WINTER 1992

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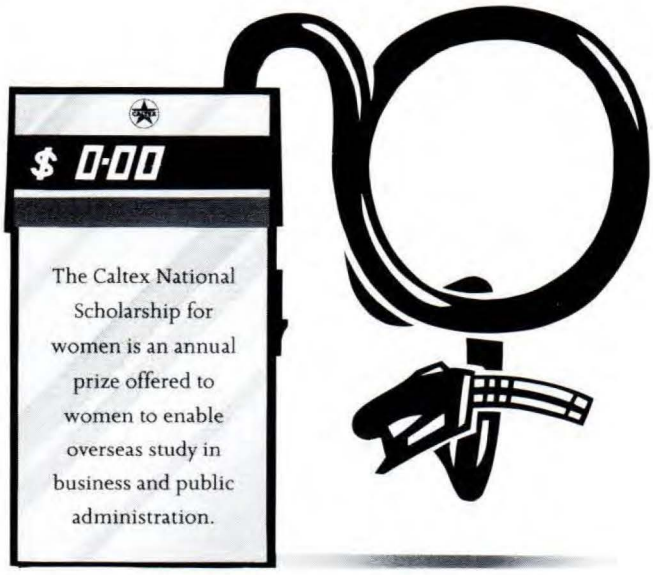

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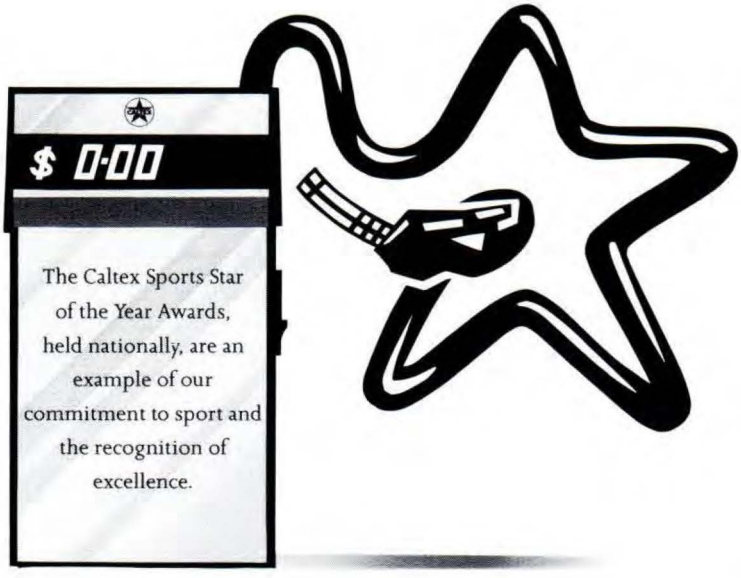

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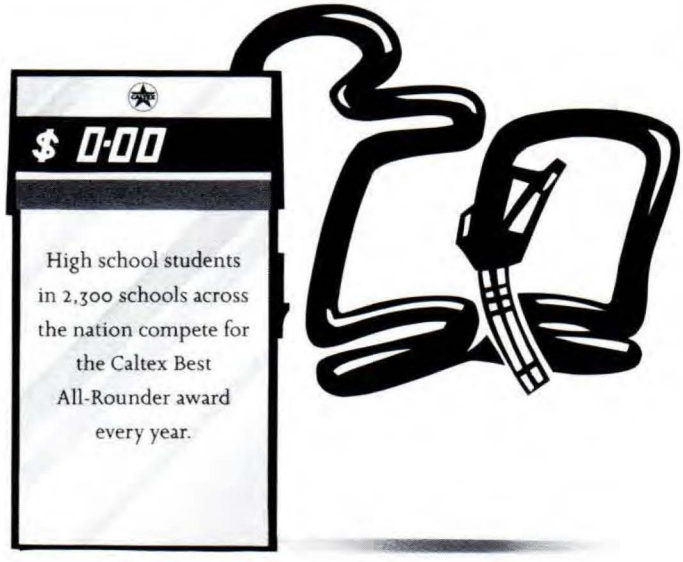

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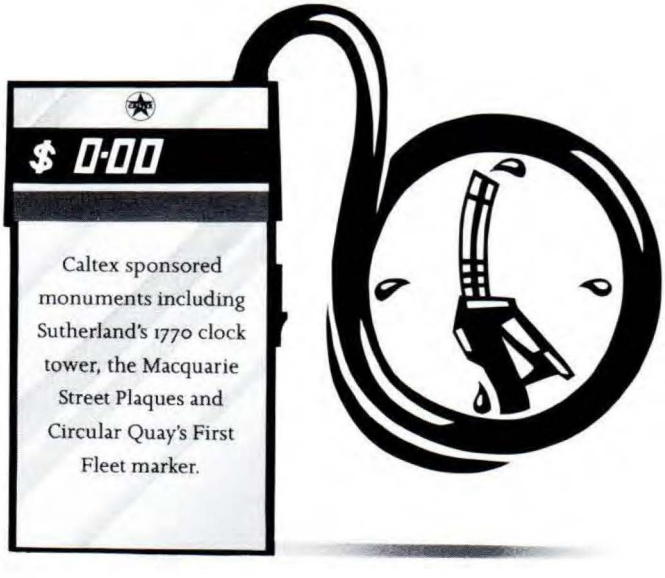

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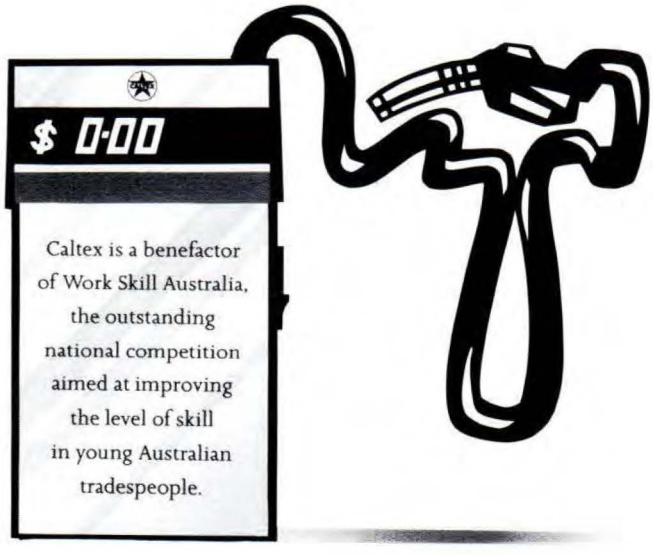

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Up Front

To launch the new volume, this issue takes you all over Australia and the world.

The inimitable Tim Flannery recently had his curiosity whetted by the puzzling realisation that the greatest diversity of plants and animals occurred in areas of poor fertility. Tim's explanation takes us on a journey from the heathlands of Western Australia, to the Great Barrier Reef and the mountains of New Guinea.

COURTESY TIM FLANNERY

Britain's premier environmental activist, Jonathon Porritt, addresses the problems with pollution for the Third World and proposes a simple solution that benefits all.

We also look at those peculiar plants called grasstrees. These amazing, useful plants, surrounded by myths of their apparent antiquity and resilience, are discussed by David Bedford of Sydney's Royal Botanic Gardens.

Bill Freeland questions the value of the introduced Water Buffalo in the Top End—is it really such a pest? Bill explains what went wrong with its introduction and what can be done to satisfy both the tourism industry and the environmentalists.

Regular readers will notice great improvements in the new volume; we thank those readers who participated in our reader's survey. Taking on board your comments, we've returned to the photographic poster, by popular demand, and will continue to bring you more exciting, cutting-edge articles.

—Fiona Doig, Editor & Georgina Hickey, Scientific Editor

ANH

Volume 24 Number 1

Published by
The Australian Museum Trust
6-8 College Street,
Sydney, NSW 2000
Phone: (02) 339 8111
Fax: (02) 339 8313
Trust President: Robyn Williams
Museum Director: Desmond Griffin

MANAGING EDITOR
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ART DIRECTION
Watch This! Design
TYPESETTING
Keen Permofilm
PRINTING
Excel Printing Company, Hong Kong
ADVERTISING
Mike Field
Phone: (02) 339 8119
SUBSCRIPTIONS
Mary Pollinger
Phone: (02) 339 8119
Toll-free (008) 028 558
Fax: (02) 339 8313
Annual subscription (4 issues)
Within Australia $A30
Other Countries $A42 (8 issues)
Two-year subscription
Within Australia $A58
Other Countries $A78

New subscriptions can be made by credit card on the ANH toll-free hotline 008-028 558 or use the form in this magazine. If it has been removed, send cheque, money order or credit card authorisation to the address above, made payable to the 'Australian Museum' in Australian currency.

ANH is printed on archival quality paper suitable for library collections.

Published 1992
ISSN-0004-9840

ANH is audited by the Audit Bureau of Circulations.

ANH is proud winner of the 1987, '88, '89, '90 & '91 Whitley Awards for Best Periodical.

Front Cover
The tiny Honey-possum feeds entirely from flowers. The heaths of south-western Australia are so rich in nectar and pollen that this possum can usually get all its food from an area of no more than 40 square metres. And yet its food plants occur in a very nutrient-poor environment! Tim Flannery investigates the phenomenon of infertile places producing great diversity in 'The Diversity Enigma'. Photo: Wesley Tolhurst.

