal with an ancient association with humans. *Homo sapiens* and its ancestors evolved in Africa and South-East Asia in the presence of cobras and large constricting snakes for millions of years, so these snakes presumably always had a place in human culture and mythology. While both types of snakes have been implicated in the serpent myths discussed above, cobras are the more likely source. Throughout their distribution cobras are feared for their highly potent venom and large size (up to nearly six metres in the King Cobra, *Ophiophagus hannah*), but often also venerated, playing a central role in Hindu and some African creation myths. Their unusual and disconcerting habit of 'standing' upright and looking a person in the eye (and in some species, spitting venom into the face as well) certainly adds to their 'magical' aura. The 'hood' that they spread in this threat display (produced when long mobile ribs stretch the skin of the neck into a disc) might reasonably be described as 'wings' or 'a beard', and is often made more conspicuous by a banded or eye-like pattern. Thus, the serpent myths of humans might have originated very early in the history of our species, inspired by the cobras our ancestors coexisted with. When people spread out into Europe, northern Asia, the Americas and Australasia—areas that lack cobras—the memory of these winged, bearded, lethal snakes may have lingered on as the Rainbow Serpent and similar myths.

JOHN SCANLON

The brain case of *Wonambi naracoortensis* reveals details of the cranial nerves, blood vessels and ear canals, which have been compared with those of other snakes, modern lizards and mosasaurs.

lived within the last half-million years, with *Wonambi* surviving to within the last 100,000. Although the dates of their final extinctions are not yet known, it is possible that one or both of these massive serpents was still living when the first humans arrived in Australia, perhaps 60,000 years ago.

The discovery of *Wonambi*, *Yurlunggur* and the other madtsoiids has not only demonstrated that these giant snakes inhabited Australia and persisted here for much longer than elsewhere, but it has revealed for the first time what madtsoiids were actually like. Although abundant madtsoiid remains had already been found in other continents, nearly all this material consisted of vertebrae and ribs. The sum total of skull remains consisted of a few pitiful jaw fragments. Vertebrae and ribs are rather simple bones, and thus can only provide limited information on a snake's biology and evolutionary relationships. Skulls, and in particular brain cases, are much more complex. The brain case forms an intricate mould of an animal's cerebral lobes and associated nerves, veins and arteries. The complex and detailed anatomy thus revealed by brain cases makes them one of the most useful body parts for unravelling an organism's biology and evolutionary relationships. But, of course, brain cases are rarely found, since each snake has only a single fragile skull but hundreds of durable vertebrae and ribs.

KATHIE ATKINSON

Rainbow Serpent painting, Mt Borradaile area, Northern Territory. Serpent myths in Australia and other continents may derive from human interaction with cobras, but other animals, including living or fossil madtsoiids, could also have contributed to their development in Australia.

BRIAN CHOO

***Pachyrhachis*, a Cretaceous marine snake with tiny hind legs. It was found on the West Bank near Jerusalem, which was then part of a massive reef system.**

Based on ribs and vertebrae, the best guess of most scientists was that madtsoiids were relatives of pythons and boas (they were classified as a subfamily of Boidae). Since pythons inhabit Australia today, this would not be too surprising. The Naracoorte skeleton of *Wonambi*, however, contains fine skull material, including an almost perfect brain case. And this skull, first partly described by John Barrie, proved something of a revelation when studied by us. Contrary to predictions, it was not remotely python-like, or indeed similar to the skull of any living snake. Rather, the skull was exceedingly primitive, being most similar to the skulls of middle to late Cretaceous snakes that lived alongside the dinosaurs (97–74 million years ago). This meant that madtsoiids were not relatives of modern pythons, but were relicts of the earliest phase in snake evolution. Their survival into the Australian Pleistocene represents the serpent equivalent of dinosaurs lingering on to overlap with cave men.

The appropriateness of the name *Wonambi* might therefore be twofold. There is a (slim) chance that this madtsoiid survivor (or even its fresh subfossil bones) contributed to the Rainbow Serpent legends of the Aboriginal Dreamtime (see box). Additionally, the primitive skull of *Wonambi* (and by implication all madtsoiids) indicate they are holdovers from one of the first chapters in snake history. As such, Wonambi has the potential to teach us much about the origin of snakes—the 'dreamtime' of snake evolution.

ALMOST EVERYONE AGREES that snakes are derived from some group of lizards that lost their limbs and elongated their bodies. Indeed in their general anatomy snakes are little more than another lineage of long-bodied, limb-reduced lizards. However, there is little consensus on anything else about snake origins. The lineage of lizards that gave rise to snakes is disputed (see "Burying Burrowing Origin for Snakes", *Nature Aust.* Summer 2000–2001), with the major candidates being tiny burrowing lizards, or extinct marine goannas called mosasaurs—voracious predators that grew to over ten metres long. Another related debate concerns whether snakes lost their legs and evolved their long bodies in a subterranean or marine environment. The current majority view holds that small, burrowing lizards gave rise to snakes, which implies that snakes lost their legs and elongated their bodies to help them slide through burrows and crevices much more easily. An alternative scenario, once popular but currently out of favour, is that the gigantic mosasaurs were the closest cousins of snakes, implying that snakes lost their limbs and elongated their body for eel-like swimming.

Some recent finds of primitive snakes help resolve the argument. One is *Pachyrhachis problematicus*. This was a marine snake that inhabited a huge ancient reef in a shallow sea situated over the present-day Middle East. *Pachyrhachis* had a tiny head and narrow neck, presumably for poking into narrow crevices in search of hiding fish. Its two-metre-long body was flattened from side to side and probably ended in a paddle-like tail, allowing the animal to swim with graceful sinusoidal undulations. Most intriguingly, it retained tiny but largely complete hind limbs, holdovers from its lizard ancestry. Two similar but smaller forms, *Haasiophis terrasanctus* and *Podophis descouensi*, have very recently been discovered in the same area, so this reef

must have been teaming with leggy 'sea snakes'. Anatomically, these snakes appear exactly intermediate between the marine mosasaurs and snakes, thus linking the two groups. However, the skulls of these fossils are all badly flattened, resulting in heated arguments about their true structure and meaning. This makes the uncrushed, fully three-dimensional skull remains of *Wonambi* particularly important.

If madtsoiids are very primitive snakes, as their brain cases demonstrate, they too should tell us something about snake origins. *Wonambi* is clearly too large to have been a burrower, but was also not marine, its remains being found in deposits formed by terrestrial caves and freshwater pools. As it neither burrowed nor swam in the sea, it does not help arbitrate over the ecology of snake origins—whether they evolved under ground or under water. However, in terms of the debate over which lizards were ancestral to snakes, *Wonambi* is particularly instructive. *Wonambi*'s skull exhibits none of the features of those of burrowing lizards, which are short, reinforced and highly rigid, thus refuting the idea that snakes have affinities with such lizards. In contrast, *Wonambi* has long, highly flexible jaws like mosasaurs, and so provides additional evidence in favour of the once-heterodox idea that snakes are cousins of these giant sea-going goannas. Even if *Wonambi* is not the Rainbow Serpent of the Aboriginal Dreamtime, it certainly sheds light on the dreamtime of snakes.

The meticulously prepared, but unfortunately badly crushed, skull and neck of the first specimen of *Pachyrhachis*.

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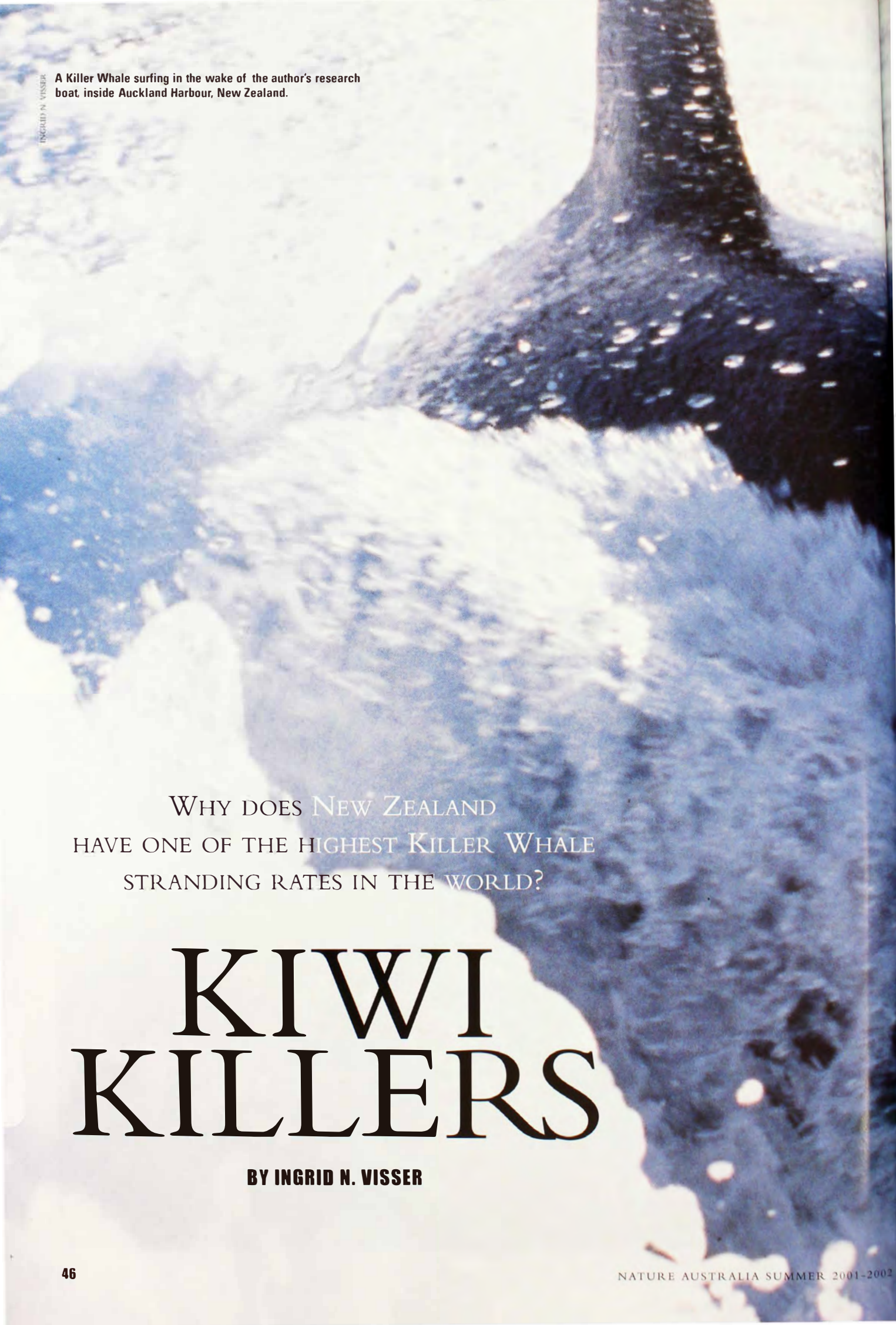


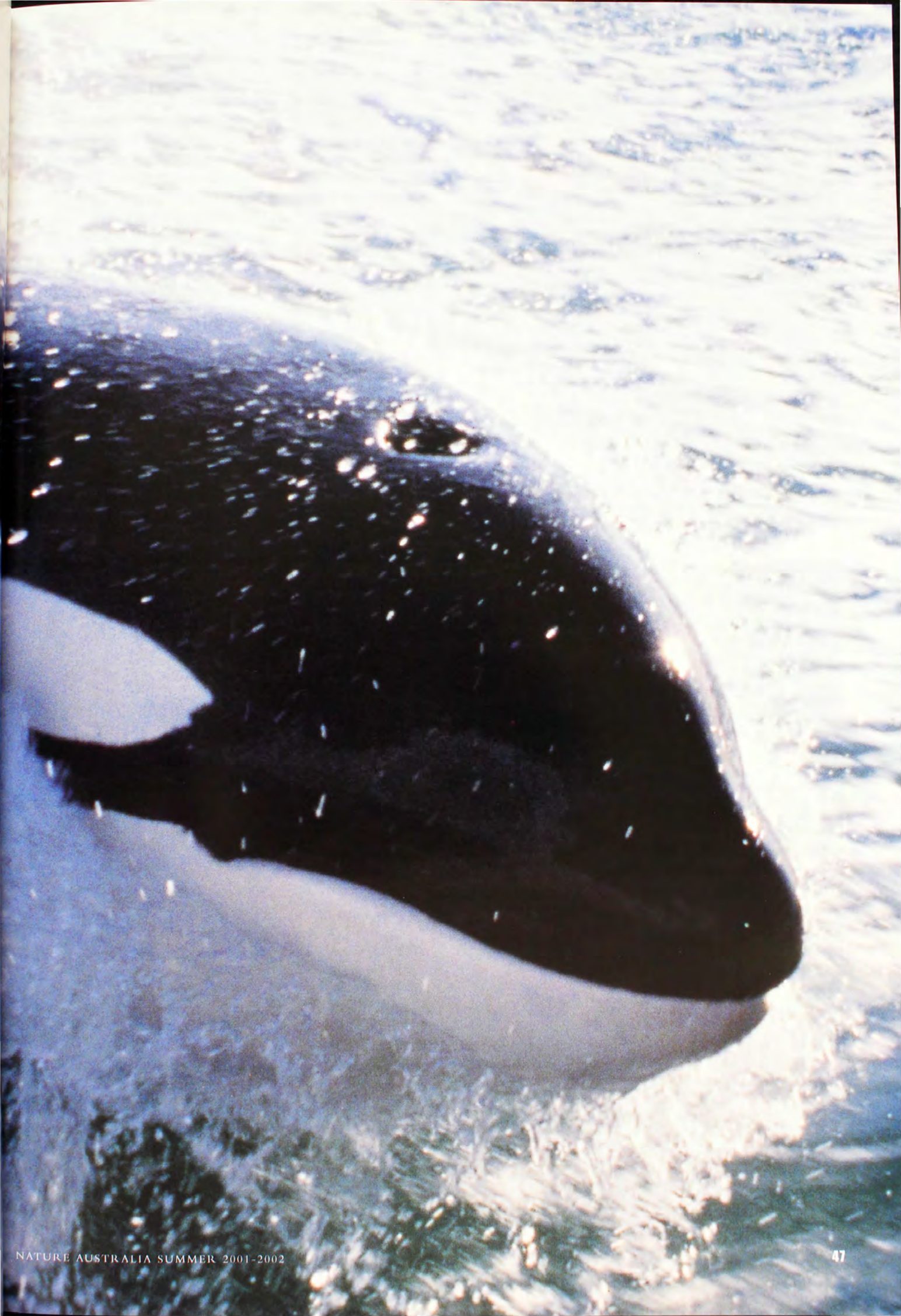
A Killer Whale surfing in the wake of the author's research boat, inside Auckland Harbour, New Zealand.

