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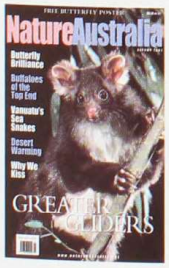


FRONT COVER
Long claws and elongated toes help the Greater Glider grip trunks at the end of a glide. The large distance between the eyes (intra-orbital width) may also act as a mini GPS to help the animal assess distances and select a suitable path between trees when gliding. Photo by Esther Beaton.

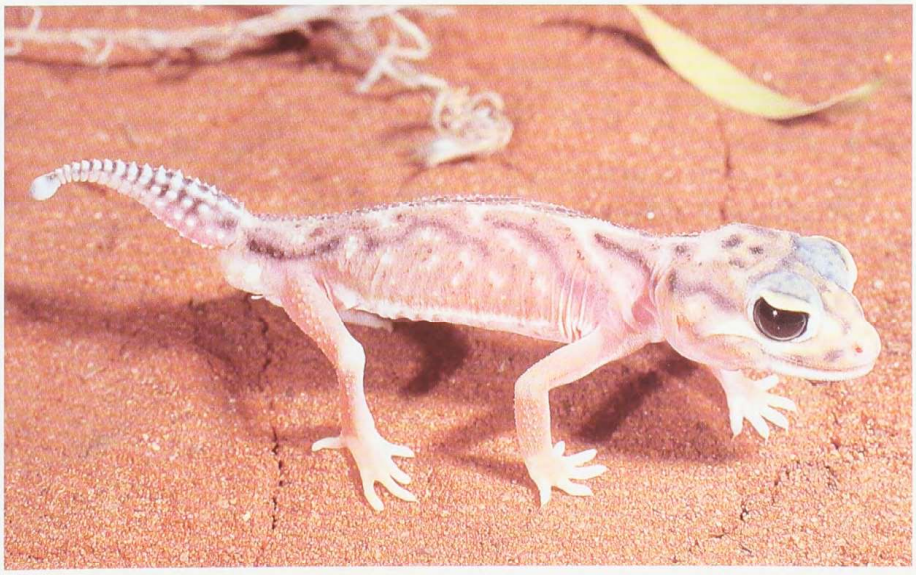
up front

If asked to discuss the impacts of global warming, you're likely to start talking about rising sea levels, melting ice caps and bleaching of coral communities. What probably won't come to mind is the effect global warming could have on our desert environments. Most people would assume that a small rise in temperature wouldn't make much difference in an already blisteringly hot environment, and as for an increase in rainfall, well surely rain is always welcomed in central Australia. Unfortunately these assumptions are wrong and the consequences of global warming have the potential to put some of our toughest reptiles at risk. In "Desert Warming", John Read introduces you to some amazing reptiles and highlights how we cannot predict all the implications associated with climate change.

In 1932 the extensive eucalypt forests around Tumut began to be cleared for Radiata Pine plantations. Since then over 70,000 hectares of native forest have been replaced. In amongst this sea of pines 192 patches of eucalypts survived, and these patches are providing scientists with the opportunity to undertake a large-scale natural experiment studying the impacts of habitat loss and fragmentation on wildlife. Beginning their study in 1995, the researchers first concentrated on possums and gliders. In "Ghosts of Gliders Past", David Lindenmayer and Andrea Taylor focus on Australia's largest gliding marsupial, the Greater Glider, which has been found to occur in around 40 per cent of the eucalypt patches. The work on Greater Gliders has already provided insights into both the lives of these fascinating animals and the effects of fragmentation.

Also in this issue we discover that, in their pursuit of brilliance, butterflies have become some of the most ingenious and innovative optical inventors known to science. We highlight the complex and confusing relationship between Swamp Buffaloes and humans in the Top End, and put our feet up for a relaxing trip to Vanuatu to meet some of the most laid-back snakes on the planet. And last, but by no means least, we take a revealing look at kissing and what drives our desire to share bacteria, food, proteins and chemicals with another person.

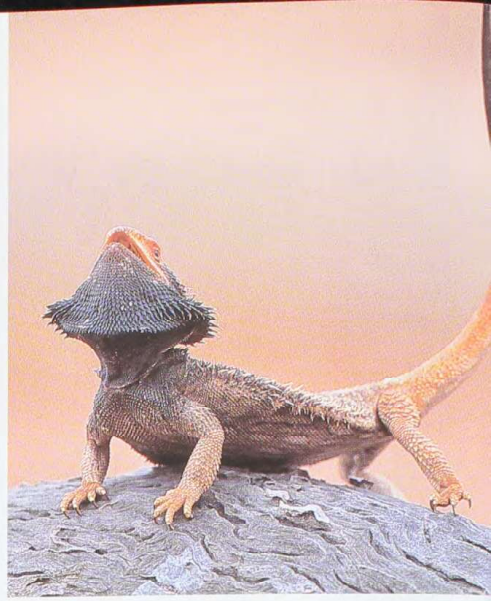
— **JENNIFER SAUNDERS**
Publishing Manager



H. EHMANN

The rare Pernatty Knobtail.

contents



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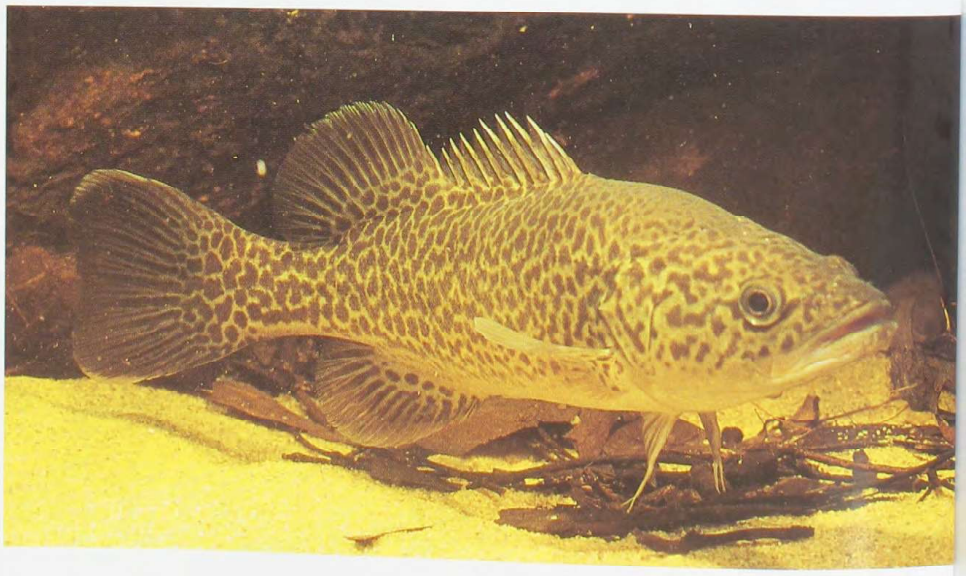
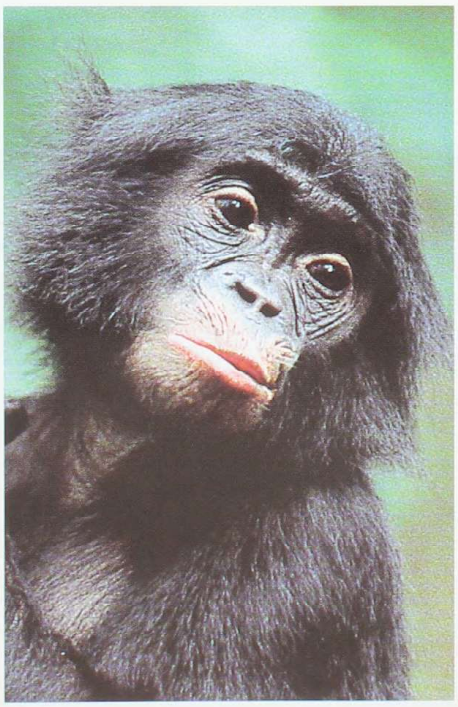




COLUMNS

letters

Relief Calls

In regards to why chooks cackle after laying (*Nature Aust.* Spring 2002), may I venture a very unscientific and amateurish suggestion? Egg-laying might involve some pain, or at least a certain amount of difficulty and discomfort. And just before laying, a hen may feel, for want of a better word, constipated. Rather than the various complicated theories, could it simply be that, after expelling the egg, she sings (cackles) from sheer relief and joy at suddenly feeling so well again?

—William H. Miller
Hawthorn, Vic.

Stop the Splits

Some years ago William of Occam said we shouldn't needlessly multiply entities. In the same way, taxonomists shouldn't needlessly multiply genera. I am referring to Tim Low's article on the splitting up of *Acacia* and *Eucalyptus* (*Nature Aust.* Spring 2002).

One must wonder whether taxonomists have a death wish. Their finances come from taxpayers. If they continue on the present path of making technical names unpronounceable and incomprehensible for ordinary people, their funds will dry up—as we're seeing.

Before embarking on wholesale and expensive rearrangement of herbaria and museums, it will be wise to pause. The process can yield little benefit and is apt to destroy the whole Linnean edifice. Already, reputable people are avoiding technical disputes by referring to eucalypts by their well-established popular names.

—Peter Fannin
Uluru, NT

Wattle Be Will Be

I refer to Tim Low's "Wattle Become of Acacia?" (*Nature Aust.* Spring 2002).

In biology names change for two reasons—taxonomic and nomenclatural. Scientists use characteristics of organisms to group species together into evolutionary family trees. For wattles and eucalypts, these genealogies have shown that older classifications were artificial and did not reflect the relationships of species, hence the taxonomic need for name changes. Whether the names of Australian or African wattles need to change will be dictated by nomenclatural rules.

Classifications based on evolutionary relationships have greater utility because they enable generalisations and predictions to be made from the groupings. If one species of the group has a certain characteristic, for example an anti-cancer compound, it is more likely that other members of the group will share that characteristic than will non-members of the group. Obviously this predictive value saves time and money and is vital when assessing genetic diversity to inform conservation decisions. A little short-term inconvenience, while new names are learnt, seems a small price to pay for a more useful classification reflecting natural relationships that, after all, serves as the foundation of knowledge upon which all other biological sciences are built.

—Frank Udovicic
(Royal Botanic Gardens Melbourne)
& Daniel Murphy
(University of Melbourne)

HANNAH FULLAGAR

Why do chooks cackle after laying an egg?

Congratulations

I have been subscribing to *Nature Australia* for a few years now and I wish to congratulate you on a great magazine. Although not scientifically trained, I am very interested in nature and tend to read it from cover to cover. Not only is the magazine beautifully presented, but the articles seem to cater for people in my position without being patronising. Even my two-and-a-half-year-old grandson loves to sit down and look at the pictures.

—Stuart Reid
Highlands, Vic.

Return Calls

I was interested in the story on cackling hens (*Nature Aust.* Spring 2002). We grew up on a wheatbelt farm during the 1920s and '30s, and we had a flock of about 50 domestic hens and several roosters that we would release from their yard to free-range during the afternoons. They would move through the understorey together, as a sort of safety precaution, and when a hen needed to lay she would leave the flock to find a secret nesting place. After laying the egg and sometimes lightly covering it, the hen would then rush out, cackling madly, in what appeared to be an attempt to find out where the rest of the group had moved to in her absence. One or more hens would reply, and sometimes the rooster as well. She would then hurry to join them, and the rooster escorting that particular party would usually make a proprietary pass at her, mostly with success, before the flock settled down to go on feeding.

So it seems that the cackle, for our flock at least, was a call to the rest of the group so that the hen could return.

—Jean C. Hooper
Maida Vale, WA

Saw Spotting

John Pogonoski asks for any information relating to the Green Sawfish (*Nature Aust.* Spring 2002). Well, in late summer I found a sawfish saw amid the fresh offal in the trailer parked for that purpose at the fish-cleaning tables in Bermagui harbour. It was probably cast away there after one of the fishing competitions held by the Big Game Fishing Club. That means it was most probably caught in the Eastern Australian current, which is compressed into a comparatively narrow band offshore. The saw was only about 45 centimetres long.

—John Crew
Bermagui, NSW

Both sawfishes (modified rays) and sawsharks have saws. The saws of sawsharks have a pair of barbels on the underside, which is absent in sawfishes. It is more likely that the saw found at Bermagui was from a sawshark. Sawsharks are common in southern Australian waters, while the mainly tropical sawfishes are rarely seen south of Sydney (if indeed they still occur in New South Wales).

—John Pogonoski
Australian Museum

Synchronised Flying

I was interested in Michelle Hall's article on duetting in Magpie Larks or Peewees (*Nature Aust.* Summer 2002-2003). These birds are notorious for attacking their reflections in a mirror and we have one that has been doing this at daybreak virtually every morning for the past two or three years. Our bedroom window faces west and has a balcony outside it with a railing on three sides. This Peewee sits on the western rail and attacks the window in a highly ritualised way, ending with a flutter, which enables him to hit the window with his feet rather than his bill.

Occasionally he is joined by his wife, who sits on the northern rail of the balcony. When he flies east to hit the window, she flies south to the opposite rail, crossing him in mid air. When he makes his next attack, she flies back, again crossing his path in mid air. They sing in duet while doing this. So, in addition to the synchronised singing, we have synchronised flight. We feel this has more to do with bonding than territory protection. Surely even a pea-brain would have worked out by now that the window is not a real threat and the 'attack' is so stylised as to not seem like a real attack.

—Ross Carlton
East Seaham, NSW

Triage

We write in response to Matt Cameron and Todd Soderquist's anti-ecological-triage Letter (*Nature Aust.* Summer 2002-2003). Unlike this pair, we strongly agree with Hugh Possingham's approach to conservation (*Nature Aust.* Winter 2002).

Most Australians don't realise that Australia has the highest number of extinctions in the world, and that it still has an extinction debt to pay as a result of land clearance over the past 200 years. More extinctions are therefore inevitable. Targeting limited resources only toward endangered species devalues biological diversity, because it fails, in many cases, to incorporate other components of the biota. However, using a triage approach in some cases may still target the most endangered species.

—Peter Tucker &
Andrew Allanson
Trees for Life, SA

Early Birds

I write in response to the "Early Birds" Nature Strip item (*Nature Aust.* Summer 2002-2003). There is no need to invoke the threat of predation as the selective force driving birds with larger, more light-sensitive eyes to sing first in the dawn chorus. A simpler, more parsimonious, explanation is that birds with eyes that can detect light at lower levels are able to wake and start their day earlier than those birds with less sensitive eyes. The selective advantage of such an adaptation would be a longer day in which to gather food.

—Tom C.R. White
University of Adelaide

For the Record

The cicada photos on pages 31 and 32 of the Summer 2002-2003 issue of *Nature Australia* were taken by David Paul.

—G.H.

***Nature Australia* requests letters be limited to 200 words and reserves the right to edit them for sense. Please supply a daytime phone number and type or print your name and address clearly. The best letter in this issue will receive a copy of *The nature of discovery*. The winner this issue is William Miller.**

Autumn

Compiled by Geordie Torr and Martyn Robinson

Honey Fungus (*Armillaria luteobubalina*).

G. SAUER-ACKER-LOCHMAN TRANSPARENCIES

Fun with Fungi

Just as spring rains send many frogs into a reproductive fervour, so too do autumn rains signal a variety of fungi to burst forth and multiply. Head out into your nearest patch of bush about four days after rain and you're sure to come across fungi of all shapes, sizes, colours and even smells.

Australia is thought to have a staggering 250,000 species of fungi, of which only about five per cent have been named, an indication of both their vast diversity and how little we know about them.

The structure that we see sprouting from the forest floor is usually the fungus's 'fruiting body'—the reproductive part that produces spores—which typically represents only the proverbial tip of the fungal iceberg. The rest of the fungus, known as the mycelium, does the important job of feeding, and is usually hidden within its current meal, be it a rotting log or some tasty pile of animal dung.

A good place to look for fungi is around the bases of trees. Many of the fungi from which these fruiting bodies have sprung have a symbiotic relationship with those trees. Known as mycorrhizae or 'root fungi', their mycelia grow in and around the tree roots. The fungi provide their host trees with nutrients such as phosphorous and nitrogen and receive energy-rich sugars in return.

It's been said that the study of fungi, known as mycology, is about 100 years behind research into plants and animals. You can do your bit to help drag the discipline into the present by signing up with Fungimap (**www.rbg.vic.gov.au/fungimap/**), a project aimed at determining the distributions of about 100 easily recognisable fungus species. The project began six years ago in Victoria and now boasts more than 600 volunteers and 5,000 records.

A word of warning: many fungi are highly toxic, and because there are so many different, difficult-to-identify fungi in Australia, dining on them is generally not a good idea.

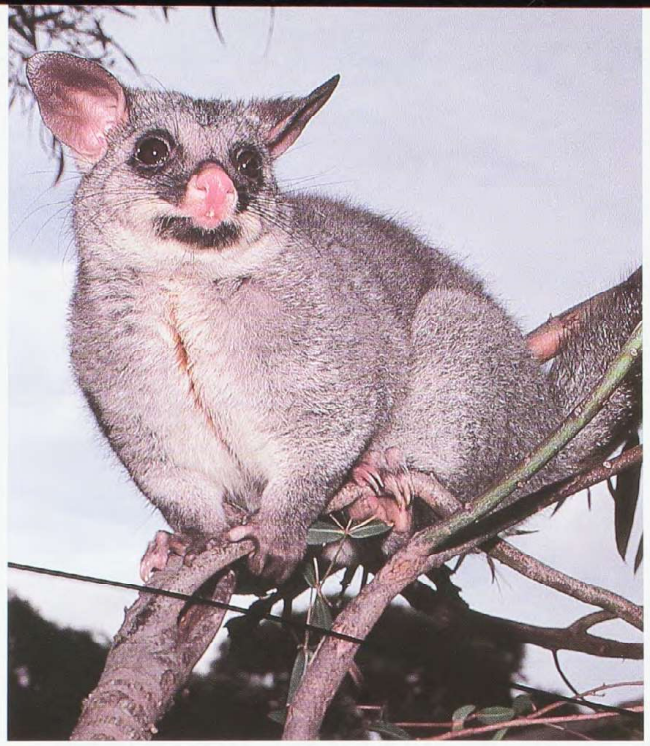
New Season's Penguin Fashions

The image of the dapper penguin all dressed up in his neat tuxedo takes a bit of a battering come autumn, as the birds begin to look like they've spent a bit too long at the ball. It's then that scruffy, bedraggled Little Penguins (*Eudyptula minor*) head into their burrows for a change of clothes, replacing their worn-out feathers with some nice new ones. Adults that have recently bred look particularly ragged, having worked so hard feeding their ravenous chicks.

It isn't modesty that sends the birds down into their burrows to get changed, but rather the cold. Little Penguins'

STEVEN DAVID MILLER/AUSCAPE

Little Penguin.



PAVEL GERMAN

Common Brushtail Possum.

feathers are extremely short and stiff, forming a dense, insulating cover over the birds' entire body. A gland near the base of the tail produces a waxy oil that they preen through their feathers to help keep them waterproof. Lacking this dual protection, the moulting penguins can't go to sea, so they will have spent the late summer indulging in a serious seafood binge, trying to pack on as much fat as they can. Even with this added bulk, they can lose up to half their body weight during the two-week wait for the new feathers to replace the old.

To learn more about these endearing birds, which are found along the southern coast of the mainland and in Tasmania, grab a copy of *Little Penguins: Fairy Penguins in Australia* (1987) by Colin Stahel and Rosemary Gales.

Playing Possum

Fear not. Those strange, other-worldly shrieks and gurgling growls filling the autumn night don't herald the arrival of a supernatural being; they're merely a sign that love is in the air, for possums anyway.

Autumn is the main breeding season for many of Australia's possums, a fact that male Common Brushtail Possums (*Trichosurus vulpecula*) seem particularly intent on advertising. Their strident, unsettling calls are an attempt to keep rivals at bay and probably also alert any females in the vicinity that they're available.

If you see a male Common Brushtail around this time, you may notice an orange stain on his chest. This is caused by a gland that, together with others on the chin and near the anus, produces secretions that he rubs onto branches and around nesting sites to declare them occupied.

Should a male be successful in his courting, the resulting young will be born a mere 16–18 days later. It sensibly stays snuggled up in its mum's pouch during winter, emerging onto her back in spring. Some brushtails also mate in spring and, come autumn, these females can be seen carrying young, but they're in the minority.

The smaller Common Ringtail Possum (*Pseudochirus peregrinus*) also begins breeding in autumn, but it's a lot more discrete about it. If you hear something at night that sounds like a small bird twittering, it's most likely a ringtail calling.

For more on possums, get hold of Anne Kerle's book, *Possums: the brushtails, ringtails and greater glider* (2001).

Geordie Torr is a freelance science writer and Martyn Robinson is the Australian Museum's resident Naturalist.

FROM THE COLLECTION

This is the only known Australian specimen of the Upland Sandpiper (Bartramia longicauda). *It was collected in 1848 in Centennial Park, Sydney, and this very specimen was illustrated by John Gould in his supplement to* Birds of Australia.

The Upland Sandpiper is normally found in northern USA and Canada, and winters in the pampas of southern South America, returning north in February/March. Occasionally, however, migrating birds get blown off course. Such 'vagrants' have also been recorded in the UK.

Unlike most sandpipers, which frequent tidal mudflats and other wetland areas, the Upland Sandpiper prefers open grasslands and often perches on fence posts. Sadly, during the late 19th and early 20th centuries it was shot in large numbers for food and sport. Combined with loss of habitat, the range of this species has decreased. Nonetheless, it remains abundant in some areas, with airfields providing much of its suitable habitat.

AUSTRALIAN MUSEUM

nature strips

COMPILED BY GEORGINA HICKEY

RICHARD FULLAGAR, KARINA HOLDEN, MICHAEL LEE, KAREN MCGHEE, RACHEL SULLIVAN, ABBIE THOMAS, GEORDIE TORR AND PAUL WILLIS ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Eat Dung and Dye

As if dining on rotting flesh and bones wasn't bad enough, the rare Egyptian Vulture (*Neophron percnopterus*) pushes back the gastronomic boundaries even further by adding dung to its diet.

Although faeces lack the things we usually associate with food, such as protein, carbohydrate and fat, they often contain large amounts of carotenoids, important nutrients that act as antioxidants and immunostimulants. Vertebrates don't have the required physiological machinery to make their own carotenoids, so they need to get them from their diet.

The Egyptian Vulture's diet is particularly low in carotenoids, but according to a group led by Juan Negro (Estación Biológica de Doñana, Spain), the birds make up for this deficiency by feeding on the droppings of Cattle, Goats and Sheep. Cow dung in particular is so carotenoid-rich that it provides the vultures with considerably more than they need. This is the first time that a vertebrate has been found to use faeces as a source of dietary carotenoids.

Carotenoids also act as pigments—they make carrots orange, for example—and the Egyptian Vulture's unusual diet has turned its head bright yellow. The researchers speculate that the yellow heads may have become a social signal, used in mating displays and/or advertising dominance. Birds could use the colour of a mate's head as a signal of vigour—only a strong, healthy bird could withstand the onslaught of the parasites likely to be found in dung (and have the

Pretty yellow. The Egyptian Vulture gets its facial colour from an ugly source.

M&C DENIS-HUOT-BIOS/AUSCAPE

intestinal fortitude to eat it in the first place!). So, in a somehow fitting twist, this 'ugly' dietary supplement may actually help make the birds more 'beautiful'.

—G.T.

Arrested for Rape

An adult male Orangutan (*Pongo pygmaeus*) is a formidable sight, with his enlarged cheek pads, hulking stature and shaggy red coat. So formidable are those secondary sexual characteristics that adolescent males can remain in a state of arrested development for many years if there is a dominant male in the vicinity. Now new research has shown that, rather than taking a back seat in the mating game, these adolescents are pursuing an alternative reproductive strategy, one that involves forcing themselves onto females.

It was thought that the immature physique was a pathological response to stress caused by aggressive adult males. But when Anne Maggioncalda (Stanford University) and colleagues analysed the levels of stress hormones in 23 captive male Orangutans of varying states of development, the results were surprising.

They found that adolescent males in the process of developing have significantly higher levels of stress hormones than juvenile, developmentally arrested, or adult males, probably because developing males are a target of aggression by dominant animals. This suggests, say the researchers, that the arrest of secondary sexual development is not a *result* of stress, but rather a strategy to *avoid* stress during the adolescent or subadult phase.

They also showed that adolescent males in a state of arrested development are still capable of impregnating females, but by remaining small they reduce the risk of serious conflict with adult males. However, females tend to be unreceptive to arrested males' advances, defending their honour fiercely, and biting and emitting loud, guttural 'rape grunts' when they are forced upon by the youngsters.

The researchers urge caution, however, against drawing simplistic parallels between the behaviour of

JOHN CANCALOSI/AUSCAPE

A mature male Orangutan—a formidable sight.

COURTESY R.R. SWAISGOOD

Some Giant Pandas will literally turn themselves upside down to get their message across.

Pandas Aim High

The higher they pee, the higher they stand. This, basically, is the conclusion of Giant Panda researchers, working in China's Wolong Nature Reserve.

Giant Pandas (*Ailuropoda melanoleuca*) are solitary animals and communicate with one another by marking their territories with urine or glandular secretions. Pandas adopt four distinct postures for this: they either squat on the ground (all pandas), or scent-mark a vertical object by reversing up against it (mainly adult females), cocking a leg doggy style (mainly adult males) or doing a handstand (only adult males).

To understand why some Giant Pandas go to such extraordinary lengths to deposit their scent, Angela White (San Diego Zoo) and colleagues studied 28 pandas, including adult and subadult males and females, and compared their responses to the same male and female odours placed at various heights above the ground. They found that pandas of all age-sex classes spent more time investigating and sniffing, and then moving farther away from, higher-placed odours. Subadult males in particular were very wary of urine that was placed to mimic the handstand positions of adult males and exhibited the greatest avoidance behaviour.

According to the researchers, scent height provides a reliable indicator of the scent-marker's size, and thus competitive ability. In other words, a well-aimed squirt tells other individuals to keep away.

—G.H

Orangutans—the only non-human primates to engage in rape as a routine means of siring offspring—and that of humans.

—R.S.

Ancient Nut-crackers

Pitted stones, discovered in 780,000-year-old deposits in Israel, were used to crack nuts, according to a team led by Naama Goren-Inbar from the Hebrew University of Jerusalem. Found on the banks of the Jordan River, at a site known as Gesher Benot Ya'aqov, the basalt stones were once thought to have been used as anvils or hammers for splitting rocks into sharp-edged cutting tools, but plants preserved at the site suggest otherwise. In the same levels as the pitted stones, the researchers found the remains of seven species of nuts—two pistachios, two oaks, Wild Almond, and the extinct Prickly Water Lily and Water Chestnut—mostly hard-shelled nuts that must be cracked open to get to the edible kernels.

Goren-Inbar and colleagues compared the results of stone-knapping experiments with wear patterns found on the ancient Israeli tools. Experimentally produced pits resembled the shallow, rough pits on the artefacts, but deeper, smoother pits on the ancient tools suggest an additional activity, which the researchers suspect was nut-cracking. They also suspect, based on observations of present-day hunter-gatherer societies, that our nut-cracking ancestors were mainly women with a good understanding of plants.

Chemical traces, starch granules and other organic

residues could not be detected on the artefacts, buried so long in the waterlogged sediments. But further nut-cracking experiments may provide more clues for interpreting wear patterns.

I have worked with Australian Aborigines who use stones to crack open edible nuts and fruits, and I would reckon that there are few modern humans who have not used rocks for similar purposes. Even Chimpanzees (*Pan troglodytes*) do it! Julio Mercader (George Washington University) and colleagues recently excavated a Chimpanzee 'archaeological site' on the Ivory Coast of Africa,

Australian Aborigines use stones to crack open hard-shelled nuts and seeds, such as those found in the Green Plum (*Buchanania obovata*).

LESLEY HEAD

where Chimps have developed a nut-cracking tradition spanning several generations. They collected and studied 40 kilograms of nutshells and four kilograms of stone 'artefacts', arguing that the Chimps engage in 'cultural' activities that can mimic early human sites in Africa. Like us, Chimpanzee nut-crackers plan carefully to get the right kind of hammers and anvils, they accumulate refuse middens of stone chips and nutshells, and females gather most of the nuts.

Clearly, nut-cracking tools are not just artefacts of modern humans. Our extinct hominid ancestors, and closest living relatives, used them too.

—R.F.

Lick Me, Moosey

Next time your garden looks a bit tired, it might be worth getting yourself a Moose. A rather bizarre experiment by Margareta Bergman (Swedish University of Agricultural Sciences) has found that Moose slobber actually stimulates sallow (*Salix caprea*) shrubs to grow.

Bergman re-created grazing by a Moose (*Alces alces*) by tearing off the top third of plants with a real Moose jaw, then applying Moose saliva (obtained under anaesthetic) with a pipette. Other plants were torn without being treated with saliva, or left alone. After 15 weeks, the saliva-treated plants had produced nearly twice the number of branches as the other two groups, although they did not grow taller or sprout more buds. Bergman suggests that if the experimental plants had been deprived of more nutrients or water, the saliva may have had an even greater growth-promoting effect.

Grazing by some large animal species is known to stimulate plant growth, but it seems the effect is more than just mechanical in this instance. So what's so great about Moose saliva? One possibility is the thiamine it contains, which plants need to metabolise nitrogen. Another is epidermal growth factor, a hormone often present in saliva and known to enhance shoot growth in sorghum.

Moose, like other ruminants, produce copious amounts of saliva—up to 50 per cent of their entire bodily moisture production per day. During courtship they positively drool all over their mates and anything else that gets in the way. Perhaps some plants have evolved to reap the benefits of eons of Moose-grazing, by producing a growth spurt to take advantage of this bounty.