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FROM THE ARCHIVES

GARDEN PALACE UP IN SMOKE

In 1879 the Australian Museum was given the opportunity to display a collection of ethnological specimens in Sydney's newly constructed Garden Palace. The offer was immediately accepted, as lack of room had become a paramount problem. Unfortunately, never before was free space to prove so expensive.

BY PAUL McKEON

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RARE & ENDANGERED

THE PLAINS-WANDERER

The Plains-wanderer is a bird that was once widespread in the lowland native grasslands of south-eastern Australia. Its distribution, however, has been greatly reduced as a result of cultivation of native habitat and overgrazing. Find out how farmers in the Riverina and elsewhere can do their bit for this bird.

BY DAVID BAKER-GABB

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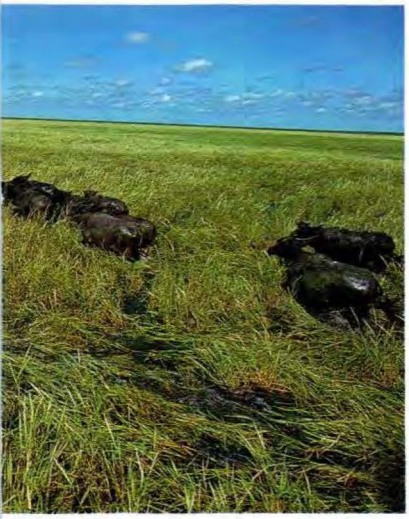

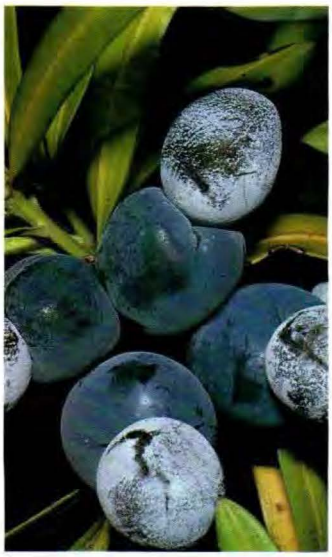

WILD FOODS

A TRIBUTE TO ROWNTREES

Tasmanian smoked salmon with lilly pilly, banksia-smoked Water Buffalo with Bunya nuts and Riberries. Sound good? These are just a couple of the dishes that were on offer at Rowntrees–the first wild foods restaurant in Australia. Although Rowntrees is no more, a new restaurant with the same imaginative chef has opened up in Sydney.

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Rabbit-driven lawn mowers, messages in a bottle, and the role of motor cars and trouser turn-ups in seed dispersal. These are some of the research topics dreamt up by ANU's Nigel Wace. And they just go to show that you don't have to be solemn to be serious.

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As animals, we tend to regard plants as defenceless blobs of mindless biota whose purpose is to be laid down on a plate before us. However, the consumer–consumee relationship is rarely so peaceful and an exploration of the War of the Kingdoms reveals some prickly situations.

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THE MAWSON HUSKIES: THE CASE FOR RETENTION

The decision to remove the huskies from Antarctica was based on concerns about their environmental impact. But those concerns are unfounded and huskies provide the safest form of human transport.

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LETTERS

Comments, criticisms and congratulations from concerned correspondents. Readers are invited to air their views.

Top Tour

Not only did ANH advertise a tour tailored to my requirements but it also provided me with information that made that tour most enjoyable and helped me plan other interesting holidays for the future. Please encourage all tour operators who specialise in nature tours to advertise in this magazine! It's where nature addicts like myself look for ideas and new places to visit.

—R. Zhang
Vaucluse, NSW

Sago So So

In her letter, Pamela Reid suggested that sago discourages ants in the kitchen (ANH vol. 23, no. 6, 1990). We've tried it over the last six months or so and it does work, but only if you don't have much of an infestation. Open dishes of sago kept the ants away for a couple of months, but once they had really established themselves in the house, I'm afraid it was back to attacks on the nests and pesticides in the roof. We really didn't want to try petrol or boiling water there! Have readers any other suggestions?

—Peter White,
Redfern, NSW

Obituary Part Two

Reading the letter "Obituary for a Lizard" (ANH vol. 23, no. 10, 1991) brought a flood of memories back to me. I, too, remember Campsie Pet Shop. In the late 1960s and '70s thousands of reptiles passed through this shop, the majority of which died prematurely because of ignorance and neglect.

Regularly my boyhood companion Peter Rankin and I would peruse the shopfront looking in awe at scenes like a dead Black-headed Python, or a Lace Monitor eyeing off the next Blue-tongue to be his dinner. All types and sizes of reptiles were housed there! One week Peter actually bought a Blue-tongue. Unfortunately, it did not live as long as the Blotched Blue-tongue, Freckles.

Twenty years later I still collect reptiles, but do not keep any in captivity. It takes a long time for herpetologists to get over the need to keep animals in cages. Although Peter died about ten years ago while on a collecting trip, the memories of those days are still strong. I fondly recall the time spent looking in the shopfront at the pet shop, collecting reptiles at nearby 'Pencil Rock', and the thousands of hours spent with Peter discussing aspects of herpetology.

Fortunately pet shops do not deal in reptiles any more. Unfortunately the bush at Pencil Rock no longer exists, replaced by a clear line of Kikuyu.

—Garry Daly

A Cyclonic Experience

Recently I had the unfortunate experience of a cyclone ripping through our little township of Manyana Beach on the New South Wales south coast.

I was out watering the lawn when all of a sudden this powerful force came pounding down our street. I ran inside the house, shutting all the windows and doors, completely scared out of my wits. The cyclone had such an eerie feel about it. It sounded like a thousand people trying to get into our house.

We watched as three 30-metre *Casuarina* trees next door snapped like broken toothpicks, narrowly missing our house. Rooves were uplifted and blown around like deadly missiles. A lounge ended up down the beach and yet, with all this energy, miraculously my washing stayed on the line!

The whole event left me thinking how small humanity is even with all our powerful technology; we are powerless when confronted with natural disasters like cyclones and floods. Maybe we should start cleaning up the huge mess we've made before nature does it for us!

—Vicky Kapatos
Manyana Beach, NSW

Devastation caused by a cyclone.

ROBERT ESTALL / HORIZON

Good Work

Australian Natural History is a wonderful and far-sighted magazine. We learn a lot from it.

—A. Seddon & R. Ryan
Candelo, NSW

Rosy Glow

The QQC article on fluorescence in parrots (ANH vol. 23, no. 10, 1991) showed a picture of an Eastern Rosella under normal white light and under ultraviolet light. The colour differences are due to fluorescence, a physical property of pigments that allows them to absorb light at one wavelength and re-emit it at another, higher, wavelength. The observations reported are interesting, but do not support

the article's inference that parrots might be able to see into the UV range.

The author of the article illuminated the parrots with a UV source; he observed them with his own eyes and what he saw and the reader sees from

CARL BENTO / AUSTRALIAN MUSEUM

Fluorescing Eastern Rosella.

the photograph is light in the visible region of the spectrum, because that is what *our* eyes can see. That cannot tell us whether or not parrots can see into the UV; to support that contention, the light emitted by the parrot when illuminated in the UV would have to be analysed by a device that can record UV light.

The question remains, why *do* parrots have interesting markings that show up when illuminated with UV light? As the author mentions there are other instances of markings that look more interesting when illuminated in the UV, such as nectar guides in flowers (which have similarly been misinterpreted to suggest that pollinating birds and insects can 'see in the UV'). I don't know the answer and, without knowing what range of UV was used in the experiments, it is difficult to guess. It is conceivable that some of these patterns show differently in the visible spectrum depending on the amount of UV in sunlight (something that varies, as we are now reminded daily). A wise Eastern Rosella may look for cover when it sees its mate looking rather purple around the head. It is also quite possible that birds and humans see colours differently, although still in the visible region, because of a different mix of colour-sensitive receptors in their eyes.

All that is speculative; what is clear is that we cannot infer that birds can see in the UV in experiments where we irradiate with UV, but look for signals in the visible part of the spectrum.

—Heddy Zola
Seacliff, SA

Several valid points have been raised concerning a rather overly enthusiastic inference about the ability of parrots to see UV. Certainly the presence of fluorescing pigments is not the same as the ability to see into the ultraviolet. An analysis such as that suggested would be required but, to my knowledge, has not been carried out.

Although the evidence exists that some groups of birds can see UV, no-one, unfortunately, has done the necessary work on parrots. There are several ways this could be pursued: checking the structure and chemistry of the eye for the requisite features for UV perception; or studying behavioural responses to visual stimuli at different wavelengths (variations of this method have been successfully used to determine visual resolution in birds of prey).

It is interesting to speculate on the function of the fluorescing markings. I suspect that the presence in parrots of interesting, UV-responsive pigments may be largely coincidental. That these pigments fluoresce could be merely a chance by-product of its chemistry. Another group of avian pigments, the porphyrins, fluoresce red; however they occur in sections of the feathers that are not exposed (such as in the concealed bases of feathers) or in nocturnal birds (owls). Fluorescence of these pigments does not appear to serve any obvious role. A similar situation may exist for those in parrots.

Hopefully someone will tackle these interesting questions, and not just for parrots. Fluorescing pigments have since been found in other groups for which it was previously unreported, including some of the birds of paradise and in the bill of a strange group of African birds, the turacos (Musophagidae).