INGRID N. VISSER

WHY DOES NEW ZEALAND HAVE ONE OF THE HIGHEST KILLER WHALE STRANDING RATES IN THE WORLD?

KIWI KILLERS

BY INGRID N. VISSER



With a fearsome reputation as top predators, Killer Whales (*Orcinus orca*) have long struck fear into the hearts of humans. But for me, Killer Whales only produce excitement. I have always been fascinated by these animals and dreamed of working with them, right from when I was a child. Even after studying them for eight years, I still get a thrill every time I see one. On my way to an encounter, I wonder if I will meet up with animals that I know, or that I haven't come across before.

How could I even begin to tell these animals apart, you might ask? The concept is quite simple—just like us, every Killer Whale looks different, and can be recognised by distinct features. By taking photographs of each animal I come across, I now have a collection of 117 'mug shots' of Killer Whales I've sighted around the New Zealand coastline. Among the features that I use to distinguish them are their pigmentation patterns. For example, the shape of the white patch found just behind the eye (the eye patch) is as individual as a human fingerprint. In addition, during the course of the animals' lives, they acquire marks such as cuts, scratches and injuries, all of which help with identification.

Being able to recognise individuals is the key to my study. For instance, I can work out how far a Killer Whale has travelled if I have photographs of the same animal in different places, over a known time frame. I have found that New Zealand Killer Whales travel farther than other populations of Killer Whales around the world (approximately 170 kilometres per day, as compared with 35 kilometres for Alaskan Killer Whales, and 60 kilometres for those from Argentina). Most of this travel occurs up and down the New Zealand coast, although Killer Whales have also been reported well offshore. (These animals, however, have not been photographically identified, and may belong to another population.) The Killer Whales found around the New Zealand coastline have only ever been photographed here, suggesting that they live permanently in the area. However, just because they haven't been photographed elsewhere doesn't mean they don't ever travel outside New Zealand waters. Therefore, photographs from the public* and other whale researchers around the South Pacific are checked to

** If you ever come across Killer Whales in the wild, please take photographs, along with location details and date, and send them to me so that I can include them in my database. Thankyou. (Author details at end.)*

INGRID N. VISSER

search for a match. Photographs over time can also tell me the minimum ages of individuals. One female that continues to turn up around New Zealand was first photographed, as an adult, in Auckland Harbour on the North Island in 1977. Given that females take about 15 years to reach physical maturity, this makes her at least 38 years old!

However, for me, the most exciting thing I gain from recognising the animals is how each one has a personality. This isn't as far-fetched as it might seem—ask any Dog or Cat owner and they will tell you how their pet has its own likes and dislikes, its own 'personality'. I have christened many of the Killer Whales I see regularly on the basis of their personalities. For example, one of my favourites is Digit, named after a wild Gorilla that would reach out and touch the researcher, Dian Fossey (of "Gorillas in the Mist" fame).

STEVE WHITEHOUSE

Digit the Killer Whale is very trusting and will swim up to my boat and touch my outstretched hand. I don't feed her; she does this without any rewards. I am not really sure why Digit should display this type of behaviour, but another Killer Whale has begun to show an interest in humans, and a little more is known about her history.

Called Miracle, she got her name in a roundabout way. In 1993 she stranded on a beach in northern New Zealand. I couldn't attend the stranding and only

(Left) Spike (catalogue number NZ7), breaches inside Auckland Harbour after crossing a shallow sand bar. Spike, an adult male, got his name from his large 'spike-like' dorsal fin (not visible). Note the large pectoral (side) fins typical of adult male Killer Whales.

(Above) The author with Digit (NZ50), a wild, friendly female that often swims right up to the research boat.

Killer Whale

Orcinus orca

Classification

Order Cetacea (whales, dolphins and porpoises), suborder Odontoceti (toothed whales), family Delphinidae (dolphins). Also known as Fat Chopper, Demon Dolphin and (preferred by New Zealanders) Orca.

Identification

Largest of the dolphin family. Distinctive black and white colouration. Grey area behind the dorsal fin (saddle patch), white area behind eye (eye patch) and on underside of body and tail. Adults sexually dimorphic. Males larger (up to 9.8 m), females 8.5 m. Dorsal fin of males tall (up to 1.8 m) and triangular; female dorsal find shorter (up to 0.9 m) and slightly curved.

Distribution

All oceans of the world, from polar to tropical regions, although each population so far investigated is genetically and behaviourally distinct and may reside in 'home' areas. Although sighted around Aust. coastline, to date no population estimates available.

Habitat

Coastal and offshore waters. Coastal animals typically found in 'open-water' areas or near areas high in prey, such as seal haulouts. Occasionally reported in fresh water. In NZ waters, Killer Whales often found in shallow inner-harbour areas.

Reproduction

Males mature at about 20 years old, max. life span 60 years old. Females mature at about 15 years old, max. life span 90 years old. Birth interval 2–14 years (average 5 years). Gestation 468–539 days. Killer Whales and pilot whales are the only non-human animals identified as having post-reproductive females survive and still remain in the social group.

Status

Listed by IUCN as 'Lower Risk, Conservation Dependent', with 2 Canadian populations now reclassified as 'Threatened' and 'Vulnerable'.

INGRID N. VISSER

two photographs were taken. However, in one, a black dot (a sort of a beauty spot!) can be seen on her eye patch. She was rescued and put back into the water. Three years later I photographed a Killer Whale with a black dot in the eye patch and matched this photograph to the one from the stranding. It was a miracle that the photographs from her stranding showed the mark, it was a miracle that she had been rescued, and it was a miracle that I had photographed her and matched these photographs, hence her name. Miracle is a friendly Killer Whale that seems to take delight in coming over to boats and checking people out. Although she is yet to actually touch me, she is getting bolder in her encounters with humans. She has seen Digit interact with me, so perhaps she has learnt from her; or perhaps, after her stranding, she has no fear of humans, just an interest.

One Killer Whale I have seen many times is called Rocky. He isn't named after a Sylvester Stallone movie; rather his name comes from the way he hunts in amongst the rocks. At times he hunts between rocks, in water so shallow that I am unable to follow in my boat. Rocky is one of the Killer Whales in New Zealand that have developed a special way of feeding. I call it 'benthic foraging'—feeding on the bottom of the sea—and it has not been reported in any other Killer Whale population. New Zealand Killer Whales dig into the sandy and muddy bottom with their rostrum (a whale snout or beak), in search of rays. Although digging in the bottom has been reported for other species of cetaceans, such as Bowhead Whales (*Balaena mysticetus*), Gray Whales (*Eschrichtius robustus*) and Bottlenose Dolphins (*Tursiops truncatus*; see "As the Tide Turns", *Nature Aust.* Autumn 1993), it has not been reported for Killer Whales, which typically hunt in open water or in the water column. I have seen them take four different species including both stingrays and electric rays. And not only do they dig for them, but they chase them up onto beaches and flip them through the air like frisbees (see "Kiwi Killers Play

Rocky (NZ6), an adult male, in shallow water. Rocky earned his name from his habit of foraging in shallow water, typically in amongst rocks.

TERRY HARDIE

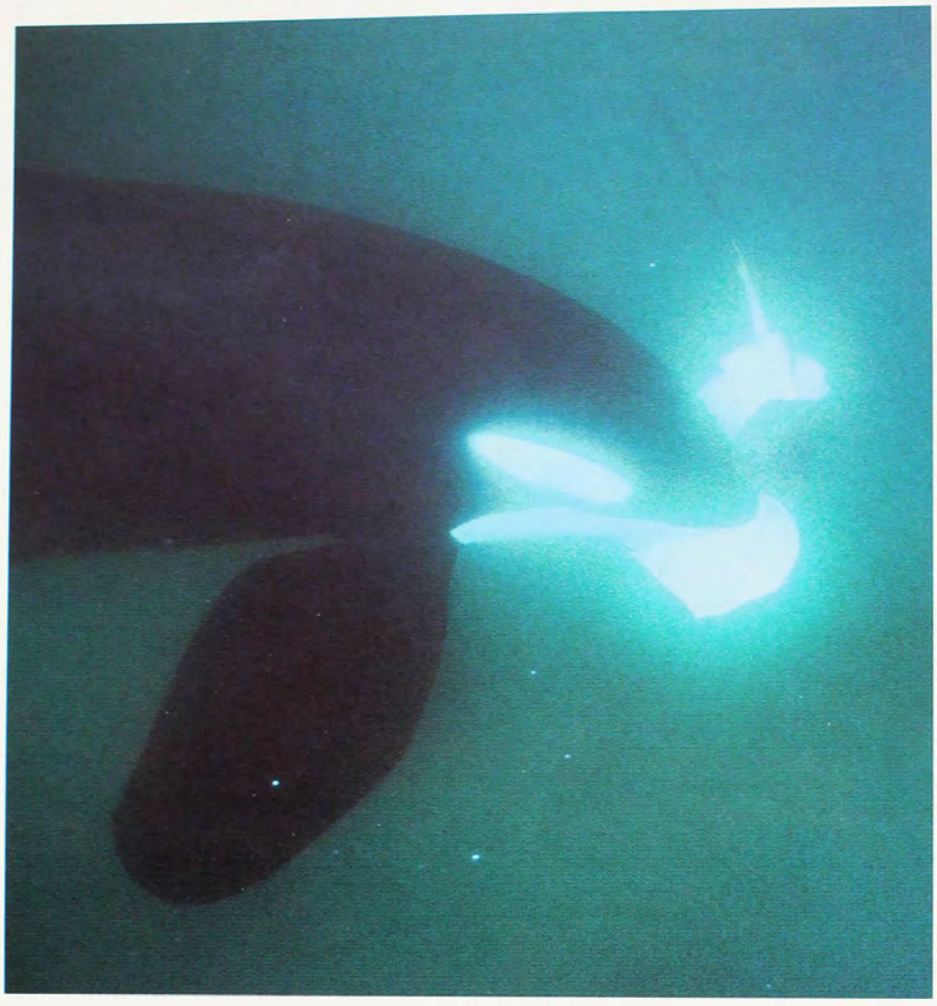
Ben (NZ101) in rescue pontoons, during his return to the sea after his overnight sojourn on the beach. The pontoon system is in ankle-deep water, but this is sufficient to allow him to float. Upon entering the water, Ben attempted to move himself by thrashing his tail.

Frisbee", *Nature Aust.* Spring 1999). I have a theory about this 'flipping', as I have also seen them flip rays under water. It is possible that flipping the rays allows the Killer Whales to immobilise them, deactivating their defence systems (stings or shocks). Research has shown that, if you quickly flip a shark or ray onto its back, it will remain motionless. When the ray or shark drifts back upright, it can swim off or defend itself, but while it remains upside down it is defenceless. One New Zealand Killer Whale, found dead, had stingray barbs embedded in its spine and in the muscles of its neck, showing that rays can indeed be a dangerous source of food.

STINGS MAY NOT BE the only danger associated with hunting rays. New Zealand has one of the highest Killer Whale stranding rates in the world. Over 70 Killer Whales have stranded since 1860, and in recent years there has been an average of one stranding every two years. Australia, by contrast, has only had 12 Killer Whales strand since records began in 1924. Although Killer Whales are sighted around the entire New Zealand coast, there is a pattern to the strandings. All live strandings have so far occurred on shallow sandy beaches, or on sand bars into harbours, suggesting that the Killer Whales are in these areas for a reason...perhaps it is rays. I have seen Killer Whales get stuck on sand bars while chasing rays and, although they managed to free themselves, they are possibly not always successful and may end up being stranded.

Although it has been suggested that number of strandings may be linked to population density, whale and dolphin researchers have so far not found any support for this. I wondered whether the high incidence of strandings might by linked to the relatively long length of the New Zealand coastline, but again could find no correlation. For example Norway, which also has an extensive coastline and yet double the Killer Whale population of New Zealand, has only had one stranding (of 14 animals) reported. Could New Zealand's high number of strandings be an artefact of the relatively well-populated coastline of New Zealand (compared with, say, Australia's vast unoccupied coastal areas) and the fact that New Zealand has one of the most comprehensive networks for the notification of marine mammal strandings? Are there simply more opportunities for the New Zealand public to report strandings when they happen? Possibly, but I think it is more than this. I investigated the aspect of dead versus live strandings of New Zealand Killer Whales and found that dead animals washed up on all coast types (sandy beaches and rocky coasts) but live strandings only occurred on sandy beaches. This lends support to the idea of live Killer Whale strandings in New Zealand being an occupational hazard in pursuit of their unusual bottom-dwelling prey.

New Zealand has a high success rate of refloating and rescuing stranded Killer Whales. One example was a young male, called Ben. He spent an entire night on the beach, and the next day was put back in the water by a dedicated team of volunteers. He reunited with his group (which had been in a nearby harbour all night, feeding on rays). Since stranding, Ben has been the victim of another threat to whales and dolphins around the world—boat strike. Sixteen months after his dramatic rescue, Ben was hit by a boat and struck at



INGRID N. VISSER

Rocky (NZ6) with a stingray. The ray is positioned upside down in what may be induced 'tonic immobility' to reduce the risk of being stung.

least three times on his back by the spinning propeller. He was cut so badly that I didn't expect him to live. Fortunately he did survive, but his dorsal fin is permanently split and the posterior portion has collapsed.