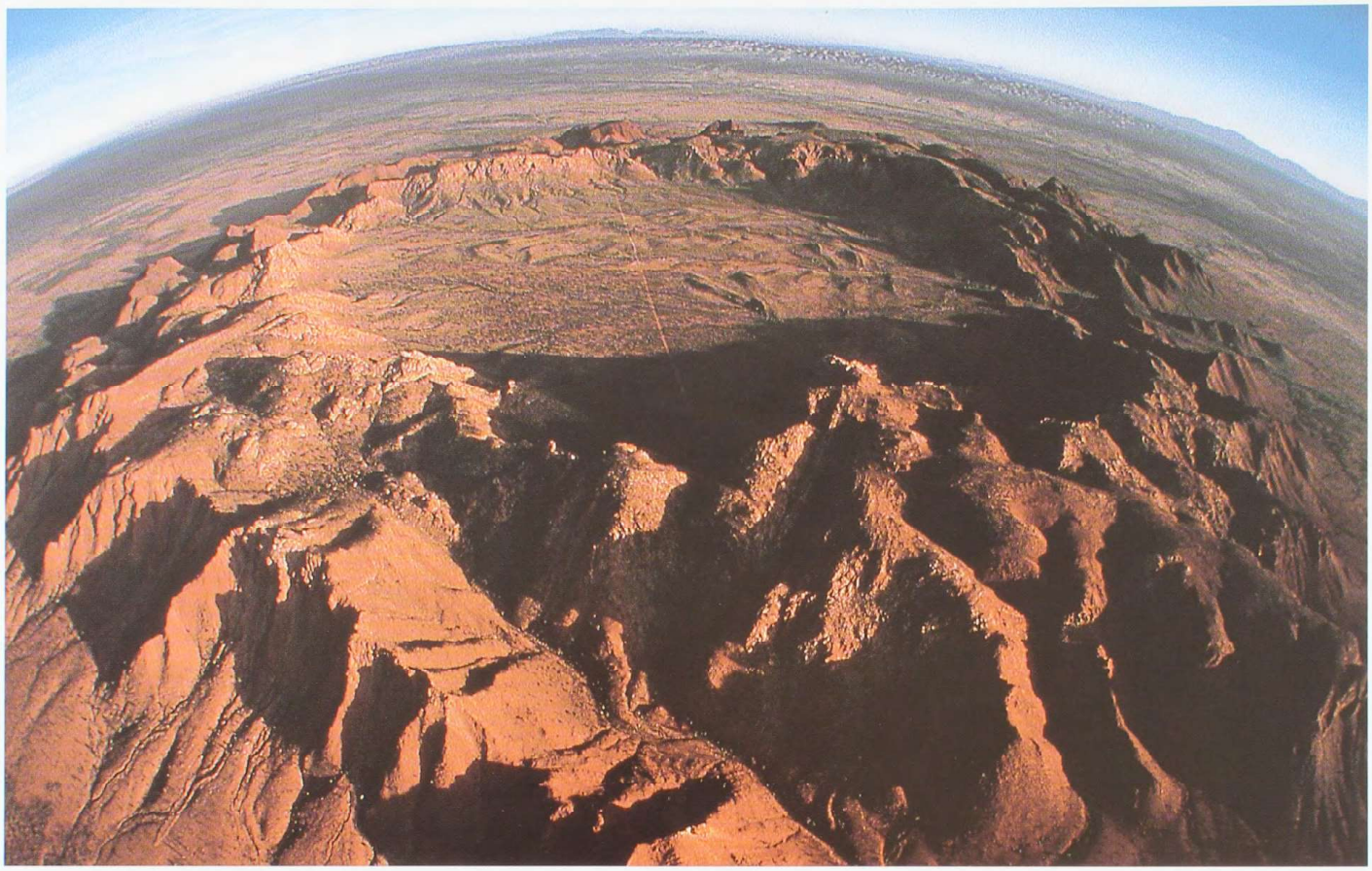
—A.T.

In with a Bang?

The demise of the dinosaurs 65 million years ago, as a result of a massive meteorite impact, has transcended science and

STEVE McCUTCHEON/ AUSCAPE

Some plants thrive on Moose slobber.



REG MORRISON

Meteorite impact site at Gosse Bluff, central Australia. Could a similar catastrophe have paved the way for dinosaurs?

captured the imagination of the general public. Now Paul Olsen (Columbia University) and colleagues have produced evidence for a similar cataclysm 200 million years ago that might have given these reptiles their evolutionary kick-start. In other words, in with a bang, out with a bang.

The team analysed deposits from an ancient lake system in eastern North America, which preserved an excellent geological record spanning this critical Triassic–Jurassic time period. Fossil footprints document an abrupt increase in both size and abundance of dinosaurs, and a corresponding reduction in other reptiles, including the ancestors of mammals.

Like Father, Like Son

It's a scene repeated thousands of times worldwide every day: relatives jostling for position over a newborn's crib discussing family resemblances. But does it really matter whom the children look like? It does if you're the father. New research, led by State University of New York psychologist Steve Platek, supports the view that men respond more favourably to children who look like them.

The researchers showed each of 20 male and 20 female undergraduates computer images of a toddler's face morphed with their own, plus the same toddler's face morphed with four different adult faces. Oblivious to the manipulations, the students were asked to rank the faces according to attractiveness and other related criteria.

Men were found to be more likely than women to nominate the face morphed with their own as the most attractive and the child they'd prefer to adopt and spend time and money on, and feel least resentment about paying child support for. In contrast, the females were indifferent to the images of babies' faces, including those that contained their own features, and took much longer to decide how to rank them.

After the experiments, all students said they couldn't detect any personal resemblances in any of the faces.

The researchers concluded that the way men react to children is subconsciously affected by paternal resemblance. This may have evolved originally to help males judge whether offspring they were investing time and energy raising were actually their own. Women, by contrast, have no need for recognising maternal resemblance because mothers always know who their children are.

—K.McG.

COURTESY B.D. PATTERSON

Maneless in Tsavo: how does lack of a mane affect a Lion's social life?

The Mane Thing

Balding middle-aged men react in myriad ways to their hair loss, from buying red sports cars to the dreaded comb-over. But how does the King of Beasts deal with the 'stigma' of male pattern baldness? Is it a case of no mane, no gain? Not according to a recent study of Lions (*Panthera leo*) from Tsavo East National Park in Kenya.

The Tsavo Lions are best known for the two hungry males that killed and consumed more than 135 railway workers in 1898 (see "Lion with a Sore Tooth", *Nature Aust.* Autumn 2001). But they also represent the only well-documented population where the males are maneless. Instead of the familiar big, bold, golden ruff, the Tsavo males sport a dorsal crest, chest tufts and some rather fetching sideburns.

Roland Kays and Bruce Patterson (Field Museum of Chicago) were interested in how manelessness affected the social lives of the Tsavo Lions. Because the Tsavo region is very hot and dry and food is scarce, they expected prides to be smaller with fewer males governing them.

They were correct on the latter point—in each of the five prides they observed, a single male ruled, compared to the two to four of the Serengeti. But contrary to their expectations, the prides were slightly larger, with seven or eight females rather than six or seven.

The researchers speculate that high levels of testosterone are behind both the Lions' manelessness and the characteristics of their prides. Testosterone is thought to be partly responsible for balding in humans and also plays a role in aggression. Tsavo Lions are thought to be especially aggressive and this would help to explain not only the males' apparent unwillingness to form the coalitions seen elsewhere, but also the ability of these single males to control a pride.

—G.T.

In addition, rocks at the Triassic–Jurassic boundary contain elevated concentrations of iridium and fern spores. This, the authors believe, might be evidence for a meteorite impact, since iridium is a rare metal found in high concentrations in meteorites, and ferns, which have the ability to disperse and recolonise areas quickly by means of their tiny wind-borne spores, could be expected to dominate in a post-impact world.

However, the evidence for the impact is more tantalising than compelling. For instance, iridium can also be produced by volcanic eruptions, and the 'spike' in iridium is weak compared with that 65 million years ago. Furthermore, additional evidence for a cataclysmic impact, such as 'shocked quartz', fossilised soot, and a crater of the appropriate size and age, remains elusive.

—M.L.

With 1,500 tactile hairs covering each side of the body, they appear to paint a three-dimensional picture of the environment.

Hairy Mermaids

Dugongs and Manatees have inspired many myths about mermaids, yet rather than lolling about seducing sailors, these gentle creatures spend most of their time

Body whiskers on a Florida Manatee: all the better to feel you with.

rooting up plants from the sea floor. Their life is a murky one and they can't rely on eyesight alone; so they have developed a unique arrangement of tactile body hairs that may allow them to 'feel their way' through the water.

Roger Reep (University of Florida) and colleagues took a close look at the hairs on the Manatee (*Trichechus manatus*) and discovered that each specialised hair follicle is linked to a series of nerves embedded in connective tissue. With approximately 1,500 tactile hairs covering each side of the body, they appear to paint a three-dimensional picture of the external environment, detecting water currents, tidal flow, as well as other animals and objects, through water displacement. This type of sensory detection system is analogous to the lateral line in fishes.

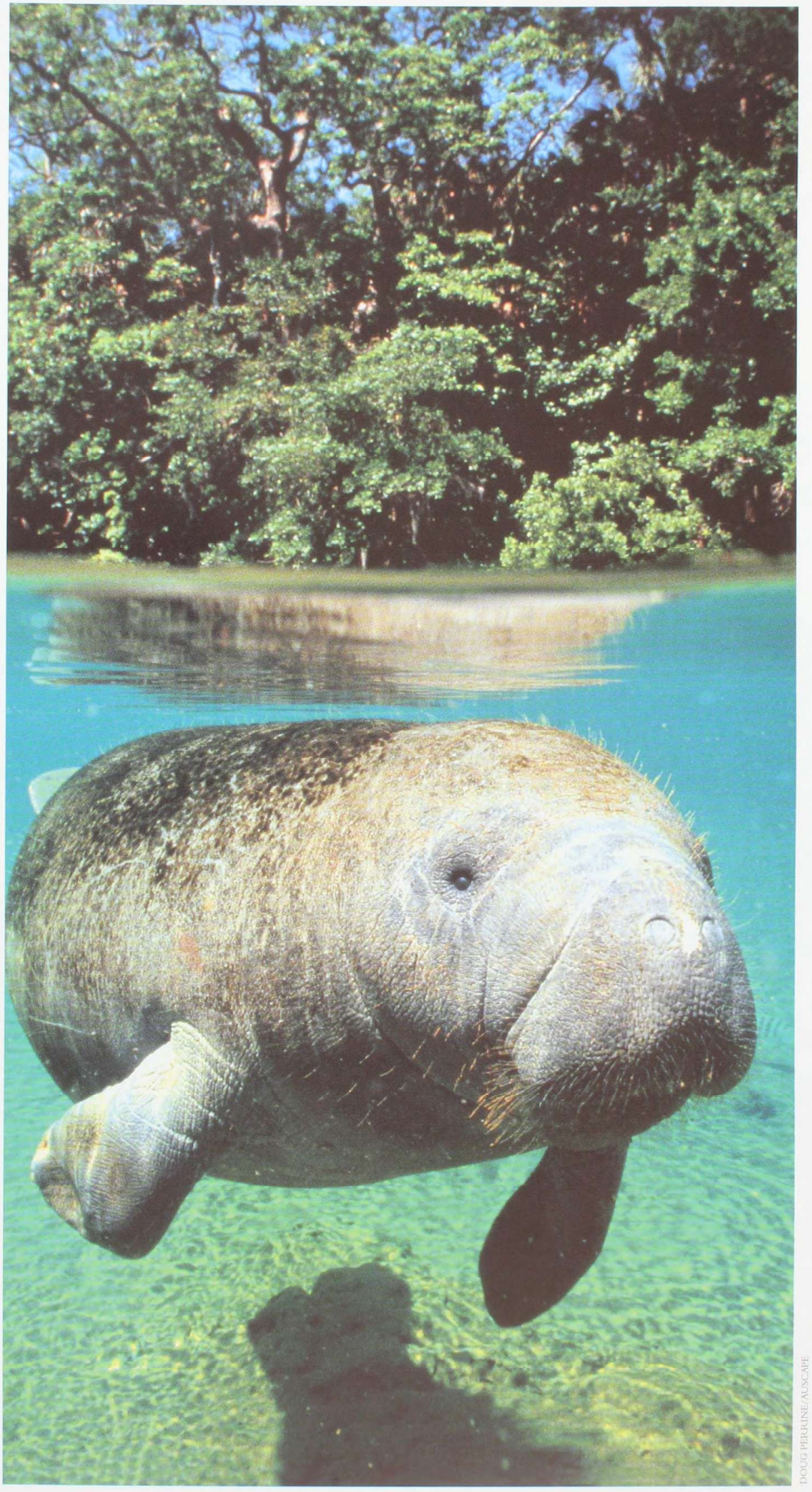
Although other mammals like cats and seals have tactile hairs known as vibrissae, Manatees and Dugongs are the only known creatures to have such bristles covering the whole of their bodies. And, while this condition may make them the hairy mermaids of the sea, it certainly beats fumbling around in cloudy waters.

—K.H.

Sensitive Crocs

Do crocodilians 'feel' for their prey? According to Daphne Soares from the University of Maryland, yes, and they have specialised organs for doing it.

Surrounding the mouths of crocodilians are lots of small, dark, zit-like bumps that Soares has named 'dome



DOUG PERRINE/AUSCAPE

pressure receptors' or DPRs. They hook up to the trigeminal nerve, the nerve responsible for sensory input and muscle activation around the mouth. By conducting behavioural experiments in total darkness, Soares demonstrated that they are pressure sensors. But what pressures are they sensing?

With the help of infrared film, Soares observed Alligators (*Alligator mississippiensis*) in a tank, watching their reaction to water droplets onto the surface of the pool.

LYNN M. STONE/AUSCAPE

Thick-skinned they may be, but semi-aquatic crocodilians like this Alligator are also very sensitive.

Alligators that were fully submerged or had their heads completely out of the water paid no attention to the drops, while those beasts that had their head half-submerged would quickly spin around to face the drop, or lunge at the source. But when Soares covered the DPRs with plastic elastomer, not even the half-submerged gators orientated themselves toward the drops. Along with anatomical and physiological data, Soares concluded that DPRs detect pressure differences travelling across the surface of the water—a useful skill if that's where most of your food comes from.

Fortunately for crocophiles, DPR nerves go through holes in the underlying bone. This means that fossils can be checked to determine when DPRs evolved. It turns out that they first appeared as soon as crocs became semi-aquatic creatures some 180 million years ago. Interestingly, a couple of weird, extinct crocs that are thought by some palaeontologists to have returned to the land lack DPRs.

Could the smile of the crocodile be a sign of a meal to come? Whatever you do, don't splash!

—P.W.

Incy Wincy Spiders

In the world of spiders, it's commonplace for a female to outsize her mate. In fact, the biggest size difference between the sexes of any land animal occurs in the arachnids. Next to the tiny male, the female can be colossal, weighing up to 100 times as much. So what causes these immense differences in size? While scientists explain female gigantism in terms of the number of eggs that can be produced, the reason for male dwarfism has been elusive, until now.

To examine the exaggerated sexual size dimorphism in spiders, Jordi

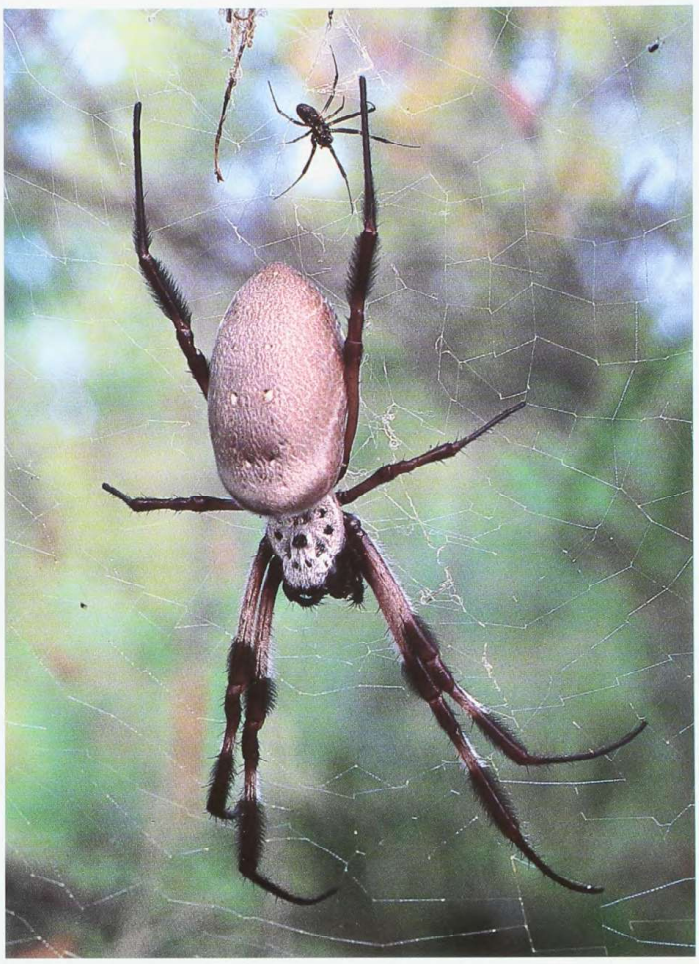
Moya-Laraño and colleagues from the University of Kentucky compiled a dataset of 112 species in 25 families, arranging them according to their habitats, in particular the height above ground that the females foraged. They found that the higher a species lived above ground, the smaller the size of the male.

The researchers believe that the shrinking size of males is a result of scrambling for sex. For spiders living high in the trees, males must climb to seek out females and so it follows that smaller, faster searchers will have the mating advantage.

This 'gravity hypothesis' explains why male and female ground-dwelling spiders are more similar in size, while those living in the tree tops are so bizarrely disproportionate in size. For the high-climbing incy wincy spider, smaller is smarter for sexual success.

—K.H.

Why is this male orb-weaving spider (*Nephila* sp.) so much smaller than his mate?



ANDREW DWOLL/LOCHMAN TRANSPARENCIES

Head-butting Whales

The classic tale of *Moby-Dick* was, like many novels, based partly on reality. Nineteenth-century documents contain several factual accounts of angry Sperm Whales (*Physeter catodon*) turning on whalers and, just like Herman Melville's Moby Dick, using their heads to charge and sink solidly built ships many times their size.

Sitting above the jaw and in front of the skull and brain is the 'spermaceti organ'—a robust arrangement of thickened

The Truth about Oil Spills

An environmental catastrophe loomed in January 2001 when the oil tanker *Jessica* hit a reef and spewed three million litres of fuel into the sea near the Galapagos Islands. Favourable winds and ocean currents, however, carried the slick away from the islands' unique wildlife. Disaster, it seemed, had been narrowly averted, and only six animal deaths were officially recorded as a direct result of the accident.

But investigations since then, led by Princeton University ecologist Martin Wikelski, have revealed that tragedy did in fact ensue.

For more than a decade before the accident, the researchers had fortuitously been gathering data on Marine Iguanas (*Amblyrhynchus cristatus*) on two of the Galapagos Islands—Santa Fe and Genovesa. Traces of oil reached the former, but not the latter. This provided some baseline data with which to compare before and after the spill. They found that, in the 11 months after the accident, almost two-thirds of the Santa Fe iguanas—some 15,000 individuals—had died, while mortality rates on Genovesa had remained normal. All evidence pointed to low-level oil contaminaton as the cause.

The iguanas, which are endemic to the Galapagos Islands, graze on marine algae growing on rocks. The researchers believe oil traces on the algae killed the gut bacteria that allow Marine Iguanas to digest their specialised diet. The resultant stress to the lizards probably killed them.

The research emphasises the potential long-term impacts of oil spills and has led to a reopening of the environmental law suit relating to the accident.

—K.McG.

D. PARER & E. PARER-COOK/AUSCAPE

Oily food is bad for your health, especially if you're a Marine Iguana.

FRANCOISE GOHIER/AUSCAPE

skin, connective tissue fibres, and two huge oil-filled chambers. This structure is thought by some to play a role in sound production or buoyancy control. However David Carrier and colleagues from the University of Utah believe it functions as a weapon in male–male combat.

Big male Sperm Whales have the most noticeable spermaceti organs (which are responsible for their square-shaped heads), but many other whale species also have oil-filled chambers, called melons, in their heads and have been observed head-butting when angry. Carrier and colleagues compared these species and

Sperm Whale, is that a weapon on your head?

found that whales with the largest melons relative to body size are also considerably bigger than females. In most animal species with extreme sexual size dimorphism, males clash with other males over breeding rights and they are commonly equipped with a weapon. In some whale species, the researchers say, the melon may be the marine mammal equivalent of antlers.

The researchers devised a mathematical model to determine whether it was physically possible for the spermaceti organ of a Sperm

QUICK QUIZ

1. *What colour eyebrows does a male Magpie Lark (Peewee) have?*
2. *Which assumed physical constant was reported last year to have decreased?*
3. *What do sandgrinders, drummers, bladders, blackboys and bunyips refer to?*
4. *What is the nickname given to Australia's largest sauropod dinosaur fossil, discovered in 1999 near Winton, Queensland?*
5. *How many species of living elephants are there?*
6. *What type of bird was the Dodo?*
7. *What was the world's longest fence built to keep out?*
8. *In which State would you find the Coorong wetland?*
9. *What are the two main elements in ochre?*
10. *What, apart from a melon, is honeydew?*

(Answers on page 83)

COURTESY DAVID L. BRILL/BRILL ATLANTA

Berhane Asfaw (left) and Henry Gilbert compare the 'Daka' *Homo erectus* skull, held by Asfaw, with African and Asian specimens. The anatomical similarities bridge the continental gaps and unify the species.

Whale to function as a battering ram. They found that the momentum of the spermaceti organ in an accelerating whale could seriously injure a stationary opponent of similar body mass, while at the same time cushioning the blow to the attacking whale. While head-to-head combat most likely delivers equal forces to both whales, landing a head butt to any other part of the body could be fatal.

—K.McG.

Goodbye *Homo ergaster*?

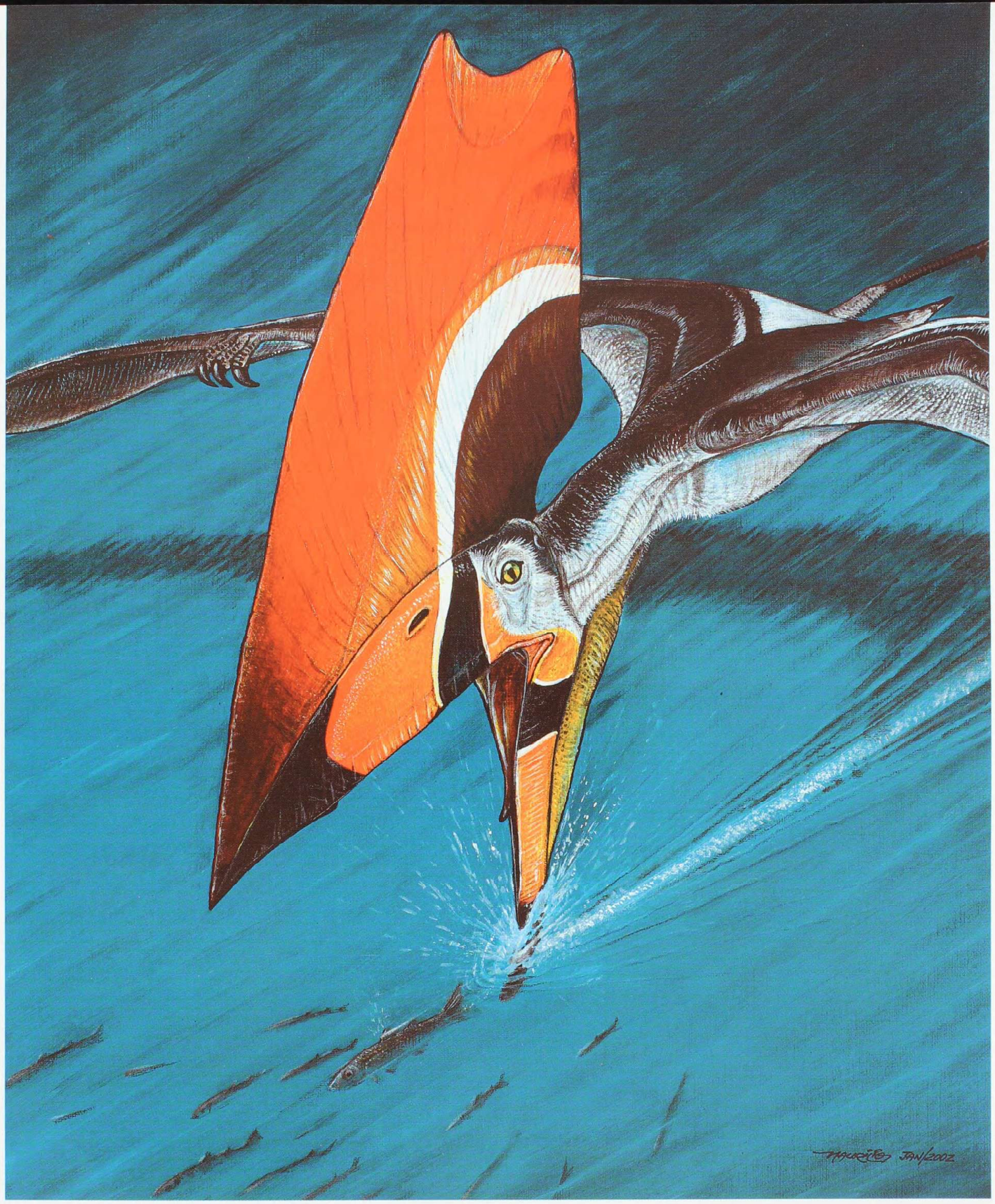
Debate has raged over whether *Homo erectus* is one species on the direct human line, or should be split in two: *H. erectus* in Asia, and *H. ergaster* in Africa and perhaps Europe (see "New First out of Africa", *Nature Aust.* Winter 2001). Scientists have argued that Asian *H. erectus* went extinct, and that only *H. ergaster* gave rise to modern humans (*H. sapiens*). However, recently discovered fossils from Africa have been assigned to *H. erectus*, indicating that there was no deep split between African and Asian representatives and that *H. erectus* was indeed our immediate ancestor.

Scientists have argued that Asian H. erectus *went extinct, and that only* H. ergaster *gave rise to modern humans.*

The fossil bones—a skullcap and three thighbones—come from the one-million-year-old 'Daka' Member sediments in Ethiopia's Awash Valley. Berhane Asfaw (Rift Valley Research Service) and colleagues examined the thighbones and noted their similarity to those of *Homo erectus* in Asia. They then compared the skullcap with other skulls from Africa and Asia, and found a considerable overlap in features. Based on this anatomical intermediacy, the researchers argue for a single, varied and widespread *H. erectus* species from about 1.78 to 0.5 million years ago.

Assigning a different name to the older specimens in Africa and Europe is, according to the researchers, misleading. Just as modern humans are a widespread and varied bunch, so too were *Homo erectus* individuals. Still, some prominent scientists disagree and simply refuse to say goodbye to *Homo ergaster*.

—R.F.



COURTESY MAURILIO OLIVEIRA

The distinctive skull of *Thalassodromeus sethi* suggests this pterosaur spent its days skimming over the surface of lakes or oceans, occasionally dipping its head into the water to nab a fish or two.

Skimming Hotheads

It had a head almost 1.5 metres long and a wingspan of more than four metres. Meet *Thalassodromeus sethi*, a newly described species of pterosaur (flying reptile) whose exquisitely preserved skull was found in the 110-million-year-old Araripe Basin deposits in Brazil. Most notable are the creature's huge yet largely hollow crest, and scissor-like bill.

The bony crest is proportionally one of the largest known from any vertebrate (living or extinct), making up about three-quarters of the length of the skull. And etched on its surface is a system of channels that appears to have once contained blood vessels. According to Alexander Kellner (Museu Nacional/UFRJ) and Diogenes de Almeida Campos (Museu de Ciências da Terra/DNPM), the crest most likely acted as a heat

exchanger, in much the same way as elephants' ears help to cool them.

The tip of the pterosaur's bill was strongly compressed side to side, a feature also present in the beak of a North American bird known as the Black Skimmer (*Rynchops niger*). As its name suggests, this fish-feeder skims across the water surface, catching its prey by dipping its lower jaw into the water and snapping up anything that gets in its way. The similarities in form between the bills of bird and beast suggest to the researchers that *Thalassodromeus sethi* also caught its prey by skimming.

—G.T.

Only Booby Girls Get the Blues

A study of the Blue-footed Booby (*Sula nebouxii*) has found that when the going gets tough, male chicks fair much better than females.

Working with a breeding colony of Blue-footed Boobies on the Peruvian coast, Alberto Velando (Universidade de Vigo, Spain) selected nests each with two eggs in them. After the chicks had hatched, and he had determined the sexes of the broods, he manipulated the ability of ten of the mothers to collect food for the chicks by trimming their flight feathers ('handicapping' them), thus increasing flight costs by five per cent. He then compared the fate of these mothers and their chicks with another ten that he had left untrimmed (the control group).

After 45 days, the daughters of handicapped mothers weighed eight per cent less than daughters of unhandicapped birds. Sons from both groups, however, weighed the same. In addition, Velando found that hatchling sex ratios were related to the mother's body condition: the lower the mass of the mother at hatching time, the more sons she produced, and *vice versa*.

What's going on here? It turns out that, under normal conditions, female booby chicks grow much faster than males, eat three times as much, and end up being about 30 per cent heavier than males. When reared under poor conditions, however, the more food-dependent female chicks become disadvantaged, and so it makes sense for mothers to invest in lower-maintenance sons. They do this by somehow manipulating the sex ratio of the brood before hatching.

—A.T.

FURTHER READING
References for the stories that have appeared in this edition of Nature Strips are available online:
www.natureaustralia.net

D. PARER & E. PARER-COOK/AUSCAPE

Politically incorrect? When times are tough, Blue-footed Boobies display sexual discrimination.

Snap, Crackle and Pop

In an area prone to fires, it makes sense that the resident animals possess special fire-detection abilities to maximise their chances of survival. Now Ulmar Grafe and colleagues from the University of Wurzburg in Germany have observed frogs fleeing from the sounds of fire, demonstrating for the first time that amphibians detect and respond to airborne sounds other than their own calls.