—Walter Boles
Australian Museum

ANH welcomes letters for publication and requests that they are no more than 400 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter.

QUOTES & CURIOS QUIPS

COMPILED BY GEORGINA HICKEY

Left-handed Cradling

Human mothers cradle their babies on their left side about 80 per cent of the time, independent of whether they are right- or left-handed, or from which breast their infant prefers to suckle. Scientists John Manning and Andrew Chamberlain from the University of Liverpool in the UK have now found that female great apes—Gorillas, Chimpanzees and Orang-utan—also cradle their babies on the left side about 80 per cent of the time (*Anim. Behav.* 39: 1224–1227; 1990).

The traditional explanation for left-handed cradling in humans is that it places the baby over the mother's heart and the sound of her heartbeat quietens the infant. But, argue Manning and Chamberlain, heart sounds actually emanate from the midline—not the left side—of the chest and they suggest that the behaviour may have evolved for very different reasons.

It has to do with the fact that the left and right sides of the human brain process different sorts of information. In the right hemisphere, much of the sensory input from the mother's left eye and ear is processed. Here, too, is processed emotional information such as that gleaned from facial expressions. It is also generally accepted that emotions are more intensely expressed on the left side of the face than the right.

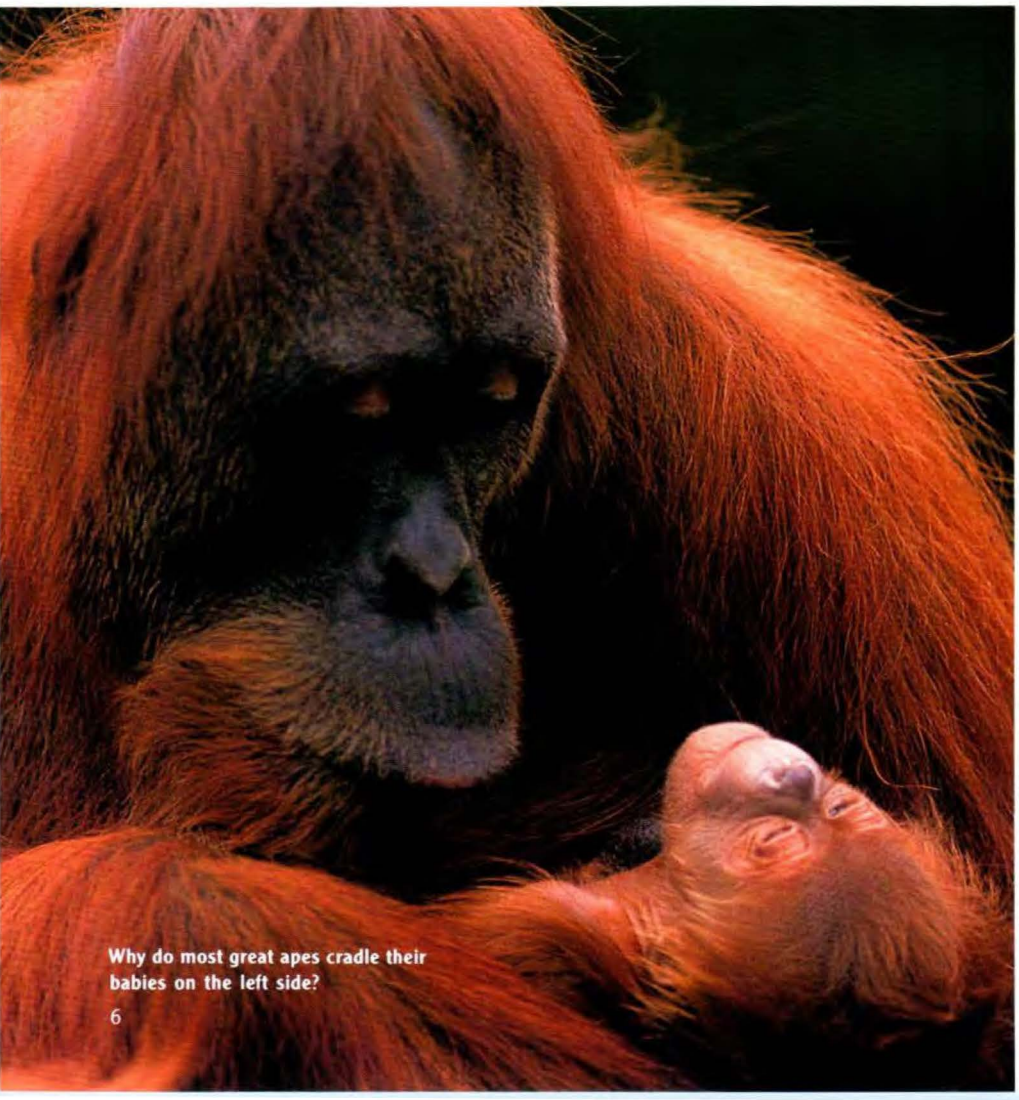
The authors believe that, because of this brain 'lateralisation', left-handed cradling might have a two-fold advantage. First, the mother is able to more effectively monitor her baby's well-being with her left eye and ear and, second, the infant is able to monitor its mother's emotional condition better, because her most expressive, left side is visible to it.

Emotions are more intensely expressed on the left side of the face than the right.

If ths interpretation is correct, it could be that the specialisation of the right hemisphere for the interpretation of emotion is present not only in humans but also in great apes, suggesting that it evolved more than six to eight million years ago (and, incidentally, pre-dates the evolution of right- or left-handedness, which is seen only in humans). Curiously, the preference for left-handed cradling is lacking or at least poorly developed in human fathers. Why this should be so is perhaps one of the most fascinating aspects of Manning and Chamberlain's ongoing research.

—S.H.

Dr Suzanne Hand, a biologist at the University of NSW, and Karen McGhee, a freelance science writer living in Newcastle, are regular contributors to QQC.



EVAN COLLIS/AUSTRALIAN PICTURE LIBRARY

Why do most great apes cradle their babies on the left side?

OTTO ROGGE / ANT PHOTO LIBRARY

Seaweed hats keep mussels warm in winter and cool in summer.

Mussels with Hats

Natural sunscreens have been found in corals from the Great Barrier Reef, so it shouldn't be surprising to hear that mussels may wear hats.

In the widely shifting fortunes of the seashore, mussels offer organisms such as barnacles and seaweed a relatively stable substrate on which to settle, take hold and grow. It is usually assumed that the mussels only suffer from the opportunism of these interlopers. The water drag on their shells is increased causing higher mortality rates during storms; they use more energy attaching their heavier loads to rocks; and their growth suffers when the currents they circulate to filter feed are interfered with by the trespassers.

The relationship may not, however, be so one-sided. Deborah Brosnan, from Oregon State University, suggested at a recent Systematic's Association Symposium in the UK that, under certain circumstances, the trespassers could be important to the mussels' survival (*BBC Wildlife* 8: 721; 1990).

While studying an Oregon population of *Mytilus californianus*, a mussel species common along the west coast of the US, Brosnan had the opportunity to observe the potential benefits of seaweed 'hats'. A period of freezing weather caused high mortality in the population but survivors tended to be graced by attachments of the red seaweed *Endocladia muricata*. The seaweed appeared to insulate the mussel, providing it with the ability to survive very low temperatures. This was supported by laboratory experiments.

Brosnan's work also revealed that the hats worked just as effectively at keeping the mussels cool in very high temperatures. When exposed to air temperatures that would normally be lethal to mussels, she found that the temperature inside mussel shells with hats was significantly cooler than in those without the seaweed. The cooling effect was provided by evaporation of water from seaweed.

—K.McG.

LET'S HAVE LUNGE

Research on Northern Hemisphere Humpback Whales led scientists to believe these whales don't feed during migration. However, unconfirmed reports had suggested that Humpbacks from the Southern Hemisphere feed opportunistically towards the southern end of their journey. At last clear photographic evidence shows that they do just that. This photo, taken off the New South Wales southern coast at Eden, shows typical lunge-feeding behaviour, in which the whale makes an open-mouth grab for prey, either from below or by making the sideways lunge shown here.

Humpbacks are baleen whales, which feed by taking a large mouthful of water containing prey (usually krill or small fish), closing their mouth and forcibly expelling the water through the baleen plates, rather like a sieve. Dr Bill Dawbin, a Research Associate of the Australian Museum, has been observing and sound-recording Humpbacks for the last ten years. He hopes to lead a team of researchers to Eden later this year to determine exactly what the whales are feeding on.

— Linda Gibson

ROSALIND BUTT / CAT BALOU CRUISES

KEN McNAMARA

The 420-million-year-old euthycarcinoid—clue to the origin of insects.

Insects' Missing Link

Every once in a while a fossil is found that turns existing wisdom on its head. Such a specimen was found in July 1990 in Western Australia by members of the Department of Earth and Planetary Sciences at the Western Australian Museum. Looking a bit like a long cockroach with a few extra pairs of legs, this fossil adds another bit to the jigsaw of the early origins of insects and the colonisation of land by animals.

Found close to the Murchison River near Kalbarri, this 13-centimetre-long specimen represents the impression of an arthropod (the group of invertebrates that includes insects and crabs, and such like). Not only does it represent the first body fossil from the 420-million-year-old sandstones through which the Murchison River has cut, but more importantly it belongs to a very rare but taxonomically significant group of arthropods known as euthycarcinoids.