Another threat to a top marine predator such as the Killer Whale is pollution. This comes in many forms and includes fishing line, which can cut off the tops of fins (one New Zealand Killer Whale has the whole top of her dorsal fin missing), and plastic bags (dead dolphins have been found with plastic bags in their airways, or in their stomachs, which they may have consumed thinking they were jellyfish, or just out of curiosity; the same could apply to Killer Whales, which are known to eat jellyfish). However, there are also the more hidden, but no less threatening, pollutants from chemicals and heavy metals that are a direct result of our industrialised world. These enter the water via the air, run-off from cities and farms, and direct pumping into the

INGRID N. VISSER

Ben (NZ101), a subadult male, after being hit by a presumed boat strike, only a day or so after the hit. This boat strike occurred about a year after he stranded and was rescued. He survived and in fact has been repeatedly seen over a number of years since the boat strike and the stranding. The rear portion of his fin has subsequently collapsed.

oceans from factories and effluent plants. Once there, the contaminants 'bioaccumulate'—that is, build up in an animal, mostly through their food. In a Canadian study, researchers found that Killer Whales have the highest levels of contaminants ever recorded. One scientist even proposed that when these animals die their carcasses should be disposed of as if they were nuclear waste! At this stage, we just aren't sure how heavily loaded the New Zealand Killer Whales are, and looking at this will be part of my ongoing research.

Bioaccumulation occurs primarily because the Killer Whales are at the top of their food web. They eat animals that eat other animals that eat other animals. For instance, the New Zealand Killer Whales eat rays, which in turn eat molluscs—animals known to filter-feed and collect all manner of detritus and small animals such as zooplankton. But New Zealand Killer Whales don't only eat rays. I have also seen them take sharks, even dining out on the formidable Shortfin Mako (*Isurus oxyrinchus*), and other cetaceans such as Bottlenose Dolphins and Common Dolphins (*Delphinus delphis*). These prey types are also top marine predators, so it doesn't take much imagination to realise that contaminant accumulation will increase the higher up the food chain you go.

All these issues show how continued research may not only benefit the Killer Whales from New Zealand, and elsewhere, but may also provide vital information on the ocean habitats of New Zealand and the rest of the world. There is still a lot to be learnt about these animals and the ways in which we need to protect them and their environment. In the meantime, small lifestyle changes for humans (such as using biodegradable products and picking up plastic bags at the beach) may result in a huge global benefit for the environment, ensuring that our future generations have the opportunity to experience the wonder and joy that I have had in the presence of wild Killer Whales.

A juvenile Killer Whale delicately takes a School Shark off a longline, Northland, New Zealand.

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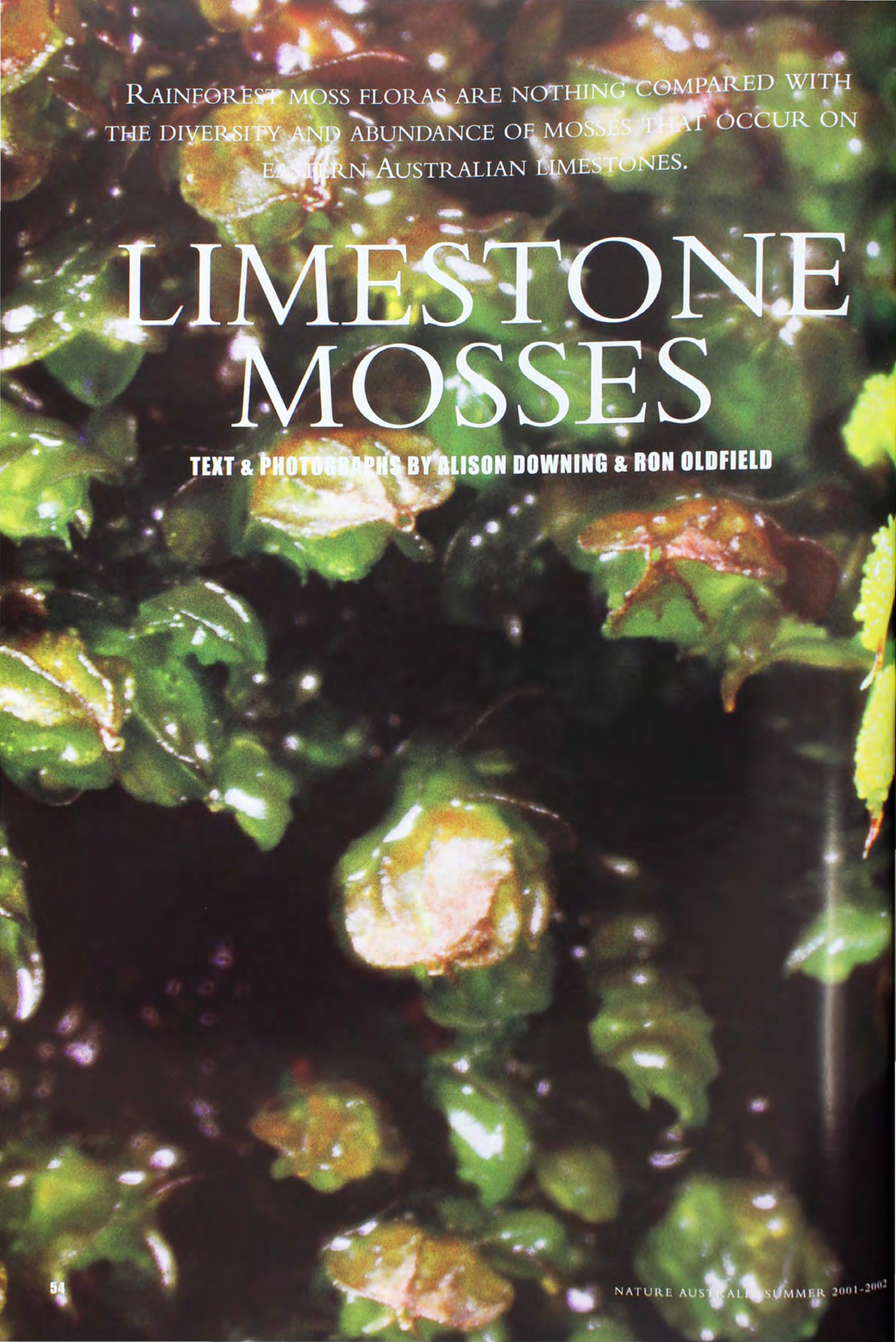
DR INGRID N. VISSER COMPLETED HER PH.D. AFTER WORKING WITH NEW ZEALAND KILLER WHALES FOR EIGHT YEARS. HER RESEARCH PROJECT IS ONGOING. SHE IS A TRUSTEE FOR ADOPT AN ORCA, PO BOX 1233, WHANGAREI, NEW ZEALAND, WHICH SUPPORTS KILLER WHALE RESEARCH THROUGH ADOPTIONS AND DONATIONS.

PHOTO COURTESY INGRID N. VISSER



RAINFOREST MOSS FLORAS ARE NOTHING COMPARED WITH THE DIVERSITY AND ABUNDANCE OF MOSSES THAT OCCUR ON EASTERN AUSTRALIAN LIMESTONES.

LIMESTONE MOSSES

TEXT & PHOTOGRAPHS BY ALISON DOWNING & RON OLDFIELD

Golden spheres on the leaf tips of the moss *Tortula papillosa*, if dislodged, have the potential to grow into a new plant on limestones and sometimes on the bark of trees.

MENTION THE WORD limestone and images come to mind of sculptured, underground caverns with narrow, twisting passages and trickling streams. The slightly acidic water slowly dissolves the calcium carbonate that is the major part of limestone, and redeposits it in the form of those awe-inspiring speleothems (stalagmites, stalactites etc.) by which we recognise a limestone cave.

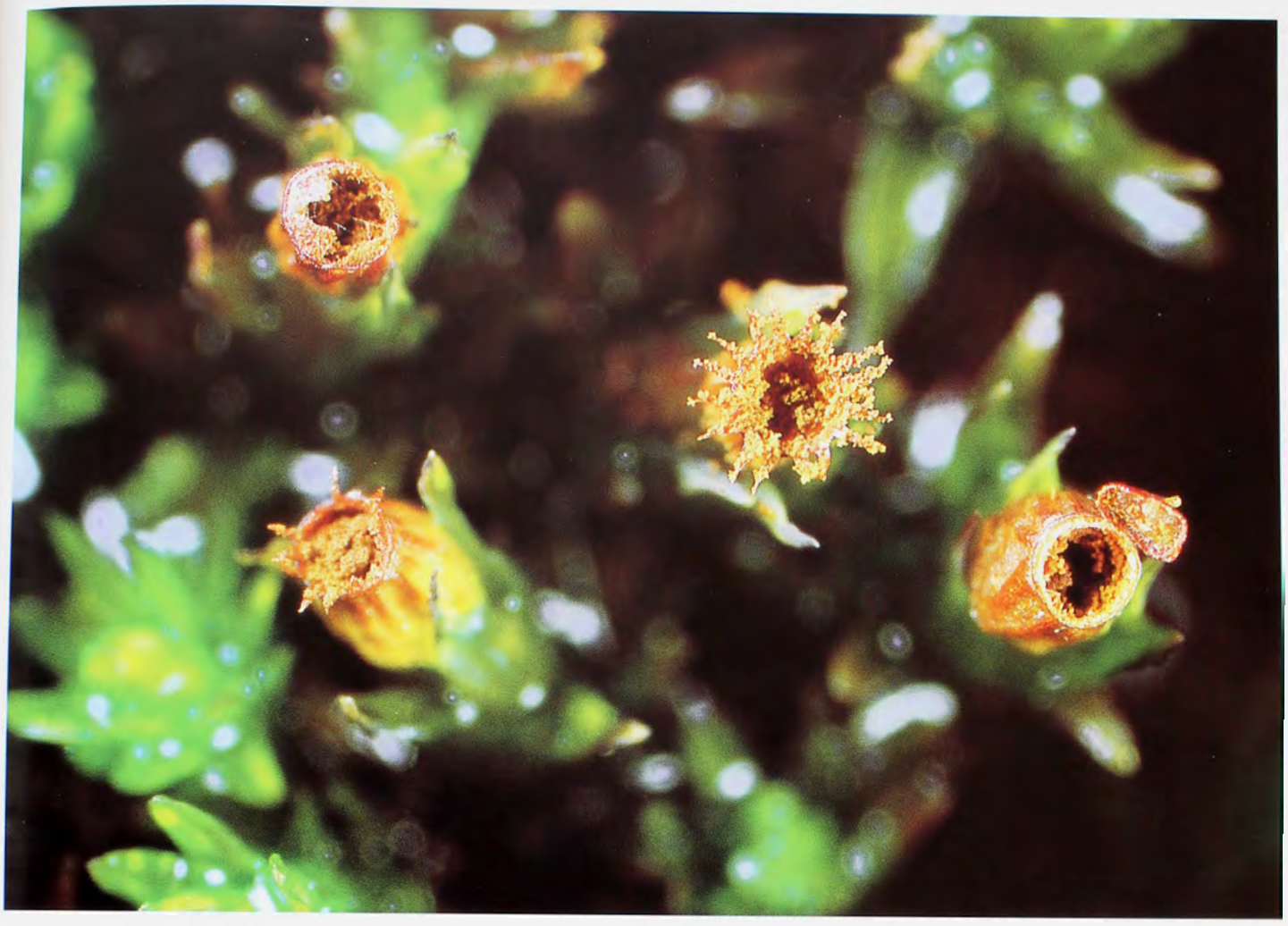
The characteristic land-surface features and underground drainage of limestones is described as a karst landscape, named after the Karst region of north-western Yugoslavia. Karst typically includes caves, dry river beds, underground streams, sink holes and a vast array of sculpturing and fluting in surface-rock formations. In eastern Australia, limestone karst occurs as small, isolated outcrops, mostly along the Great Dividing Range. Many of these cave systems, such as Buchan in Victoria, Mole Creek and Hastings in Tasmania, and Jenolan, Wellington, Wombeyan, Yarrangobilly and Coolemon in New South Wales, have attracted tourists since the 1800s.

But karst landscapes are special not just because of their interesting geological features. In the northern hemisphere, the vegetation on limestone substrates is unique, and very different from that of other rock types such as sandstones, shales and granites. Plants that grow exclusively on limestone are known as calciphiles ('lovers of calcium'), while calcifuges are plants that never grow on limestone. On the small, isolated areas of karst in eastern Australia, the differences between the vegetation of limestones and of non-limestones are not as obvious. However, there are some distinguishing features. Most notably, eucalypts do not grow as readily on limestone substrates, and in geological surveys, limestone can often be identified by the presence of open grasslands. For this reason, limestones were often some of the earliest areas to be settled by Europeans, because the open pastures provided fodder for Sheep and Cattle without the need for extensive tree clearing. Some unusual Australian trees and shrubs are often associated with limestones. The list includes the Kurrajong (*Brachychiton populneus*), cypress pines (*Callitris* spp.) and the Port Jackson Fig (*Ficus rubiginosa*). The terrestrial fern *Asplenium trichomanes* is one of those species that usually only grows on limestone. But in higher rainfall areas, there are minimal differences between vegetation on limestones and vegetation on other nearby rock substrates, because high rainfall and humidity appear to reduce the toxic effect of calcium carbonate on calcifuges.

Mosses and liverworts are extraordinarily diverse on limestone substrates. To put this into some sort of perspective, many botanists speak disparagingly of *Eucalyptus* forests and woodlands of eastern Australia, referring to them as 'deserts for mosses'. Sheltered gullies and basalt outcrops in rainforest provide much richer moss floras, but still these are nothing compared with the diversity, abundance and unusual combination of mosses that occur on eastern Australian limestones.