The team was in Africa's Ivory Coast following up Grafe's earlier observations of juvenile Reed Frogs (*Hyperolius nitidulus*) fleeing from an advancing fire well before other sensory cues such as heat or smoke could have been detected.

During the peak fire-danger period, the researchers played back recordings of crackling grass fires to aestivating (summer hibernating) frogs. They found that, despite the increased risks of desiccation and starvation, almost all the study animals responded by quickly hopping away from the noise towards protective cover.

Frogs flee from an advancing fire well before other sensory cues such as heat or smoke could have been detected.

Further analysis of the recordings revealed that it is the crackling and popping sounds, made up of rapid, broad-frequency sound bursts, that give Reed Frogs the cue to flee. The researchers explain that these acoustic characteristics are not found in other environmental signals, such as the rustling of leaves by other animals.

The team also played the recordings later in the dry season, when the risk of fire was lower but the chance of starvation and desiccation even higher. The playbacks elicited little response, suggesting that the frogs make a choice between the possibility of being barbecued and the probability of death by dehydration.

—R.S.

Kamikaze cuckoos

The Pheasant Coucal was never intended for high flying or aerial acrobatics.

NOT LONG AFTER MY GRANDparents finished building a retirement humpy overlooking a great steaming swamp at Bateau Bay, near Gosford, my grandfather, in a moment of heightened conscience, dismantled his unlicensed World War I revolver, and threw the bits far out into the swamp. That act, to a 13-year-old, amounted to admissible evidence that the old soldier had lost his marbles. How could he deny me the 'coolest' of all holiday toys, especially when, at that stage, I still hadn't managed to hit a jam tin with it at two paces?

So from then on, every time I went sloshing around in the marsh, one eye would be peeled for snakes or quicksand while the other eye would be scouring the swamp for the jettisoned pistol parts I secretly longed to reclaim and reassemble.

I'm now relieved to say the revolver bits never surfaced from the dark waters of the tannin swamp, but something from the bog did end up exploding in my face.

The swamp was full of eye-jabbing reeds and wallaby tracks, and one day, at the end of one of these alleys, I came across a small scruffy platform of broken stalks. Under the stalks and inside the shambles I could see a pair of red goblin eyes watching me from the dark. Whatever owned the bloodshot eyes let me creep up to within about 30 centimetres of it, and then with an awful squawk everything went black as a cloud of churning feathers and claws burst out of the hole and ricocheted off my head. It was a broody coucal, heaven bound after pressing the ejector button inside its nest.

We'd often seen them cruising low over the swamp, and we were familiar with their booming calls, but no-one had a clue about their nesting habits. My grandparents called them 'Swamp Pheasants', and that name really suited them, but having found a nest and seeing the four eggs in it made accepting the later discovery that they were really *cuckoos* something of a conceptual challenge! Wasn't it axiomatic that cuckoos had abandoned parental duties like Tasmanian Devils had forsaken table manners? Well, no. The surprising fact is that, while *all* Devils slurp their soup, only 50 of the world's 135 species of cuckoos are locked in to dumping their babies on neighbours. Cuckoos are defined on more rational grounds (anatomy, genetics etc.) than just their moral code, and because Swamp Pheasants qualify, we now acknowledge their cuckoohood in the 'new' name of Pheasant Coucal (*Centropus phasianinus*).

But even with the sophisticated name in tow, they are, without a doubt, the most ebullient buffoons of the Australian cuckoo clan and, while they are commonly heard whooping it up in spring, sadly they are most often seen either dead on the side of the road, or running head-down, flat-out toward your car's radiator grill. Not only do these Kamikaze cuckoos look like *Archaeopteryx* clones, but also their modest brains seem dogged by a determination to go down the same one-way track.

The flight of the Pheasant Coucal often approximates one of those early pedal-powered flying contraptions that would glide and flap to maintain a few metres of altitude before folding up and plummeting into the scrub. If a coucal manages to reach a tree or a shrub, its spectacular emergency landings usually leave it with wings and tail outstretched and scrunched up in twigs, its feet up around its ears. Then it slowly clambers lizard-like up through the branches until, at the top of the shrub, it sprawls out, sitting awkwardly and waiting for the next chance to bail out onto a lizard or a frog.

But the Pheasant Coucal was never intended for high flying or aerial acrobatics. Its coarse spiny feathers are perfect for the tangled swamps and grasslands where it hunts and nests. In fact nothing can prepare you for the feel of a coucal in the hand. Like a barbed spear, you can only stroke a coucal one way. The central shaft of each feather is thickened, sharp, and burnished like a modified fish scale. If you were going to engineer a lightweight, armour-plated frog-catching machine designed to slide efficiently through stalks and tangled

Pheasant Coucal

Centropus phasianinus

Classification
Order Cuculiformes (cuckoos), family Centropodidae (coucals).

Identification
Pheasant-like, male 550 mm, female 650 mm.

Habitat and Distribution
Dense riverine vegetation, swamp margins, mangroves, long grass, sugar cane, lantana, pandanus thickets. Broad distribution through non-arid northern Aust. south to near Ulladulla, NSW. Also in PNG, Timor and Torres Strait islands.

Biology
Eats insects, grubs, small crabs, snails, frogs, lizards, baby birds, rodents. Breeds Sept.–May (shorter season in monsoonal tropics), 3–5 eggs, incubated for 15 days. Chicks fledge in 17 days.

BY STEVE VAN DYCK

MICHAEL CERMAK

Hungry Pheasant Coucal chicks sing for their supper.

twigs, you might end up with a snake, but you could also end up with a coucal. And when a coucal comes up saturated from skulking around in the wet undergrowth, it simply spreads itself out like a picnic rug over a stump or a grass tussock, and waits for the sun to dry its bristly quills.

Coucals come in two popular colours, mainly mottled rusty brown for the winter, and resplendent black and rusty brown for the summer when fine feathers could make or break a cuckoo's bid for love. Both males and females put on their raven colours for the breeding season and establish territories with the aid of a booming call that sounds like 'Koop! Koop! Koop!...', each 'koop' repeated about 12 times, slowly and descending at first, then accelerating and rising. Although it probably won't come as a shock that the deeper call is produced by the female, and not by her scrawnier mate, there are still a couple of surprises left in this cuckoo that builds its own nest, sits on its own eggs, raises its own chicks and prefers walking to flying. For one, male coucals have only a single testis (on the left). Also, according to Aboriginal superstition, the approach of a coucal will cause the hair on the head and face to grow long.

I'm told the swamp where the pistol bits rusted and the Pheasant Coucals nested is now a car park for a shopping centre. Trading cuckoos for Kmarts might not come so automatically if our balding city fathers were occasionally reminded that flowing locks could come to those councillors who keep coucals above their scruples. □

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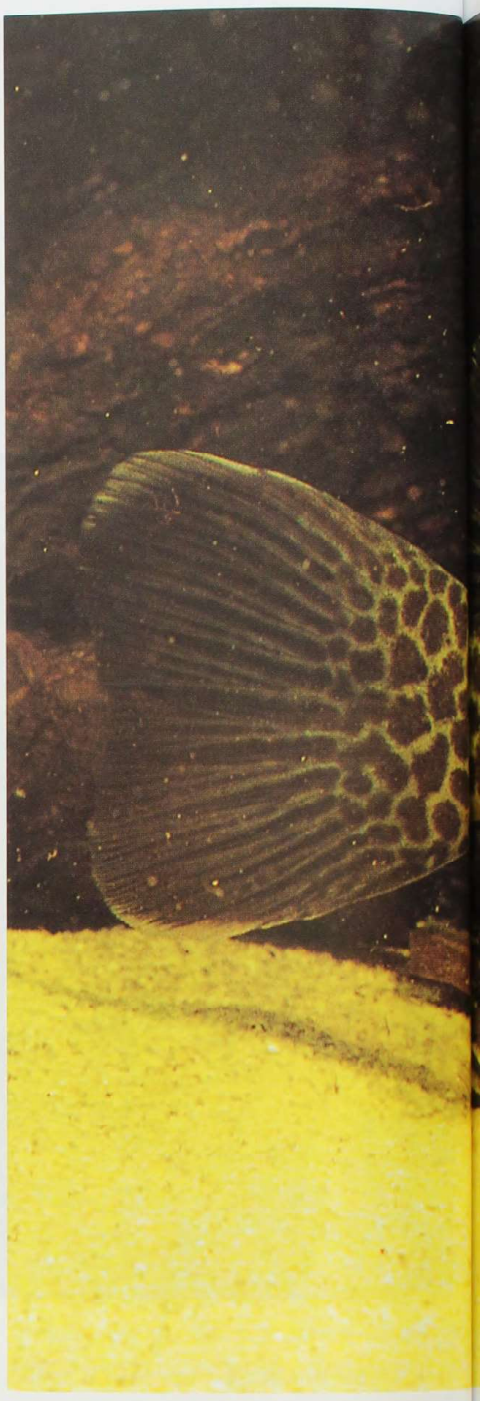
DR STEVE VAN DYCK IS A SENIOR CURATOR OF VERTEBRATES AT THE QUEENSLAND MUSEUM WHERE HE HAS WORKED SINCE 1975.

Mary River Cod

It was not until the 1980s that the unique status of the Mary River Cod was revealed.



THE SHADED, TIMBER-STREWN streams around Gympie in south-eastern Queensland are home to an impressive but until recently undescribed fish, the Mary River Cod (*Maccullochella peelii mariensis*). Closely related to the Murray Cod (*M. p. peelii*), the Mary River Cod was overlooked by scientists for many years despite its renown among anglers and landowners for its large size and excellent eating qualities. It was not until the 1980s that the unique taxonomic status of the Mary River Cod was revealed, and not until 1993 that the first formal scientific description of the subspecies was published.

Freshwater cod were common and abundant throughout coastal south-eastern Queensland as recently as 100 years ago. Years of overfishing and the effects of habitat changes have, however, taken their toll on Queensland's cod, and today wild populations are known to survive only in the Mary River system.

The Mary River Cod is very similar in appearance to the Murray Cod, leading early naturalists to assume the two forms were identical. Compared with the Murray Cod, however, the Mary River Cod has longer pelvic fins, and a deeper and shorter caudal peduncle (the area where the tail connects to the body). It also does not grow as large as the Murray Cod. Individuals have been reported up to about 38 kilograms, compared with over 113 kilograms for Murray Cod.

The Mary River Cod feeds on just about anything it can fit into its cavernous mouth. The main foods are smaller fishes and crustaceans, but there are also reports of birds, water dragons, Water-rats and bats being taken. The cod typically ambushes its prey from a hiding spot among sunken timber or rock ledges, but assumes a more active hunting role after dark, sometimes chasing its prey well up into the shallows.

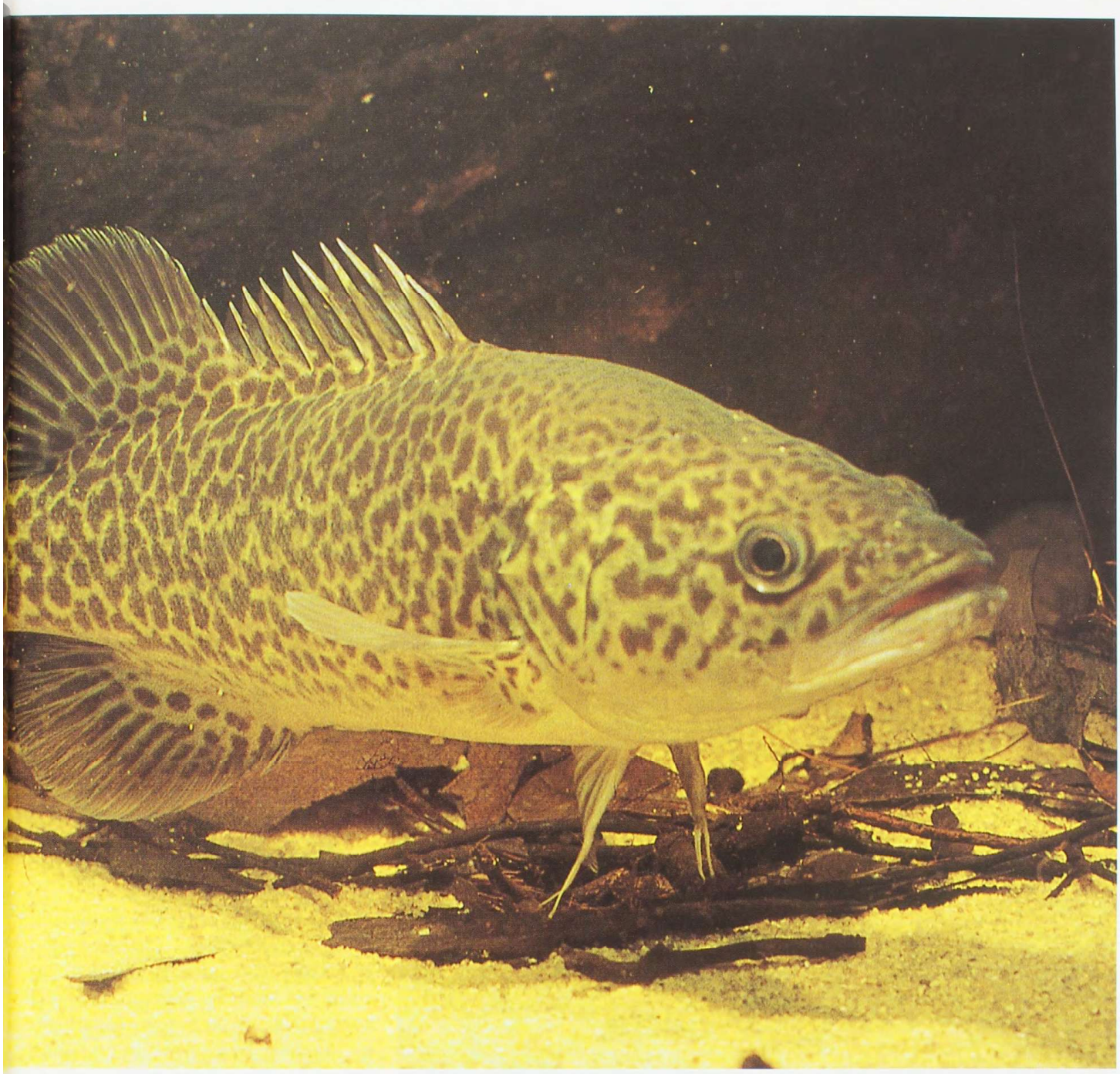
For most of the year, Mary River Cod occupy home ranges of between 100 and 1,000 metres of the river, but high water levels during the summer/autumn wet season stimulate many of the cod to move considerable distances—more than 30 kilometres in less than a week is not uncommon. The cod take advantage of high water levels to disperse to new areas that may provide untapped food resources and potential new mates. Some cod will repeatedly return to the same location year after year. This 'homing' behaviour presumably helps cod make best use of the limited resources in a stream by taking them back to an area with which they are familiar and has provided for their needs in the past.

The Mary River Cod feeds on just about anything it can fit into its cavernous mouth.

Breeding behaviour has not been observed in the wild, but during spring males in fish hatcheries select hollow nesting pipes, which they defend against all intruders. They allow a female into the nest to lay her tens of thousands of eggs, and then chase her off. They guard the eggs for around a week until they hatch, and guard the hatchlings for another week until they disperse and start feeding.

Perhaps the greatest impact leading to the decline of the Mary River Cod has been the loss of deep, shaded riverine habitats following extensive clearing of riparian (river) and floodplain vegetation for farming and forestry. Parts of

BY BOB SIMPSON



GUNTHER SCHMIDA

the Mary River where cod numbers have remained highest are those that have not suffered the extensive erosion and sedimentation now evident throughout the main river channel. Although vegetation clearing is not a major issue in the Mary River basin today, erosion of unstable stream banks continues to contribute to the infilling of cod habitats.

The Mary River Cod is listed as endangered under the *Environment Protection and Biodiversity Conservation Act* 1999. A Recovery Plan highlights breeding and restocking, habitat restoration, and research and monitoring as key issues for cod recovery. Significant progress is being made in all of these areas, and while the future of the Mary River Cod is not yet assured, the chances of it regaining its position as top aquatic predator in the Mary River appear promising. □

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BOB SIMPSON IS A FISHERIES BIOLOGIST WITH THE AGENCY FOR FOOD AND FIBRE SCIENCE (FISHERIES), QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES. HE HAS BEEN RESEARCHING THE MARY RIVER COD SINCE 1991.

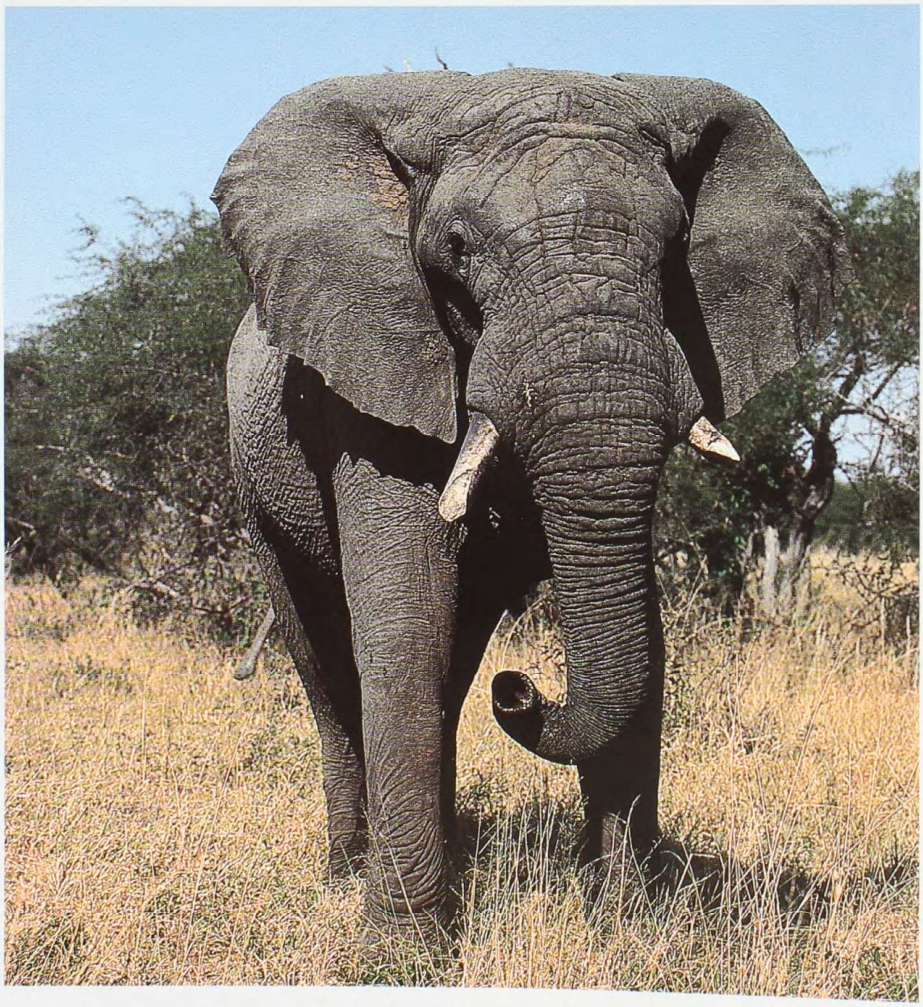
Ecosystem engineers

The power to change landscapes does not, on its own, make us unique.

HUMANS, LET'S FACE IT, ARE animals, but we don't usually think of ourselves that way because we seem so different. We don clothes, drive cars, spend long hours in little offices, and pretend to comprehend talkback radio. But, as biologists keep observing, we aren't always as special as we think we are. There are animals out there that use tools, take medicines, sing, farm, and transmit culture.

One reason for setting ourselves apart from other species is that we behave so destructively. We can't afford to think of ourselves as just another mammal when we continue to level forests, build ever more cities, roads and dams, and cause erosion and pollution. Yet other animals do these things too.

Some years ago I was amazed to come across a massive erosion gully in a Zimbabwean national park—denuded, crumbling banks around a quagmire of mud. In another park I saw a hillside that was slowly sliding away. Had a farmer caused this instability he would be hounded off the land. But the damage had been done by elephants.



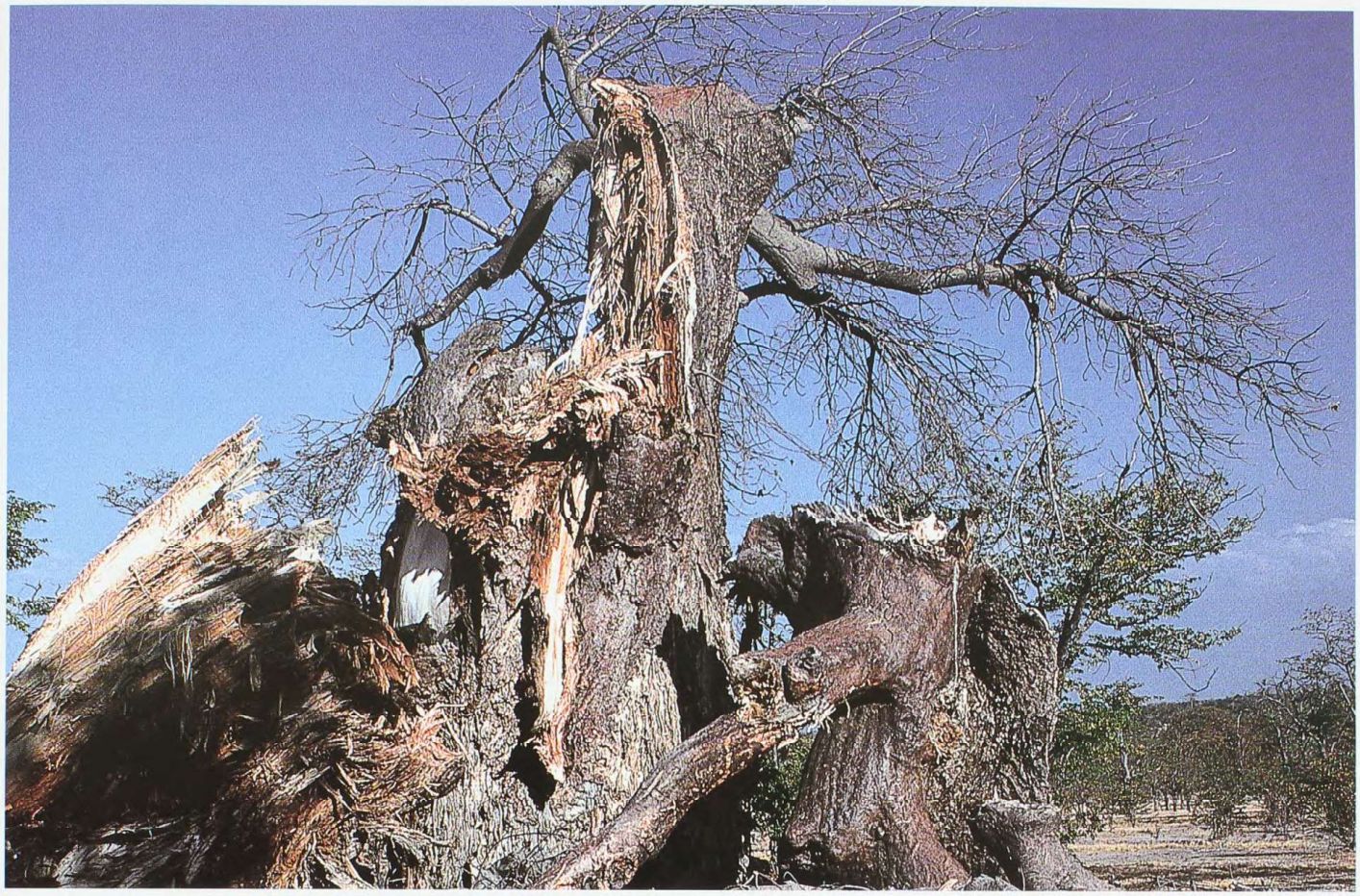
African Savanna Elephants (*Loxodonta africana*) also flatten woodlands, excavate dams, and forge roads through forests. Many of the waterholes in Africa's national parks began life as termite mounds. Elephants gouging into old mounds to eat mineral salts leave hollows that collect rain. Wallowing elephants, buffaloes and warthogs eventually create deep pools by carrying off coats of mud. Elsewhere in the world, beavers and alligators create dams, and beavers also fell trees.

Australia lost its giant mammals some time ago, so we don't know to what extent diprotodons and giant wombats fashioned the land. But Tim Flannery (South Australian Museum) refers to *Palorchestes azael* as the 'Tree-feller' because the forearm architecture of this massive tapir-like marsupial suggests it tore down branches to feed. In western New South Wales, James Noble (CSIRO) has found large crescents of sand and circular mounds that he attributes to extinct animals. The sand crescents, up to 100 metres long, were left by giant burrowing rat-kangaroos, he suspects, and the 20-metre-wide mounds by oversized mallee fowl.

Australia's living animals are still busy reworking the land. Orange-footed Scrubfowl (*Megapodius reinwardt*) in northern Australia rake up immense nesting mounds up to five metres high. In south-eastern Australia foraging Superb Lyrebirds (*Menura novaehollandiae*) erode steep slopes, shifting rocks up to two kilograms in weight and moving up to 45 tonnes of soil per hectare per year. In Tasmania, where lyrebirds were introduced (to help conserve them) in the 1930s, their earthmoving impacts are a significant ecological problem, especially for the critically endangered Myrtle Elbow Orchid (*Arthrochilus huntianus nothofagicola*). Breeding seabirds on steep-sided islands not only trigger erosion, they also pollute the earth, often killing the plants that hold soil in place. Seals do this too. Pebble-

BY TIM LOW

The African Savanna Elephant is the world's most damaging animal after *Homo sapiens*.



PHOTOS: TIM LOW

Destruction of ancient Baobab Trees (*Adansonia digitata*) by hungry elephants is a concern in African national parks. The larger Baobabs are thought to exceed 4,000 years in age.

mound mice (*Pseudomys* species) form enduring stone mounds up to nine square metres in area, and the earthen mounds built by False Water-rats (*Xeromys myoides*) on mudflats often support their own distinctive vegetation. Even tiny termites contribute to landscape change when they build their massive mounds.

Both 'city-building' and 'farming' go on in the sea. Coral polyps build vast 'cities' that end up housing myriad organisms, ranging from octopuses and algae to moray eels, and Western Australia's Buffalo Bream (*Kyphosus cornelii*) create patchwork 'farms' of grazed algal turf bordered by seaweed hedges (see "Marine Buffalos", *Nature Aust.* Autumn 2000). Their paddocks, each about six metres across, can be seen from low-flying planes.

In 1994, Clive Jones and colleagues (Institute of Ecosystems Studies, New York) coined the term 'ecosystem engineers' for habitat-changing animals and plants. They described *Homo sapiens* as a "physical ecosystem engineer par excellence". Their classification puts a new perspective on human behaviour, by showing that the power to change landscapes does not, on its own, make us unique. Rather, we lie on a continuum alongside elephants, termites and other engineers.

Recognising this could prove helpful in our quest to live sustainably. Implicit in many conservation arguments is the message that humans are an inherently destructive species. Nature is portrayed as essentially good, *Homo sapiens* as bad. This message is so negative it often fails to win much-needed converts or spur positive action. It also distances us from nature when a closer relationship is required. I believe that, yes, we are far more destructive than any other species, but that we are not fundamentally unique, only different by degree. If erosion, pollution and deforestation are fundamentally 'bad', then nature can be bad too, because there are animals that erode, pollute and knock down trees, to the detriment of other species.

Today's environmental challenges are immense, but that's because there are too many people exerting too much impact, not because we are inherently destructive. If six billion elephants were roaming the globe instead of six billion humans, things might not be much better. □

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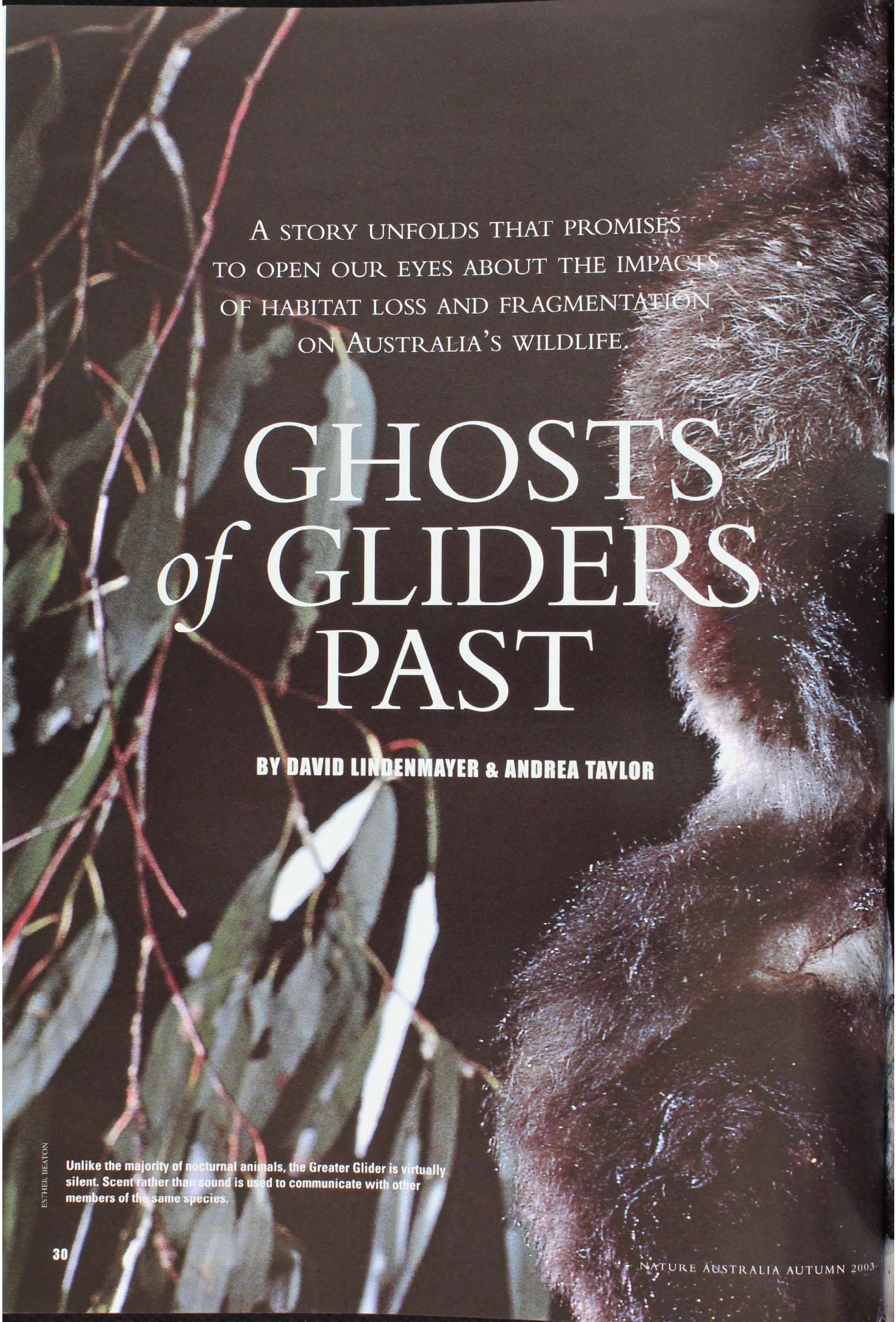
TIM LOW, A BRISBANE-BASED CONSULTANT AND WRITER, PONDERS ECOSYSTEM ENGINEERS IN HIS LATEST BOOK, *THE NEW NATURE* (PENGUIN).