When we found the fossil our first thought was that it was the remains of a 'sea scorpion', the group of arthropods more formally known as eurypterids that grew to two metres in length and ruled the rivers and lakes 400-odd million years ago. However, our fossil had far too many pairs of legs, and the more we looked at it, the less it looked like a sea scorpion or, in fact, any other group of arthropods known from rocks of that time. Eventually we came to the conclusion that it could only be a euthycarcinoid. But what this meant was that we had extended the range of this group back by about 120 million years!

Previously euthycarcinoids had only ever been found in rocks between 230 and 300 million years old in France, the USA and New South Wales. When first recognised in 1914, euthycarcinoids were thought to be crustaceans. But with the discovery in the 1970s of exceptionally well-preserved specimens in France and the USA it became clear that euthycarcinoids were more closely related to myriapods (centipedes and millipedes) and hexapods (insects), and so they were placed in the same phylum, the Uniramia (*Naturwiss. Ver. Hamburg Abh.* 23: 742; 1980)

The Western Australian specimen is very similar to its younger cousins, with six overlapping plates called tergites covering 11 segments, each of which carried a pair of segmented walking legs. This is followed by five narrower tergites, ending in a long spine. The head is very small.

Although we have recently tried to find more specimens, we have so far been unsuccessful. However, we have discovered trackways that we think were made by this beast and, like trackways made by sea scorpions at the same site, it is clear these creatures were walking out of water and were therefore among the first creatures to venture onto land.

The importance of the specimen lies not only in the fact that the range of this group of animals has been greatly extended back in time, but also because ten years ago palaeontologists Fred Schram and Ian Rolfe suggested that the euthycarcinoids possessed all the right morphological features that would be expected in an ancestor of the insects (*J. Palaeontol.* 56: 1434–1450; 1982). The problem was that the oldest euthycarcinoid was only 300 million years old, whereas the oldest fossil insect remains were from rocks about 380 million years old. Now that we know that the euthycarcinoids lived before the

insects, the argument for them being ancestral to insects is greatly strengthened.

Combined with other recent discoveries of terrestrial arthropod remains in New York, USA (see "In Search of the Oldest Spider" in QQC vol. 23, no. 12, 1992) and in Shropshire, England, the Western Australian findings provide evidence that the colonisation of land may not have been an orderly progression from plants, followed first by plant-eating animals, and then meat-eating animals. Instead, all of the arthropods wandering on this ancient land surface were doing so about the same time that the first vascular plants were taking root on land, or perhaps even earlier, and these animals were all carnivorous. Thus it seems, even in its infancy, nature would have been 'red in tooth and claw'.

—Ken McNamara
Western Australian Museum

CARL BENTO / AUSTRALIAN MUSEUM

Posture of a 'falling' mouse.

Don't Sleep with Your Mouse Fall

Have you ever held a mouse by the tail? And have you ever then jerked your hand down while still holding onto the mouse's tail? You will have noticed that it adopts a perculiar, yet characteristic posture—jaws agape, ears erect, toes spread, legs straight and stiff with front ones together and back ones spread. This is the same posture that the mouse adopts when dropped.

Armed with this knowledge that mice can fall considerable distances without injury, M.R.A. Chance, back in 1953, decided to investigate whether this posture protects the mouse during falls *(Brit. J. Amin. Behav.* 1: 118-119). Five adult male mice were completely anaesthetised and dropped over three metres onto a hard surface. Five normal, that is unanaesthetised, male mice were also dropped and, upon landing, all walked away apparently unharmed. One hour later, before the anaesthetised mice had a chance to wake up, all mice were killed and examined for haemorrhages. Only one of the normal mice was found to have suffered a minor lesion in the hip region; whereas all of the anaesthetised mice had extensive internal haemorrhaging, especially in the lining of the gut.

Assuming that the drug used to anaesthetise the animals did not induce the bleeding, I think one could safely say that the posture of a falling mouse does indeed protect the animal against damage of impact at the end of the fall.

— G.H.

The Biggest Dinosaur

The large dinosaurs, when first recognised in the 19th century, so impressed palaeontologists that they were given grand, imposing names: *Atlantosaurus*, the saurian of Atlas; *Brontosaurus*, the thundering saurian; *Gigantosaurus*, the gigantic saurian; and *Titanosaurus*, saurian of the Titans. Our Australian *Rhoetosaurus* was named for a mythological giant. There was even a minor crisis in coining names and the name *Titanosaurus* was proposed independently for two different dinosaurs, as was *Gigantosaurus*. This tradition was recently revived with the names *Supersaurus* and *Ultrasaurus* (also proposed twice), so named because they were thought to have lengths 'above' and 'beyond' other dinosaurs.

Which was the biggest dinosaur is a matter not often considered scientifically important. But it is. The great dinosaurs were the largest land-dwelling animals, and may therefore demonstrate the structural and physiological limit of the terrestrial vertebrate form. Even so, only three scientific papers have been devoted to the sizes of the largest dinosaurs: one in 1962 on their weights by Edwin H. Colbert, then of the American Museum of Natural History (*Amer. Mus. Novit.* 2076: 1–16); one in 1969 on their lengths by Leigh Van Valen, at the University of Chicago (*Copeia* 1969: 624–626); and recently (1988) one on both lengths and weights by Greg Paul, a freelance palaeontologist in Baltimore, Maryland (*Hunteria* 2(3): 1–14).

There are several ways in which something can be the 'biggest'; here the longest and the most massive (heaviest) of the dinosaurs are considered. The length is usually measured along the curve of the backbone. Although there were large and small kinds in most dinosaur groups, the largest of all belong to the Sauropoda. These, with their elephantine legs, long serpentine necks and tails, and rela-

COURTESY RALPH MOLNAR

The most massive dinosaur known from a reasonably complete skeleton is *Brachiosaurus brancai*. The skeleton is mounted in the museum of the Humbolt University in Berlin.

CARL BENTO / AUSTRALIAN MUSEUM

Propolis: nature's antiseptic courtesy of the bees.

Bee Glue Makes a Comeback

To seal their hives against invasion by other insects and the weather, bees use a form of natural glue called propolis. This is a pleasantly aromatic, sticky, brown substance that effectively prevents bacteria and moulds from flourishing. If an intruder does happen to enter the hive and it is too large to remove, to prevent it rotting it is wrapped in propolis and slowly mummified.

Humans throughout history have also found propolis to be a most useful commodity, as explained by W. McL. Thomson in *The Medical Journal of Australia* (153: 654; 1990). Stradivarius, for example, varnished his violins with it (as do modern violin makers) and there is evidence that it was used as an antiseptic in prehistoric surgery. As recently as the Boer War, 90 years ago, an ointment of propolis and Vaseline was used to treat battle wounds.

Propolis is currently enjoying renewed popularity as a health product and is being marketed as an antiseptic, a dressing for wounds and leg ulcers, and is being used in throat lozenges, soaps and cosmetics.

A mixture of balsams, resins, waxes, oils and pollen, propolis is initially collected by bees from the buds of trees, which are themselves coated with the sticky substance to protect them from moulds and infection during winter and spring. It is carried to the hive as globules in the pollen baskets on the bees' rear legs where secretions from the glands of worker bees are added.

Propolis was once regarded by beekeepers as a nuisance because the glue had to be regularly scraped from the wooden frames of artificial hives. Now beekeepers are selling their propolis for up to a dollar per ten grams. And it has been found that, if propolis is rubbed over empty hives, swarms of bees can be attracted by the scent, no longer necessitating the time-consuming collection of new swarms.

—S.H.

tively small heads, first come to mind when thinking of dinosaurs.

The longest reasonably complete dinosaur skeleton is that of *Diplodocus carnegiei*, from the western United States: it is 24.8 metres long. The most massive dinosaur known from a reasonably complete skeleton is *Brachiosaurus brancai* from Tanzania, 22.2 metres long, and variously estimated as weighing from 45 to 80 tonnes.

However, just as the largest fish get away, so are the largest dinosaurs known only by fragmentary specimens. How can the size or weight of a dinosaur be estimated from just one bone? To begin with, the length of the bone is assumed to be a consistent proportion of the length of the skeleton. Next we must choose some well-known sauropod as a model. If all sauropods looked alike, this would not be too difficult, but there were three different forms. The dicraeosaurs had long tails and rather short necks; brachiosaurs had long necks and relatively short tails; and most of the others, including *Diplodocus*, had long necks and long tails. So, if *Diplodocus* is used as the model to estimate the length of the skeleton from a few bones, a greater length, but lower weight, will result than if *Brachiosaurus* was used. Thus there has always been room for disagreement over which sauropod was really the longest, or heaviest.

So what can we reasonably estimate? The aptly named *Supersaurus vivianae* from Colorado (USA) was probably about 42 metres long. This was a close relative of *Diplodocus*. Slightly shorter were *Amphicoelias altus*, also from the USA, and a recently discovered titanosaurid from Argentina, still unnamed, which were both about 38 metres long. The longest, it appears, is *Seismosaurus halli*, the earth-quaking saurian. It is estimated to have been between 39 and 52 metres long, but more likely toward the long end of the range. Because all these dinosaurs were closely related to *Diplodocus*, that dinosaur was used as the model. *Ultrasaurus* (now renamed *Ultrasauros) mcintoshi*, on the other hand, was more closely related to *Brachiosaurus*. Using that as a model suggests that *Ultrasauros* was no larger (longer) than *Brachiosaurus brancai*.