MOSSES, LIVERWORTS and hornworts are probably the least well known of all plant groups. Together they are known as bryophytes and form

Almost invisible in dry conditions (top right), the liverwort *Riccia limbata* has curled up into a tube to expose the dark, glossy scales of the leaf undersurface. The scales then form a protective cover to the more sensitive, green photosynthetic tissue, which shows only when moisture is available (bottom right).



A hand-lens view looking into capsules of *Orthotrichum cupulatum*, a moss that grows exclusively on limestone rock. Tiny golden spores, awaiting dispersal, cling to the teeth of the opened capsule.

their own division of the Plant Kingdom. Mosses typically have stems, well-developed leaves each with a midrib, and reproduce by the production of spores from capsules at the tip of wiry stalks. Moss capsules have a beauty of their own. They are edged with a row of complex, highly ornamented teeth (called the peristome) that regulates the outward flow of the spores to coincide with favourable germination conditions. A simple hand lens is all you need to observe many of these small structures.

Liverworts come in two forms. Leafy liverworts have well-developed stems, often creeping along the supporting soil, rock or bark. Their leaves have no midrib and usually grow in three flattened rows (one row of leaves on each side of the stem, and one on the undersurface of the stem). Thallose liverworts have a flattish pad (or thallus) of relatively undifferentiated tissue. Liverwort capsules are dark brown or black, globular, and grow from fragile, succulent stems. Spore dispersal in liverworts is very different from that seen in mosses. Specialised, tightly coiled cells in the capsules uncurl to explosively eject all the spores away. The word 'liverwort' is an unfortunate label, especially since the group contains some exquisitely beautiful plants. The much-admired 'mossy' log, for example, is often actually clothed with leafy liverworts.

Hornworts are rather like thallose liverworts, and have a flattened, dark, blackish-green thallus. However, the capsules are quite different from those of mosses and liverworts, and look like short grasses. They split and twist from the tip to release their spores.

Our studies have taken us to many famous limestone outcrops in eastern Australia. At each location, the bryophyte flora of mosses, liverworts and hornworts is uniquely different from that found on other adjacent rock substrates. Not only are there more species present on the limestone, but they are also in much greater abundance.

Unlike the bryophyte flora of the northern hemisphere, only a few species of Australian mosses and liverworts occur exclusively on limestones and are genuine calciphiles. The exquisite *Encalypta vulgaris* has a distinctive calyptra or cap on top of its capsule that resembles an old-fashioned candle snuffer. Known as the 'Candle Snuffer Moss', it is one of the few mosses with a common name. Other calciphiles include *Pseudoleskeopsis imbricata*, a moss that clings tightly to smooth limestone walls; *Gymnostomum calcareum*, the 'Bat Moss', which is usually associated with bat guano; *Orthotrichum cupulatum*, another moss that grows in tight clusters in small

A sharp variation in vegetation defines the border between limestone and shale near the mouth of the Devil's Coachhouse, Jenolan Caves. The limestone site of the Caves is more open, with few trees, but the higher slopes on shale are covered with a dense eucalypt woodland.

depressions in roughened limestone rock; and *Targionia lorbeeriana*, a thallose liverwort that only thrives on damp, limey soils.

A second group can best be termed opportunists, growing successfully on limestone as well as other rock types. *Grimmia pulvinata* is a small, rounded moss, and its long, hair-like leaf tips give the plants the appearance of tiny, soft, grey animals. *Barbula crinita* is a handsome, golden-leafed moss. Another golden moss is *Tortula papillosa*, which gains its colour from clusters of golden spheres that it produces on the upper surfaces of its leaves. Each sphere of cells, when dislodged, has the potential to develop into another individual plant. (The ability to regrow from tiny fragments of leaves and stems, as well as by spores, is a feature of all bryophytes.) Thallose liverworts are more common on limestones than leafy liverworts. *Asterella drummondii* grows on damp soil in rock crevices, producing its spores in capsules suspended from 'umbrellas' growing upwards from the main body of the thallus.

WHY SPECIES

characteristic of rainforest should be present in such hostile conditions is unknown and is the subject of our current research.

Absent, of course, are the calcifuge mosses and liverworts that are never found on limestones, such as *Campylopus introflexus*, the moss that forms khaki green carpets on sandstone outcrops throughout south-eastern Australia.

IN THE LAST FEW YEARS, we have found certain bryophytes that were once thought to be confined to the damp and shade of rainforests, flourishing on limestone areas with dry, harsh environments. These include mosses such as *Papillaria* and *Cratoneuropsis* spp., *Leptodon smithii* and *Hypopterygium rotulatum*, and liverworts such as *Frullania* spp. and *Porella crawfordii*. Why species characteristic of rainforest should be present in such hostile conditions is presently unknown and is the subject of our current research.

Also surprising was the large proportion of limestone bryophytes that are more usually associated with the Australian arid and semi-arid zones. For example, many limestone mosses tend to be either small, wiry plants with tough, leathery, pigmented leaves (such as *Didymodon torquatus*) or plants with colourless upper leaves giving them a whitish, reflective surface (such as *Gigaspermum repens*)—both adaptations to cope with hot, dry conditions. Liverworts, such as *Riccia limbata* and *R.*

lamellosa, are thallose, with glossy scales on the undersurface. In hot, dry weather, they curl up into a tube so that the scales finish up on the upper surface, protecting the plant from high temperatures, desiccation and damage to photosynthetic tissue.

We found a similar assemblage of mosses and liverworts at each limestone site we studied in south-eastern Australia. But when we worked at Yarrangobilly Caves in Kosciusko National Park in the southern tablelands of New South Wales and compared our collections with a collection of mosses made in 1906, we realised that since European settlement there had been considerable change in the bryoflora at Yarrangobilly and probably also at all other eastern Australian limestone sites.

The Reverend W. Walter Watts was an extraordinarily industrious and gifted botanist. Watts had a particular interest in mosses and liverworts, and there are now many species that bear his name. In 1906 Watts visited Yarrangobilly Caves and, over the period of a week, collected many (95) species of mosses that he sent to a colleague in Germany. Together, in 1912, they published *The mosses of Yarrangobilly Caves*. Fortunately, their original collection is now housed in the National Herbarium of New South Wales in the Royal Botanic Gardens Sydney.

We were astonished to find that we had collected many more mosses (131) in 1993 than the very dedicated Watts had collected in 1906. Trying to piece together the manner in which these unreported mosses might have arrived at Yarrangobilly proved a little more difficult. To understand the way in which these 'new' species had arrived, it is necessary to accept that the colonisation process has three separate requirements: a source of plant material (spores, plant fragments, or whole plants), a suitable means of transport, and a suitable substrate for establishment.

The development of Yarrangobilly as a tourist destination began in 1879, but it was not until early in the 20th

Targionia lorbeeriana **is a liverwort that only thrives on damp, limey soils.**

The exquisite moss *Encalypta vulgaris* has a distinctive calyptra or cap on top of its capsule that resembles an old-fashioned candle snuffer. Here it is shown growing on a limestone outcrop.

century that most of the roads, paths, buildings, farms and gardens were constructed. Clearing removed the natural vegetation of trees, shrubs, native grasses and herbs, leaving bare ground and rock, ideal substrates for colonisation by mosses and liverworts. Spores probably arrived with building materials, on the wheels of vehicles and on the hooves of animals. Some epiphytic mosses (those growing on trees) not recorded by Watts probably arrived on the bark of exotic trees, brought to Yarrangobilly and planted there to give it a more European appearance. From the 1840s until 1969, Sheep and Cattle were herded from the western plains of New South Wales, up through the Yarrangobilly valley, to graze on alpine pastures through the summer, returning to the lowlands before the onset of winter. Some non-indigenous mosses, and some with a worldwide distribution, are believed to have been introduced this way.

But what about many of the 'arid-zone' mosses present at Yarrangobilly in 1993 not recorded by Watts almost a century ago? It now seems probable that they were introduced to Yarrangobilly by dust storms. Although dust storms are known to have occurred in Australia for thousands of years, the wind-borne spores and fragments of arid-zone mosses were unlikely to colonise ground already covered with natural vegetation. But once the land had been cleared for tourist development, many suitable substrates suddenly became available. It also seems probable that the use of tractors to plough vast tracts of land in semi-arid and arid areas of western Victoria, New South Wales and South Australia broke up the extensive carpets of mosses and liverworts that form on pristine inland soils. In the process, spores and plant fragments would have been released from the soil and readily picked up and carried by the wind.

The Yarrangobilly study appears to indicate that there has been a significant change in the mosses and liverworts of most of the eastern Australian limestone outcrops since European settlement. To limit further introductions of non-native moss species, we recommend management practices that are similar to those used to manage non-native flowering plant species. Most of our recommendations are directed towards minimising disturbance to the natural vegetation. Specific suggestions include: keeping all buildings outside karst areas, keeping the construction of paths and roads to a minimum, building raised walkways where possible, excluding Sheep and Cattle, retaining natural

The tiny moss *Gigaspermum repens* is widely spread in the arid and semi-arid zones of Australia. The minute, reflective leaves are adapted to withstand hot, dry conditions. Why then is it present in moist limestone gullies? Relatively large spores can just be distinguished inside the capsules.

(Above) The opportunistic liverwort ***Asterella drummondii*** has its globular spore capsules suspended from umbrella-like structures that grow upwards from the thallus.

(Right) The 'Bat moss' (***Gymnostomum calcareum***) is a limestone exclusive often associated with bat guano. Although very small, the moss stems and leaves build up a corky supportive mat of old and compacted leaves.

vegetation, and avoiding any changes to natural wetland features, such as streams, swamps, pools and bogs.

Limestone landscapes are extraordinary not only for their geology, but for their vegetation as well. Mosses, liverworts and hornworts are an important component of that vegetation. There is a multitude of different species, diverse and beautiful, and at their best after rain or early-morning mist. They impart to the landscape a quilt-like cover of green, yellow and brown softness, a stark contrast to the rugged majesty of massive grey–white limestone cliffs and bluffs.

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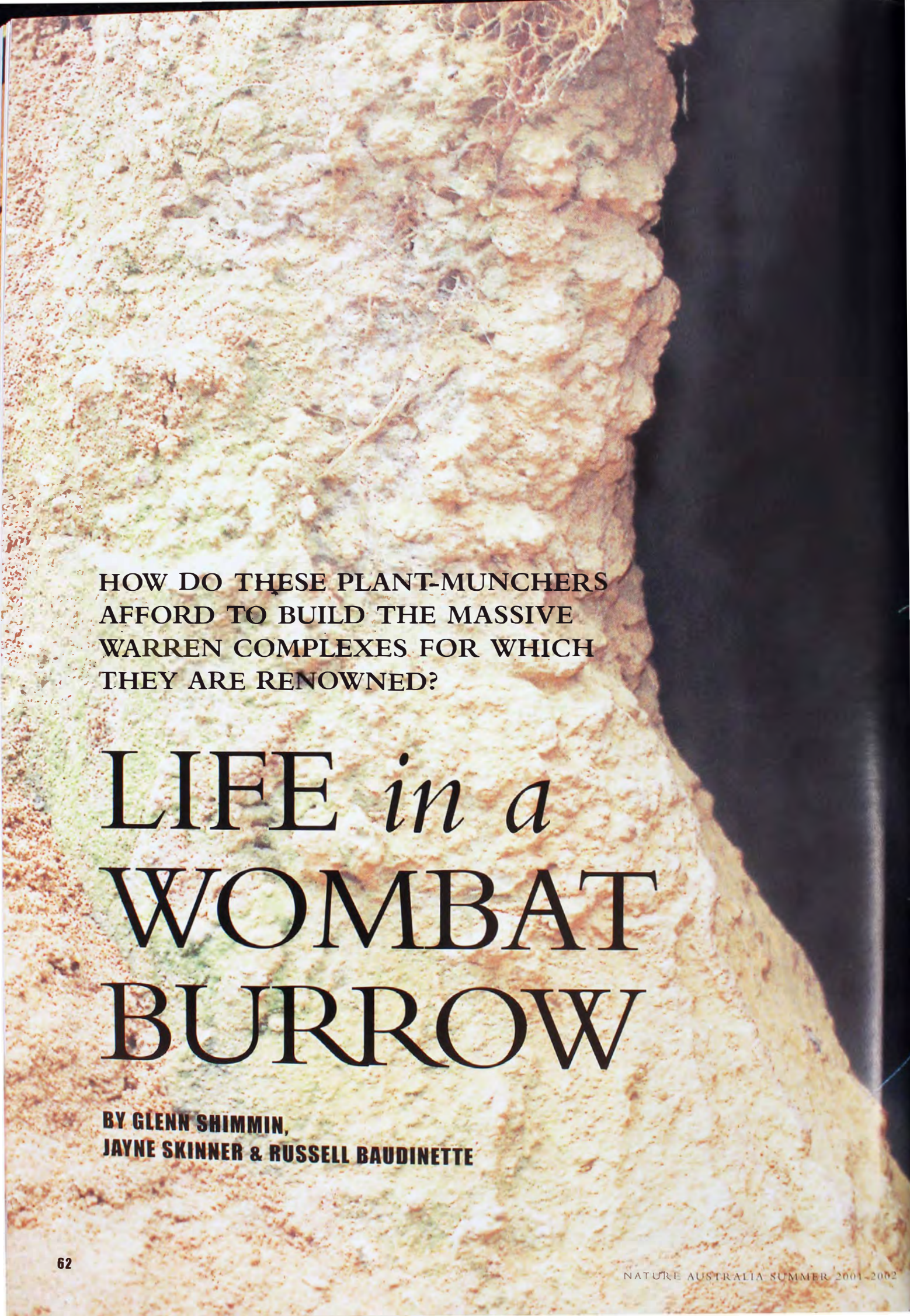


HOW DO THESE PLANT-MUNCHERS AFFORD TO BUILD THE MASSIVE WARREN COMPLEXES FOR WHICH THEY ARE RENOWNED?