A STORY UNFOLDS THAT PROMISES TO OPEN OUR EYES ABOUT THE IMPACTS OF HABITAT LOSS AND FRAGMENTATION ON AUSTRALIA'S WILDLIFE.

GHOSTS *of* GLIDERS PAST

BY DAVID LINDENMAYER & ANDREA TAYLOR

ESTHER BEATON

Unlike the majority of nocturnal animals, the Greater Glider is virtually silent. Scent rather than sound is used to communicate with other members of the same species.

THIS IS A GHOST STORY. Set in Tumut, 100 kilometres west of Canberra, it all started in 1932 when extensive native eucalypt forests near the town were being cleared and replaced with exotic stands of Radiata Pine (*Pinus radiata*). The plantation (now called Buccleuch State Forest) has since expanded to over 70,000 hectares. The deep green of Radiata Pines is occasionally broken up with patches of smoky green—islands of native bush that escaped clearing and are now scattered as archipelagoes within the sea of American imports. In this vast pine-dominated landscape a story unfolds of ghosts of past gliders—a story that promises to open our eyes about the impacts of habitat loss and fragmentation on Australia's wildlife.

In all, 192 patches of original eucalypt forest escaped clearing at Tumut. The remnants range in size, shape and composition, but the main tree species are Ribbon Gum (*Eucalyptus viminalis*), Narrow-leaved Peppermint (*E. radiata*) and Red Stringybark (*E. macrorhyncha*). Unwittingly, by leaving the patches of native bush, State Forests of New South Wales, which manages the Buccleuch State Forest, provided an extraordinary opportunity for a large-scale natural experiment that statistician Ross Cunningham and one of us (David Lindenmayer) began with many of our colleagues in 1995 and that continues to this day.

One of the aims of the work at Tumut has been to determine which species of vertebrates and invertebrates have managed to persist in the remnant patches of eucalypt forest since their isolation some 70 years ago. The first group of animals studied were the arboreal marsupials—possums and gliders—and it soon became clear that virtually none of these animals lived in the stands of Radiata Pine. This is hardly a surprising result since these enormous areas of conifers do not produce flowers, nectar or fruit, important foods for many possum and glider species, and the pines are harvested well before they can develop hollows necessary for shelter and nesting. However, exhaustive field surveys showed that several species of arboreal marsupials survived in the eucalypt patches surrounded by pines. One of these was the Greater Glider (*Petauroides volans*), which was found in about 40 per cent of the patches surveyed by spotlighting.

C. ANDREW HENLEY/LARUS

A Greater Glider in flight. The Greater Glider is the largest but least manoeuvrable of the six species of Australian marsupial gliders, but can nevertheless glide distances in excess of 100 metres.

THE GREATER GLIDER IS AN EXTRAordinary animal. It is the largest species of gliding marsupial in Australia, with adults weighing up to 1.3 kilograms. In many respects it could be likened to a small gliding Koala because its diet is comprised almost entirely of eucalypt leaves. It also spends a large

C. & D. FRITH/FRITHFOTO

Greater Gliders are often seen feeding in the outer canopy of eucalypt trees, where younger, nutritious leaves are more common.

amount of time at night doing very little. Such prolonged periods of inactivity are designed to save energy—energy that is directed toward digesting difficult meals of eucalypt leaves containing toxic chemicals, including some with properties not unlike cyanide!

The research at Tumut showed that not all eucalypt remnants are created equal from the perspective of the Greater Glider. The species prefers the larger remnant patches, particularly those bigger than about eight hectares and containing stands of some of their favourite food trees such as Ribbon Gum and Narrow-leaved Peppermint. The Greater Glider is also less likely to be found in eucalypt remnants surrounded by pines than in identical but unfragmented areas of forest in the nearby national parks. This suggests that the pine plantation might have limited the amount of movement between continuous eucalypt forest and the remnants, and acted as at least a partial barrier to the dispersal of the Greater Glider.

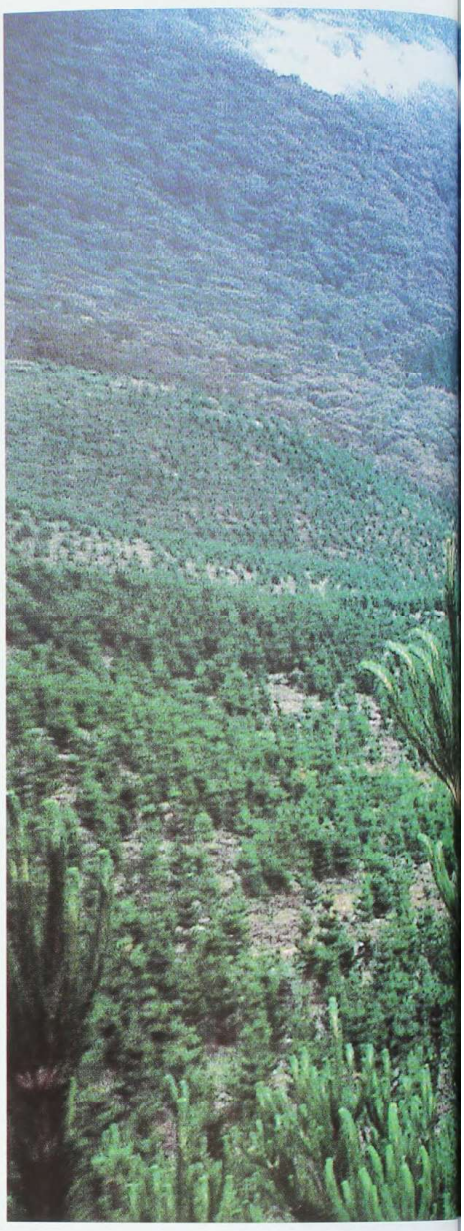
After the research at Tumut had begun, we discovered that the study area was the same one that had been used in an earlier seminal investigation of the Greater Glider by Hugh Tyndale-Biscoe (CSIRO) and his colleagues. Their work, conducted during the 1960s, revealed the sobering discovery that Greater Gliders stay faithful to their home range, even when massive disturbances like forest clearing are taking place. Essentially, animals die *in situ* rather than move to adjacent undisturbed forest. Enormous numbers of Greater Gliders would have died in this way as thousands of hectares of native forest were cleared. Tyndale-Biscoe and his team also showed that the few individuals that did manage to survive the initial stages of habitat destruction were often found in places they would never normally use, such as in small short saplings close to or even on the ground.

As a result, they were easily caught by predators such as Foxes, Dogs and Wedge-tailed Eagles.

Given that so many gliders were going to die because forestry operations had eliminated habitat for them, Tyndale-Biscoe collected and deposited numerous specimens of the Greater Glider in the major museums around Australia. Immaculate records were kept for every Greater Glider collected at Tumut, including maps of the precise locations where each animal was found. Tyndale-Biscoe then diligently archived this information and 40 years later it has proved to be valuable in ways that could never have been imagined when it was first gathered. We have visited these museums and collected small samples of skin and fur as well as a tooth from each glider. As this article is being written, a team of geneticists at Monash University is extracting DNA from these specimens. By linking the location record of each animal with its genetic profile, it will be possible for us to reconstruct the former 'genetic landscape' of the populations; that is, the patterns of genetic relatedness among the populations of gliders that used to exist at Tumut at the time the forest was being cleared.

THE SECOND EXCITING EPISODE OF this ghost story arises from the fact that several remnant patches of native eucalypt forest still exist within the areas studied by Tyndale-Biscoe in the 1960s, and some of these still support Greater Gliders. This makes it possible to compare the genetic landscape of the patchy populations that persist today with the genetic landscape as it was 40 years ago. To do this we had to catch animals that currently live in the eucalypt patches, collect a small tissue sample for genetic studies, and then release the animals where we caught them. We

ESTHER BEATON



(Above) Strips of native eucalypt vegetation, even those only 20–30 metres wide, can provide suitable habitat for Greater Gliders within a sea of inhospitable Radiata Pine plantation forest. (Left) Two colour forms of the Greater Glider. Multi-colour pairings are not uncommon in some parts of the species' range (such as the Brindabella Ranges near Canberra).

DAVID LINDENMAYER

also caught animals in the large nearby areas of continuous eucalypt forest to compare unfragmented populations with those in the eucalypt remnants.

Because Greater Gliders spend so much of their time high in the canopy of eucalypt trees, it is far from straightforward to set traps at the appropriate height for them. Even if this were logistically feasible, baiting a trap with foliage plucked from trees is hardly going to entice an animal into a trap when it has an almost infinite choice of other fresh leaves to eat! So we decided to follow the lead of several workers in Queensland and elsewhere in southern New South Wales who had previously found that the most effective way to capture a glider is to use a rifle to shoot down the branch on which the animal is sitting. The glider 'rides' the severed

Greater Glider

Petauroides volans

Classification
Family Pseudocheiridae.

Identification
Largest of all Aust. marsupial gliders, with animals in southern part of range weighing up to 1.3 kg. Distinctive bright white eye-shine under spotlight. Long pendulous tail. Dorsal coat colour varies from creamy white to jet-black. Rarely makes any vocalisations. Two subspecies: smaller 650-g *P. v. minor* from far north Qld, and larger 1.0–1.3-kg *P. v. volans* from central Qld south to Melbourne.

Habitat and Distribution
Wide range of tall open eucalypt forest and taller dry eucalypt forest, throughout Great Dividing Range from far-northern Qld to Melbourne, Vic. Absent from Tas.

limb until it is less than five metres from the ground, and then glides off and lands on the ground. Researchers then have about 20 seconds to capture the animal by hand before it reaches the trunk of a nearby tree and climbs back into the canopy. Once captured, the animal is bundled into a hessian sack and sedated to minimise stress. A tiny blood sample is then taken and the animal released back into the forest once the sedative has worn off. The team, which consisted of expert marksman Matthew Pope (ANU), several energetic biologists and a highly experienced wildlife veterinarian, made several hundred successful captures of Greater Gliders in this way. The only hiccup that occurred was a shoulder injury to one of the biologists who ran into a tree while apprehending a glider!

While gliders from some of the patches were sedated, we took the opportunity to attach radio-collars to them so we could track their night-time movements and identify the large hollow trees they used for resting during the day. Five patches of different sizes and shapes were targeted for tracking over a 12-month period, and the work has formed the basis of Pope's Master of Science study.

Integrating the radio-tracking work and the genetic studies has provided an outstanding opportunity to address a range of key questions associated with the effects of habitat fragmentation on the Greater Glider. For example, do patterns of home range use and the occupancy of tree hollows change according to patch size and shape? Are populations in the eucalypt remnants genetically isolated from one another and/or those in the continuous forest? We should also be able to identify the genetic origins of animals in the eucalypt remnants and to determine whether there has been any dispersal from other patches or the continuous forest, or whether the animals in the patches represent 'relict' populations that have survived despite being completely isolated for up to 70 years. If the second scenario arises, then it may be possible to explore potential genetic problems like inbreeding.

There are already some significant results. For example, Pope has found that home ranges of animals are smaller in small fragments. Fewer hollow trees are also used in the smaller eucalypt patches. The genetic analyses have revealed that most animals within each eucalypt remnant are related, which means there has been limited dispersal between remnants, and also between the continuous eucalypt forest and the remnants. However, there have been some rare long-distance movements by a few individuals that have clearly originated from other patches several kilometres away. Importantly, a radio-collared disperser was among those independently verified by genetic methods as having dispersed, which gives us hope that these new and relatively untested genetic analyses tell us something real about the movements of animals.

THE ONLY

hiccup that occurred was a shoulder injury to one of the biologists who ran into a tree while apprehending a glider!

Extracting 'ghost stories' from the gliders at Tumut would have been impossible had it not been for the immaculate recording-keeping of Tyndale-Biscoe—a valuable lesson on careful and systematic data collection for all field biologists—and the collaborative efforts of scientists from several disciplines (ecology, genetics and statistics). It has also demonstrated the importance of museum collections and the critical role they can play in revealing new insights into the biology, ecology and conservation of Australia's native fauna. Our work at Tumut will improve our understanding of the impacts that habitat loss and habitat fragmentation have on populations of gliders. This will, in turn, assist in developing ways to better conserve not only gliders, but also other elements of Australia's unique biota. □

A pale colour form of the Greater Glider. Some populations such as those in the forests near Healesville in Victoria are comprised almost solely of white-furred animals.

ELIZABETH TASKER/WILDLIFE IMAGES

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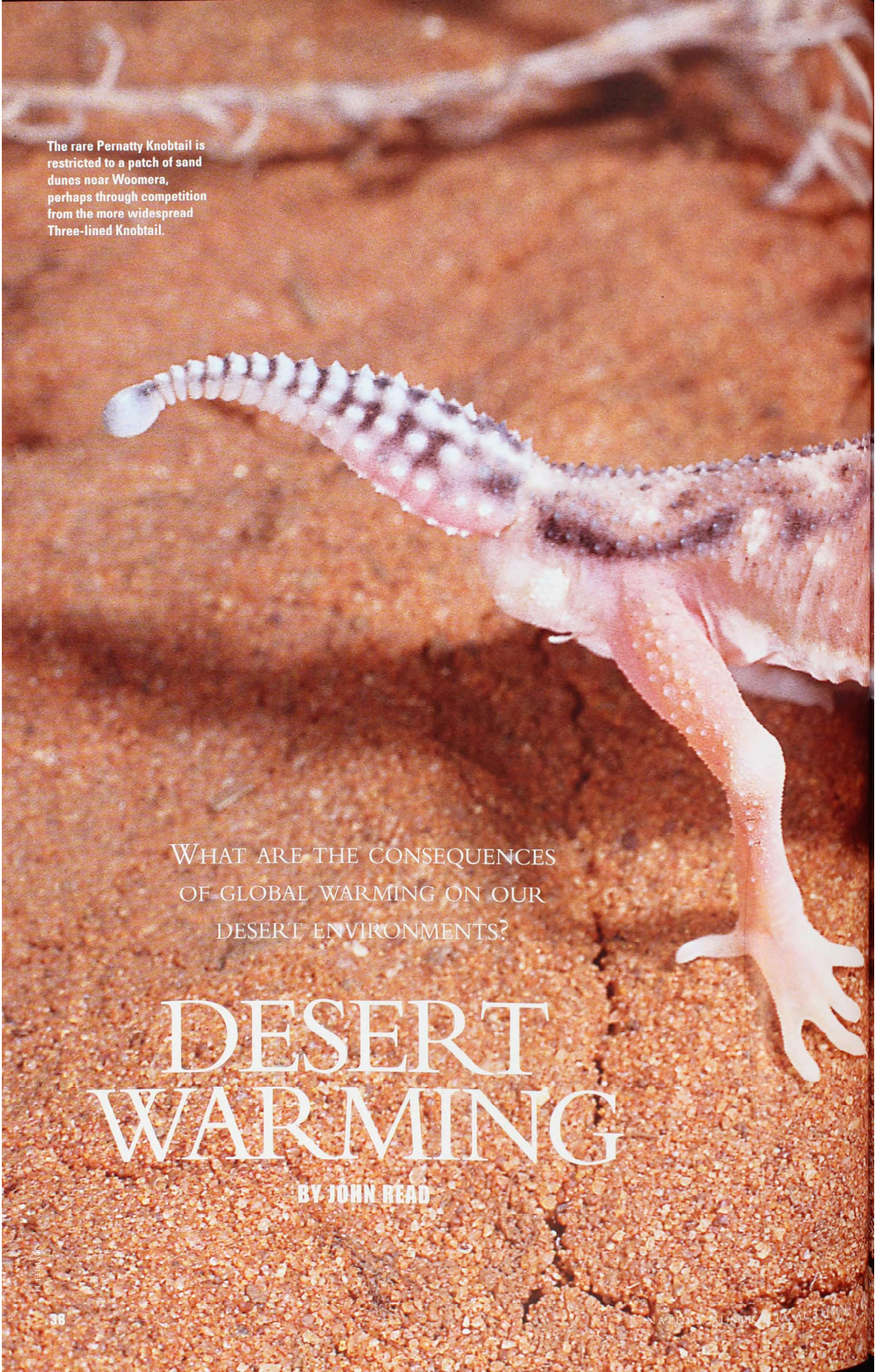
ASSOCIATE PROFESSOR DAVID LINDENMAYER IS A SENIOR RESEARCH FELLOW AT THE CENTRE FOR RESOURCE AND ENVIRONMENTAL STUDIES (CRES) AT THE AUSTRALIAN NATIONAL UNIVERSITY (ANU) IN CANBERRA. ANDREA TAYLOR IS A RESEARCH FELLOW IN THE DEPARTMENT OF BIOLOGICAL SCIENCES AT MONASH UNIVERSITY IN MELBOURNE. THEY ARE JUST TWO OF A LARGE TEAM OF RESEARCHERS WORKING ON THE TUMUT FRAGMENTATION EXPERIMENT.



The rare Pernatty Knobtail is restricted to a patch of sand dunes near Woomera, perhaps through competition from the more widespread Three-lined Knobtail.

WHAT ARE THE CONSEQUENCES OF GLOBAL WARMING ON OUR DESERT ENVIRONMENTS?

DESERT WARMING

BY JOHN READ

BLEACHED CORAL AND DISPLACED coastal communities are key images in the once-controversial, yet now widely accepted, debate on global warming. 'Greenhouse' gases, released by the burning of fossil fuels for transport and power generation, are partially responsible for this major environmental and economic threat to marine and beach environments. Given the predicted disastrous consequences for our heavily populated and much-visited coastal regions, it is not surprising that scientists, activists and the general public have joined forces in campaigning for Australians and other industrialised nations to reduce our dependency upon fossil fuels.

Although there is widespread concern over the effects of climate change on our coastal environments, the consequences of global warming on our desert environments have received far less attention. At first it would appear that the arid-adapted plants and animals in the harsh Australian deserts would be exceptionally tolerant of a slight temperature increase. However, not only are temperatures rising, but the frequency of heavy rainfall events are also expected to increase over much of inland Australia. Despite our intuition that rain is always welcomed in central Australia, some of our toughest reptiles may disagree.

LAKE EYRE DRAGONS
have few competitors or predators in their favoured salt-crust habitat.

LAKE EYRE DRAGONS (*Ctenophorus maculosus*) are spectacularly adapted to living on the salt beds of dry inland lakes. During the morning and late afternoon they patrol their salt-encrusted territories for *Melophorus* ants and unfortunate insects that have succumbed on the lake bed. Their high temperature tolerance, well-shielded eyes, and lack of external ear openings to keep out dust and salt, make them one of the toughest reptiles on Earth.

Because other vertebrates cannot tolerate such harsh conditions, Lake Eyre Dragons have few competitors or predators in their favoured salt-crust habitat. However, when floods course down the typically dry creek beds from as far away as central Queensland and inundate Lake Eyre and other inland lakes, the dragons are left stranded, like fish out of water. All of a sudden they not only have to evacuate their territories and swim or float to the shore, but they have to compete with other reptiles. Superabundant Painted Dragons (*Ctenophorus pictus*) and the large Central Bearded Dragons (*Pogona vitticeps*) are more at home in the sandy shoreline habitats, while brown, stone-like Smooth-snouted Earless Dragons (*Tympanocryptis intima*) are better camouflaged than the pale Lake Eyre Dragons where the shoreline is rockier. These displaced salt-lake specialists are also now vulnerable to

MICHAEL CERMAK

The fat-filled tail of the Three-lined Knobtail may help it overcome the unpredictable conditions of Australia's most arid regions.

D. PARER & E. PARER-COOK/AUSCAPE

Lake Eyre Dragons will have to leave their preferred salt-crust habitat more often if global warming increases the frequency of floods in the outback.

predators, such as snakes and Gould's Goannas (*Varanus gouldii*), that patrol the shoreline but don't venture onto the lake bed.

Waterbirds, however, may present the greatest threat to Lake Eyre Dragons. Gull-billed Terns (*Sterna nilotica*) prey heavily on dragons near their outback nesting colonies. Silver Gulls (*Larus novachollandiae*) also flock to flooded inland lakes in their thousands, where they breed rapidly while gorging on aquatic life, the eggs and chicks of nesting waders, and also stranded dragons. In recent years the numbers of these voracious predators have increased dramatically with devastating consequences for threatened Banded Stilts (*Cladorhynchus leucocephalus*). Although no specific studies have been carried out on Lake Eyre Dragons, I can only assume that they too suffer from increased gull predation during floods.

Another arid-zone lizard that may be particularly vulnerable to climatic change is the Pernatty Knobtail (*Nephrurus deleani*). This rare gecko lives in an isolated patch of dunes just south of Woomera in northern South Australia. It has a slender tail, which, like other members of its genus, has a characteristic knob at the end.

An interesting feature of knobtails is that rarely are more than one species found in the same habitat. The broad-tailed Three-lined Knobtail (*Nephrurus levis*) is widespread throughout most of Australia's driest sandy deserts. A large, fat-filled tail is beneficial to animals like geckoes and dunnarts (*Sminthopsis* spp.) living in arid environments where they must survive long periods with little food. By contrast, slender-tailed knobtails tend to live in areas where food supplies are more predictable, such as mallee regions (*N. stellatus*) or sand dunes in the wetter deserts (*N. laevissimus*). My guess therefore is that food supplies within the small enclave of the slender-tailed Pernatty Knobtail are

DESERT SPECIALISTS MAY NOT BE ABLE

to compete with those native or feral animals that will be able to swarm into their hostile refuge if conditions become less arid.

more reliable than in the surrounding desert, which is occupied exclusively by the fat-tailed Three-lined Knobtail.

The Three-lined Knobtail seems to have the ecological advantage both in the arid central deserts north of Woomera, where food is often limited during droughts, and also 200 kilometres south of Woomera, near Port Augusta. Maybe, because knobtails are rarely active on cold nights, there are not enough warm hunting nights in cooler coastal regions for slender-tailed species to maintain body condition. If this is the case, the Three-lined Knobtail excludes the rare Pernatty Knobtail from the cooler dunes near Port Augusta as well as the drier dunes north of Woomera, sandwiching it into the narrow belt of dunes where the climate allows for more reliable food supplies.

Shifts in rainfall or temperature profiles could alter this fine balance between these two knobtail species. If the climate changes too rapidly, the Pernatty Knobtail will not be able to penetrate the barriers of open stony plains surrounding its favoured dune habitats, and may find itself effectively trapped in a sub-optimal zone.

THE DILEMMAS FACED BY OUR restricted arid-zone reptiles warn of an even more widespread threat to arid-zone biodiversity than that from increased predation or unfavourable climate. Competition from related or ecologically similar species from wetter areas is likely to be a serious threat to many plants and animals that have evolved mechanisms to tolerate extreme aridity. Desert specialists, such as several species of earless dragons, grasswrens and native rodents, may not be able to compete with those native or feral animals that will be able to swarm into their hostile refuge if conditions become less arid.

In the same way, many weeds, which to date have been excluded by the hot, dry conditions, will be able to invade the dry deserts to the detriment of native ecosystems. Desert-adapted plants may also face attack from new pests and diseases, and be threatened by more fires and floods. Even a seemingly modest shift in the timing of rainfall within the year will have widespread implications for the types of plants that can grow in central Australia.

Changes to temperatures or rainfall patterns are likely to first affect highly specialised or restricted species like the Lake Eyre Dragon and Pernatty Knobtail. Scientists and land managers in the outback are only able to guess at the factors that restrict many of our unique species. Therefore we cannot predict all likely implications of a change in climate; even less are we able to protect most of the vulnerable species. Instead we can only join our coastal colleagues

H. EHMANN

The Smooth Earless Dragon uses its superb camouflage to minimise predation in gibber habitats.

KEN GRIFFITHS

Bearded Dragons and other reptiles may compete with or prey upon Lake Eyre Dragons forced off the lake shore by floods in the outback.

in encouraging society, industry and governments to reduce the production of 'greenhouse' gases. Only when we stop shaking the climatic tightrope can we confidently predict a secure future for our outback ecosystems. □

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DR JOHN READ IS AN ECOLOGIST AND LAND MANAGER AT OLYMPIC DAM, SOUTH AUSTRALIA. HIS PRINCIPAL RESEARCH INTERESTS INCLUDE THE ECOLOGY OF ARID-ZONE VERTEBRATES, BIO-INDICATORS AND LAND-MANAGEMENT ISSUES IN NORTHERN SOUTH AUSTRALIA.

IF THERE IS A LAID-BACK MENTALITY TYPICAL OF THE INHABITANTS OF TROPICAL ISLANDS, THEN SEA KRAITS TAKE IT TO THE EXTREME.

SEA KRAITS *of* VANUATU

TEXT & PHOTOS BY ROBERT N. REED

AS SEA KRAITS GO, THIS individual was fairly ugly. It was a small, skinny male about to shed its skin, so its normally brilliant black and white bands were muted. Still, it was the first sea snake of any kind I had seen in the wild, and I danced a little jig after it was captured and safely ensconced in a bag.

Venomous sea snakes of the genus *Laticauda* are commonly known as sea kraits. Most species are banded, and females tend to be larger than males of the same species. Their amphibious nature sets them apart from the other 'true' sea snakes, which lead a completely aquatic existence. Sea kraits divide their time between aquatic and terrestrial habitats, with most of the six known species coming ashore to digest food, court and mate, lay eggs (all other sea snakes are live-bearing), shed their skin, and rest. The main reason for entering the water is apparently to locate, subdue and swallow their aquatic prey which, for at least half of the laticaudid species, consists of eels and other fishes.

I recently spent five weeks studying sea kraits on the island of Efate in the Republic of Vanuatu. Research on sea kraits is wonderfully appealing for a number of reasons: they tend to be found on idyllic tropical islands (often in close proximity to beachside bars that serve fancy drinks with little umbrellas in them!); they are found in very high densities (we captured almost 300 snakes during our stay); and they are amazingly docile. If there is a laid-back mentality typical of the inhabitants of tropical islands, then sea kraits take it to the extreme. Only two snakes went so far as to open their mouths during our research project, despite being unceremoniously dumped into bags, and yanked out for measurements, blood samples and regurgitation of prey.

Vanuatu is an archipelago of over 30 inhabited islands and hundreds of smaller islands, lying between New Caledonia and the Solomon Islands to the west and Fiji to the east. My opportunity to go to Vanuatu came about while I was a Fulbright Fellow at the University of Sydney. At the time Sohan Shetty,

The author with Blue-banded Sea Kraits found at the base of rocky cliffs on Efate. Note how nicely the snakes match the author's Fijian lava-lava!

under the supervision of Rick Shine, had just finished his Master's research on the Yellow-lipped Sea Krait in Fiji (see "Sex & Size" box). Previous work during the 1980s had shown that Vanuatu is home to three species of sea kraits: the Yellow-lipped Sea Krait (*Laticauda colubrina*), Blue-banded Sea Krait (*L. laticaudata*) and *L. frontalis* (no common name and awaiting formal description). How they manage to coexist, when available information indicates that all three species prey *exclusively* on eels, was a mystery. Shetty and I cajoled Shine into funding a five-week trip to investigate the biology of sea kraits in Vanuatu. As little else was known of the ecology of Vanuatu sea kraits, especially regarding differences in ecological niches, we set out to gather ecological, behavioural and morphological data on as many individuals of each species as possible.

The Blue-banded Sea Krait is a gorgeous animal. Blue is a rare colour among snakes, and its significance in this species has not been investigated.

Sea Kraits

Laticauda spp.

Classification
Six species recognised—*L. colubrina, L. laticaudata, L. schistorhynchus, L. crockeri, L. semifasciata* and *L. frontalis* (this last species awaits formal description but has been shown to be unique). Others certain to emerge as taxonomic work continues. Currently classified in 'family' Laticaudidae, but see "Where Did Sea Snakes Come From?"(*Nature Aust.* Winter 2002).

Identification
All banded to some degree. Flattened, paddle-shaped tail for swimming, and glands in mouth for excreting excess salt, like all sea snakes. However, their amphibious nature sets them apart, as do a number of more subtle features. Most species exhibit some degree of sexual size dimorphism, with females being larger than males.

Distribution and Habitat
From north-east India to central Pacific Ocean, although only 2 species (*L. colubrina* and *L. laticaudata*) found over a large part of this range. Mostly associated with rocky coastlines

Biology
Shelter in crevices. Make lengthy (up to 2 weeks) forays in water in search of food. Most species marine, but *L. crockeri* found only in a brackish lake on Rennell in Solomon Islands.

THE LOCALS OF VANUATU (THE Ni-Vanuatu) are primarily of Melanesian descent. They were uniformly friendly and helpful, and seemed genuinely interested in our work. They displayed a thorough knowledge of the plants and animals found in the area and gave us great tips on the best places to look for snakes along the coast. They also helped by directing us to the appropriate traditional chief, for permission to hunt snakes in each new area.