Giant sauropods are also represented by tracks and trackways, such as *Breviparopus taghbaloutensis* from Morocco. Measurements from trackways can give a good estimate of the distance between the shoulder and hip joints. For *Breviparopus* this is 5.1 metres. Again using *Diplodocus* as a model, this gives an overall length of about 39.5 metres. Although not as long as *Supersaurus* or *Seismosaurus*, it is still impressively longer than the longest sauropod skeleton on display. A trackway from a sauropod of comparable size has also been found in Texas.

Seismosaurus seems to be the largest dinosaur known, by quite a margin: some of its bones are as much as 100 per cent longer than those in the related *Diplodocus*. Only the back of the trunk, pelvis and tail are known, but they suggest that *Seismosaurus* did not look like the better known, smaller sauropods. Its tail was relatively much deeper, and the pelvic structure suggests that the limbs were rather short, earning it the title of 'the dachshund of dinosaurs'.

Turning to the weight, estimates for *Brachiosaurus* of about 80 tonnes are now thought to be exaggerated, and a weight of 45 tonnes is regarded as more likely. *Supersaurus* seems to have been slightly more massive, at about 50 tonnes. *Antarctosaurus giganteus*, from Argentina, may also have weighed 50 tonnes. Paul points out that these estimates probably represent animals in lean condition, so they may have been heavier in prime condition.

And how do these compare with whales? Whales are clearly more massive: the Blue Whale (*Balaenoptera musculus*) typically weighs 80–100 tonnes, and as much as 200 in prime condition. It reaches 35 metres in length. The heaviest terrestrial mammals, baluchitheres (extinct giant rhinos) and mammoths, were probably not much over 20 tonnes. So the living whales are the most massive vertebrates, but the dinosaurs were the longest.

—Ralph Molnar
Queensland Museum

GREGORY K. SCOTT / HORIZON

Squirrel Nut-ken

Grey Squirrels *(Sciurus carolinensis)* are well known for their habit of burying acorns or hickory nuts in separate sites and retrieving them months later. But how do they find them? Do they randomly detect buried nuts by their odour? Or do the squirrels remember where they buried the nuts and make a beeline for them?

Experiments carried out by Lucia Jacobs and Emily Liman of Princeton University on captive Grey Squirrels indicate that, while squirrels can locate buried nuts by their odour, they can also remember the individual locations of the nuts they have buried (*Anim. Behav.* 41: 103–110; 1991).

In the experiments, Grey Squirrels were tested for their ability to retrieve hazelnuts from their own storage sites and from ten sites used by other squirrels in a large outdoor test arena. Although each squirrel's own caches were close to the caches of the others, the squirrels retrieved significantly more nuts from their own sites than from sites used by other squirrels, even after delays of four or 12 days.

The captive squirrels appeared to run from one patch of caches to the next, harvesting them with little retracing of their steps. It seems possible that, like Chimpanzees, squirrels can remember a series of locations in relation to each other and use this to form a mental map in which information about cache sites may be stored.

In the wild, Grey Squirrels bury thousands of nuts over areas of a few square kilometres and retrieve them up to eight to nine months later. They are active throughout winter and spend a lot of time on the ground searching for caches and occasionally digging up and reburying a nut or acorn. Jacobs and Liman suggest that such husbandry of caches might refresh the memory of cache sites and thus reduce the length of time the squirrels must remember locations.

—S.H.

JIRI LOCHMAN

Operation Desert Storm

During rainstorms, desert-dwelling lizards have been observed to crawl out of the sand and adopt a most peculiar stance in order to harvest the precious rain that falls into their arid world. By lowering their heads and tails, flattening their bodies, splaying their legs and rhythmically opening and closing their jaws, Texas Horned Lizards *(Phrynosoma cornutum)* collect drinking water on the surface of their backs and, via a network of narrow, interconnecting channels between body scales, direct it into their mouths (*J. Herpetol.* 24: 302–308; 1990).

It had already been shown (in the 1960s) that water taken up onto the skin surface of Australia's desert-adapted Thorny Devil *(Moloch horridus)* was transported to the mouth for ingestion through such a network of channels and not, as suggested previously, absorbed through the skin. A similar water transport system was found in another agamid lizard *(Phrynocephalus helioscopus)*, this time from arid western Asia and Asia Minor.

However, the actual collection of water had not been observed in nature until researcher Wade Sherbrooke of the American Museum of Natural History recently recorded it in Texas Horned Lizards. Sherbrooke, who kept the lizards in outdoor enclosures in Tuscon, Arizona, used a blue dye to prove that during the rain-harvesting be-

Rain-harvesting stance in Australia's Thorny Devil?

haviour water was actually channelled from the lizard's back to its mouth.

The flattened stance adopted by the Texas Horned Lizards clearly maximises the number of falling raindrops intercepted. But it is also similar to a defence posture (termed 'dorsal shield') that is well known in this and closely related lizard species, and Sherbrooke suggests that the evolution of water-harvesting techniques may have involved modifications of more primitive, widespread stereotyped behaviours. (An interesting parallel is the 'fog-basking' stance of the desert beetle *Onymacris unguicularis*, which again appears to be a modified use of a widespread defensive behaviour in beetles.)

—S.H.

Quick Quiz

1. What sort of animal is a goatsucker?
2. In what year were rabbits introduced into Australia?
3. Which phobia is the fear of public and open spaces?
4. Name the chairperson of the CSIRO appointed in 1991?
5. What sea separated the two major landmasses of the world 190 million years ago?
6. To the nearest billion, how many people inhabit the Earth?
7. What is the largest fish in the sea?
8. Which country boasts the heaviest cockroach?
9. What does the Richter Scale measure?
10. What national park would you have to enter to see Ayers Rock?

Answers in the Questions & Answers section.

Today only a few pieces of the Museum's pre-1882 collection exist.

GARDEN PALACE UP IN SMOKE

BY PAUL McKEON

FROM ITS EARLIEST DAYS, THE AUSTRALIAN Museum has been on a quest for space. Last century's annual reports show a recurring theme: many wondrous new additions to collections yet dismay at the lack of room to display them in. As the Museum's role expanded to include new material, so too did its demand for space.

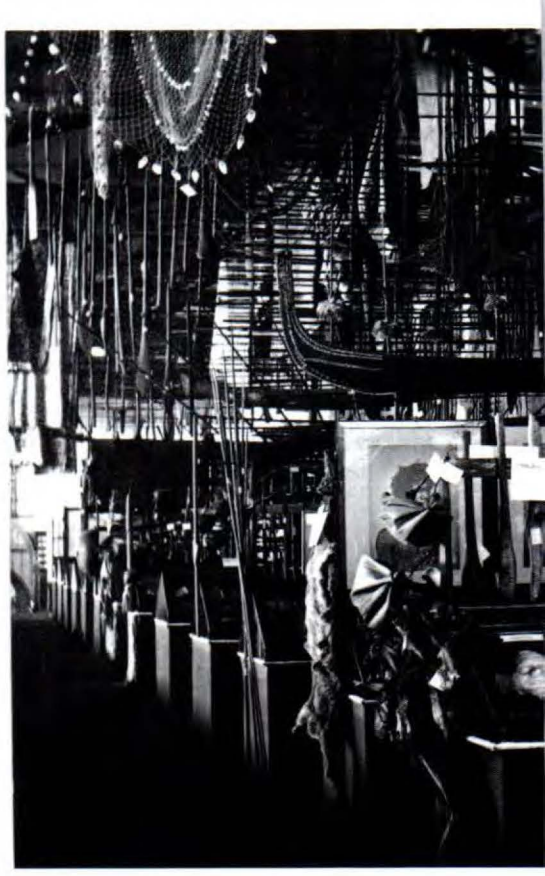
The invitation to display a collection of ethnological specimens at the Sydney International Exhibition of 1879 must have seemed like the work of providence. Not only did it provide the Museum with much needed space but it also presented an opportunity to exchange specimens with representatives from other parts of the world, and to acquire donations of specimens for the natural history collections.

Following a worldwide trend set by London's Crystal Palace built in 1851, an ostentatious building was erected on a site at Sydney's southern Domain. The Garden Palace, as it became known, was immense. A grand and ornate building, it occupied about three and a third hectares, today part of the Royal Botanic Gardens. The exhibition space was neatly divided by two intersecting passageways of 213 metres and 122 metres long and 15 metres wide. At the centre was a great fountain, surmounted by a colossal statue of Queen Victoria. The central glass dome above her was 30 metres in diameter and, at its peak, 64 metres above the ground.

Construction of the building aroused considerable interest among the people of Sydney. As it neared completion, the building became something of a tourist attraction. On warm afternoons the intricately landscaped grounds would be dotted with picnickers, presumably munching on cucumber sandwiches. In order to bring visitors to the Exhibition, Sydney's first tramway was built running up Hunter Street to the Macquarie Street entrance to the site and linking the area to what was then the nearest railway station at Redfern.

Remarkably, the Garden Palace was completed in time for the official opening, at a total cost of £191,800. This was despite the fact that work began only nine months earlier, that it was hampered by a carpenter's strike and that 25 centimetres of rain fell in the fortnight prior to the opening. Electric light was used at night to speed up progress—a surprising move as it had only been introduced to Sydney that year—and this most likely helped blow out the original £50,000 budget.