LIFE *in a* WOMBAT BURROW

BY GLENN SHIMMIN, JAYNE SKINNER & RUSSELL BAUDINETTE

A Southern Hairy-nosed Wombat emerging cautiously from its burrow.

C. ANDREW HENLEY/LARUS

WOMBATS ARE AMONG the world's largest burrowing animals, and hold the title of biggest herbivores to adopt a subterranean lifestyle. Many animals live underground, for burrows provide a relatively stable environment, often close to food and safe from predators. However, most burrowers are quite small and live in large communities (think of ants and Rabbits). The costs of burrow construction increase with the size of the animal, and only a few species over ten kilograms build burrows. Most of these large burrowers, such as the Aardvark (50–70 kilograms) and Giant Pangolin (30–35 kilograms), live on high-quality insect diets, rich in proteins and carbohydrates. Wombats, however, forage only on relatively low-quality grasses and other herbage. How do these plant-munchers, on presumably low energy budgets, afford to build the massive warren complexes for which they are renowned?

To investigate, we studied the warrens of two Southern Hairy-nosed Wombat (*Lasiorhinus latifrons*) populations in South Australia—one at Swan Reach in the Murraylands, and the other near Ceduna on the west coast. But first we had to work out the metabolic costs of digging a burrow.

EXCAVATING *a ten-metre-long tunnel would require a greater energy investment than walking 120 kilometres!*

DETERMINING HOW MUCH energy a wombat uses to dig a burrow required a bit of digging ourselves. Back in the University of Adelaide's outdoor animal enclosure, we dug a trench about a metre long into which we lowered a rectangular-shaped timber box, open to the dirt at one end and with a lid and perspex viewing window at the top. The trench was just deep enough so that the top of the box was level with the ground surface. Into this contraption we placed one wombat at a time and let them dig to their hearts' content. We measured the volume and weight of dirt moved relative to time and oxygen consumed. The maximum amount of dirt excavated was an incredible 42 kilograms in only 50 minutes! On average, however, 20–30 kilograms of dirt were moved in the same period, which is equivalent to 15–20 litres of dirt, or 10–15 centimetres of an average tunnel. Amazingly, the oxygen consumed while excavating this 10–15 centimetres of tunnel was about 12,000 times greater than that used by a wombat walking the same distance. At this rate, a ten-metre-long tunnel would take about 80 hours of vigorous digging and require a greater energy investment than walking 120 kilometres!

Do the costs of building a burrow outweigh the energetic savings from living in one? To answer this question we needed to measure the conditions inside the burrow. How much do they vary, for example, with seasonal changes in temperature, humidity and food availability on the surface? By establishing

This photo illustrates the Southern Hairy-nosed Wombat's long ears and prominent nasal hairs.

JEAN-PAUL FERRERO/AUSCAPE

GLENN SHIMMIN

Wombat burrow interiors were viewed using a porthole camera lowered down PVC casings into the tunnel, with footage viewed and recorded on the surface.

PHOTOS: GLENN SHIMMIN

Shelves of limestone, similar to those pictured, often form either the roof or floor of wombat warrens in the Swan Reach area.

Southern Hairy-nosed Wombat

Lasiorhinus latifrons

Classification

Family Vombatidae. One of 3 wombat species (the others being the Common Wombat, *Vombatus ursinus*, from Vic., NSW and Tas., and the endangered Northern Hairy-nosed Wombat, *L. krefftii*, from Qld).

Identification

Typical wombat build (stocky, short limbs, stout face, flat rump) with long nasal hairs. Fur varies from light brown through to silvery grey, and is soft and silky to touch. Height 35–45 cm, body length 90–100 cm, weight 25–35 kilograms.

Habitat and Distribution

Common, patchily distributed over southern, semi-arid regions of SA and into WA.

Behaviour

Predominantly nocturnal, although occasionally basks in mid-afternoon sun. Grazes on native/pastoral grasses and other herbage. Humid burrows with relatively stable temperatures, entrances number from 1 to >100.

Reproduction

Mating between Oct. and Dec., single young born 20–22 days later weighing 0.5 g. Young permanently in pouch for first 300 days, weaned at 400 days at 2–3 kg weight, sexually mature at 3 years. Very difficult to breed in captivity.

sampling points along wombat tunnels in our two field sites, at known distances from entry/exit points, we were able to monitor the burrow environment for such factors as temperature, airflow, humidity, and oxygen and carbon dioxide levels, at different times throughout the year. But to establish the sampling points we had to first map a series of about 30 warrens of varying complexity without destroying any of the above- or below-ground architecture. For this we developed a 'porthole' camera, which we lowered vertically from the surface into the tunnel through five-centimetre-wide, PVC-lined pipes. Clear images that told us about the tunnel size, depth and direction were then relayed to a television screen on the surface.

This method of establishing sampling points may sound straightforward enough, but it was not without its physical and mental challenges. The reason wombats live underground is to avoid the harsh environment on the surface, which, after many weeks on the end of a hand auger, we all fully understood. To position the first porthole, one lucky member of the team had to crawl down the tunnel entrance to determine the tunnel direction. On particularly hot

days this job was 'almost' sought after! Each subsequent porthole location was then determined by the camera orientation, and the porthole casings then capped and left in place for future monitoring.

There is an enormous range in the complexity of warrens, from single-entrance burrows to extensive warrens with up to 100 entrances and interconnecting tunnels. The largest we measured contained about 30 entrances and 100 metres of tunnelling. In the sandy soil areas of the west coast of South Australia, the tunnels descended sharply, giving them greater structural stability at the entrance. They then levelled out at 1.5–2.5 metres in depth, and proceeded in relatively straight lines to their end point. However, warrens dug in clay soils, from both field sites, needed only to be shallow to support a tunnel roof, but more often descended to similar depths as sandy-soil warrens. The major difference in tunnel architecture between these two soil types was the convoluted nature of warrens dug in clay soil. These tunnels bent sharply, ascended and descended, and often joined up with other tunnels. Warrens dug in clay/calcrete areas also generally incorporated shelves of calcrete, which are impenetrable even to wombats. These slabs of stone, often up to half a metre thick, generally formed either the roof or floor of the tunnels and occasionally both. The presence of large rocks at bends, divisions and the ends of tunnels indicated that wombats tend to dig in the earth offering least resistance and perhaps give up when no seams of soft clay can be found.

Barring the odd protruding rock or internally collapsed wall, the tunnels we studied were surprisingly uniform in shape and size. They were generally quite small and elliptically shaped in cross section, often only 25–30 centimetres high and 40–50 centimetres wide—just big enough for one wombat to scramble through. The floors were covered in loose dirt and littered with fecal pellets, and often we uncovered bones of wombats that had died in the depths of the tunnels but were yet to be raked to the entrance by the current occupants. Evidence of tunnel-clearing following rain was also frequently observed, although some clearing probably occurs all year round.

THE REASON

wombats live underground is to avoid the harsh environment on the surface.

Small chambers were often found along the tunnel length, however they were rarely greater than twice the normal width of a tunnel and their role is as yet unknown. They may be resting points closer to the entrance, or areas where a female can leave her young unattended. Warrens of the Common Wombat (*Vombatus ursinus*), on the other hand, usually have only a single entrance and often contain large nesting chambers, the size of which has rarely been seen in Southern Hairy-nosed Wombat burrows. Our porthole camera revealed that the wombats share their burrows with other species as well. Insects, spiders, lizards, frogs, Rabbits, Foxes, goannas and snakes all gain the environmental advantages of a burrow-dwelling lifestyle without the energetic costs of construction.

So what exactly are the advantages of a burrow-dwelling lifestyle? In the Swan Reach area, the temperature above ground ranged from as high as 45–50° C in the middle of summer to –5° C on a cold winter's night. This corresponded to a seasonal change in deep-burrow temperature from 27° C in summer to 12° C in winter. But these changes occurred very slowly,

The characteristic broad head and shoulders of the Southern Hairy-nosed Wombat are illustrated well in this photograph. Also clear is the asymmetrical nose pattern, which is thought to be specific to the individual (much like a human fingerprint).

GLENN SHIMMIN

© ANDREW HENLEY/ARUS

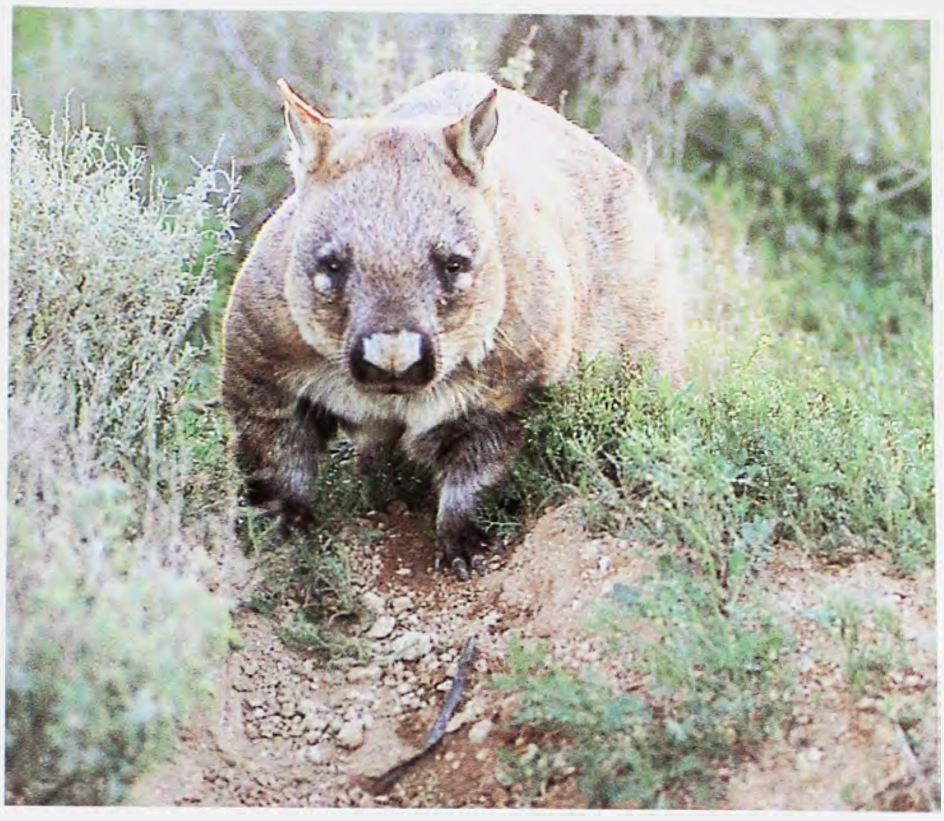
This wombat is seen raking the loose earth from around its burrow entrance, a common behaviour, particularly following rain. The strength of the forelimbs, which are responsible for most of the digging work, is clearly evident.

GLENN SHIMMIN

The 'wombat digging chamber' gave wombats free digging access to an earth wall and allowed the researchers to calculate the volume of dirt excavated relative to the energy consumed.

with daily fluctuations rarely exceeding a single degree at the deepest points of the tunnels. In the laboratory we have found this range in burrow temperature to be within the thermo-neutral or comfort zone for wombats, with only slightly elevated levels of energy required at the lower temperatures to maintain body warmth. Not surprisingly, tunnels that were less than a metre deep, or were relatively short, or had an entrance at each end, were more susceptible to temperature fluctuation, although still considerably less than that recorded above ground. Avoidance of temperature extremes, however, cannot fully account for the complex and extensive burrow architecture, as daily temperature stability was reached within the first few metres of blind tunnels that descended quickly.

Our next avenue of investigation was that of water conservation, which is a key element to survival in an arid environment. Free water is rarely available to wombats, with most of their water intake coming from that contained within the grasses and bulbs eaten, and from the dew that falls on the plants overnight. Body water is lost in urine and through respiration (breathing), which is greatest in a dry environment. By feeding at night, wombats not only



DAVE WATTS/NATURE FOCUS

Heading for home. This Southern Hairy-nosed Wombat ambles slowly through the thickets of saltbush obscuring its burrow entrance.

get the maximum benefits of increased humidity but also take in greater amounts of water through their food. Burrow humidity also affords wombats significant water savings. We found that, in contrast to temperature stability, burrow humidity continually increased along the tunnel. This may in part explain the extraordinary length of tunnels, as the highest levels of humidity were reached at the farthest points from the entrance. Short, shallow or open tunnels, however, did not have increased humidity because of the increased flow of dry air.

Airflow through tunnels, while having an undesirable drying effect on the air, ensures carbon dioxide levels do not rapidly rise to intolerable levels. We found unoccupied tunnels, regardless of length, depth or entrance number, typically had oxygen and carbon dioxide levels equivalent to those found above ground (20.9 per cent oxygen and 0.04 per cent carbon dioxide) and this was despite airflow falling to levels of one per cent of that recorded on the surface. By contrast, carbon dioxide accumulation in occupied burrows was as high as 2.6 per cent and oxygen levels as low as 16.3 per cent. When one wombat was burrowing at the end of a blind tunnel, gas levels changed so rapidly that within four or five hours it had to abandon its excavation work in search of oxygen-rich air. But it didn't have to exit the burrow system. By simply moving around in the tunnels, the wombat could refresh its air to tolerable levels. Once an animal leaves an area of the tunnel, oxygen and carbon dioxide levels return to normal within five or six hours, depending on tunnel complexity.

In the first 12 months of our study, we found that the rate of tunnel expansion was highly variable in the 30 warrens we monitored. Most of the warrens changed very little during the year, even though they were actively used, while some underwent significant and rapid expansion (the greatest was a ten-metre expansion in just four weeks). We suggest that large warrens are most likely the work of many generations of wombats, which presents further questions on family structure, dispersal of young and/or inheritance within a warren complex.