While over 100 native dialects are spoken on various islands in Vanuatu, the *lingua franca* of the archipelago is Bislama, a pidgin language with English roots. Composed of less than 2,500 words, Bislama is easy to learn and fun to use. Descriptors are added after a word along with *blong* (an abbreviation of belong). As examples, a sea krait is called *blakanwhite* (black and white, after their colouration), a public toilet is a *ples blong pispis blong yumi* (place to piss for you and me), and a condom is a *rubba blong fakfak* (no translation needed!). Thus, the enclosures we constructed for snake-mating trials and other experiments became known as the *ples blong blakanwhite blong fakfak*.

We arrived in Port Vila, the capital of Vanuatu, during mid November. Shetty and I spent a couple of days obtaining our research permit and stocking up on provisions before establishing our base in a tiny bungalow at the Nagar Resort on the northern end of Efate.

Sea-krait activity peaks in the first hour of darkness, especially during high tides, when many snakes move between water and land. A good proportion of the snakes coming ashore were bulging with food, and some adult females had consumed eels so large that their movements on land were noticeably

Adult female Yellow-lipped Sea Kraits eat impressively large meals. Here, Sohan Shetty measures a large female, stretched out next to the conger eel she regurgitated. The eel was close to a metre long and weighed over 900 grams.

impaired. We spent some evenings searching for snakes along the rocky shoreline around Nagar and the nearby village of Sama. We also regularly searched tiny islands farther offshore, but we were limited by the fact that motorboats could not be hired after dark. A good number of snakes were caught by peering into rock crevices during the day, and gently noodling them out of their refugia with hooks made from old coathangers. We gently palpated the stomachs of those snakes that had recently eaten and we ended up counting at least 13 species of moray and conger eels in their diet.

SNAKES WERE CAUGHT *by peering into rock crevices and gently noodling them out of their refugia with hooks made from old coathangers.*

The nearest island to Nagar was uninhabited Kakula Island, to which Shetty and I often paddled in a dugout canoe at dusk, usually returning several hours later with a dozen or so snakes. The quiet trips back to Nagar were lit only by the Moon and by the sudden phosphorescent gleam of plankton startled by the swoosh of our paddles. Paddling back from Kakula one evening, we met a stiff breeze and, about halfway across, I noticed that the water in the dugout was over my ankles. Suddenly we were hit by three big swells in rapid succession. If you ever want to be truly terrified, I suggest putting yourself in a position where your boat unexpectedly and rapidly sinks from underneath you (especially at night, in an area known for its large hammerhead sharks). We were left sitting in our seats with water above our waist, but mercifully the canoe had attained neutral buoyancy and didn't sink any farther. We couldn't figure out an effective way of emptying a partially sunken boat equipped with outriggers, so we stayed in our seats and laboriously paddled towards shore. For once in our lives we had exhibited a smidgin of forethought before leaving Kakula and had tied all our gear and snake bags to the thwarts of the canoe, so we didn't drown any snakes.

On a few occasions, I spent the night on one of the offshore islands so that I could spend more time looking for snakes. These evenings were productive in terms of the numbers of snakes bagged, and even more productive in terms of memories to take home. Having a tiny tropical island to one's self is a magical thing. I set up my tent under a

bower of vines, caught snakes in the evening by the light of my headlamp, and slept to the sound of wavelets on the reef—a welcome respite from Shetty's sonorous snoring back at Nagar! I woke to the sound of fish jumping in mirror-flat seas, and rose to watch the Southern Cross fading from the sky. Breakfast was usually triggerfish caught using hermit crabs as bait, cooked over a driftwood fire. Robinson Crusoe never had it so good.

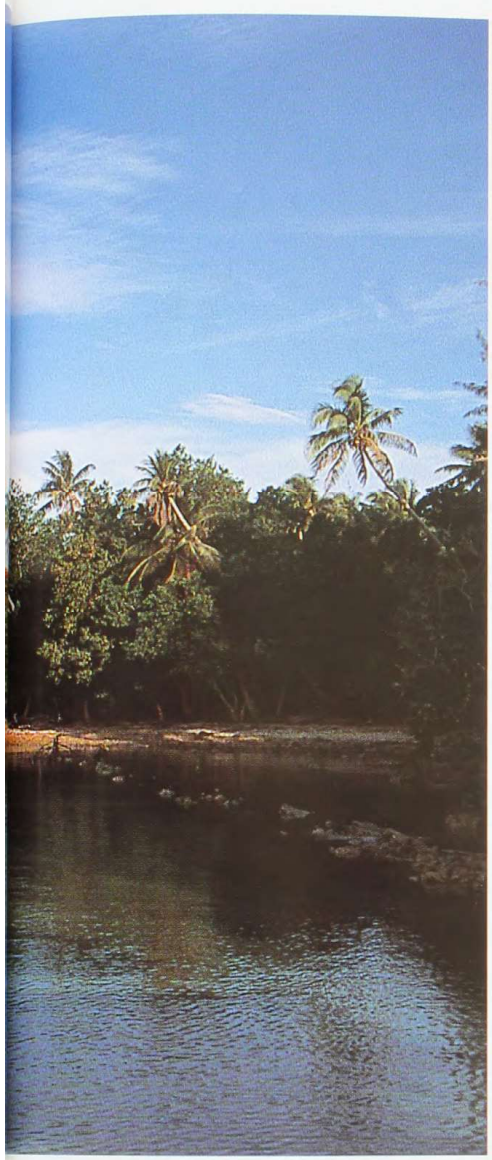
After a month on Efate, Shetty and I were joined by Shine, Bob Mason (Oregon State University) and Hal Cogger (formerly of the Australian Museum). Shine and Mason had worked on the ecology and mating systems of Red-sided Garter Snakes in Manitoba (Canada) and we hoped to use some of their techniques on sea kraits, while Cogger and his Japanese colleagues had pioneered the study of sea kraits in the western Pacific. After their arrival, research activities reached a frenetic pace. As part of his ongoing taxonomic studies, Cogger counted scales on all the snakes we had accumulated over the week. Meanwhile, Shetty and I helped Shine and Mason with experiments in the enclosures.

WE TESTED

the crawling and swimming speeds of snakes using a makeshift runway.

Using a harmless solvent, we removed pheromones from some of the snakes to determine whether these chemical signals are important in courtship. Our results indicated that male snakes use chemical cues to distinguish between sexes and species. Subsequent laboratory work identified this chemical as a lipid (fatty) molecule secreted by females onto the scales, and we identified subtle differences between species that allow males to distinguish between the 'right' and 'wrong' females.

Our field research showed that *Laticauda frontalis* is much smaller than *L. colubrina* and is largely confined to shallow reef flats. *Laticauda colubrina*, on the other hand, often consumes eels from deeper waters. By using different habitats, these two species may reduce competition between them. Our sample sizes of *L. laticaudata* were insufficient for strong scientific conclusions, but this species appears to be the most aquatic of



The shoreline of northern Efate, as viewed from a dugout canoe. This is where many snakes were captured as they moved from foraging areas on the reef to refugia on land.

the Vanuatu sea kraits and may specialise on just a few species of eels.

We also tested the crawling and swimming speeds of snakes using a makeshift runway. We found that male snakes are generally capable of faster movement than females, especially on land. This makes sense, as natural selection should favour those males able to move about efficiently on shore while searching for mates. Slower swimming speeds exhibited by females may be related to their stouter body shape, needed to carry their relatively large eggs.

At one point during the swimming trials, we enlisted a crew of local children to help us hold our three-metre-long runway in place against the waves. My job was to pull the snakes from the bags and introduce them to the runway, while Shine videotaped them swimming and Shetty caught and bagged them at the other end. About halfway through, Shine started laughing so hard that he couldn't hold the camera still; he had captured on film the agony of a little boy who really needed to go to the bathroom but who didn't want to lose his prestigious post to another child. The poor kid was holding the runway steady with one hand and grabbing his crotch with the other, while jumping from foot to foot and grimacing with the effort of holding it in. I'll never know why he didn't just pee in the surf; to me it looked like a fine *ples blong pispis*.

THE CONSERVATION OF SEA KRAITS is a pressing issue for some populations, and there is some evidence that numbers are decreasing even among those species with wide distributions. Although Cogger saw up to 100 snakes per day on the offshore islands around Nagar in the 1980s, we never found more than 18 snakes in a night on these same islands. Some populations in the Philippines have been wiped out by collectors for the skin trade, and the land-locked Rennell Island Sea Krait (*Laticauda crockeri*) may be threatened by the introduction of tilapia as a food fish for humans; these fish apparently compete with the native gobies that are prey for the snake.

Sea krait conservation is made more

A Blue-banded Sea Krait leaves the shoreline and heads out to sea to forage for moray eels. The hunt may last two weeks or more before the snake returns to land.

This writhing mass of sea kraits has just been released from snake bags onto the shoreline, and the snakes will soon disperse to limestone crevices or offshore reefs.

complex by the apparent tendency for these snakes to return to their home site (philopatry). In Fiji, Shetty found that, if snakes were captured on one island and released on another island over five kilometres away, they rapidly swam back to the original island. We found the same to be true in Vanuatu: even juvenile snakes released in an unfamiliar spot returned to their original capture site, sometimes within three days. This behaviour means that a population of snakes on an island may recover very slowly from exploitation, because snakes from other populations would be unlikely to colonise new areas.

Fortunately, education seems to go a long way towards changing anti-snake attitudes in Vanuatu. We gave talks in local schools about the snakes, and also talked informally with the villagers. We stressed the relationships between healthy snake populations and human welfare, explaining how sea kraits control fish-eating eel numbers, thus indirectly providing more reef fish for human consumption. These talks were successful, judging by the number of times we heard people telling each other "*Yu no kilim blakanwhite nomo*" as we walked through villages. Seeing people taking conservation lessons to heart so quickly was surprising to us jaded Westerners, and gave us hope for

the long-term prospects of the glorious sea kraits of Vanuatu. □

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DR ROBERT (BOB) N. REED HAS RECENTLY COMPLETED HIS PH.D. IN ZOOLOGY AT AUBURN UNIVERSITY, ALABAMA, USA. HE HAS BROAD INTERESTS IN THE ECOLOGY AND EVOLUTION OF REPTILES AND AMPHIBIANS. BESIDES LATICAUDID SNAKE ECOLOGY, HIS RESEARCH EFFORTS HAVE SPANNED RATTLESNAKES, VARANID LIZARDS, AUSTRALIAN ELAPIDS, AND THE MACROECOLOGY OF REPTILES.

APART FROM THOSE MENTIONED IN THE ARTICLE, HE WOULD LIKE TO THANK HENRY CYREL (AKA CHIEF MANLAIWIA) AND HIS FAMILY FOR HONOURING THE RESEARCHERS' ODD REQUESTS AND FOR GENERALLY PUTTING UP WITH THEM, AND THE NI-VANUATU PEOPLE OF EFATE FOR THEIR HONESTY, ENTHUSIASM AND HELPFULNESS.

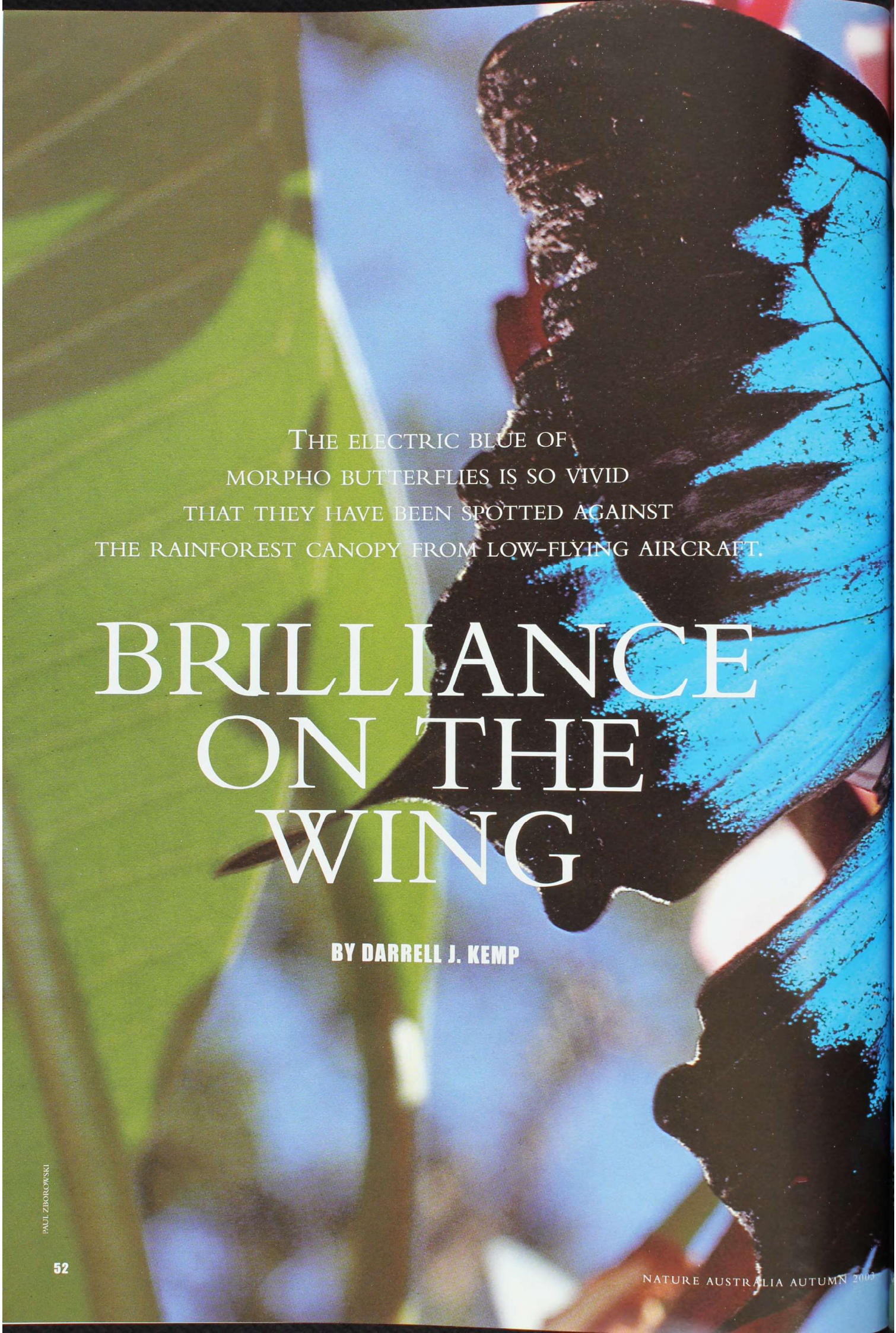
Sex & Size

Sohan Shetty and Rick Shine studied the Yellow-lipped Sea Krait (*L. colubrina*) in Fiji. Combined with our studies in Vanuatu, the results have revealed a surprising degree of sexual dimorphism in body size, head shape and diet. Females are often over 50% longer than males, and are much heavier-bodied, possibly as an adaptation for carrying their relatively large eggs.

Females also have heads that are disproportionately huge, even when accounting for their larger body size. Increased head size is apparently an adaptation to eating very large prey items, and females often contain a single moray or conger eel over a metre long. In contrast, male stomachs are more likely to contain multiple small eels of the type commonly seen on shallow reefs.

These differences in head and body size appear to reflect ecological differences in habitat use. Larger eels are usually found in deeper water, so adult female snakes must forage in aquatic habitats different from those used by males. This situation may have the unexpected benefit of decreasing levels of competition between males and females, allowing maintenance of large populations of snakes.

Most sea kraits spend their time on land holed up in rock crevices within 20 metres or so of the shore. The refugium chosen by this Blue-banded Sea Krait is typical.



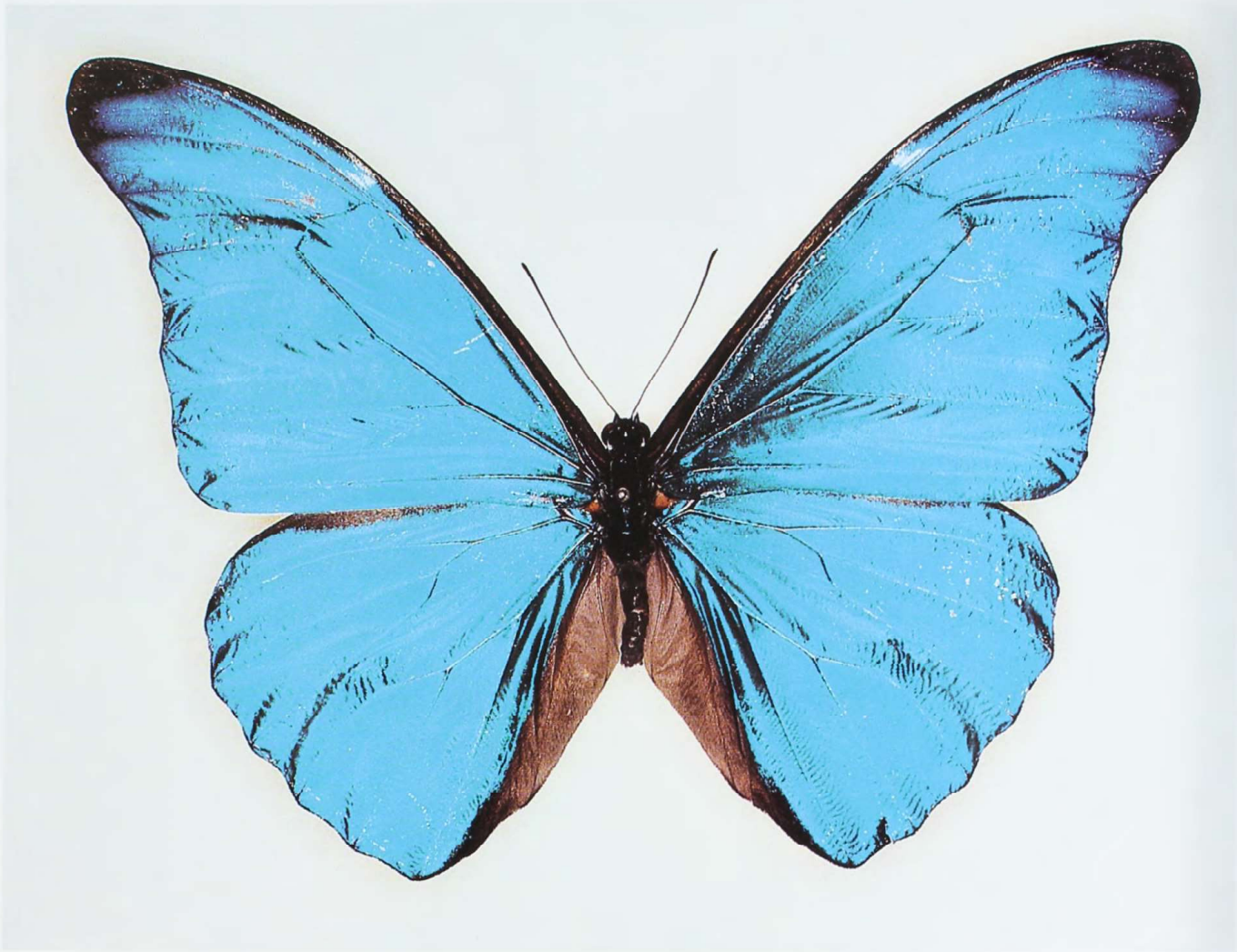
THE ELECTRIC BLUE OF MORPHO BUTTERFLIES IS SO VIVID THAT THEY HAVE BEEN SPOTTED AGAINST THE RAINFOREST CANOPY FROM LOW-FLYING AIRCRAFT.

BRILLIANCE ON THE WING

BY DARRELL J. KEMP

PAUL ZBOROWSKI

The Ulysses Swallowtail, undoubtedly Australia's finest exemplar of the brilliance afforded by structural colouration.



MICHAEL CERMAK

The brilliant, metallic Morpho Butterfly (*Morpho rhetenor*) is the New World Tropics' equivalent to the Ulysses, however the micro-scale wing structures that produce the reflectance in each species are very different.

I FIRST ENCOUNTERED THE Ulysses Swallowtail (*Papilio ulysses*) in a steamy rainforest in far-northern Queensland. Sure, I'd pinned specimens of this butterfly before, and read tales of its stunning appearance, but none of this prepared me for the real thing.

It was late December, the beginning of the tropical rainy season, and I'd driven inland from Cairns up the leafy slopes of the Kuranda Range. At one point the road crossed a freshly slashed corridor through the rainforest and, encouraged by the morning's first real burst of sunshine, I pulled over to check out the butterfly activity. Like any rainforest edge, this site was alive with species, and representatives of Australia's five main butterfly families were winging around the groves of flowering lantana. The real action, however, at least as far as I was concerned, was staged 30 metres above in the rainforest canopy. Here was a parade of Ulysses Swallowtails (family Papilionidae), each blinking 'on' and 'off' like strobe lights as rays of sunlight intermittently bounced off their mirror-like wings. Although these majestic creatures were cruising high, their staccato blue flashes easily outshone everything else in the forest. Still, to get a closer look, I pinned a preserved specimen to some sunlit foliage. One by one, wild Ulysses Swallowtails came floating down to briefly inspect my decoy before flying back into the canopy.

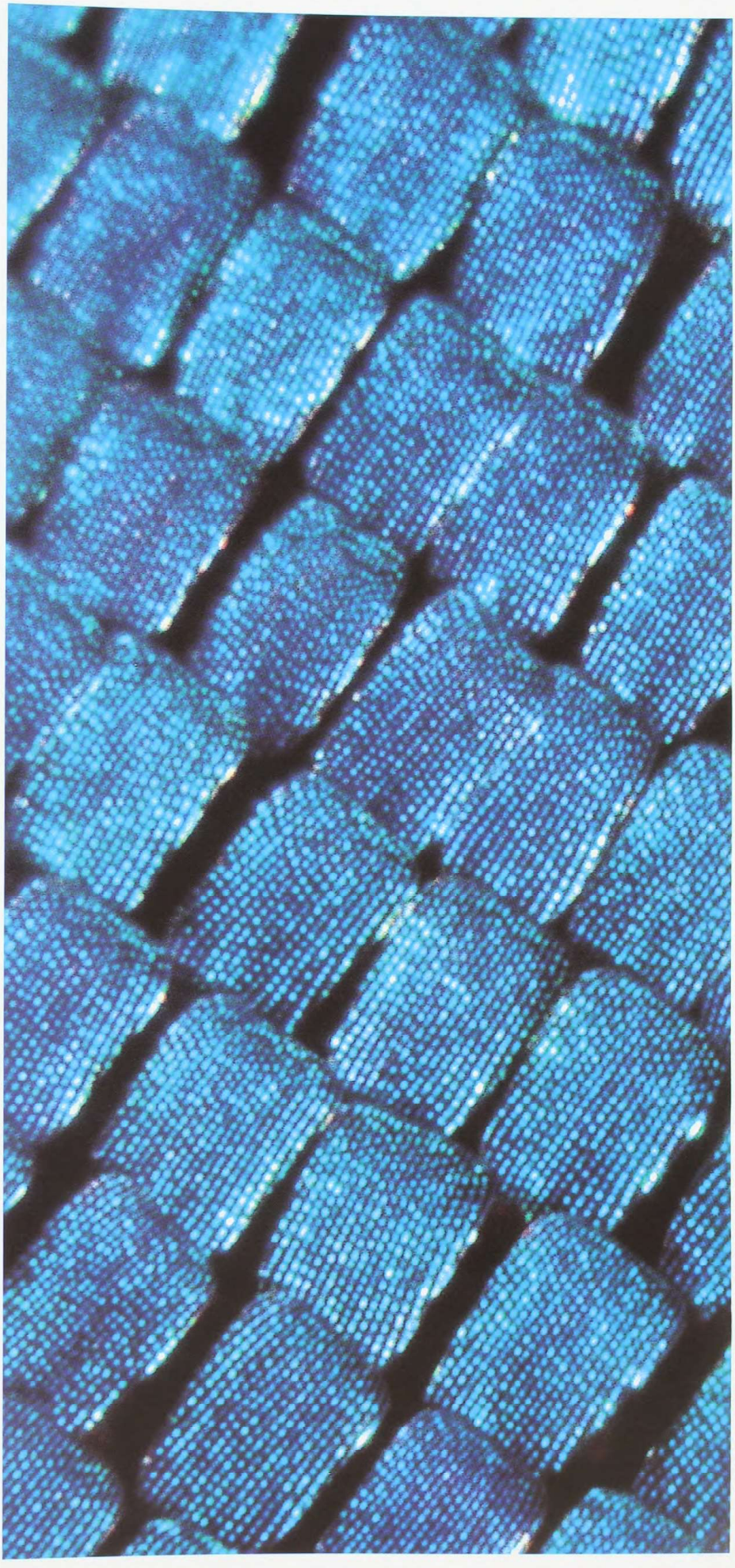
For many naturalists the first glimpse of a butterfly like the Ulysses in the wild can be likened to a religious experience. Similar reverence is associated with the butterfly genus *Morpho* (family Nymphalidae) from the New World tropics. Indeed, the electric blue of morpho butterflies is so vivid that they have been spotted against the rainforest canopy from low-flying aircraft. On a smaller scale, many blues (family Lycaenidae) sport an equivalently neon-like visage, as do a large range of whites, yellows and sulphurs (family Pieridae) and swallowtails. The brilliance of these butterflies, however, should not be portrayed as simply aesthetic. In fact, their most remarkable property is not the way they look, but rather how they manage to *achieve* their look. This feat involves a range of ingenious optical mechanisms, the diversity of which we are only now beginning to comprehend.

MOST COLOUR IN NATURE ARISES from the presence of pigments that selectively reflect certain wavelengths of light and absorb others. The green colour in plants, for instance, results from pigments such as chlorophyll that absorb all wavelengths except green; similarly, blood looks red due to the presence of a pigment (haemoglobin) that reflects only red wavelengths and absorbs the rest. As any artist

knows, the whole paint industry is based upon the use of pigments (such as zinc oxide and cadmium) to provide tubes of 'colour' that can then be splayed across a canvas. However, while pigments are a convenient and widespread source of hue, they are forever limited in the intensity—or saturation—of colour they can produce, reflecting at best only 60–70 per cent of the incoming light. So, although an animal or plant may use pigments to achieve a certain colour, this colour will never be as bright or intense as it theoretically might be. We can therefore imagine that, in species for which outshining others is crucially important, there would be quite an incentive to conjure up new and more efficient means of colour production. As it happens, such inventions have been made—many times in fact—and none is more striking than the optical mechanisms harnessed by butterflies like the Ulysses and morphos.

Along with many other species, the Ulysses Swallowtail dispensed with the use of pigments long ago, and instead built miniscule yet intricate sculpted patterns on the upper surface of their wings. These micro-scale structures interact with incoming light and produce special optical effects, resulting in the reflection of intense colour. Butterflies have used various optical mechanisms to produce colour via structural means, but the most common one is known as 'thin-film interference'—the effect responsible for the rainbow-like reflectance often seen on the surface of soap bubbles.

When a beam of light strikes a semi-transparent layer or film (such as a soap bubble), it is reflected both from the upper and lower surfaces of the film, and these two reflections have the ability to either combine additively (thus resulting in strong reflectance) or to cancel each other out. Depending on the thickness of the film, and other optical properties such as its refractive index (a measure of the extent to which light is slowed down by the material), it



JIM FRAZIER

Under high magnification the partially overlapping, colour-producing scales on the wing of a Ulysses Swallowtail resemble the shingles on a house roof.

PAVEL GERMAN

The metallic greens and yellows of Birdwing Butterflies (*Ornithoptera priamus*) are generated by microstructures on the wing.

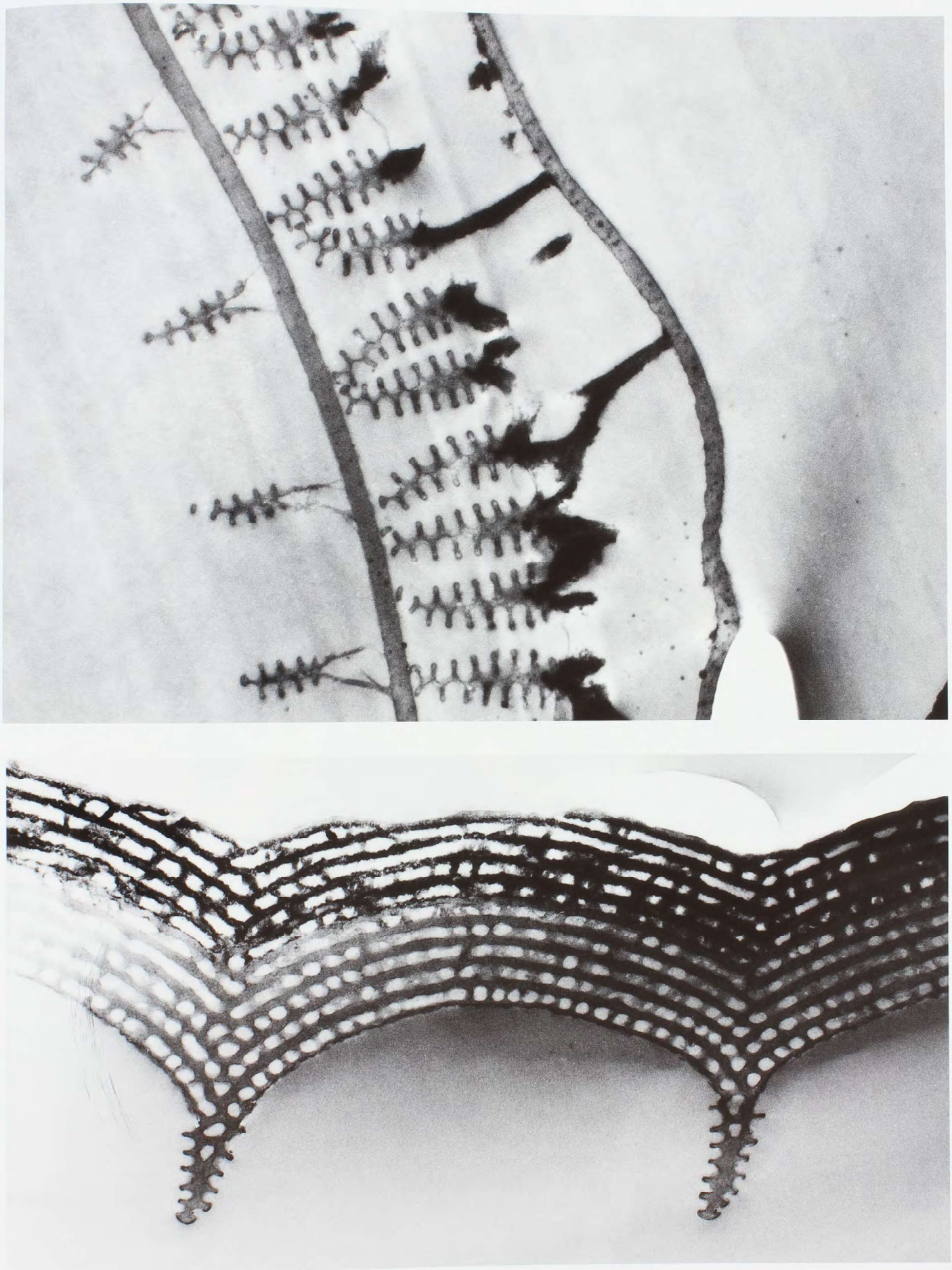
is possible for reflected light of one specific wavelength (or collection of wavelengths) to combine additively while all other wavelengths are cancelled out. This type of selective reflection can therefore produce colour and, if enough of these thin films are arranged in the one place, the ensuing reflection may be far more intense than that allowed by pigments.