The official opening on 17 September 1879 was an extremely grand affair, presided over by the new Governor of New South Wales, Lord Augustus Loftus, and attended by nearly 24,000 people. The Sydney Morning Herald reported



A bird's-eye view of the Garden Palace burning from across Sydney Harbour.

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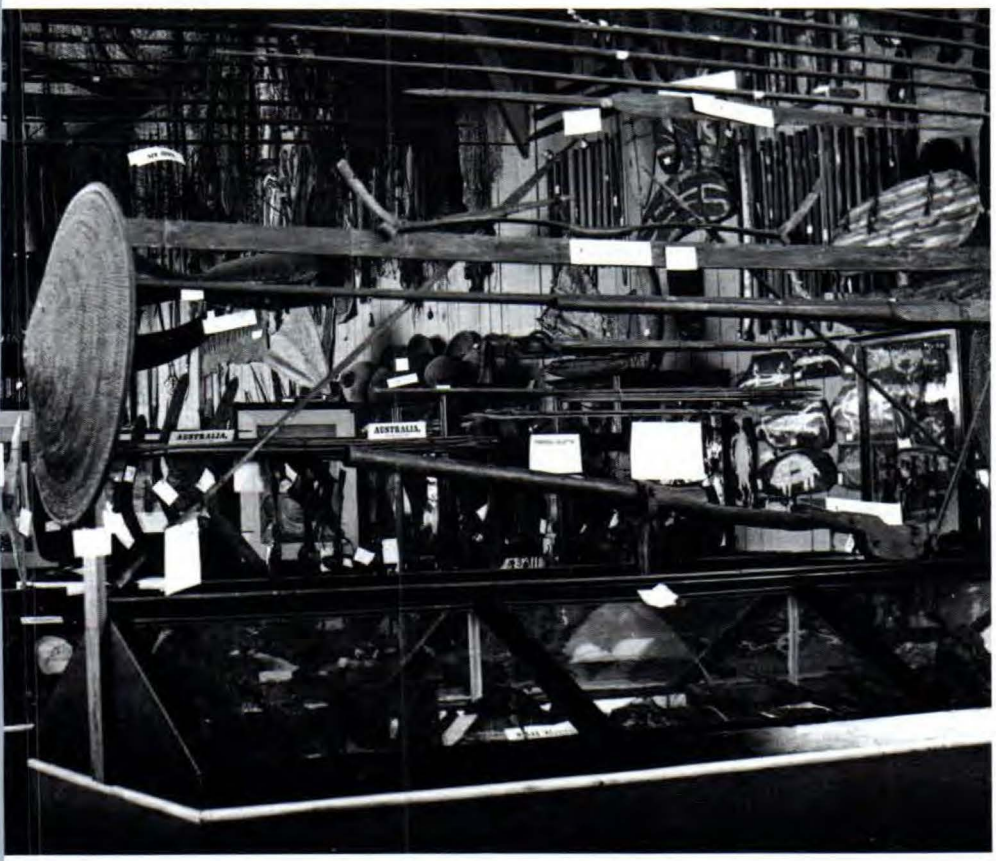

This archival photo shows the richness and variety of the collection at the Ethnological Hall.

"the day was unmistakably a holiday, as evinced by the throngs of people streaming in, dressed in their best and brightest apparel".

The Exhibition areas themselves were open weekdays only (which at the time included Saturdays) and, in response to public demand that the Exhibition be more accessible to the working classes, the hours were extended to 7pm during the summer months.

Exhibits came from around the world and they were certainly an awesome array of items. Anything and everything was included, from steam shovels to paintings; even a bridge and a passenger elevator.

The public, however, had to wait another two months to see the Ethnological Hall, which along with the Fine Arts Gallery (the building that is now part of the Art Gallery of New South Wales) opened on 11 November in celebration of the birthday of the Prince of Wales, a significant event for the colony.

The Ethnological Hall itself was extremely tightly packed, accommodating 5,200 items. Many of these came from private collectors, including some of the Museum's own Trustees, but the largest came from the colonial governments and the New Zealand Museum in Wellington. The Australian Museum's own contribution numbered over 2,000 specimens. The Museum's collection was awarded the First Degree of Merit, the highest honour possible at the Exhibition.

The Official Record of the Sydney International Exhibition, a copy of which is held in the Australian Museum Research Library, is an impressive volume of over 1,000 pages. Another, smaller, volume catalogues some of the different collections displayed, including the ethnological collection, and several of these pages are marked in pencil with what appear to be prices. Although it was noted elsewhere that some items were for sale, the Commissioners attempted to discourage the practice lest the Exhibition take on the appearance of a market place.

Initially surprising is the fact that comparatively few of the Museum's items related to Australian Aborigines or Torres Strait Islanders. They numbered 342 as opposed to 1,576 from the Pacific Islands and even then only a small number of those Aboriginal artefacts were from New South Wales. Jim Specht, the Museum's Head of Anthropology, remarked in *Rare and Curious Specimens* (1979) that, had the Aboriginal people of the Sydney region "made monumental structures and sculptures, bronzes and ornately adorned pottery, many examples of their work would no doubt have survived–probably in the major museums of Europe. But they were hunter-gatherers, with a simple but highly efficient material culture that easily perished and did not catch the eyes of the dilettanti".

When the International Exhibition closed after eight months on 20 April 1880 over one million people had attended. The highest number (27,000) was recorded on Australia Day, 26 January. (The population of Australia at the time was only about two-and-a-half million!) Despite the official ending, the Museum Trust elected to leave its collections at the Garden Palace. The sheer lack of space at the College Street building meant that, had the specimens been returned, they would have had to have been put into storage indefinitely.

Then fate intervened. On the evening of 22 September 1882 a spectacular fire consumed the Garden Palace and the entire building was reduced to charred rubble. Speculation existed that the fire was deliberately lit in order to destroy records of the 1881 Census and thus convict records, which were stored in Government offices housed there, but no proof was uncovered. The entire ethnological collection present at the time was destroyed. Today only a few pieces of the Museum's pre-1882 collection exist; those surviving were most likely on loan at the time of the fire:

The Trustees described the event in the 1882 annual report as "the most serious loss ever sustained by the Museum." It spurred the Museum's Curator, Edward Ramsay, to attempt to reconstitute its ethnological collection. Shortly after the fire, the Trustees authorised an initial £50 toward that aim, themselves noting "this is a work which admits no delay, as genuine ethnological examples from the islands are becoming scarcer every day, in consequence of the general spread of trade and civilisation throughout the whole of Polynesia".

Speculation existed that the fire was deliberately lit but no proof was uncovered.

Although Ramsay's efforts were very successful and saw some 7,500 specimens housed in a newly constructed Ethnological Hall within five years, much of what was lost, sadly, was lost forever. ■

Suggested Reading

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Paul McKeon is a member of the Community Relations team at the Australian Museum and has a BA in Mass Communication. Paul's interest in this subject was sparked by illustrations of the Garden Palace he spotted at the Oaks Hotel in Neutral Bay.

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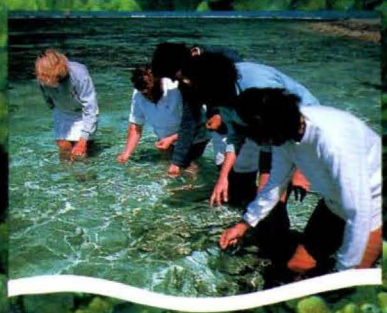

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The main threats to Plains-wanderers are cultivation of native grasslands and overgrazing.

THE PLAINS-WANDERER

BY DAVID BAKER-GABB

T. PESCOTT/NPIAN

THE DESTRUCTION OF LOWLAND native grasslands is not unique to temperate south-eastern Australia. The pampas of Argentina, the prairies of America and the chalk grasslands of Europe have all been drastically altered and depleted due to their suitability for, and sensitivity to, agriculture. Threatened grassland fauna, such as the Plains-wanderer *(Pedionomus torquatus)*, have undergone a concomitant decline.

The Plains-wanderer is a small, cryptic, ground-dwelling bird that superficially resembles button-quail *(Turnix* spp.). As well as resembling button-quail in shape and size, like them the female is larger and more brightly coloured than the male. The male does most of the incubation and all of the chick rearing, leaving the female free to pair with another male. This reversal of the sizes and roles of the sexes during breeding is unusual for birds and, among other things, led taxonomists to classify the Plains-wanderer in the same order as button-quail.

The Plains-wanderer has always been of great scientific interest as the sole member of a family of birds (Pedionomidae) found only in south-eastern Australia. This interest was heightened recently when the species was reclassified as a shorebird most closely related to seed-snipe *(Thinocorus* spp.), a group of South American inland shorebirds. This relationship gave rise to speculation that the Plains-wanderer is a very ancient member of Australia's avifauna, with its origins tracing back over 60 million years to when Australia was part of the Gondwanan supercontinent and connected to South America via the Antarctic land bridge.

This bird is a very ancient member of Australia's avifauna.

Plains-wanderers were formerly widespread in the lowland grasslands of south-eastern Australia. They have declined markedly in range and numbers, particularly in coastal areas, and now have a very patchy distribution in their remaining strongholds in the Riverina of New South Wales, north-central Victoria and south-western Queensland.