Although individuals may not necessarily invest large portions of their annual energy budget on excavation work, the net value of the warren in terms of the energy spent on its construction over the years remains high. The energetically favourable humid conditions that we have found in the longest, deepest tunnels further suggest that occupying the largest warrens is of most benefit to wombats, particularly during the hottest, driest weather when food is scarce. While we can use energetics to explain the costs and benefits of the length of a tunnel, we cannot fully explain the complexity of old warrens, with their varying lengths and depths of tunnels, and multiple branches and entrances. However, we have now started behavioural studies on the use of tunnels and the social structure of the animals sharing a warren, and hopefully we will soon be able to answer some of these more complex questions.

FURTHER READING

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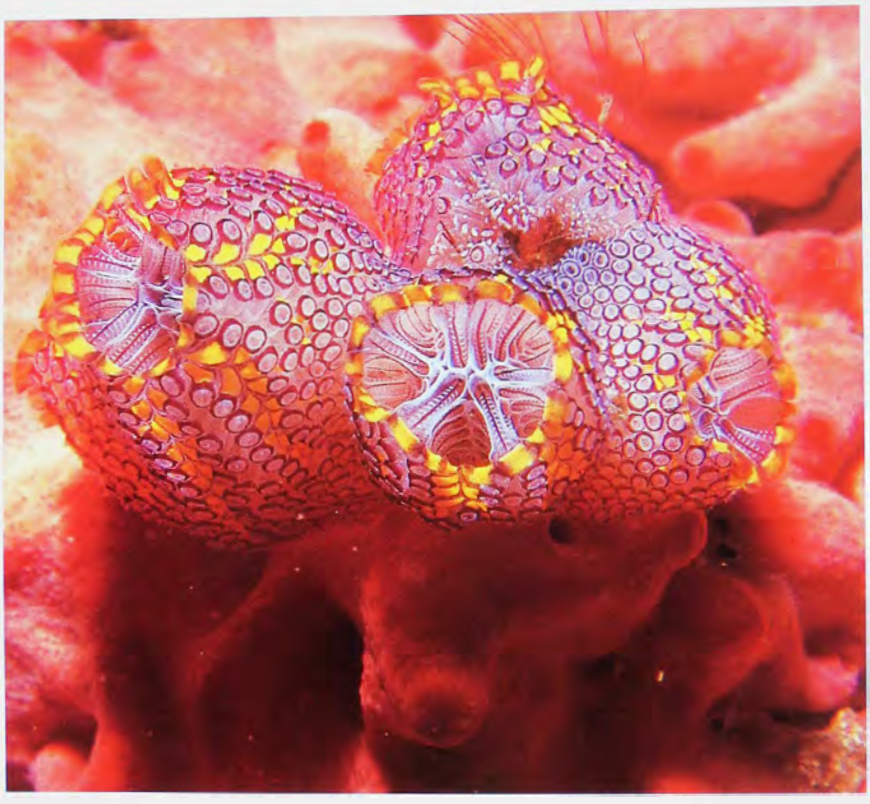
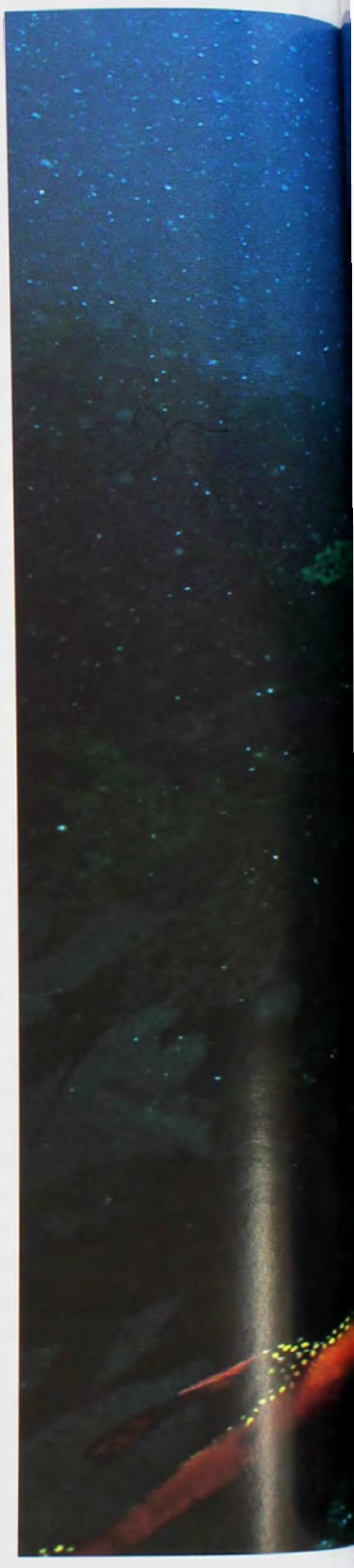
ALL AUTHORS WORK IN THE DEPARTMENT OF ENVIRONMENTAL BIOLOGY, UNIVERSITY OF ADELAIDE, WHERE DR GLENN SHIMMIN IS A RESEARCH FELLOW, JAYNE SKINNER A TECHNICAL OFFICER SPECIALISING IN ANIMAL HUSBANDRY AND PROF. RUSSELL BAUDINETTE HEAD OF THE DEPARTMENT. TOGETHER THEY HAVE WORKED ON THE WOMBAT BURROW ECOLOGY PROJECT SINCE 1999. FOR GLENN, THIS FOLLOWED FIVE YEARS OF WOMBAT ECOLOGY AND REPRODUCTION WORK, WHILE RUSSELL HAS BEEN RESEARCHING MARSUPIAL ENERGETICS AND LOCOMOTION FOR THE PAST 30 YEARS.

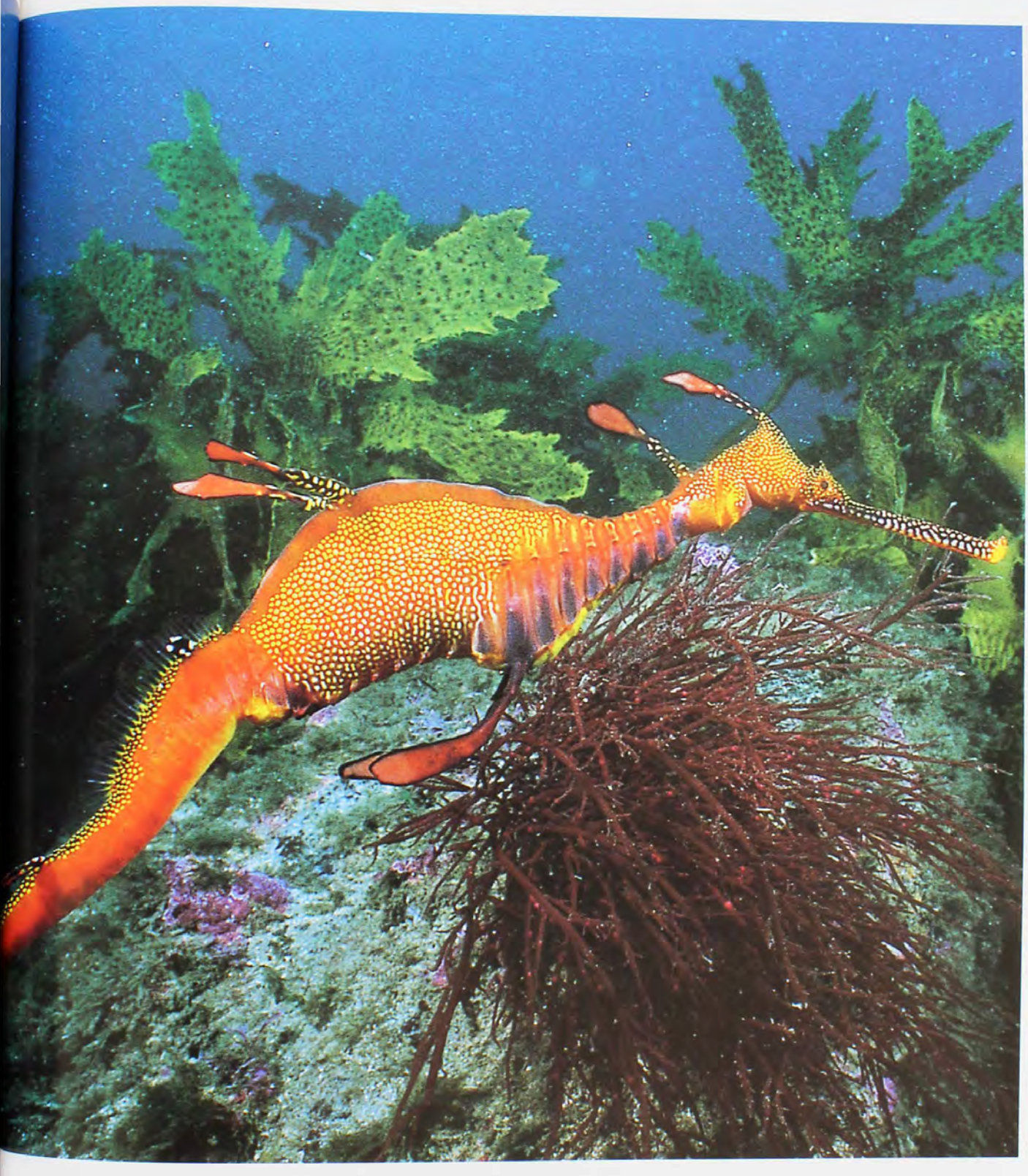
Seasquirt (*Botrylloides* sp.).



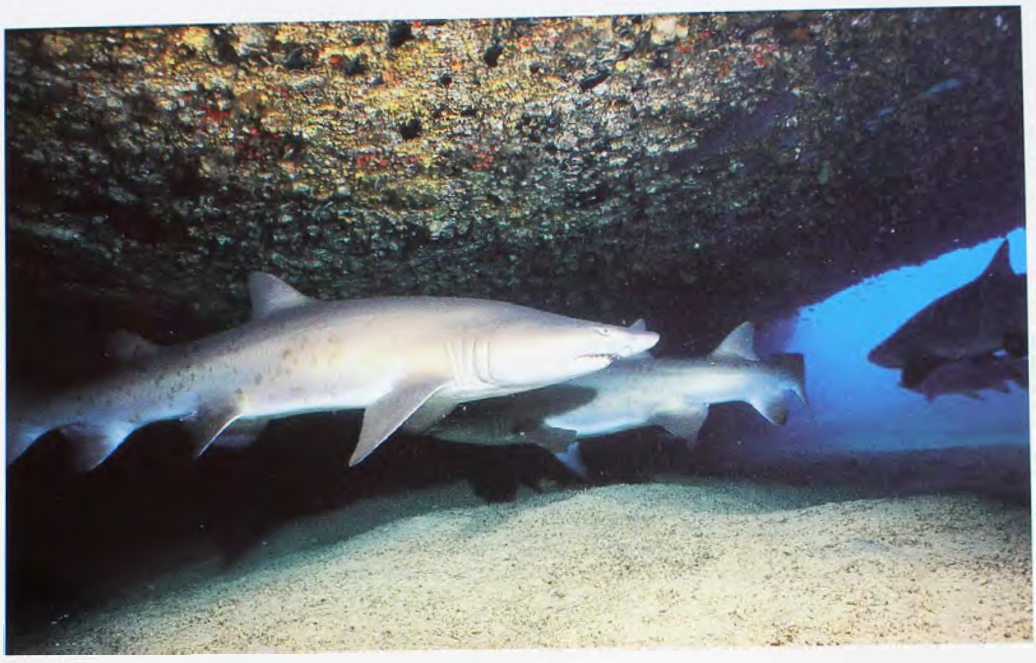
catching the harbour

BY AKOS LUMNITZER





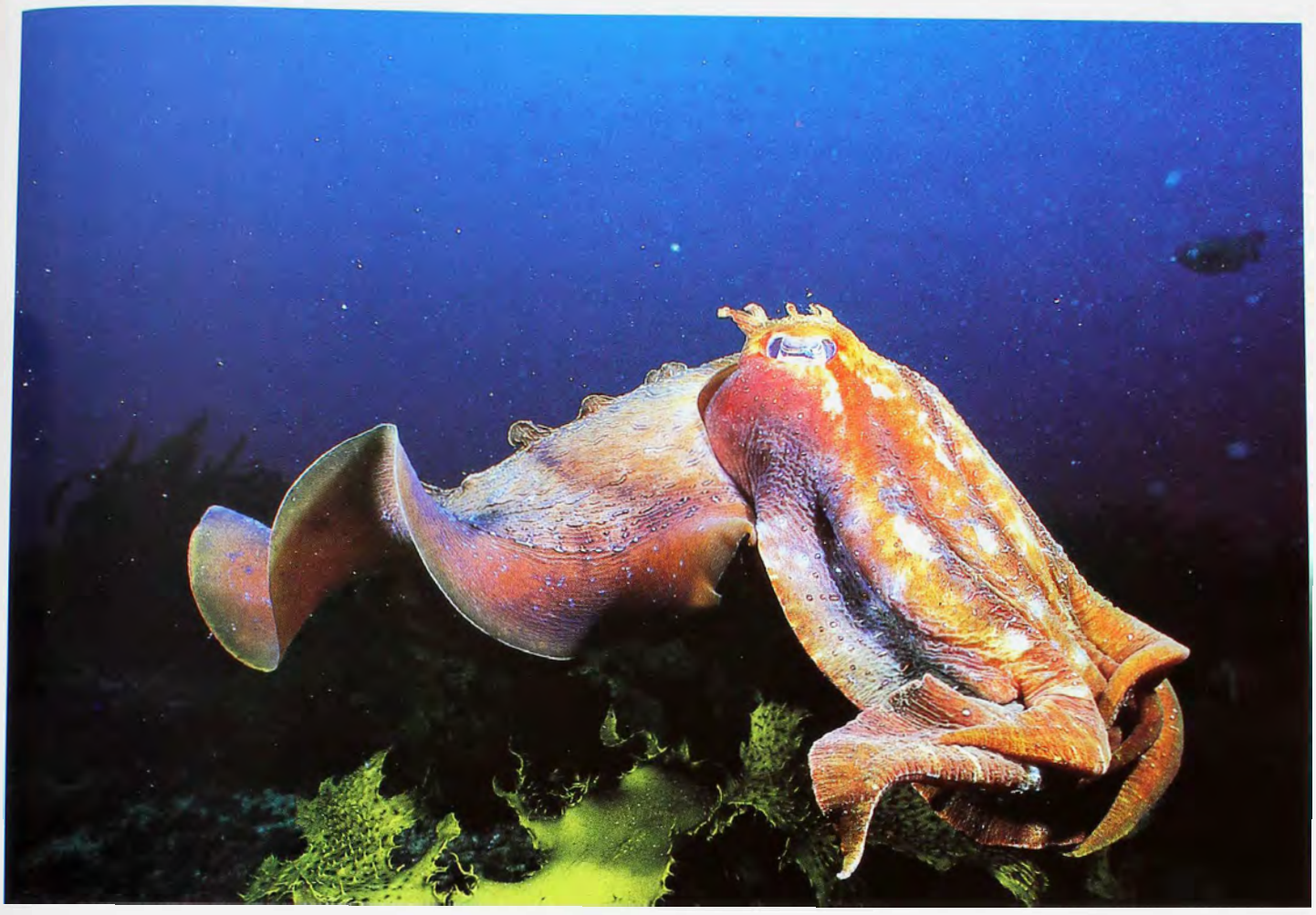
Weedy Seadragon (*Phyllopteryx taeniolatus*).