Butterflies exploit this phenomenon by building thousands upon thousands of tiny thin-film mirrors on the upper surfaces of their wing scales, each reflecting a certain colour. In many species, like the morphos, these mirrors are arranged in rows, which in cross-section resemble the branches of a forest of identical, miniature Christmas trees.

The concept of structural colouration, although ingenious, is not new. Biologists have known for decades that many butterflies are 'optically enlightened' creatures. However, not until very recently have we fully appreciated the depth of their wizardry in making use of these structural mechanisms. For instance, although it is common knowledge that butterflies use thin-film mirrors to generate interference effects, it is only just coming to light that several different microstructures are used, each with their own unique set of properties. Thus, the striking blues generated by the Ulysses and morpho butterflies actually result from two radically different structures. Even closely related species routinely differ in crucial aspects of their thin-film architecture, sometimes leading to spectacular divergence in their outward appearance, sometimes not.

These and many other recent advances in our knowledge of butterfly signals are primarily the result of a renewed thrust of research headed by Peter Vukusic, an optical physicist at the University of Exeter. Together with his colleagues, Vukusic has been busy scrutinising butterfly wings using a barrage of high-powered optical and microscopy techniques, including spectroradiometry and transmission electron microscopy. Although the ultimate aim of this work is to understand the optical mechanisms at play, the findings are also of much interest to biologists, such as myself, who are trying to understand the selection pressures that mould the way animals appear.

BIOLOGISTS, PARTICULARLY evolutionary biologists, tend to be preoccupied with 'why' questions. Why, for example, do many animals, particularly males, sport such bright colouration when it potentially makes them more vulnerable to predators? In butterflies, this conundrum was deepened by the discovery of structural colouration in only the males of many species: here not only were individuals obscenely bright, they were obviously going to a fair degree of trouble to be that way (having 'invented' a completely new and potentially costly way of colour production,



COURTESY DR PETE VUKUSIC/EXETER UNIVERSITY

SEM images of a cross-section through a wing scale of a morpho (top) and Ulysses (bottom), showing the elaborate microstructures used to reflect brilliant colour. Although vastly different, the end results are similar.

PETER MARSACK/LOCHMAN TRANSPARENCIES

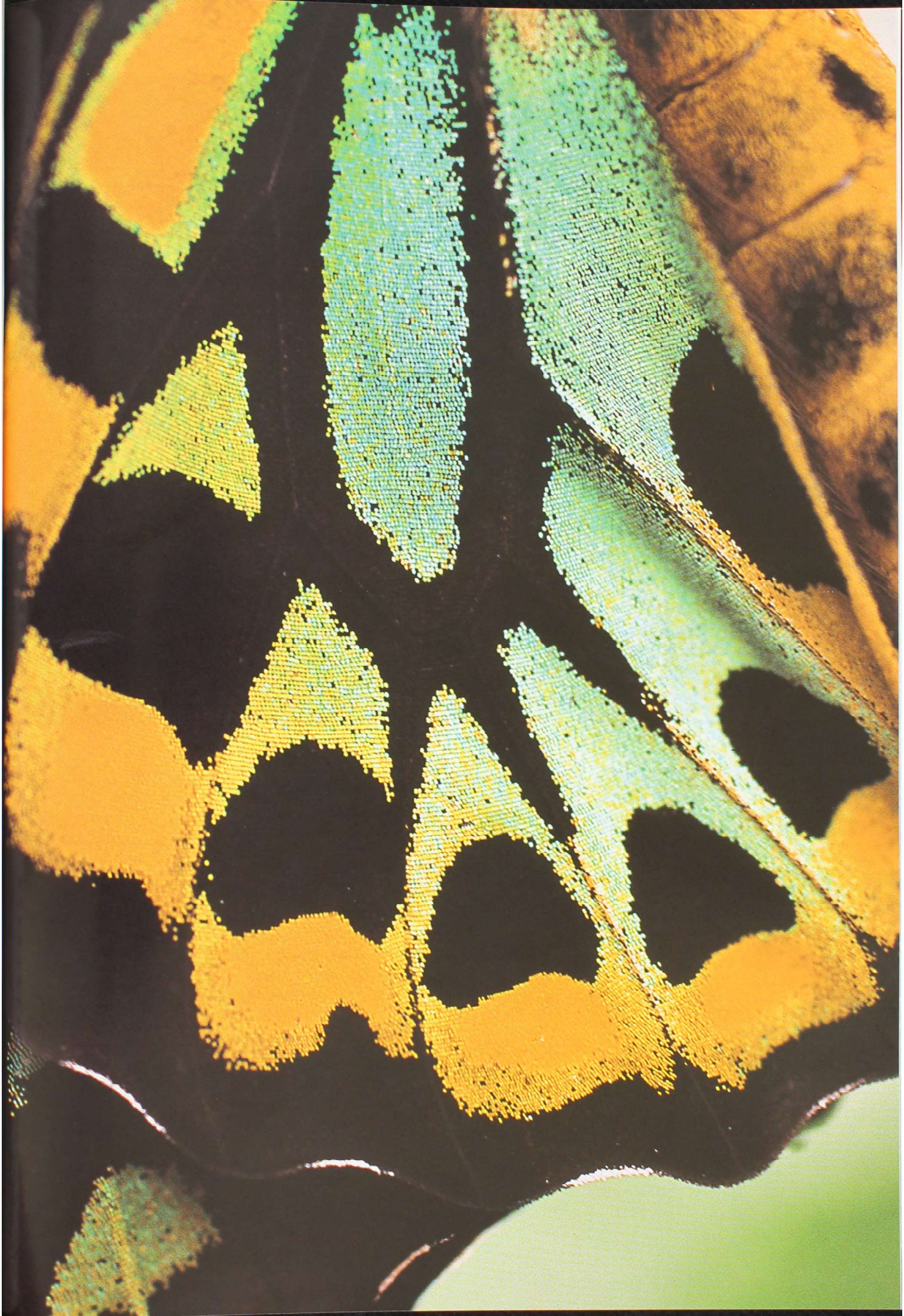
(Left and Right) Most butterflies, like this Birdwing (*Ornithoptera priamus*), use wing microstructures to produce relatively cool colours—violets, blues and greens—although there is no physical reason why warmer colours cannot be generated.

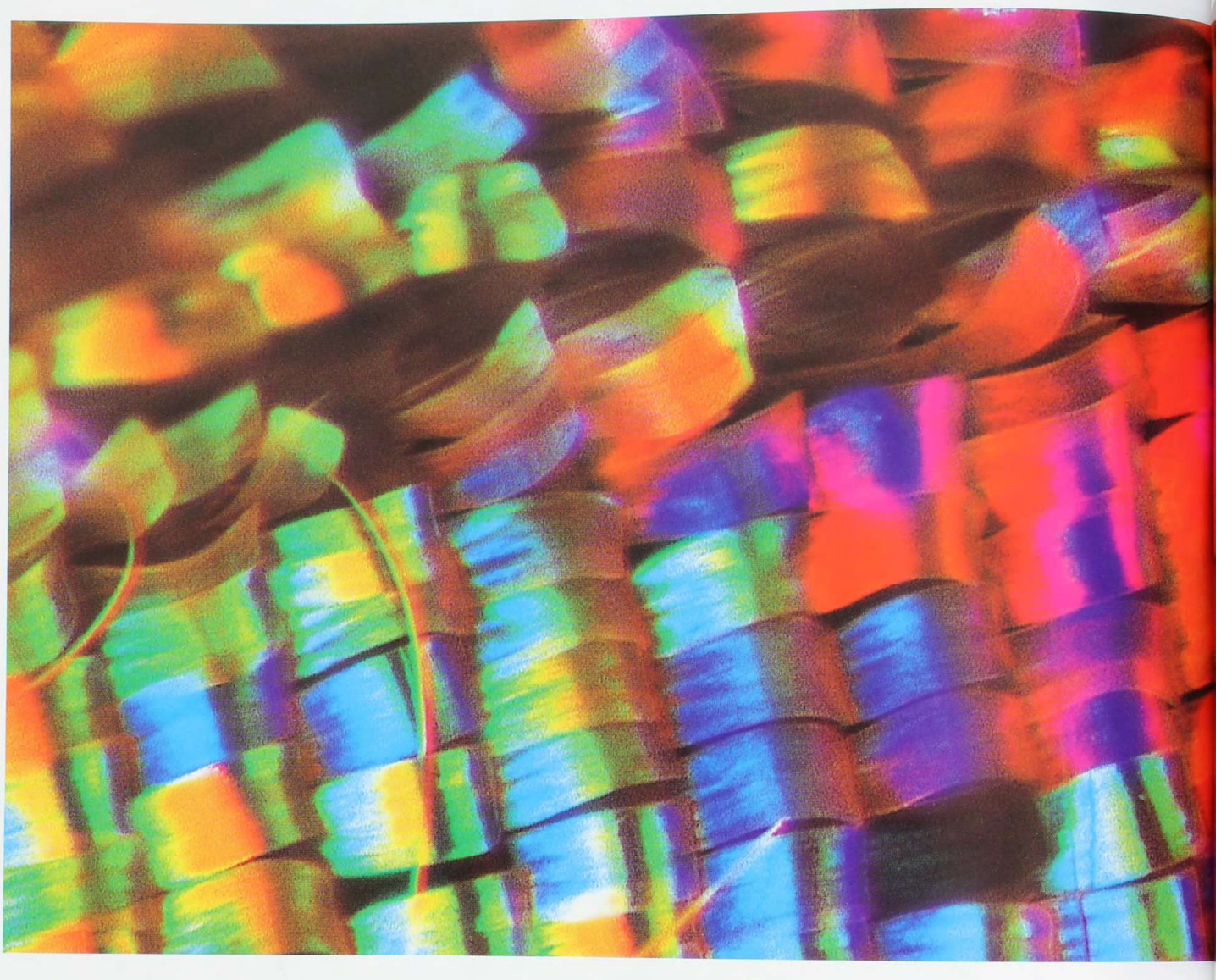
relative to the females). Thus it became clear that there must be a rather large reproductive advantage for a male to sport this visual brilliance, and the hunt was on—and indeed still is on—to discover exactly how this advantage might play out. Because male butterflies are typically the more competitive sex with respect to mating opportunities (see "Sex Butterfly Style", *Nature Aust.* Autumn 2000), the leading idea is that bright colouration has somehow evolved in the context of mating competition. Butterflies that incorporate a structural component to their colouration are investing heavily in their gaudy appearance, and so are particularly suitable animals for studying these evolutionary ideas.

There are two main thoughts about how bright colouration in male butterflies affects mating opportunities. The bright colouration may somehow affect a male's ability for direct competition, such as territorial fighting between males. Alternatively, it could serve to attract females, which may prefer to mate with brighter individuals. If the first hypothesis is true then it might be expected that the males of territorial species are more adorned with bright structural colours. Given the new data streaming in from Vukusic's laboratory, this comparative test should now be possible. However, this question has also been tackled more directly. Working with one of Australia's most aggressive territorial butterfly species, the Common Eggfly (*Hypolimnas bolina*), Ronald Rutowski of Arizona State University conducted an experiment whereby he directly manipulated male colouration and assessed its effect on fighting ability.

Male Common Eggflies—common backyard visitors anywhere north of the mid New South Wales coast—have large sections of structurally generated ultraviolet colour (largely invisible to us but clearly visible to eggflies and indeed most other animals) on their upper wing surfaces. Having kept tabs on a series of territory holders, Rutowski captured each male and effectively 'rubbed out' the ultraviolet markings using a black pen. He then released the males and found that, rather surprisingly, this manipulation had absolutely no effect on their ability to continue to defend their territories. At least on the strength of this experiment, it seems unlikely that structural colouration has

STEVEN DAVID MILLER/AUSCAPE





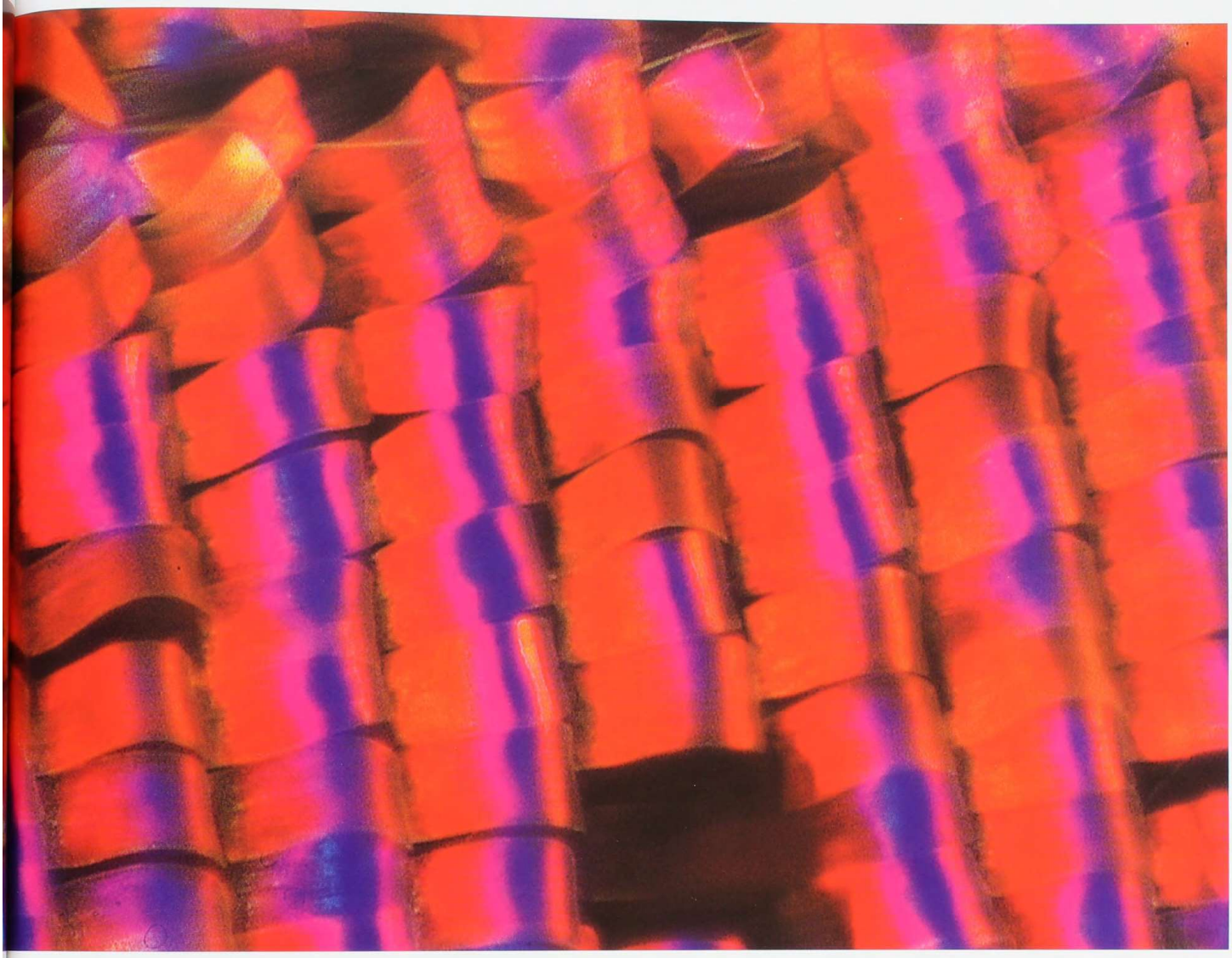
PASCAL GOETGHELUCK-PHONE / AUSCAPE

Minute changes in wing-scale microstructure can radically change the optical properties and hence colour that is ultimately reflected. This close up of the wing of *Urania ripheus* from Madagascar shows the kaleidoscope of colours that can be produced this way.

evolved as a weapon, or badge of competitive ability, used in the context of settling territorial fights.

The second hypothesis, concerning female preference, has also been evaluated. Although this question has been addressed with several different species, the most notable series of experiments was conducted by the late Robert Silberglied (Harvard University) and colleagues using the Orange Sulphur Butterfly (*Colias eurytheme*). Like the Common Eggfly, males of this species reflect brilliantly in the ultraviolet wavelengths and this brilliance is the result of thin-film interference. Silberglied undertook a series of experimental manipulations, using a range of different inks to block out different components of the male's visual appearance, before presenting the males to virgin females. The result, although slightly equivocal, suggested that females were less likely to accept males that had their ultraviolet reflectance extinguished. Moreover, changes to only the human-visible component of male colour (males look yellow-orange to us) had absolutely no effect on their mating success. Female sulphurs therefore have a penchant only for males that are well dressed in ultraviolet.

Although scientists are well on the way to understanding the evolution of visual brilliance in butterflies, there is still a lot to learn. For example, not all species make use of structurally generated colour, and in some species like the Ulysses both sexes are equally as vivid. In fact, new and ingenious ideas are constantly arising with respect to the possible evolution of bright colour. One is the 'you-can't-catch-me' hypothesis—the idea that vivid structural colours function as signals used by agile, fast-flying species to warn potential (feathered)



predators not to bother hunting them.

The new optical discoveries made by Vukusic and colleagues also raise plenty of other interesting questions. For instance, why do butterflies use so many different methods of producing structural colour? Why do closely related species vary in the structures they use? Another curious puzzle is that all of the species known to utilise optical microstructures do so to produce relatively 'cool' colours—greens, blues, violets and ultraviolets. There are plenty of yellow, orange and red butterflies, yet none generates its colour via structural means, despite the fact that there is absolutely no physical reason why it couldn't be achieved.

While some mysteries remain, there seems little doubt that modern science will eventually unravel the full business of butterfly colouration. Indeed, the recent entry of optical physicists into the fray promises a raft of cross-disciplinary collaborations, and these collaborations could see many of the core issues resolved quickly. In the meantime, as data accumulate, we have more and more reason to appreciate the full beauty—not just the aesthetic beauty—of the winged maestros strutting their stuff in our parks, gardens and backyards. Among these seemingly carefree and casual visitors of flowers reside some of the most ingenious and innovative optical inventors known to science. □

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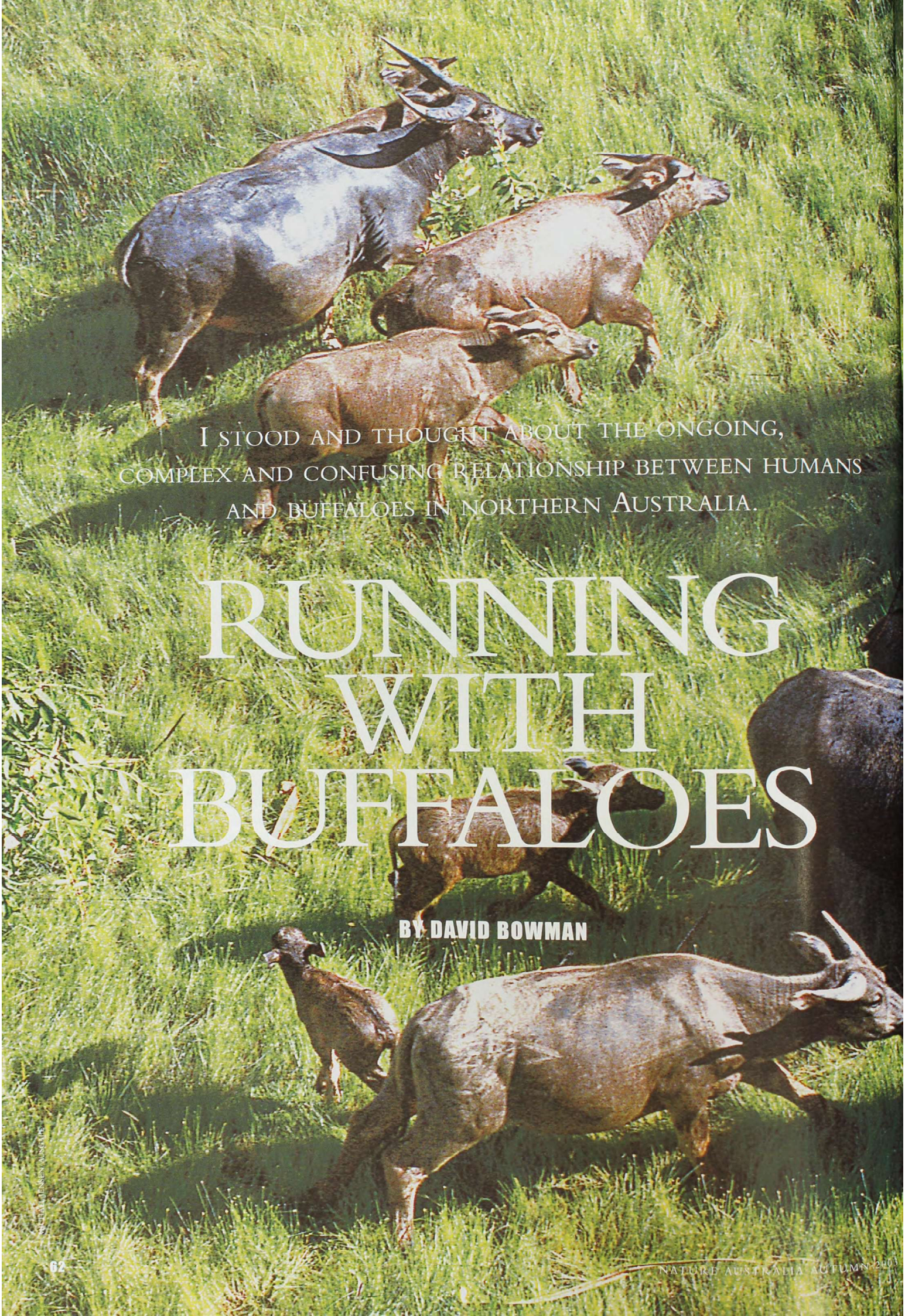


I STOOD AND THOUGHT ABOUT THE ONGOING, COMPLEX AND CONFUSING RELATIONSHIP BETWEEN HUMANS AND BUFFALOES IN NORTHERN AUSTRALIA.

RUNNING WITH BUFFALOES

BY DAVID BOWMAN

Disturbed family group stampeding across a floodplain. Herds of buffaloes create tracks that can change the hydrology of freshwater floodplains, in some cases allowing the entry of seawater, which kills the freshwater floodplain vegetation.

BOOM! A BULLET RIPS through the dry, still air. Moments before I had watched the Aboriginal hunter crouching, ducking, beetling, pausing, looking, ever intent on the grazing buffalo. It was a dance that seemed to crystallise the eternal mysteries of life and death, predator and prey, the hunter and the hunted. The buffalo stoically took the impact of the bullet, but was felled by a second shot. Silence. Then, exhilarated by some primeval force I didn't understand, I ran to the dead buffalo. Its eyes were black, shiny hemispheres that reflected the world of the living. My Aboriginal companions quickly started to butcher the beast, turning buffalo into meat.

As I looked on, I recalled a Banjo Paterson essay on buffalo hunting in the Top End. It was infused with a similar sense of exhilaration, but had the cocky confidence of a white man, enjoying a spot of 'sport' in the north. While readers of *The Sydney Mail* in 1899 no doubt gained vicarious pleasure as they read his racy yarn, no writer these days would dare adopt such a brash and unreflective manner on so sensitive a topic. I also remembered my astonishment when my linguist friend Murray Garde had asked an Aboriginal hunter in Kunwinjku, a western Arnhem Land language, "What is a buffalo?" and was confidently told "The rainbow serpent." I stood and thought about the ongoing, complex and confusing relationship between humans and buffaloes in northern Australia.

DISCUSSION

about their control opens up a Pandora's box of problems for which there are no neat solutions.

FOR MOST naturalists and conservationists, feral animals like the Swamp Buffalo (*Bubalus bubalis*) are a clear-cut negative environmental influence; they *know* they have no place in Australian landscapes. However, those acquainted with feral-animal management know that discussion about their control opens up a Pandora's box of problems for which there are no neat solutions. Just as Australia is a diverse multicultural society, so too is our flora and fauna becoming more mixed because of accidents of recent history. The story of how Swamp Buffaloes became part of the north's wildlife assemblage underscores this point.

Swamp Buffalo

Bubalus bubalis

Classification
Family Bovidae.

Identification
Up to 1,200 kg and 180 cm tall with large pair of crescent-shaped, backward-pointing horns. Skin dark grey and very thick with sparse covering of black, robust hair.

Habitat and Distribution
Freshwater floodplains and adjacent slopes of Top End, but also creek lines and associated habitats throughout rugged Arnhem Land Plateau. Native to South-East Asia, where it is domesticated and few wild animals remain. Introduced to coast of NT in early 1800s but has since spread.

Behaviour
Active mainly at night and at dusk, spending heat of day wallowing in mud or resting in woodlands. Feeds predominantly on grasses and sedges, but also browses foliage of woody species. Herds of up to 12 females and their offspring, and smaller groups of males, seasonally track resources within defined home ranges. Older males often solitary and can wander large distances.

HANS & JUDY BESTE/LOCHMAN TRANSPARENCIES

Wandering buffaloes spread the serious environmental weed *Mimosa pigra*, the fine-leaved shrub in the background, throughout the freshwater floodplains.

Originally buffaloes were introduced to the north as beasts of burden for early 19th-century British outposts. While the settlements failed, the buffaloes that were released or escaped prospered on the vast coastal plains that, each year, become swamps during the wet season. At first the 'feral' herds were no more than incidental biological debris from colonisation, but by the late 19th century they had become valued as a source of stupendously tough leather. The buffalo-hide industry was widely regarded as being an uncivilised affair because of the waste of large quantities of meat in the pursuit of hides and the close involvement of black, white and Chinese people, which no doubt threatened colonial sensibilities. The industry waxed and waned until eventually collapsing in the 1950s after a slump in world demand

and a drop in quality of the northern Australian product due to poor handling and treatment of hides.

The collapse of the buffalo-hide industry raised new issues that highlighted the 'feral' nature of the buffalo. Coming a full circle, attempts were made to re-domesticate the buffalo to support a meat-production industry. This would have also provided a means of controlling infectious livestock diseases that were resident in feral herds and that could threaten pastoralism (widely perceived as the 'proper' use of the north). Yet despite considerable government assistance, these initiatives never prospered. The population explosion of buffaloes and growing environmental awareness raised concern over the dramatic environmental impacts of unmanaged herds. Mobs of buffaloes trampled rainforests and paperbark forests, created 'swim' channels through coastal landforms that enabled salt from seawater to poison the freshwater floodplains, and turned billabongs boiling with wildlife into stinky, black quagmires. However, buffaloes had also become an icon of the 'Territory' and thereby an important part of any tourist experience of the northern 'frontier'.

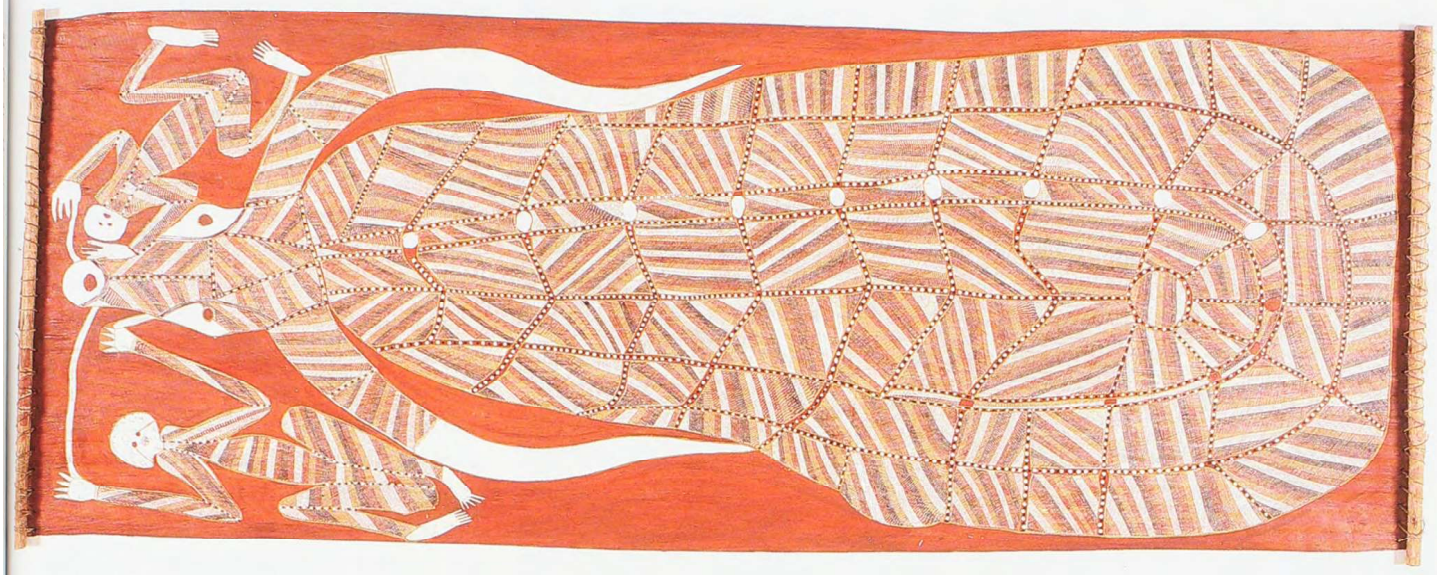
During the first half of the 1980s, the Brucellosis and Tuberculosis Eradication Campaign (BTEC), funded by the Commonwealth Government, sought to control two diseases that posed a threat to Australia's cattle industry, particularly meat exportation to the United States. BTEC appeared to provide a 'final solution' to the buffalo 'problem'. The Northern Territory component of that program, costing $8 million (out of a $750-million budget), remains the single largest land-management program ever conducted in the north. Although BTEC was 'packaged' as solving the serious environmental problems caused by buffaloes, this was never an overriding objective of the program. Rather, the primary objective was to eliminate infected cattle and buffaloes from managed herds, and to reduce feral populations to low densities, thereby limiting the spread of the diseases from any remaining infected animals.