Areas preferred by Plains-wanderers are sparse grasslands with about 50 per cent bare ground, ten per cent fallen litter, and the rest comprising of low (less than five centimetres) vegetation with a small amount of taller vegetation important for concealment. Plains-wanderers are about 15 centimetres tall when on tiptoe. It follows that in sparse, but not dense, grass they can see over the vegetation, move freely when foraging and running away from predators in a hunched posture, while also being able to avoid detection by aerial predators.

Plains-wanderers forage during the day for a wide variety of seeds and ground-dwelling insects. Grass and saltbush seeds, and beetles, ants, sucking bugs and caterpillars, are most frequently taken. Nests consist of a shallow grass-lined scrape. In the southern part of their range first clutches are laid between late August and early November, and second clutches in January if summer rains fall. In south-western Queensland they breed in autumn and early winter. Plains-wanderers have the ability to recover quickly from low population levels following droughts.

The main threats to Plains-wanderers are cultivation of native grasslands and overgrazing, which result in permanent or temporary loss of habitat respectively. Any areas to be managed for Plains-wanderers need to be fenced to exclude rabbits and to control domestic stock. This applies to areas acquired as reserves or private land managed under voluntary conservation agreements. In the Riverina and north-central Victoria, at least, long-term exclusion of grazing from reserves is not likely to result in their becoming dominated by woody plants. Nevertheless, monitoring of the grassland's structure will be necessary to ensure it does not become too dense for Plains-wanderers.

Most areas favoured by Plains-wanderers are on eroded country with the lowest productivity for grazing. In areas managed under voluntary conservation agreements, the intermittent removal from grazing of, say, less than one per cent of the poorest land on a large property should have negligible financial impact for graziers. In southern areas stock should be excluded in early August at the start of the Plains-wanderer breeding season. Reintroduction of stock will depend on rainfall and may be as early as February in a wet year, as late as May in a dry year, or not at all during a recognised drought. While reserves containing more than 450 hectares of suitable grassland are ideal, even appropriately managed areas of 50 to 100 hectares can serve as drought refuges when overgrazing occurs, and subsequently act as nuclei for recolonisation of surrounding districts. ■

Suggested Reading

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Dr David Baker-Gabb is a senior wildlife planner with the Wildlife Branch of the Department of Conservation and Environment in Melbourne, where he has a major role in threatened wildlife management and implementing Victoria's Flora and Fauna Guarantee Act.

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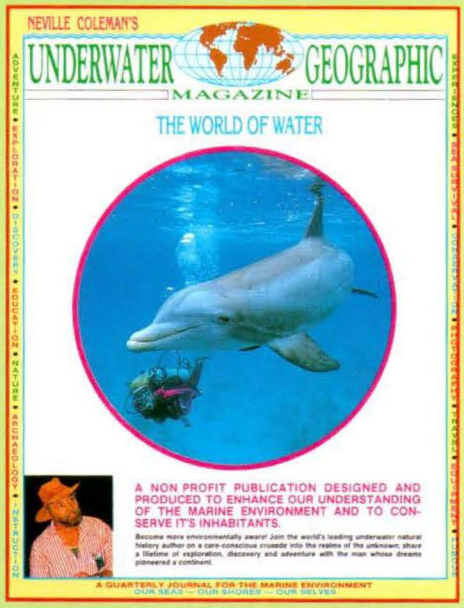

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Most food writers have been dismissive of bush tucker.

A TRIBUTE TO ROWNTREES

BY TIM LOW

ONE OF THE VICTIMS OF LAST year's recession was a restaurant on the Pacific Highway at Hornsby in northern Sydney. The demise of Rowntrees Australian Restaurant was a particularly sad event, for Rowntrees was the restaurant that pioneered Australian wild foods cuisine.

For eight years the patrons of Rowntrees were treated to an extraordinary parade of dishes based upon native meats, seafoods, bush fruits, nuts and greens. The meals tasted as enticing as they sounded: Tasmanian smoked salmon with lilly pilly; banksia-smoked Water Buffalo with Bunya nuts and Riberries; witchetty grub and Bunya nut soup, and so on.

Jean-Paul has one of the most curiously stocked refrigerators I have ever seen.

I must admit I was a late convert to the Rowntrees cuisine. My interest in wild foods developed from a love of the bush, and the Sydney restaurant scene seemed worlds away. It was not until 1990 that I finally ventured into the Rowntrees foyer, to be met warmly by owners Jean-Paul Bruneteau and Jennie Dowling.

Jean-Paul and Jennie are passionate advocates for an Australian cuisine—one based upon uniquely Australian ingredients. Years before the bush tucker boom, and before Aboriginal culture came into vogue, they devised a menu incorporating Aboriginal and colonial ingredients.

The dishes were created by Jean-Paul. Born in France in 1956, he came to Australia aged 13 and was naturalised at 21. While travelling the world as a chef in the merchant navy, he puzzled over Australia's lack of a national cuisine. Even in New Zealand he noted that indigenous Maori ingredients were used.

In 1982 Jean-Paul teamed up with Jennie to produce a limited Australian-style menu, featuring Water Buffalo meat and witchetty grubs. But the big break came when they were approached by Vic Cherikoff, a science graduate who worked on the nutrition of bush foods before setting up his Bush Tucker Supply Company. Vic was able to supply a wealth of raw materials for Jean-Paul's experimentation.

The results have proved amazing. Jean-Paul's Bunya nut puree tastes more like Bunya nuts than the nuts themselves. By mincing and mixing them with cream he has magnified their flavour. His witchetty grub soup is simply superb. And his Brown Pine Plum syrup tastes clean and tangy, with none of the astringency of the raw fruit.

Jean-Paul experimented for three years before learning how to rid the plums of their astringency. The trick, he told me, is to simmer, not boil, the plums in a stainless steel (not aluminium) pan, then to refrigerate overnight. (He is remarkably generous about sharing his secrets.)

Restaurant owner Jean-Paul Bruneteau putting the finishing touches to his banksia-smoked Water Buffalo with Bunya nuts, Riberries and Warrigal Greens.

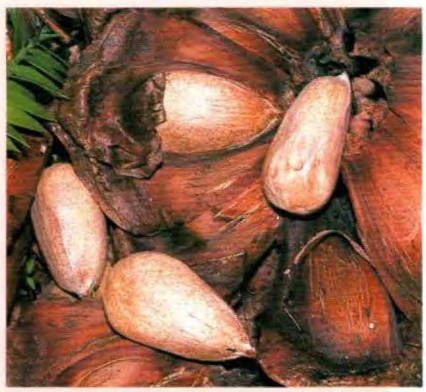
PHOTOS: TIM LOW

During my visit Jean-Paul led me into his restaurant kitchen for a tour of one of the most curiously stocked refrigerators I have ever seen. Above sacks of frozen witchetty grubs stood racks of dark red Emu meat and small bags of fruits still in the experimental stage, such as Native Tomatoes *(Solanum centrale)* from central Australia and Russell River Limes *(Microcitrus inodora)* from the tropics.

The main plant foods featured on the Rowntrees menu were Bunya nuts *(Araucaria bidwillii)*, Riberries *(Syzygium luehmannii)*, Warrigal Greens *(Tetragonia tetragonoides)*, wattle seed *(Acacia* species), Brown Pine Plums *(Podocarpus elatus)*, and a couple of other rainforest fruits. The puree of Bunya nuts was usually presented in place of potatoes or pasta, the fruits were served as sauces, wattle seed as a coffee–hazelnut flavouring, and the Warrigal Greens as spinach.

Jean-Paul's dishes have won coveted prizes overseas, including the Nestle special prize for overall originality at the Second International Cooking Festival in Tokyo in 1988. But in Australia, recognition has been less than forthcoming. Most food writers have been dismissive of bush tucker. Jean-Paul has been snubbed by the food snobs.

The Brown Pine fruit consists of a swollen succulent stalk attached to the hard seed, and it is only the soft stalk that is edible. Brown Pines are often planted along streets and in parks as ornamental trees, and the fruits used in restaurants come from these trees, not from the rainforest.



BUNYA NUT PUREE

Bunya Pines are widely grown in city parks, and the nuts can be gathered from beneath the trees in late summer and autumn. Boil the nuts in a stainless steel saucepan for 15 minutes, cut them open with a Stanley knife while still hot, and put them through a mixer. Mix the minced nuts with cream in the ratio of one cup of Bunya to three-quarters of a cup of cream. Heat for 56 minutes over a very low heat. Do not let the mixture brown. Serve hot with meat and vegetables. The puree has a delightfully gritty texture reminiscent of couscous. Jean-Paul has discovered that boiled Bunya nuts can also be made into excellent pastry simply by rolling them while hot. Good eating!

But acceptance of his pioneering work may be on its way. Stephanie Alexander's new food book, *Stephanie's Australia*, contains a generous section on Rowntrees. She comes out strongly in favour of bush foods: "The foods I have tried taste excellent. They are Australian foods and they offer the opportunity for an intelligent and open-minded Australian chef to make new culinary discoveries. The food commentators who usually describe such experiments and discoveries in the most patronising and amused manner clearly still have a problem seeing themselves as Australian."