(Top) Grey Nurse Shark (*Carcharias taurus*).
(Above) Eastern Frogfish (*Batrachomoeus dubius*).

Spiny Gurnard (*Lepidotrigla papilio*).

Striped Anglerfish (*Antennarius striatus*).



(Above) Giant Cuttlefish (*Sepia apama*).
(Left) Hermit crab (*Pagurus* sp.).

reviews

Handbook of Australian, New Zealand and Antarctic Birds. Vol. 5. Tyrant-flycatchers to Chats

Ed. by P.J. Higgins, J.M. Peter, & W.K. Steele. Oxford University Press, Vic., 2001, 1,269pp. $385rrp.

THIS IS THE LATEST VOLUME OF A SERIES that started in 1990. Previous volumes have been reviewed in earlier issues of *Nature Australia*; each received highly favourable comments at those times, and the current volume easily measures up to them. This massive work will be one of the most consulted of the series. Marking the start of the songbirds, it contains several of the best-known and most widely studied Australian families: the lyrebirds, fairy-wrens and honeyeaters. Other groups include the New Zealand wrens, pittas, scrub-birds and treecreepers—118 species in all. As such, this book will be of tremendous value as a reference, and there is no doubt that it will remain so for many years to come. The format of the species accounts remains the same as before, with the biggest difference from previous volumes being some changes in the artists. The current contributors have not let the side down, maintaining the high standard of illustration in the 42 colour plates. Once again, the price will prevent many people from acquiring personal copies; however, because of this book's exceptional and long-term value, anyone interested in these groups of birds will need to ensure that they have access to it.

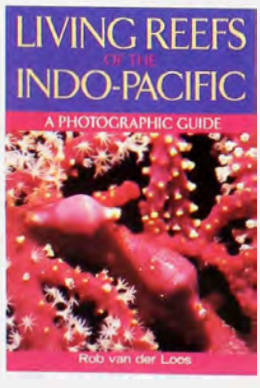
—WALTER E. BOLES
AUSTRALIAN MUSEUM

Where to Find Birds in North-East Queensland

By J. Wieneke. 3rd ed. Published by the author (bowerbird@msn.com.au), 2000, 132pp. $20rrp.

THIS THIRD EDITION IS A MAJOR REVISION of a guide that first appeared in 1992, which speaks well for its popularity and usefulness. It covers important birdwatching localities in the coastal region and ranges bounded by Bowen in the south, north to the Daintree area and west to, and including, the Atherton Tableland. The locality accounts range from sites suitable for a quick stop to ones that warrant a more extended visit, augmented by a series of maps that will greatly facilitate getting to a chosen spot. Also included are contacts for more information, local guides, suggested accommodation and other nearby attractions. The second part of the guide presents brief summaries of the many exciting species that might be found. The entry for each species is brief but gives the best habitats and seasons, and, often, specific sites at which they might be most likely encountered. Small and concise, yet highly informative, this guide will considerably enhance any visitor's birdwatching trip to this region.

—WALTER E. BOLES
AUSTRALIAN MUSEUM

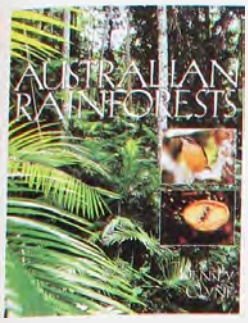


Living Reefs of the Indo-Pacific: A Photographic Guide

By Rob van der Loos. Reed-New Holland, NSW, 2001, 176pp. $32.95rrp.

IF YOU HAVE AN INTEREST IN THE TROPICAL MARINE LIFE of the Indian and Pacific oceans and appreciate strikingly colourful photographs, this book should be your cup of tea. Rob van der Loos has divulged some of the knowledge gained through his 25 years of experience as a diver, based at Milne Bay in southern Papua New Guinea. Over 350 colour photographs of marine organisms adorn the pages within. Many of the species, ranging from corals and cowries to sea slugs and scorpion-fishes, are highly cryptic and blend in with their surroundings to the extent that they are rarely seen by the average SCUBA diver. By the author's own admission, this work is not a scientific masterpiece, but it lacks little in terms of presentation and subject matter. Accompanying each image are notes on the scientific and/or common names of the organism, its distribution and depth range, its life history and the author's choice of lens for photography. This book would be a useful and inspiring addition to the library of amateur and professional marine naturalists or those interested in underwater photography.

—JOHN POGONOSKI
AUSTRALIAN MUSEUM



Australian Rainforests

By Densey Clyne. Reed New Holland, NSW, 2001, 96pp. $29.95rrp.

Australian Rainforests is a photographic exploration highlighting the variety of colours and forms found in an Australian rainforest. Many images are very delicate, with close-ups of the minutiae of the forest floor such as lichens, mosses and tiny invertebrates. Others explore the shapes and changing nuances of light and shade in the rainforest canopy.

The chapters are arranged in an informal fashion, with titles such as "The Forest Floor" and "Special Forms and Habits". The publication does have some problems with layout, having oddly placed captions that can make it hard to match the information to the image. The captions themselves, however, are informative and lively. Some minor spelling errors can be found, but overall the information is good, placing each image in context. The book achieves its aim of taking you "on a journey" into the wide range of rainforest habitats in Australia, and leaves you wanting to see more.

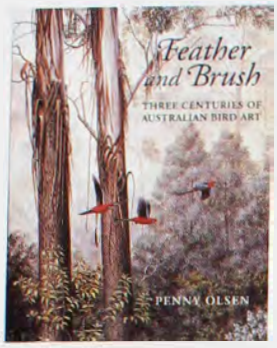
—Ondine Evans
Australian Museum

Australian Medicinal Plants

By Eric Lassak & Tara McCarthy. New Holland, NSW, 2001, 240pp. $34.95rrp.

This is a must for anyone with a serious interest in medicinal plants. When it first appeared in 1983 it provided reasonably thorough coverage of the topic, with an emphasis on plant chemistry. Knowledge has advanced since then, thanks to surveys conducted among Northern Territory Aborigines and testing of many bush remedies. Although this reprint was not updated to reflect this work, in the absence of any modern overview it remains a key reference. Several hundred plants are covered, although a few of the scientific names are now out of date. For each plant there is a description of appearance, habitat and distribution, uses, and active constituents. The book covers Aboriginal herbs, colonial remedies, and Asian medicinal plants that also occur in Australia. It is thoroughly referenced and includes more than 80 colour photos.

—Tim Low



Feather and Brush: Three Centuries of Australian Bird Art

By Penny Olsen. CSIRO Publishing, Vic., 2001, 227pp. $69.95rrp.

MANY AUSTRALIANS KNOW OF JOHN GOULD in relation to his paintings of birds but far fewer would be able to name other Australian bird artists. This country has a long history of avian art by Europeans, starting with the first voyages of exploration. (The earliest published illustrations of Australian birds appeared in a book by William Dampier in 1703.) For many years, it was difficult to preserve specimens, so early paintings by convicts, officers and settlers served as important documentation of Australian birds. Subsequent expeditions yielded more and more species to be described and illustrated. Gould was the best known of the artists, but he was certainly not the only person making important contributions at that time. In the early 20th century smaller books—field guides—were produced to be used outside the confines of a reading room. Nowadays bird art is flourishing in Australia in many forms. A sizeable part of *Feather and brush* is dedicated to over 30 modern artists, giving brief biographies and presenting examples of their work.

Penny Olsen has produced a well-researched overview of the history of bird art in Australia that will hopefully rectify the public oversight of many worthy artists. The book is attractively produced and features more than 250 colour illustrations beginning with Dampier's plate and continuing to those of contemporary bird artists. It is an impressive publication from both scholarly and aesthetic standpoints.

—WALTER E. BOLES
AUSTRALIAN MUSEUM

The Secret Life of Wombats

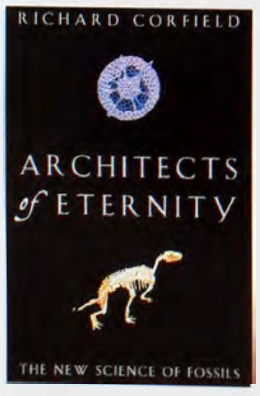
By James Woodford. Text Publishing, Vic., 2001, 226pp. $27.50rrp.

The secret life of wombats IS A CAPTIVATING LOOK into the truly secretive, and largely unknown, world of wombats. Woodford travelled over Australia researching this book, tracking down an array of remarkable people working with wombats both extant and extinct. The lifestyle, habitats, behaviour, history of human interactions, evolution and biology of these impressively rumped marsupials are explored with a very readable and entertaining result.

I was distressed to discover that one of the three living species of wombat, the Northern Hairy-nosed Wombat, is now known only to exist in one small pocket of National Park in Queensland. The entire population of this once fairly widespread animal is estimated to be around 100 individuals. As Woodford states, "the extinction will occur in our lifetimes or our children's." Despite the best efforts of the team "responsible for them", there is still an unbelievable lack of protection for this critically endangered species.

Students should find the comprehensive index useful. Some lovely colour photographs and line drawings round out an altogether fascinating volume, which makes great reading for anyone who's ever had even a passing interest in wombats.

—CATHERINE LAMOND
AUSTRALIAN MUSEUM



Architects of Eternity: The New Science of Fossils

By Richard Corfield. Distributed by Hodder Headline, Sydney, 2001, 338pp. $34.95rrp.

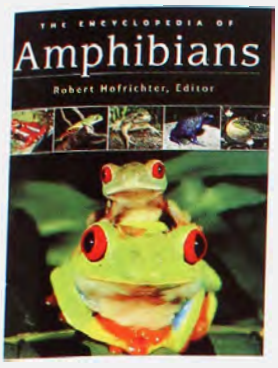
I REALLY LIKE THIS BOOK. It's informative, eminently readable and will appeal to anyone with an interest in palaeontology or seeking a more rounded understanding of how science happens. I thought I'd get this out up front, because I don't want anything negative I might say to deter prospective readers.

Corfield's book tracks the development of palaeontology since its inception, flagging and explaining most of the major discoveries, both physical and theoretical, that have contributed to the modern science of studying the preserved parts of creatures that have been dead for a very long time. He does a fine job of this. Topics covered constitute something of a grab-bag, from the impact of Darwin to ancient DNA, but then it couldn't have been done any other way. Some readers may consider the odd chapter a little heavy going (such as that concerned with the development of dating techniques) but most will appeal to all.

What makes this book really stand out is Corfield's entertaining treatment of the main players in the game—palaeontologists. Contrary to images conveyed by recent vocational-guidance handouts and the revamped sunglasses-and-black-leather-jacket stereotypes dished out by Hollywood, we scientists really are a bunch of anal retentives with appalling

dress sense. But, that doesn't mean that our lives are boring. Corfield's descriptions of the politics, intrigue and ego that have accompanied the progress of palaeontology make for very entertaining reading. Nine out of ten.

—Steve Wroe
Sydney University



The Encyclopedia of Amphibians

Ed. by Robert Hofrichter. Distributed by UNSW Press, NSW, 2000, 264pp. $59.00rrp.

Interest in amphibians has skyrocketed in recent times and this group of animals now enjoys popularity in line with the more 'charismatic' vertebrates. This is due in a large part to the attention drawn by the global decline of amphibian species and the message this sends about the health of our planet. Ironically this decline has generated considerable research into the biology of amphibians. As a consequence we not only know a lot more about the biology of amphibian species familiar to us but have also discovered many other extremes of behaviour and morphology that can only be described as fantastic.

The book contains five major 'themes', each of which consists of a series of short self-contained essays from two to six pages in length. The opening section on "Evolution, Systematics, and Biogeography" gives a well-written and presented introduction to the various amphibian families, and provides a contextual platform for the following sections. There are large sections on "Biology and Physiology" (18 topics) and "Ecology and Ethology" (13 topics), and smaller sections on "The Meaning of Amphibians for Mankind" and "Endangerment and Species Protection", plus an Appendix, which includes a list of all recent species of amphibian.

Two topics are particularly worth reading. The one on amphibians as caring parents outlines the different and bizarre strategies various groups of frogs have for caring for their offspring during metamorphosis. The other on conservation gives a global perspective on the problems faced in amphibian conservation, and the politics behind decisions made at an international level. The first of these two essays portrays the hidden and little appreciated diversity and uniqueness found among amphibians, much of which will be lost with the progressive decline and eventual extinction of many species, while the second essay shows our apparent inability and unwillingness to deal with this situation.