Within geographically accessible lands, BTEC supported a massive program of 'destocking' areas of feral buffaloes by mustering them for subsequent domestication programs or live exportation. In more geographically remote areas, buffaloes that were assumed to be infectious were shot *en masse* from helicopters. Much shooting took place in western Arnhem Land and the adjoining Alligator Rivers region that includes Kakadu National Park, while the then smaller eastern Arnhem Land populations were deemed disease-free and left alone. However, 20 years later, buffalo numbers have built up in eastern Arnhem Land and they are now reclaiming their former geographical range to the west. Like a phoenix from the ashes, the buffalo 'problem' is once again confronting and perplexing those responsible for controlling feral animals.

Some hard lessons were learned from the BTEC program. Despite massively reducing feral buffalo numbers, it was found to be economically and practically impossible to cause their localised extinction. The cost of killing the last few animals becomes prohibitively expensive, such that economic costs prohibit biological extinction. Furthermore, the intensive shooting had the effect of triggering a population explo-

DAVID BOWMAN

Buffalo hunting, besides controlling numbers and potential disease outbreaks that could threaten the Australian livestock industry, provides an opportunity for Aboriginal people to maintain links with their traditional lands, collect bush tucker and enjoy themselves.



Bark paintings of the rainbow serpent with buffalo horns, such as this one by John Mawurnjul, are a tangible example of how this feral animal has become incorporated into the religious and cultural life of some Aboriginal people.

sion because, with the near absence of competition for resources, the reproductive rate of the surviving small herds approached the maximum. The failure to mount any coordinated follow-up control measures on expanding buffalo populations post-BTEC has resulted in renewed severe environmental degradation of wetland and rainforest habitats. Once again the buffaloes pose a serious risk of spreading and harbouring bovine diseases that could threaten Australia's livestock industry. Fundamentally, despite $8 million of expenditure associated with the BTEC program in the 1980s, managers are back to square one with feral buffaloes.

BUFFALOES *not only became incorporated into traditional hunter-gatherer economies but also became incorporated in the people's cultural and spiritual life.*

AN OFTEN-UNAPPRECIATED ASPECT of the history of buffaloes in northern Australia is the complex role played by Aboriginal people. It is widely accepted that the buffalo-hide industry relied heavily on the labour, local ecological knowledge and superb hunting skills of the Aborigines. There is little doubt also that the relationship between European settlers and Indigenous Australians was frequently exploitative and occasionally brutal. However, it is often overlooked that many Aboriginal people remember the buffalo industry in a favourable light, because it is an important part of their family histories. During this period buffalo hunting, like pastoral work, provided seasonal employment for Aborigines on their homelands while allowing them time to pursue other culturally important activities. In more remote areas, traditional Aboriginal people learned to hunt buffaloes, at first with spears and later with rifles. Buffaloes, or to use the Kunwinjku word *Nganabbarru*, not only became incorporated into traditional hunter-gatherer economies but also became incorporated in the people's cultural and spiritual life. This has resulted in the belief among some groups that the buffalo is a manifestation of the rainbow serpent; indeed some paintings of the rainbow serpent have buffalo-like horns.

However, the cultural incorporation of buffaloes in the Top End is far from complete. For instance, in central and western Arnhem Land buffaloes are a valued source of meat and there are fewer cultural prohibitions on the hunting and consumption of the species, in contrast to the situation of native wildlife like kangaroos and Emus. This is important because it means that buffalo meat can be eaten by everyone in a community, regardless of their age, gender or totem. It also explains the relaxed attitude of Aboriginal hunters to utilising a buffalo carcass. For example, in some cases the hunters may slice off only the backstrap and leave the rest, yet there is no sense of waste as the amount of meat collected depends only on immediate needs.

Because buffaloes are considered by many Aboriginal people to 'belong to the country', these landowners can become confused or frustrated by non-Indigenous people who claim that buffaloes are 'alien' and must be exterminated. The automatic assumption of many environmentalists is that buffaloes are less than worthless (that is, are a cost), which completely ignores the fact that Indigenous people often value these animals for a diverse array of reasons from the spiritual to the prosaic. Furthermore the recent recognition of Native Title Rights provides a legal basis for Aboriginal people to hunt and manage wildlife, arguably including feral animals.

Despite Aboriginal people being

important stakeholders in extensive areas of land that support large buffalo herds, including jointly managed national parks such as Kakadu, to date there has been remarkably limited effort to engage Aborigines in the development and execution of control programs. For example, concerns of Aboriginal landowners about the need to control buffalo numbers and the environmental degradation are seldom heard. Another point often overlooked is that Aboriginal buffalo hunters are active land managers. Hunting trips provide them with the opportunity to monitor the health of their landscape and, if necessary, to undertake burning for future fire protection, management of game, or ease of travel. I also suspect that hunting makes Aboriginal people healthier and happier because they have autonomy, regular access to bush tucker and a capacity to actively 'care for country'. This is an important point given the horrific level of ill health among many Aboriginal communities—an enduring blot on Australia's reputation.

FERAL ANIMALS *like buffaloes are a mixed blessing.*

Because Aboriginal landowners derive a range of social and cultural benefits from hunting buffaloes well beyond procuring meat, I believe far more thought should be given to involving them in long-term programs involving sustained hunting pressure to control the buffalo herds. This could be achieved by providing funding to Aboriginal communities so they have access to reliable firearms, adequate supplies of ammunition, and logistic support to regularly visit remote areas. A critical first step to ensure the success of any buffalo-management program is to recognise that feral animals are not simply a management 'problem' but are part of Arnhem Land's cultural and ecological heritage.

Feral animals like buffaloes are a mixed blessing. Australia now boasts the largest wild herds of these and other 'megaherbivores' like the Banteng (*Bos javanicus*) that are declining in their native habitats. This fact is not lost on 'big-game hunters' who travel here and pay substantial trophy fees to shoot these animals in the wild. So, like it or not, Australia has a duty of care in the fate of these species. But the ferals can change habitat quality and may disadvantage some native species of animals and plants. Probably more worryingly for the broader Australian community,

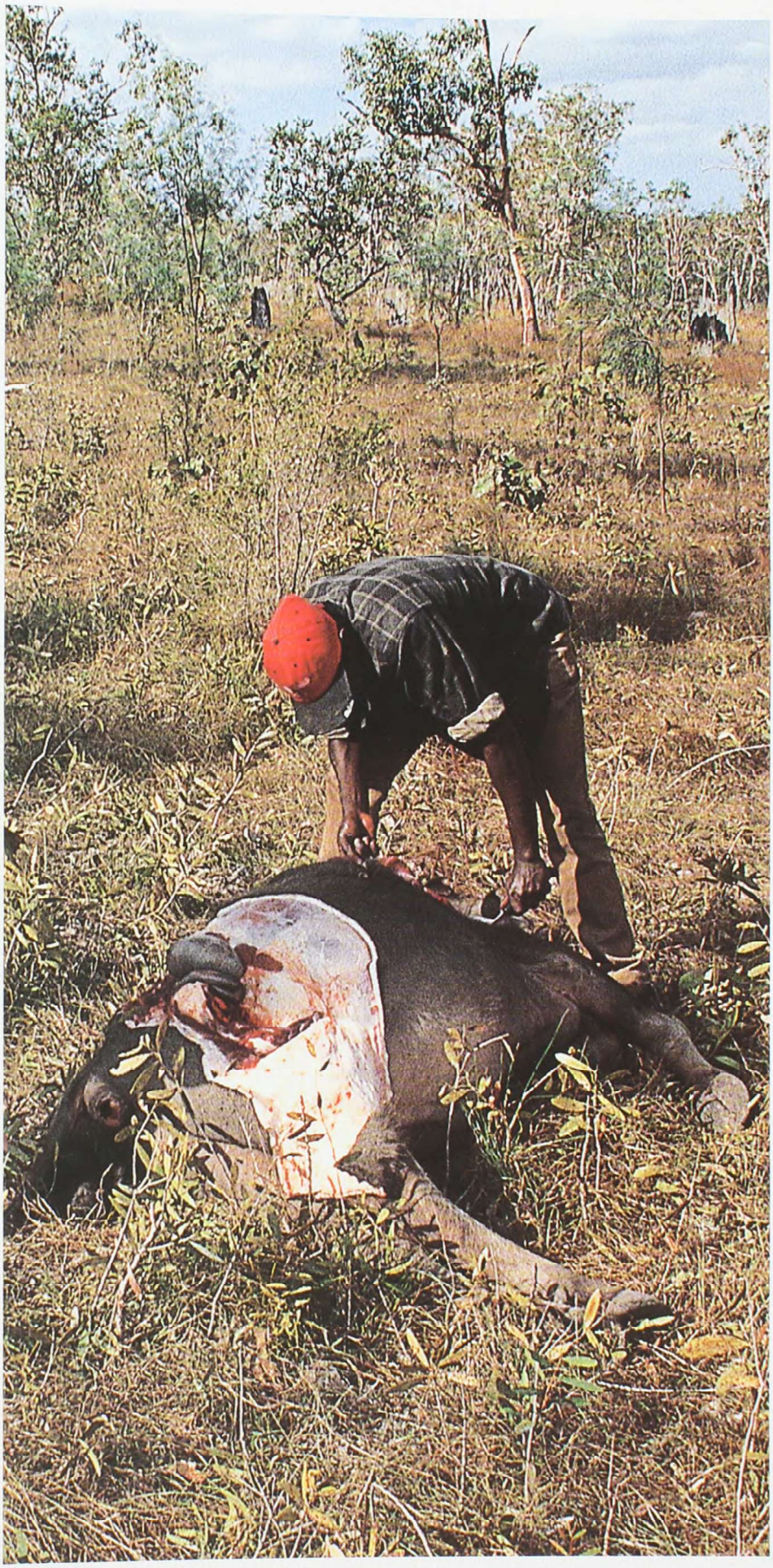
DAVID BOWMAN

In addition to controlling feral buffalo numbers, Aboriginal hunters undertake other land-management activities such as burning areas to reduce fuel loads, to improve the quality of the herbage and to make overgrown areas accessible.

the feral herds can act as reservoirs for serious livestock diseases. The economic chaos that resulted in the recent outbreak of foot-and-mouth disease in the UK would be a drop in the ocean compared with the establishment of this disease in Australia where millions and probably billions of dollars would be lost almost instantaneously from Australia's livestock industries. As BTEC showed, extermination of feral buffaloes is a fantasy given the vast intractable landscapes of the north and the reproductive capacity of ferals. In any case, some Aboriginal owners on much of this land want to retain buffaloes, albeit at controlled levels.

I suggest that, like the Arnhem Landers, other land managers need to incorporate feral buffaloes into the pantheon of northern Australian wildlife, provided the animals are controlled by long-term, sustained programs, not by flash-in-the-pan enthusiasm that characterises many government land-management programs. Involvement of Aboriginal people in such programs is an obvious approach and, if adequately supported, could lead to social, economic and environmental benefits—the so-called 'triple bottom line'.

My Aboriginal hosts have finished butchering the buffalo and we head back to their outstation. They have shared with me an important part of their life; one that I, like most non-Indigenous people, had little appreciated. Now I understand that Aboriginal people doing their thing on their country are making a much-undervalued contribution to managing our nation's biological heritage. Isn't it time that this work receives the recognition that it deserves? □



DAVID BOWMAN

The amount of meat collected from a buffalo depends on many factors including the condition of the animal, desire for red meat and the number of people that need to be fed.

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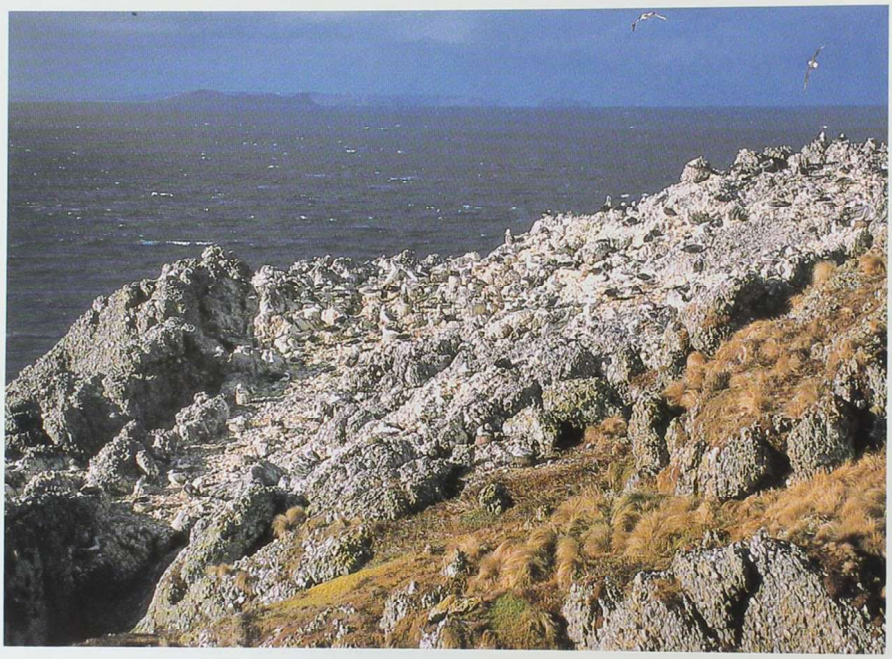
DR DAVID BOWMAN IS A PRINCIPAL RESEARCH FELLOW WITH THE KEY CENTRE FOR TROPICAL WILDLIFE MANAGEMENT AT THE NORTHERN TERRITORY UNIVERSITY, DARWIN.

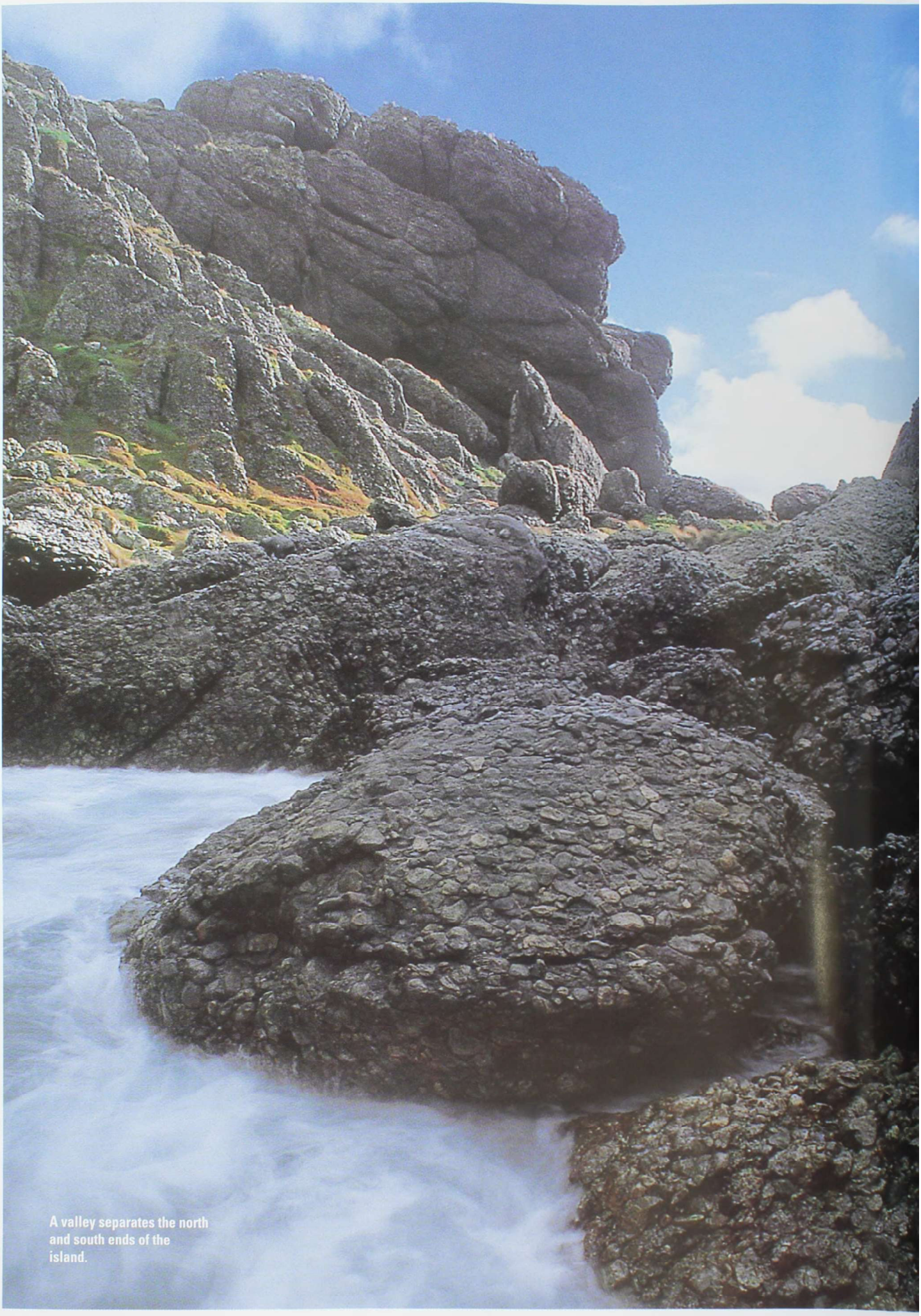
Colony of Shy Albatrosses (*Diomedea cauta*) on the south end of Albatross Island.



Albatross Island

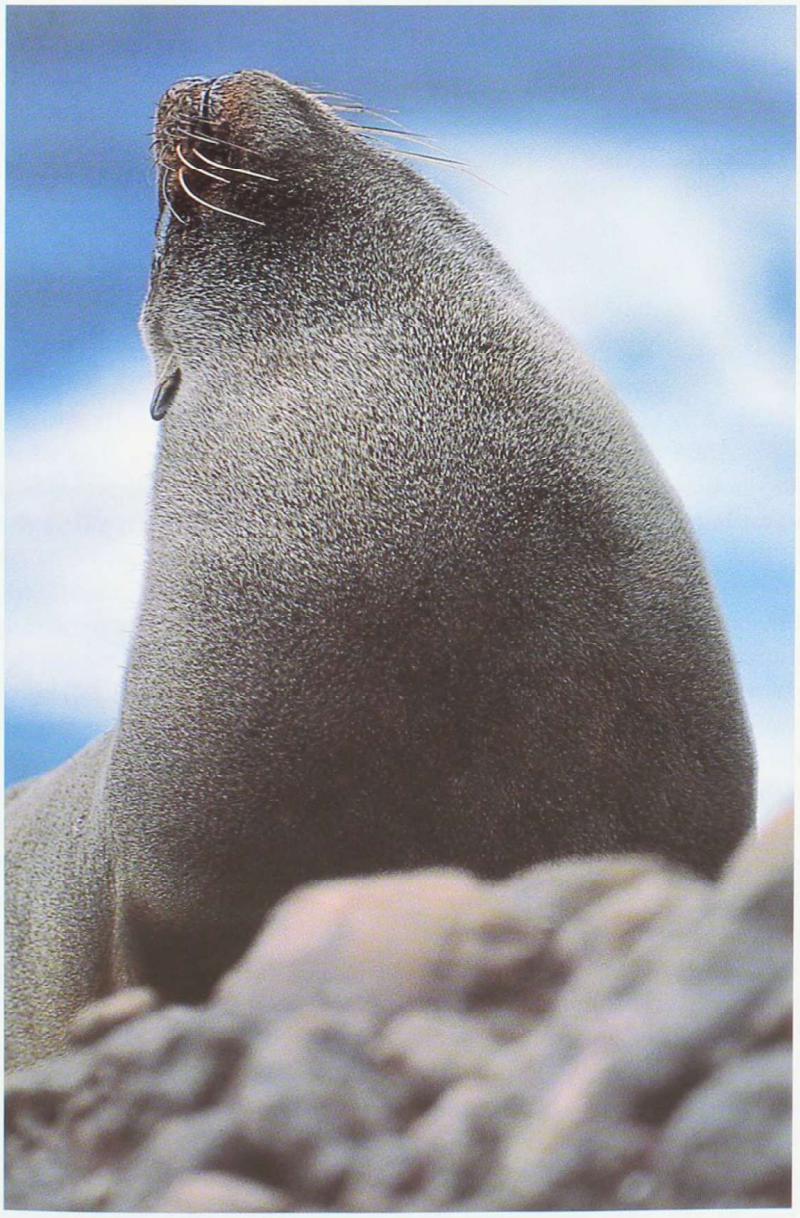
BY DAVID JAMES

Juvenile Shy Albatross (*Diomedea cauta*) on nests.



A valley separates the north and south ends of the island.

Juvenile Shy Albatross (*Diomedea cauta*) exercising before its first flight.



Silver Gulls (*Larus novaehollandiae*) scavenge around the albatross colonies on the island.

Australian Fur Seal (*Arctocephalus pusillus*).

Kiss me

A kiss is not just a kiss, but entails a story of passionate attraction that takes us back to our animal roots.

COUTESY AUSTRAL PHOTO

Kiss and tell: important chemical information is exchanged through kissing.

THE TITLE OF THE CONTROVERSIAL French movie "*Baise Moi*" inadvertently touches on the origin of kissing. I always thought the French word *baiser* meant to kiss. But the movie was not banned in Australia because of any kissing; it was banned because of its violence and explicit, uncut scenes of real (not faked) sex. Apparently *baiser* is also used for sexual intercourse, and this French connection literally linking kissing and sex is more than slang innuendo. A kiss is not just a kiss, but entails a story of passionate attraction that takes us back to our animal roots and also helps to explain why, when and what we kiss as often as we do. The evolutionary processes underlying a kiss may also connect us with even more remote roots, by intimately binding us with plants.

Scientific research reveals that the kiss and its antecedents have played a fundamental role in sexual selection and human evolution. How can this be, when simple lip kissing, let alone French kissing, is not universal among humans and seems a culturally conditioned behaviour? Even though many societies around the Pacific only practised kissing after European contact, behaviours such as rubbing cheeks and noses probably served a similar biological function. As in a kiss, any nose-to-nose or nose-to-body contact will always exchange potent chemicals of which we are hardly aware. Some recent research on kissing touches on biology, evolution and anthropology.

Kissing is often but not always pleasurable. Being kissed by certain individuals can be horrible! Either way, hundreds of bacterial colonies are exchanged, as well as food fragments, immunological proteins (which may play a role in mate selection), and other chemicals that can result in feeling good. Michael Stoddart (while at the University of Tasmania) argued that a sensitive sense of smell is a critical element in animal communication and underlies the range of greetings (nose rubbing, palm licking, sniffing and kissing) that human societies employ to identify one another and show affection (see "Picking up the Human Scent", *Nature Aust.* Winter 1993).

In 1999, renowned naturalist Lyall Watson published a lucid account on Jacobson's Organ—a pair of small tubes, one inside each nostril and connected to the brain. (Anthropologists may recall that Robert Broom published his doctoral thesis on the topic in 1897.) Well known in snakes and ground-living reptiles, Jacobson's Organ (JO), also known as the vomeronasal organ, became controversial when a group of US scientists reported in 1990 that they had discovered a functionl JO in humans—virtually a new sense organ, they claimed, insensitive to ordinary smells but capable of detecting pheromones and other large, biologically potent molecules. Further studies showed that odourless pheromones, excreted from the armpits of women, can regulate menstrual cycles in other women. Females also produce distinctive yet odourless molecules in their saliva while ovulating. Other parts of our bodies excrete gender-specific pheromones, and humans make a habit of kissing them all! Clearly, kissing and nose-rubbing transfer chemical compounds that not only affect behaviour but also potentially affect mate selection, reproduction and consequently evolution.

Ethologist Wolfgang Wickler (Munich University) maintained that the mouth kiss is a form of ritualised "brood tending" (looking after the kids) observable among many human groups and other animals. Famous British zoologist Desmond Morris also argued that mouth-to-mouth kissing was a "relic gesture" that may have had its evolution-

BY RICHARD FULLAGAR

ary origins in feeding by mothers masticating food and then expelling it into their babies' mouths. Vaughn Bryant (Texas A & M University) has challenged this argument by pointing out that women in several cultures feed their babies in this way but never practised kissing until after contact with descendants of Indo-Europeans. Early Egyptian and Greek art depicts mouth kissing. And, according to Bryant, the earliest written reference to kissing, or at least pseudo-kissing, comes from Vedic texts of India 3,500 to 2,500 years ago in which the nose-rubbing customs of the day are described. Of course, the most (in)famous reference to kissing is the Kama Sutra, written in Sanskrit over 1,500 years ago but still read widely today.

Hundreds of bacterial colonies are exchanged, as well as food fragments, immunological proteins and other chemicals that can result in feeling good.

Kissing probably has its roots in early hominid history. Erotic mouth-to-mouth kissing with extensive tongue contact is common in just one other group of apes, the Bonobos (*Pan paniscus*). Bonobos share many sexual behaviours common among humans, from masturbation and female orgasm to a full range of mating positions including face-to-face copulation. Frans de Waal (Emory University, Atlanta) and others have documented how Bonobo sex and erotic behaviour like kissing function to peacefully resolve aggression and social conflict. Moreover, studies on the sense of smell and the JO in several animal species suggest that both systems are crucial for normal mating behaviour and both have an ancient evolutionary history. Take away the JO of a garter snake, for example, and there is no *baiser*.

MARTYN COLBECK – OSF/AUSCAPE

Humans are not the only species to practise French kissing. Bonobos do it too.

However, even if the great apes (including humans) do indeed have a functional JO, that organ's role in detecting pheromones and the biological mechanisms involved are yet to be demonstrated to everyone's satisfaction. Moreover, the experiments undertaken on animals most certainly would not be permitted on humans. On the other hand, the actual existence of human pheromones is convincing and, in fact, the race is now on to develop synthetic pheromones that will increase sexual attractiveness.

Interestingly, the same organ purported to be used in *baiser* may also be used by naturopaths in their search for herbal remedies. Like humans, plants also communicate with chemical signals and Watson argues that humans unconsciously detect these. He relates a story about local healers in Madagascar. When asked how a particular extract will be good for a patient, they say they simply ask the plants! The healer goes bush, thinks about his patient's problem and literally sniffs out a remedy.

Sadly, kissing leaves no archaeological clues. So unless we uncover the Ice Couple *in flagrante delecto*, or unequivocal ochre lipstick, or jawbones with trace muscle attachments diagnostic of lip wrestling, the true nature of the origins of kissing will remain speculative. □

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Silent witness

Match the living plant to the seed carried by a defendant, and you have the beginnings of a case.

FRENCH IMPRESSIONISTS OF THE late 19th century suffered for their art. You could say it was *de rigueur* to paint *en plein air* (in the open air). The leading artists applied layers of oily pigment to a canvas battered by scorching sun, or wind and rain. Sometimes the finished work did more than evoke the scenery; it contained bits of it!

Claude Monet 'discovered' the very scenic Belle-Île, off the south coast of Brittany, in late 1886. He was at the height of his powers and looking for new challenges. Belle-Île didn't disappoint. However, frustrated by unstable weather, and the daily machinations of tides and light, he strayed from the impressionist dictum and completed some of his works indoors. A famous painting of this period, *Port-Goulphar*, was signed and dated in the year following his trip to Brittany.

Art conservators, like Paula Dredge of the Art Gallery of New South Wales where this picture is held, had assumed the inscription date and a heavier-than-usual build-up of paint placed this work firmly in Monet's studio-worked category. However, several grass seeds in the outer paint layer (identified by Barbara Wiecek and Surrey Jacobs at the Royal Botanic Gardens Sydney), and evidence of water droplets in the paint, suggest that much of it was painted outdoors. Dredge concluded that Monet might have put some minor finishing touches on the painting on his return from Belle-Île, catering to his dealer's preference for highly worked paintings, rather than painting the entire picture in his studio.

Seeds and barbed fruits are the bread and butter of the forensic botanist. They cling to clothes and socks, and even pierce flesh—an extraordinary example being a grass fruit that penetrated the skin of a Dog, through to the lung, where it caused pneumonia. Match the living plant to the seed carried by a defendant, and you have the beginnings of a case. The charge might not stick, but the fruits do: the Swiss inventor of Velcro® is said to have been inspired by cockleburr (*Xanthium*) seeds hitching a ride on his Dog and pants after a country walk.

Even fragments of plants can tell a story. Leaf and bark scraps collected from the cuffs of a convicted rapist proved that he had climbed a tree to access the victim's window rather than, as he claimed, being invited in through the front door. The absence of 'stone cells' (the cells that give the characteristic texture to pears), or needle-shaped crystals (found in pineapples) from the stomach contents of a small child, formed the basis of a poisoning conviction against his parents who swore his last meal had been a fruit cocktail.

In the last decade, molecular sequencing has added a whole new layer of evidence. The first reported case, from Arizona, was the matching of DNA from two seed pods of the Mexican Palo Verde (*Parkinsonia aculeata*) found in the truck of a murder suspect, with that from a tree of the same species at the crime site. Access to the USA National Center for Biotechnology Information's GenBank®, a rapidly expanding Internet database of DNA sequences, allows forensic botanists to discriminate more and more species from crime-scene dustings.

But classically trained taxonomists still have a major role. For a start, they have to define the species behind the molecular sequences, to narrow down the target. The trained eyes of specialist botanists can also provide identifications quickly and relatively cheaply. Stephen Skinner, of the Royal Botanic Gardens Sydney, found a variety of algal cells on the clothes and shoes of both a defendant and his alleged victim, corroborating the defendant's version of the events leading up to a shooting, involving a scuffle in a nearby pond.

Let's leave the seedy life of crime, and return to the more ethical world of art, this time involving a French conservator and an Australian painting. Anne Perrin, from Université de Paris I (Panthéon Sorbonne), was an intern at the Art Gallery of New South Wales in

COURTESY ART GALLERY OF NSW

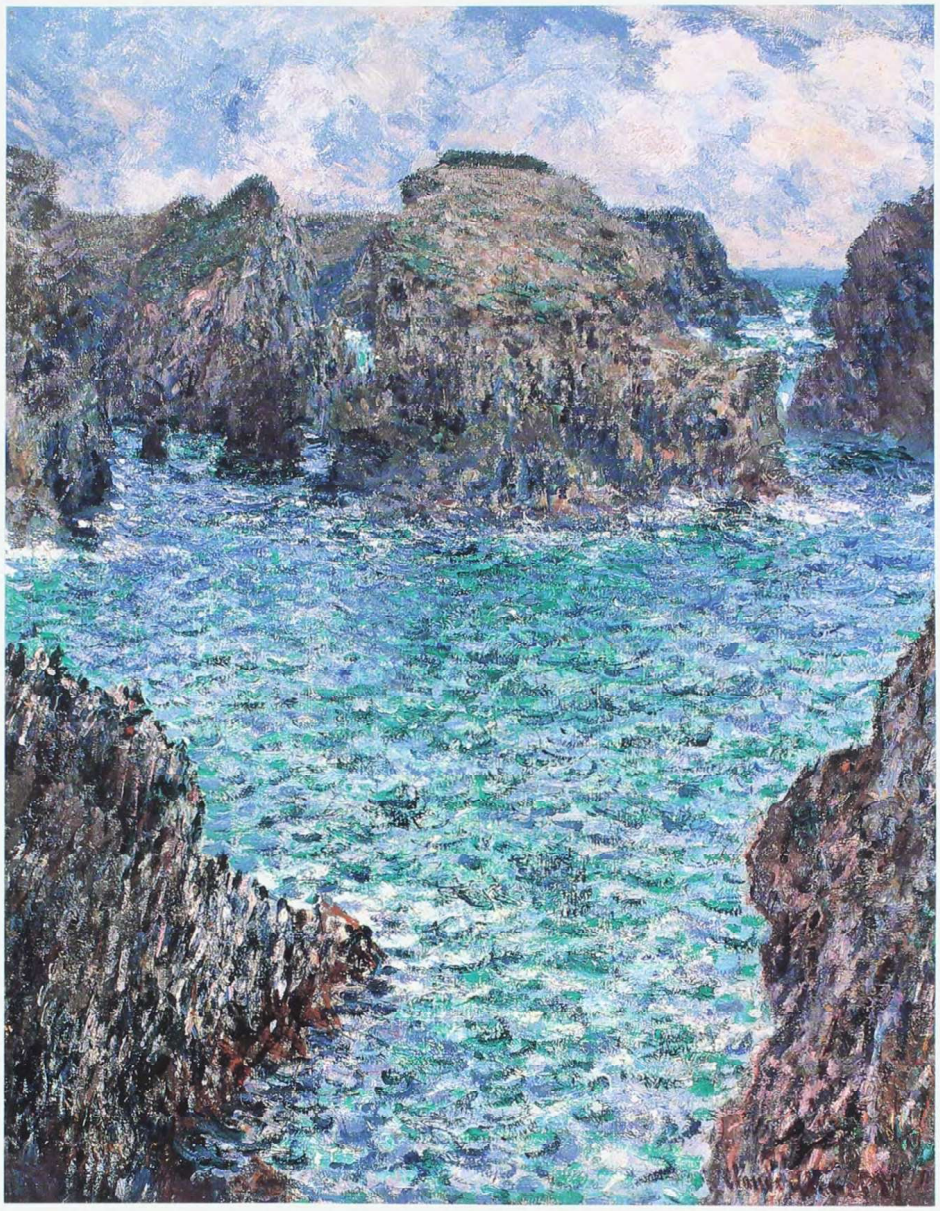
BY TIM ENTWISLE

2002. There she attempted a particularly difficult restoration of a bark painting by Arnhem Land artist Mithinari Gurruwiwi.

The Wuyal was painted in the late 1960s using traditional methods, starting with a natural binding agent mixed with red ochre, over which water-based pigments were applied. The painting was in poor condition with the white layers, in particular, flaking badly. Perrin's problem was that conventional conservation-grade consolidants (solutions that strengthen and hold the paint pigments together) allowed the red ochre pigment in the lower layer to migrate to the surface, changing the colour of the white pigments.

Leaf and bark scraps collected from the cuffs of a convicted rapist proved that he had climbed a tree to access the victim's window rather than, as he claimed, being invited in through the front door.

Botanists at the Royal Botanic Gardens Sydney were able to help by suggesting the likely source of the natural binding agent as being the sap from a species of rock lily from northern Australia, *Dendrobium affine*. Perrin extracted sap from a horticultural specimen of this species, supplied to her from the Gardens. Mixing this sap with natural ochres, she made a number of 'mock' paintings to simulate the properties of the original painting. She then tested a range of consolidants on these mock paintings before determining the best approach for *The Wuyal*.



OIL ON CANVAS, 81 X 65cm ART GALLERY OF NEW SOUTH WALES. PHOTO BY BRENTON McGEACHIE FOR AGNSW

(Above) *Port-Goulphar*, Belle-Île, 1887. Painted by Claude Monet from the south coast of Brittany. (Left) Close-up of one of the embedded grass seeds—part of the evidence showing that Monet painted this picture outdoors.

Plants clearly have an important role in forensic investigation, yet experts complain that training and facilities are lacking. An appealing solution is to make forensic botany a key part of the science curriculum. Brush down students after a walk in the bush and let them discover what the debris tells them about the vegetation they have just visited. Even if they don't end up solving crimes or appreciating art, they might learn a little botany along the way. □

FURTHER READING

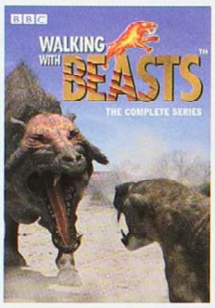
Bever, R. & Simino, M., 2002. Forensic molecular botany: identification of plants from trace evidence. *Genetic Identity Conference Proceedings: Twelfth International Symposium on Human Identification, 2001.* ***[www.promega.com/geneticidproc/ussymp12proc]***

Dredge, P., 2001. Paint, brush and canvas. Pp. 59–67 in Belle-Île: Monet, Russell and Matisse in Brittany. *Art Gallery of New South Wales: Sydney.*

Lipscomb, B.L. & Diggs, G.H. Jr, 1998. The use of animal-dispersed seeds and fruits in forensic botany. Sida *18: 335–346.*

DR TIM ENTWISLE IS DIRECTOR OF PLANT SCIENCES AT THE ROYAL BOTANIC GARDENS SYDNEY.

reviews



Walking with Beasts

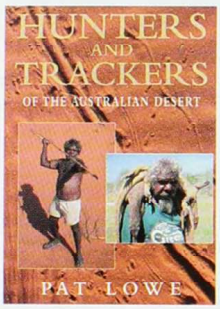
BBC and CBS FOX Video, 2002, 180 mins. $49.95 rrp.

THIS SERIES FOLLOWS THE WILDLY SUCCESSFUL "Walking with Dinosaurs", continuing with a similar 'a-day-in-the-life' documentary-style format. However, the creators faced somewhat different challenges because many of the featured animals have modern analogues and are thus more familiar to a potentially critical audience. In addition, fur is not as easily rendered as the scales of dinosaurs. There are occasional quibbles concerning appearance, movement and behaviour but, with these caveats aside, this is an admirable and appealing series.

The six parts start in the Eocene of Europe and, with each progressive episode, depict a younger age while moving to different localities (unfortunately missing Australia). The first features whales with legs, miniature horses and large predatory birds. The next concentrates on whales that have more fully moved back to the water. Episode three follows *Indricotherium*, the largest land mammal known, and some of its unpleasant neighbours. Our early ancestors, the australopithecines, appear in the fourth part, followed by the sabre-toothed tigers in the fifth. The concluding part takes place during the Ice Age, and we see Neanderthals coping with both the climate and woolly mammoths.

This engaging set of videos is recommended. The major regret is the absence of Australian content.

—WALTER E. BOLES
AUSTRALIAN MUSEUM



Hunters and Trackers of the Australian Desert

By Pat Lowe. Rosenberg Publishing, NSW, 2002, 112pp. $29.95rrp.

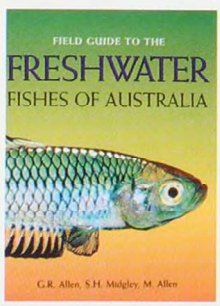
IT IS A PLEASURE ALWAYS TO FIND that Pat Lowe has written another book drawing on her life in the Western Desert. Her previous book *Jilji: life in the Great Sandy Desert*, written with partner and artist Jimmy Pike, presented a delightful and readable account of the natural resources utilised by the Walmajarri peoples.

With *Hunters and trackers* Lowe, again in a personal and whimsical way, provides great insights into one particular set of skills with which the Walmajarri (and other Aboriginal peoples) employ in their daily lives—the art of tracking. Aboriginal tracking skills, like many other aspects of Indigenous life, have often mystified non-Aborigines. Until this book, however, no-one had presented a worthwhile account of how the skill is acquired, let alone given any real idea of how much can be read into an 'empty landscape' by a skilled tracker!

As well as dealing with the art of tracking, Lowe deals with other aspects of resource utilisation. Themes such as the artefacts used, water, the uses of fire, and sign language are dealt with in astounding detail with great elegance.

This is not simply a manual of bush craft, however. The anecdotes that she tells of the process of her own bush education, and the role of her partner as teacher and mentor, generously permit the reader privileged access into the couple's own close relationship. Above all it is a sensitive expression of Lowe's deep awareness of the affinity of the Walmajarri people to the land.

—KIM AKERMAN
HOBART, TAS.



Field Guide to the Freshwater Fishes of Australia

By G.R. Allen, S.H. Midgley and M. Allen. Western Australian Museum, WA, 2002, 394pp. $45rrp.

THIS BOOK IS A HANDSOME ADDITION TO THE LITERATURE on Australia's freshwater fish fauna. It is compact, printed on high-quality paper and appears to be solidly bound, the latter important for a field guide. It claims to deal with "every fish known to inhabit fresh water in the Australian continent", including estuarine invaders and introduced species.

Most species treatments are given a full page and include morphological details and key recognition characteristics for identification, information on habitat, status and distribution (with a map), and a clear photo or illustration. The text is brief, telegraphic and informative.

I note just a couple of errors. The Tasmanian Mudfish is now included in *Neochanna*, and I don't accept the statement that New Zealand's grayling (family Prototroctidae) was driven to extinction by overharvesting. I also think it unfortunate that dual common names are given for some species. These quibbles aside, we have here a very useful book at a reasonable price

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Illustrated artefacts are from the collections of the Museum of the Qin Shihuang Terracotta Army and Xianyang Museum, PRC.

that fills a significant gap in Australia's natural-history literature.

—Robert M. McDowall
National Institute of Water and Atmospheric Research NZ

The Waterbug Book: A Guide to the Freshwater Macroinvertebrates of Temperate Australia

By John Gooderham and Edward Tsyrlin. CSIRO Publishing, Vic., 2002, 240pp. $39.95rrp.

The publication of field guides to the identification of Australian invertebrates lags well behind those devoted to vertebrates. This is due in part to the daunting task of producing comprehensive accounts of invertebrates, which are so much more diverse than their vertebrate counterparts. Even more difficult is it to produce a guide to the invertebrates of a whole ecosystem!

It is testimony to the skill of the authors and publishers that this has been so spectacularly achieved in this guide. Furthermore, the timing is immaculate as we are becoming increasingly alarmed by the extent of the destruction of our fragile freshwater environment. The diversity of macroinvertebrates in a particular freshwater system is a reliable indicator of its health.

This guide readily facilitates the identification of the major groups of freshwater macroinvertebrates. Insects constitute the bulk of the book, but sponges, hydras, jellyfishes, worms of various sorts, molluscs, crustaceans and arachnids are all given fair treatment. The text is extremely well written and authoritative, and derived from the authors' extensive personal experience and knowledge. Each group is dealt with in a standardised format, with text descriptions, superb photographs and keys to families. A comprehensive glossary of terms and extensive bibliography are also included.

The waterbug book will appeal to a whole spectrum of readers, from keen naturalists, fly fishermen and students, to water-management authorities, environmental consultants and academics.

—Noel Tait
Macquarie University

The Cane Toad: The History and Ecology of a Successful Colonist

By Christopher Lever. Westbury Academic and Scientific Publishing, UK, 2001, 230pp.

In a bibliographic tour de force, Sir Christopher Lever has woven the diverse literature on Cane Toads (*Bufo marinus*) into a very readable account of these remarkable animals, and their many deliberate and accidental translocations. There is a substantial Australian focus, and it is very up to date.

The book includes a comprehensive review of the natural history of the Cane Toad, including parasites and pathologies, which will be of great value to future researchers. The bulk of the book examines in great detail all that is recorded about the successful introductions of Cane Toads to 32 (out of 40) countries. The Cane Toad's introduction to Australia is well covered. Also included is a compendium of facts, research and anecdotes about the impact of toads in Australia. This section is a well-balanced, dispassionate treatment of a controversial topic, but I could not find a warrant for Lever's statement in the Introduction that the Cane Toad "has proved a serious ecological and economic pest in Australia". A glossary and 30-page bibliography enhance the book's value as a substantial reference. It is a milestone volume that will appeal to amateurs and specialists alike.

—Gordon Grigg
University of Queensland

Australia State of the Environment

By Australian State of the Environment Committee. CSIRO Publishing, Vic., 2001, 136 pp., $49.95rrp.

How times have changed. A pithy report like this would not have appeared 20 years ago, unless produced by a green group out to embarrass the Government, but this report is in fact a Government publication. An "Independent Report to the Commonwealth Minister for the Environment and Heritage" produced by scientists, it essentially confirms what conservationists keep saying—that Australia is failing to solve its environmental problems. On invasive species, for example, "Australia has insufficient resources to tackle even those species of identified national significance", the report notes, and our strategies for battling environmental invaders are "very weak". As for native vegetation, only four countries are obliterating it faster than Australia. The report is a timely update from Australia's first State of the Environment report of 1996. The slim summary report comes with a CD containing all the backup reports (which may also be purchased separately in printed format). These contain the many references explaining where the facts and figures come from. Everyone should read this report, beginning with our political leaders.

—Tim Low
Brisbane, Qld

SOCIETY PAGE

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.

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SOUTH LISMORE NSW 2480
Ph: 02 6628 1866
Contact: Anne Elterman
Membership: $15.00

Sydney Metropolitan Wildlife Services Inc.
PO Box 78
LINDFIELD NSW 2070
Ph: 02 9413 4300
Contact: Irene Callaman
Membership: $25.00

Wildcare Australia
PO Box 2379
NERANG MAIL CENTRE
QLD 4211
Ph: 07 5527 2444
Contact: Eleanor Hanger
Membership: $27.50 Single
$38.50 Family

WIRES NSW Wildlife Information & Rescue Service
PO Box 260
FORESTVILLE NSW 2087
Ph: 02 8977 3333 &
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Web: *www.wires.org.au*
Contact: Carol MacDougall
Membership: $40.00

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Canberra Ornithologists Group
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CIVIC SQUARE ACT 2608
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Web: *canberrabirds.dynamite.com.au*
Contact: Alistair Smith
Membership: $35.00

Cumberland Bird Observers Club Inc.
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Ph: 02 9484 3362
Web: *www.cboc.org.au*
Contact: Peter Madrig
Membership: $26.00

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Australian Platypus Conservancy
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Ph: 03 9716 1626
Web: *www.totalretail.com/platypus*
Contact: Geoff Williams
Membership: $30.00 Single
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Wildlife Preservation Society of Aaustralia Inc.
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Ph: 02 9556 1537
Web: *wpsa.org.au*
Contact: Suzanne Medway
Membership: $20.00 Single
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Ph: 02 6276 6643
Web: *www.csiro.au/helix*
Contact: Kasia Kucharska
Membership: $27.00

The Dinosaur Club
C/- Monash Science Centre
MONASH UNIVERSITY
VIC. 3800
Contact: Jenny Monaghan
Membership: $49.00 Family
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Science Teachers Association of Victoria
PO Box 109
COBURG VIC. 3158
Contact: Roger Morgan

ENVIRONMENTAL

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Web: www.gould.edu.au
Contact: Mike Suss
Membership: $10.00

INSECTS

Australian Entomological Society Inc.
C/- Private Bag 15
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Contact: Nancy Endersby
Membership: $110.00 Single
$55.00 Concession

MUSEUMS

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$68.00 Single $50.00 Concession

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Web: *www.waterhouseclub.org.au/whc*
Contact: Mary Lou Simpson
Membership: $90.00 Family
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NATURAL HISTORY

Dinosaur Club
Australian Museum Education
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SYDNEY NSW 2010
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Contact: Cathy Lamond
Membership: $15.00

NT Field Naturalists Club
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Ph: 8988 4116
Contact: Steve Popple
Membership: $30.00 Family
$25.00 Single $15.00 Concession

Wildlife Observers Club
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THE BASIN VIC. 3154
Ph: 03 9762 7671
Web: *www.scottware.com.au/woc*
Contact: Andrew Wegener
Membership: $25.00 Family

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q&a

GREG HAROLD/AUSCAPE

Clean Slaters

Q: *How do I keep slaters out of my house and how can I control/kill them? We live in a woody area with a lot of leaf mulch around and we do not want to disturb this too much. However, we do not welcome the little bugs inside.*

—Keith Gough
Carseldine, Qld

A: For a start, slaters are not 'bugs' (= insects) but are crustaceans (order Isopoda), and they will react differently from 'bugs' to any insecticides you might use. But I don't see a real problem because slaters are not pests. You should be grateful to have healthy leaf litter around your house to which these little guys contribute. They eat detritus (organic debris from decomposing organisms) and will not cause any health problems in your house other than getting underfoot, more to their detriment than yours. Your best approach to keep them out is to close up the cracks under the doors and windows where they enter. Your local hardware store probably can advise you how to do that. If they do get into the carpet, slaters will usually die fairly quickly owing to a lack of moisture that they require for survival. In this case, just suck them up with your vacuum cleaner. If they are still alive, pick them up by hand (they won't bite), and return them to the leaf litter where they belong. Remember, slaters are your friends!

—George (Buz) Wilson
Australian Museum

Slaters are a sign of healthy leaf litter.

Wheezing Frogmouths

Q: *At our old farm on the north coast of New South Wales, Tawny Frogmouths would perch on our veranda at night and make the most amazing, loud, heavy-breathing sound. The frogmouths at our new farm do not make this noise. Is the sound normal?*

—Nell Gray
Valla, NSW

A: The most recognised vocalisation of Tawny Frogmouths (*Podargus strigoides*), and the only one mentioned in most books, is a string of low, resonant, pulsing notes, 'oom-oom-oom...'. There are, however, several other calls that are less well known. Without hearing the heavy-breathing sound of your birds, it is difficult to relate it to one of these with certainty. A possibility among the vocalisations listed in *Handbook of Australian, New Zealand and Antarctic birds* is a pulsating call described as a "series of rapid continuous grunts". It is thought to be an aggressive or territorial response to intruders. If this is not the sound you heard, it might be one of the other poorly known calls or even one yet to be described.

—Walter E. Boles
Australian Museum

A family of Tawny Frogmouths.

BARRY SILKSTONE/NATURE FOCUS

AUSTRALIAN MUSEUM

Shellfish Feelings

Q: *I have recently become a vegetarian and am wondering if clams and scallops have feelings, such as fear when killed for consumption. I read the Nature Strip (*Nature Aust. *Spring 2000) about the heart rate of mussels increasing when predators eat them, but they have no brain, so do they actually feel fear? They have hearts, but do they experience love?*

—Claire Strawberry
Boston, Massachusetts, USA

A: I fear no mussel will ever love you for eating it, no matter how big your heart or its. Nor will any other living creature, except perhaps a tapeworm. The brutal truth is we are all killers in this cruel word and, even if you sacrifice yourself to the worms in the bottom of the garden, you will be murdering millions of happy little bacteria and other parasites that have sheltered for countless generations in every crevice of your body.

Yes, if pain is defined as an effort to avoid physical injury, then mussels do suffer pain. And if fear is expressed as any avoidance behaviour conducted in anticipation of pain, then yes, mussels and other shellfish must fear their predators. Screams of terror may be beyond them, but to the sensitive listener that last desperate siphon squirt can only say one thing: "I don't want to die". The only advice I can offer you is to give them the kindness of a quick death. Next time you sit down for a plate of fresh oysters, chomp before you swallow.

—Danielle Clode
University of Melbourne

Answers to Quiz in Nature Strips (page 19)

1. *White* **2.** *Speed of light* **3.** *Cicadas*
4. *Elliot* **5.** *Three* **6.** *Pigeon* **7.** *Dingoes*
8. *South Australia* **9.** *Iron and oxygen*
10. *Sweet substance excreted by sap-sucking insects*

AUSTRALIAN MUSEUM

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 *Photographic field guide: birds of Australia*. Summer's Pic Teaser was a spider's web.

A case for messy forests

While a cleansed and homogenised forest might appeal to some humans, it can be an ecological disaster for many forest species.

BY DAVID LINDENMAYER

NATIVE FORESTS ARE BACK IN the news. After a relatively short period on the 'back-bench' in the late 1990s, forest issues have returned to the political agenda. New forms of intensive forest use mean that the management and conservation of Australia's native forests are at a critical turning point.

These new forms of forest use involve 'cleaning up' native forests by removing the so-called 'waste wood' left after logging, and then either burning it completely to generate power (= biomass burning), or burning it partially to produce charcoal, which is then used in the smelting of silicon. A 200,000-tonne-a-year charcoal plant is proposed for the Mogo area of southern New South Wales and wood-burning power stations are on the drawing boards in several States.

These proposals might initially seem like a good idea—they will use forest waste for other useful purposes. However, some deeper thought about the ecological functioning of native forests leads to some concerns about the long-term impacts of biomass burning and charcoal-making plants.

The amount of wood needed to run these operations requires a significant intensification of logging because the 'waste' often consists of whole trees, and not just the residue from sawmilling. For example, the charcoal plant proposed for southern New South Wales will increase the volume of timber harvested from approximately 150,000 tonnes to around 350,000 tonnes per year. This means that over double the amount of timber must be found within the same area of forest. Many of the trees and logs that would otherwise have been left will now be 'cleaned up' to meet this demand.

While a cleansed and homogenised forest might appeal to some humans, it can be an ecological disaster for many forest species. This is because the intensification of logging leads to the simplification of the forest. Many species actually need complex ('messy') forests because critical habitat for them includes rotting logs on the forest floor, large old living and dead trees with hollows, and dense thickets of old understorey trees.

Research shows that these structures are severely depleted, or even lost, through intensive logging practices. It follows that populations of the species that depend on them will be compromised. Intensive forestry practices create what are essentially plantation-like conditions, which are poor-quality habitats for most of our native fauna and flora.

It is notable that the rationale given for these projects—cleaning up the forest—is the same as that used to instigate export woodchipping operations such as those at Eden in southern New South Wales several decades ago. The presence of a large pulpwood market in Eden has forced forest managers to extract a greater volume of wood from each unit area. This has necessitated the adoption of clear-felling in this region.

An example of the consequences of this intensification is reflected in the availability of hollows to fauna; an average of three hollow trees per hectare occur on logged sites in the Eden region compared with 22 per hectare on unlogged sites. This change will have corresponding negative impacts on the large number of vertebrate species that depend on hollows in trees for their survival.

It is also notable that ecological studies from many parts of the world have demonstrated the negative impacts on biodiversity that result from intensive harvesting methods that 'clean up' and therefore simplify native forests. A classic example comes from Sweden where anally retentive forest managers removed every defective living tree, every dead tree and every rotting log. Scores of species that depend on these features are now red-listed or endangered in many parts of Scandinavia. Just across the border, the 'messier' Russians left critical habitat structures in their logged forests and many of the endangered Scandinavian species are actually quite common there. Swedish forest ecologists now take their forest managers to Russia to show them what features need to be put back into forests to make them suitable for many elements of the biota.

Despite the experiences of Eden and overseas, proposals to greatly intensify logging in Australian forests mean that the lesson from history is that we don't learn from history. However, the adverse impacts of charcoal plants and biomass burning would be so profound that we must ensure that past mistakes are *not* repeated. □

FURTHER READING

Lindenmayer, D.B. & Franklin, J.F., 2002. Conserving forest biodiversity: a comprehensive multiscaled approach. *Island Press: Washington D.C.*

ASSOCIATE PROFESSOR DAVID LINDENMAYER IS A SENIOR RESEARCH FELLOW AT THE CENTRE FOR RESOURCE & ENVIRONMENTAL STUDIES AT THE AUSTRALIAN NATIONAL UNIVERSITY IN CANBERRA.

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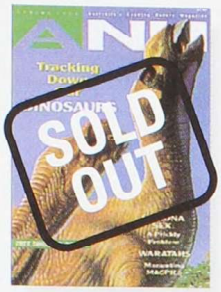

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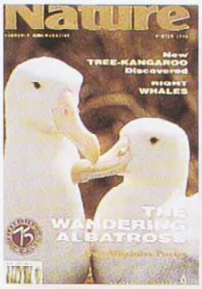

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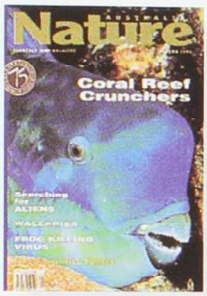

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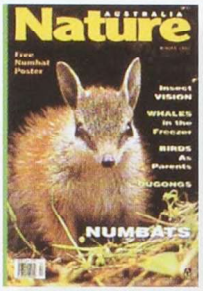

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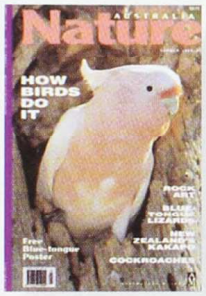

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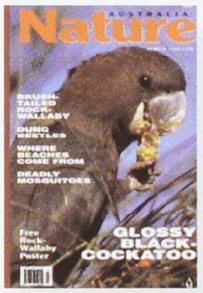

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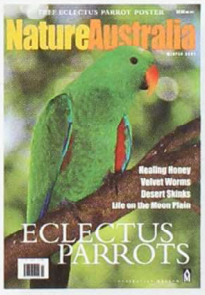

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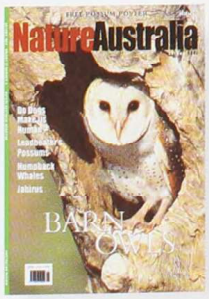

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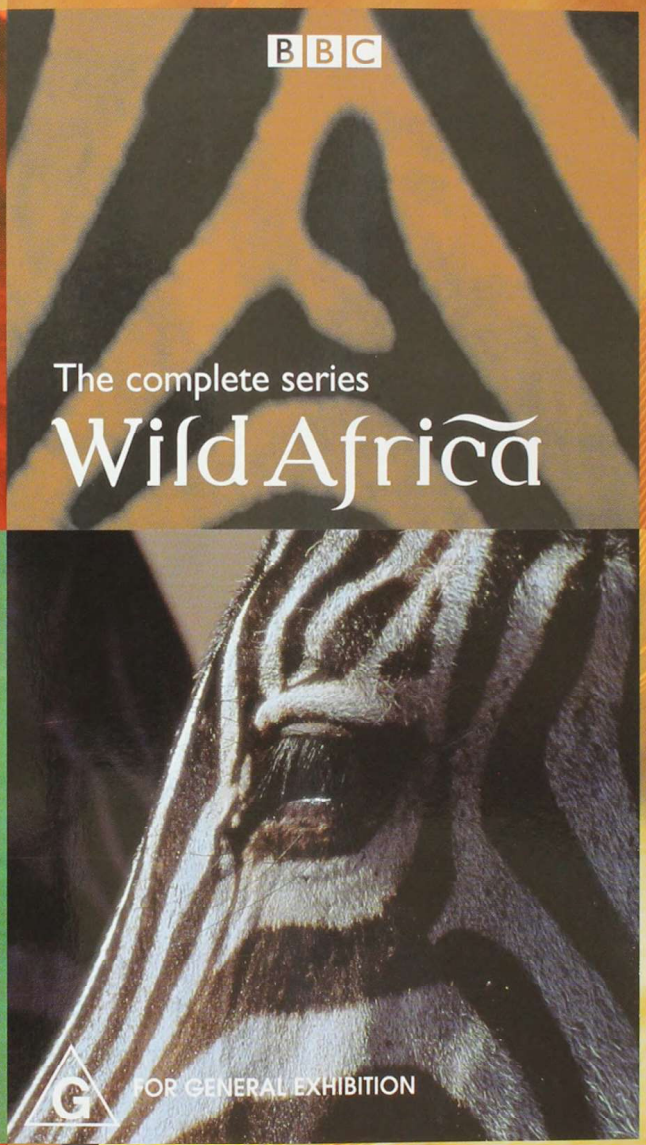

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