—Ross Sadlier
Australian Museum

SOCIETY PAGES

Get involved! Across Australia there is a network of active societies, large and small, local and national, that 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.

ANIMAL WELFARE

Fauna Rescue of SA
PO Box 241
Modbury North, SA 5092
Ph: 08 8289 0896
Web: www.faunarescue.org.au
Contact: Mrs Sheila Burbidge
Membership: $20 Single, $30 Family, $20 Family Concession, $10 Pensioner/Student

Great Lakes Wildlife Rescue (NSW) Inc.
"Huntley"
Lakes Way
Bungwahl, NSW 2423
Ph: 02 4997 6157
Contact: Margaret Seal
Membership: $16.50 Single, $22 Family

Tweed Valley Wildlife Carers
PO Box 898
Murillumbah, NSW 2484
Ph: 02 6672 4789
Contact: Ilona Roberts

Wildcare Inc.
PO Box 464
Palmerston, NT 0831
Ph: 08 8988 6121
Contact: Mignon McHendrie
Membership: $20.00

BIROS

Birds Australia
415 Riversdale Road
Hawthorne East, VIC. 3123
Ph: 03 9882 2622
Web: www.birdsaustralia.com.au
Membership: please refer to website

Birding NSW
PO Box Q277
QVB Post Shop
NSW 1230
Contact: Margot Latham
Membership: $30

Bird Observers Club of Australia
183 Springvale Road
Nunawading, VIC. 3131
Ph: 03 9877 5342
Web: www.birdobservers.org.au
Contact: Trish Teesdale
Membership: $60.50

Birds Queensland
PO Box 6097
ST LUCIA, QLD 4067
Ph: 07 3229 3554
Web: www.birdsqueensland.org.au
Membership: $38.50 City, $33.00 Country

BOTANY

Australian Plants Society NSW Ltd
PO Box 744
Blacktown, NSW 2148
Ph: 02 9621 3437
Web: www.austplants-nsw.org.au
Contact: Judith Brimage
Membership: $40 Single, $32 Single Concession, $46 Joint, $38 Joint Concession, $A50 Overseas

Society for Growing Australian Plants
PO Box 586
Fortitude Valley, QLD 4006
Web: www.sgapqld.org.au
Contact: Ian Waldron
Membership: $39 New Member, $34 Renewing Member

CONSERVATION

Australian Bush Heritage
GPO Box 101
Hobart, TAS. 7001
Ph: 03 6223 2670
Web: www.bushheritage.asn.au
Contact: Roewen Wishart

Australian Network for Plant Conservation
GPO Box 1777
Canberra, ACT 2601
Web:www.anbg.gov.au/anpc/join.html
Contact: Jeanette Mill
Membership: please refer to website

Australian Plants Society Tasmania Inc.
RMB 8987
New Norfolk, TAS. 7140
Ph: 03 6261 3976
Web: www.trump.net.au/~joroco/sgaptas-index.html
Contact: Joy Coghlan
Membership: $40.00

The Wetlands Centre Australia
PO Box 292
Wallsend, NSW 2287
Ph: 02 4951 6466
Web: http:users.hunterlink.net.au/~wetlands
Contact: B. Burgess
Membership: $33.00 Single, $55.00 Family, $16.50 Concession, $82.50 Corporate

EDUCATION

CSIRO's Double Helix Science Club
PO Box 225
Dickson, ACT 2602
Ph: 02 6276 6643
Web: www.csciro.au/helix
Contact: Kasia Kucharska
Membership: $27.00

ENVIRONMENTAL

Conservation Volunteers Australia
PO Box 423
Ballarat, VIC. 3353
Ph: 03 5333 1483
Web: www.conservation volunteers.com.au
Contact: Karen Dimmock
Membership: $30

Friends of Lane Cove National Park Inc.
C/- Lane Cove National Park, Lady Game Drive
Chatswood, NSW 2067
Web: www.acon.com.au/lcnpfriends
Contact: Jacqui Hickson
Membership: $10

Tasmanian Conservation Trust
102 Bathurst Street
Hobart, TAS. 7000
Ph: 03 6234 3552
Web: www.tct.org
Contact: Michael Lynch
Membership: $27.50

MUSEUMS

TAMS—The Australian Museum Society
6 College Street
Sydney, NSW 2010
Ph: 02 9320 6225
Web: www.amonline.net.au/tams/
Contact: Alison Byrne
Membership: $80.50 Family, $64.00 Single, $48.50 Concession

The Waterhouse Club
SA Museum
North Terrace
Adelaide, SA 5000
Ph: 08 8203 9802
Web:www.waterhouseclub.org.au/whc
Contact: Mary Lou Simpson
Monthly Meetings
Membership: $90.00 Family, $70.00 Single

NATURAL HISTORY

Dinosaur Club
Australian Museum
6 College Street
Sydney, NSW 2010
Ph: 02 9320 6223
Contact: Valerie Bower
Membership: $15.00

Field Naturalists Association of Canberra
GPO Box 249
Canberra, ACT 2601
Contact: Rosemary Blemings
Membership: $20.00

Western Australian Naturalists Club
PO Box 8257
Perth BC, WA 6849
Ph: 08 9228 2495
Web:www.wanats.iinet.net.au
Contact: George Elliott
Membership: $47 Single, Student discount offered

REPTILES & AMPHIBIANS

WA Society of Amateur Herpetologists Inc.
9 Birch Place
Stoneville, WA 6081
Ph: 08 9295 3007
Web:www.iinet.net.au/~bush/support.html
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q&a

The large mosquito, ***Toxorhynchites speciosus***. These mosquitoes feed on plant juices and nectar.

Robin in Drag

Q: *While walking in the snowy mountains, I encountered what I think was a female Flame Robin carrying food to her nest. She was joined by another female robin, both of which fed the nestlings. Were these birds in some kind of homosexual relationship? I did not see any sign of a male bird.*

—Julie French
North Rocks, NSW

A: Female Herring Gulls (*Larus argentatus*) have been known to form female–female pairs when two parents are essential for egg survival and males are in short supply. Each member of the female pair solicits copulations from a paired male, and each lays eggs in a shared nest. However, your observations on Flame Robins (*Petroica phoenicea*) are more likely to be a result of the curious male business known as Delayed Plumage Maturation. Rather than moult into their bright adult plumage, some juvenile males, from a diverse range of bird families, take on a female-like plumage. However, they can still be successful in attracting a mate and producing offspring. Several Australian robin and whistler species adopt this pattern of development.

It is interesting to consider why this strategy should have evolved, given that brighter males should be more attractive to females or be more successful in territorial battles with other males. Because young males are inexperienced in the ways of the world, they are more likely to be taken by predators, and less likely to be competent breeders. They might therefore achieve greater lifetime reproductive success by focusing their youth on survival, rather than reproduction, thus assuming a cryptic plumage, rather than driving the equivalent of a red sports car. This is known as the Cryptic Hypothesis.

An alternative explanation, the Female Mimicry Hypothesis, assumes that males take on a female-like plumage so that they are mistaken for females by territorial males and thereby avoid much of the aggression that sometimes results from attracting attention in a public place. These disguised young males can then take up residence in the same patch as bright males (albeit in the poorer sections) and may be successful in defending a territory that is attractive to a female (often also inexperienced).

The critical test between the two hypotheses is the difference between juvenile, female and immature male plumage. Juvenile plumages are the most cryptic with mottling common in many species. If, as predicted by the Cryptic Hypothesis, young males moult into a dull plumage to avoid predators, the juvenile plumage should be the plumage of choice. The fact that they moult into 'female' plumage awards points to the Female Mimicry Hypothesis.

—Richard Major
Australian Museum

From left to right: juvenile female, juvenile male, adult female, sub-adult male and adult male Flame Robins. Note the sub-adult plumage lacks mottling on the head and more closely resembles the adult female plumage than the juvenile plumage.

Huge Mosquito

Q: *I live in northern New South Wales and the other night I saw a huge mosquito buzzing around the curtains. I managed to catch it and I have sent it to you with this letter. It is much larger than any other mosquito I've seen before and its body has a metallic sheen and a very large, bent proboscis. What kind of mosquito is this and can it carry malaria or any other diseases?*

—Jenny Chan
Ballina, NSW

A: The mosquito that you sent in is *Toxorhynchites speciosus*. The female is very large (about 12 millimetres long) with a dark 'shiny-metallic' appearance. It has a large, dark, scaled proboscis that is distinctly curved down and backwards and its wings have dark 'metallic' scales. They are found along the coast and hinterland north from Sydney to Queensland and the Northern Territory. Adults are seldom collected, as they are not blood-feeders and are not attracted to humans. They feed on plant juices and nectar, and are sometimes seen in gardens and occasionally enter houses during warmer months.

The larval stages are predacious on other mosquito larvae. This species does not bite, and thus there is no relation to disease. If you want to find out more about mosquitoes go to www.arbovirus.health.nsw.gov.au.

—Stephen L. Doggett
Dept of Medical Entomology
Westmead Hospital

Answers to Quiz in Nature Strips (page 19)

1. *Centipedes and millipedes*
2. *Eros*
3. *The megafauna*
4. *Fraser Island*
5. *Birds' eggs*
6. *Cane Toad*
7. *An elephant, rhinoceros or hippopotamus*
8. The eternal frontier
9. *Dugong*
10. *Hagfishes*

DENSEY CLINE

Pic Teaser

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *The visual encyclopedia of science*. Spring's Pic Teaser depicted the hanging threads of glowworms, which are predatory fly larvae (*Arachnocampa* sp.).

Native pets: an unnatural disaster

Wildlife as pets will amuse lots of people for a while but in the end it will be the wildlife that suffers.

THE CONCEPT OF KEEPING wildlife as pets is certainly attractive on the surface, but it has serious flaws.

Advocates present four main positives: Australians would get much pleasure from having more native animals as pets (there are already many that can be kept); native wildlife could replace Dogs and Cats, which are so harmful to the environment; Australians would better conserve native animals if they had wildlife as pets; and captive stocks would provide genetic insurance for wild populations. Let's scratch the surface.

Australian marsupials have few of the attributes of domestic animals. Most live less than half the age of comparatively sized Dogs and Cats. Even research targeting quolls, the most hoped-for candidates, could not clearly show their suitability as pets. Few marsupials are social and, once past the intimacies of juvenile dependence, most are careless towards people; boisterous welcome-homes and animal-to-human play rarely occur even with juveniles.

Adult marsupials can be cantankerous and I wonder how long it would be before they would be declawed and defanged, conveniences to be followed by fashions such as tail-docking and ear-clipping. The recent suggestion that Tasmanian Devils could replace guard Dogs could only come from too much Walt Disney. Devils are sensitive and essentially timid animals that prefer to hide, only exhibiting their well-known theatrics if directly threatened. They do not show Dog-like defensive loyalties and would be terrible 'guard Dogs'. Devils are the very essence of wildness and deserve better than leash or cage, rotting as a curiosity in a backyard. Thousands of years of intimacy have not prevented us routinely mistreating traditional pets, and to glibly suggest that wildlife agencies or the RSPCA could supervise husbandry of pet wildlife is, at best, naïve.

Some say that Thylacines would still be with us if they had been pets. Well, some *were* kept but they were poor substitutes for Dogs without a smidgen of their cooperation and loyalty. Tellingly, Tasmanian Aborigines did not keep Thylacines as pets but quickly adopted Dogs.

The assumption that exposure to wildlife as pets will lead to conservation of wild populations is easily debunked. How many people with Budgies have a clue about wild populations? Similarly, the claim that pets offer genetic insurance is wobbly. What genetic insurance for wolves is there in a Dog show? How long would it be before spotless quolls or crawling hopping-mice were all the rage? Proponents of more wildlife as pets argue that only legitimately captive-bred, desexed animals would be used. Really? The very nature of fashions means demand outstrips supply. A black market in wild-caught and illicitly bred animals would be inevitable.

Australian wildlife is a mosaic of discreet genetic pools that could be permanently trashed simply by the escape and release of native pets. Any disease they may carry would be doubly disastrous. One likely reason that wild Gouldian Finches are endangered is disease introduced by escaped captives.

On the flip side, there are many diseases that people can catch from captive wildlife—salmonella from reptiles, psittacosis from parrots, tuberculosis from possums, and trichinella from Devils and quolls. A few years ago some thought that flying-foxes would make wonderful pets but now we know they can carry a lethal rabies-like disease. You can bet there are more rude surprises around the corner.

I agree that people need contact with native wildlife to appreciate it, but the answer may not lie in more pets but as stimulating, educational displays, better local tourism and wildlife rehabilitation, and integration without ownership. For example, wild animals could be brought into our lives via wildlife-friendly architecture and planning. We could have wildlife-friendly residential areas with no Dogs or Cats and where issues of roadkill, electrocutions and window collisions are dealt with.

To be sure, wildlife as pets will amuse lots of people for a while, even make a few rich, but in the end it will be the wildlife that suffers, and suffer it will.

Let's remember, though, that in conservation terms, this issue is a sideshow compared to broadacre clearing. It's a pity the high-profile advocates of wildlife as pets don't throw their weight behind the hard slog of habitat conservation, instead of flirting with 'sexy' distractions. It doesn't help at all.

BY NICK MOONEY

NICK MOONEY HAS WORKED AS A WILDLIFE MANAGEMENT OFFICER WITH TASMANIA'S NATURE CONSERVATION BRANCH FOR OVER TWO DECADES. HE HAS BEEN DEVELOPING INNOVATIVE WILDLIFE REHABILITATION AND IS ACTIVE IN PROMOTING WILDLIFE IN TOURISM, BOTH AS WILD ANIMALS AND IN PROFESSIONAL COLLECTIONS.

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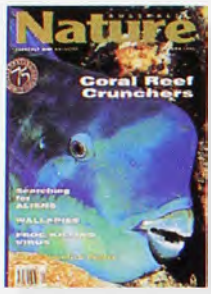

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