Rowntrees is no more, but bush food connoisseurs take note—Jean-Paul has opened a new restaurant in partnership with Jennie and Vic. It's called Riberries, and it's in Bourke Street, Sydney. Go along and try out the stewed quandongs and wild tamarind sauce; you won't be disappointed. If you can't make the restaurant, try Jean-Paul's recipe for Bunya nut puree, presented here. Yum! ■

Suggested Reading

Alexander, S., 1991. *Stephanie's Australia*. Allen & Unwin: Sydney.

Tim Low is the author of four books, including Wild foodplants of Australia, *which has just been released in a revised fieldguide edition.*

He thinks up projects that appear charmingly eccentric but which are deceptively significant.

THE MAN WITH THE TAX-DEDUCTIBLE TURN-UPS?

BY ROBYN WILLIAMS

NIGEL WACE IS THE SCIENTIST who introduced me to the botany of the motor car. His questioning, as usual, was impeccable. "If our cars are travelling such huge distances around the clock, year after year, all over Australia, couldn't they be responsible for distributing seeds of plants to fresh habitats?"

He went to a local car wash and systematically collected sludge from its settling tanks to see if live plants were carried around by cars. He germinated the sludge seeds in sterile soil and soon had hundreds of seedlings, mostly weedy exotic grasses.

So the cars we drive turn out to be seed vectors. "Next I'd like to investigate trouser turn-ups, I'm sure they must have some role in dispersal!". "If you do", I added helpfully, "you might put down your trousers as a tax deduction, used in your botanical research". "What a good idea", Nigel exclaimed, writing vigorously, "hadn't thought of that!". He later tried the idea twice on his tax returns but it was twice rejected.

Nigel Wace believes science can be fun.

Nigel Wace was one of those returned servicemen who found himself being offered a degree course after World War 2. He had no inkling what to study until someone showed him a moss leaf under a microscope. He was fascinated, never having done biology at school ("It was sissy stuff–OK for girls"). Driven by a new enthusiasm, the years at Oxford went well. Another botanist was born.

Four decades later he still shows that impish enthusiasm, thinking up projects that appear charmingly eccentric but which are deceptively significant. Like 'Operation Weed'. For the past ten years Wace has bailed up startled strangers in countries all over the world to ask them, "What is your definition of a weed?". He notes the responses in his usual careful way and sorts them into categories. He now has many thousands of definitions. I believe that one of the most common is "a plant in the wrong place", but Nigel is not telling. Yet.

Why is it important to play with ideas like this? They seem whimsical, even capricious pursuits, but they're not. Wace may be amused to seem a trifle dotty but his aim is serious. It's to measure our real human impact on the natural world and to record our attitudes to what we've done. After all, if you imagine that a weed is some product of evolution created only as a pest in gardens, then you have a decid-

THE SURFIE AND THE GREENIE

by Nigel Wace
(with acknowledgments to Lewis Carroll)

The Surfie and the Greenie fair
Were ***strolling on the beach****,*
Hand in hand, along the sand–
For each was fond of each;
They loved to walk beside the sea,
For so much could it teach.

The sun was shining on the sea,
Shining with all its might:
He did his very best to make
The billows smooth and bright–
And this was odd, because the beach
Displayed a ***horrid sight****.*

The sea was wet as wet could be,
The sand was dry as dry.
You could not see a cloud, because
No cloud was in the sky:
But ***bottles, plastic, ropes and gunk***
Along the beach did lie.

The Surfie and his Greenie fair
Were feeling rather sad–
They wept like anything to see
A beach that ***looked so bad****.*
'If this only were cleared away,
We'd both be very glad'.

'If seven blokes with seven sacks
Scavenged for half a year,
Do you suppose,' the Surfie said
'That they would ***get it clear****?'*
'I doubt it,' said the Greenie green
And shed a bitter tear.

First, there's all the picnickers
And others of their kind.
They come here to enjoy the beach–
But ***rubbish leave behind****.*
Thongs, and plates, and plastic bags–
They really must be blind.

And then, there's all the industries
With factories near the shores,
Their litter ***washes down the creeks–***
And on the beach doth pause,
Plastic foam and packaging–
Against pollution laws.

Lastly, are the mariners
Upon the ocean blue,
With ***litter louts aboard the ships–***
(Both passengers and crew).
Inshore and offshore fishermen,
With floats and driftnets too.

'The oceans are all full of gunk,
Across the world so wide–
It keeps forever floating in
On each and every tide;
People just ***chuck things overboard–***
Both port and starboard side.

Two thirds the surface of the earth
Is occupied by sea:
Our ***planetary rubbish tip***
It will too easily be;
Unless we try to keep it clean
And that means ***you*** *and* ***me****.*

COURTESY NIGEL WACE

edly narrow view of botanical nature. Wace has collected definitions that are even narrower than that!

Nowadays, having retired as Head of Biogeography and Geomorphology at the Australian National University, he's charging ahead faster than ever with a number of investigations. One is the evaluation of a rabbit-driven lawn mower. This looks like a large wheel-like cage, similar in shape to those treadmills mice run on, in which a rabbit has access to the grass below but can't get out. It grazes on the lawn until the patch is cropped, then wheels off to the next bit. The lawn is kept mown and fertilised, and the atmosphere remains free of greenhouse gases and afternoon noise.

Then there is the great bottle project that began in Drake Passage, south of Cape Horn, where Wace found himself as guest lecturer on the *Lindblad Explorer.* He noticed an extensive array of wine bottles left over after a meal and wondered whether they could be useful. "Why not", he invited his audience, "put a message in a bottle and see where it turns up? We are, after all, sitting at a key point in the Antarctic Circumpolar Current".

Over the side went the bottles, with recycled corks and messages inside. So far, on this and other cruises, 14 have been recovered, out of some 1,400 jettisoned in the south-west Atlantic. A Grand Marnier bottle took six years to drift almost all the way around the Antarctic to Easter Island. Wace is convinced that this one should be in the *Guinness book of records* "but the silly editors said it was a qualified record, and might have gone the other way around, *against* the Circumpolar Current. Can you believe it?".

Drift bottles are a form of ocean litter, and these experiments have now been turned around into a study of litter from the Southern Ocean on our beaches. Wace points out that in Australia we have long sandy beaches remote from urban influence and unvisited by people. They could give us an excellent record of ocean litter, as an indicator of human influence upon some of the least polluted seas in the world. Sounds unlikely? Not at all.

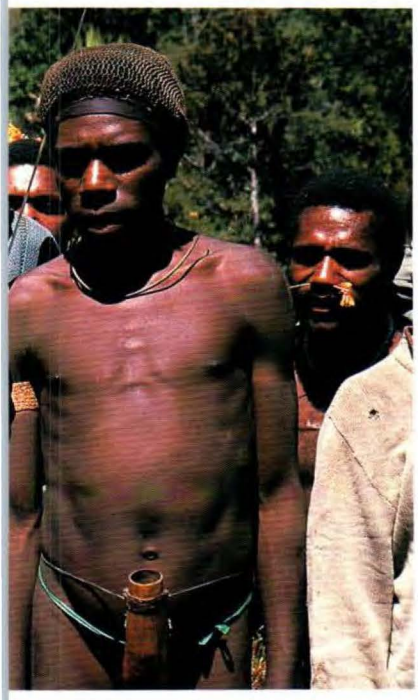
Wace has taught me several important lessons about science. First, you can turn the most common objects into a telling experiment. Second, everyone can do research if they just use their imaginations and, perhaps, get a bit of advice along the way. And third, you don't have to be solemn to be serious.

Dr Nigel Wace is now a visiting fellow of the Centre for Resources and Environmental Studies at ANU. He's also thinking of setting up his own Southern Ocean Beachcombers Company. I must get in touch with him soon to suggest he claims his wine as a tax deduction. ■

As Presenter of Radio National's Science Show, Robyn Williams has the opportunity to interview many interesting people in science.

In an apparent paradox, many plants with luxuriant blooms, like this Western Australian Christmas Tree, grow in poor soils. Likewise, the nutrient-poor waters of coral reefs support an amazing diversity of life, and the infertile soils of Irian Jaya give rise to a rich mammal fauna and spectacular heathland flowers, both used by local hunters.

TIM FLANNERY



One aspect of Australia's diversity has puzzled me: how do infertile places, like Western Australia's heathlands and the Great Barrier Reef, support such an abundance of life?

BEN CROPP

I HAVE LONG BEEN FASCINATted by the diversity of life on Earth, and the reasons why some environments support a greater number of species than others. An important factor in determining the number of species an environment can support is its productivity. Every environment has a characteristic rate of formation (through photosynthesis) of new plant material, which fuels the web of life within that environment. If the rate is high, the environment is said to be productive, and there is a widespread belief that such environments are home to a greater number of species than those resource-poor environments where productivity is low. Although this hypothesis makes intuitive sense, ecologists are now questioning it. Indeed, some have pinpointed reasons suggesting that the reverse is (or should be) the norm. This article examines the relationship between productivity and diversity in three very different Australasian environments: the heathlands of south-western Western Australia, the Great Barrier Reef, and the rainforests of New Guinea.

THE DIVERSITY ENIGMA

BY TIM FLANNERY

There is a higher diversity of sundews *(Drosera* spp.) in south-western Western Australia than anywhere else, and more than half the world's species are found here.

JIRI LOCHMAN / LOCHMAN TRANSPARENCIES

THE HEATHLANDS OF SOUTH-WESTERN Western Australia support some of the most diverse and spectacular plant communities on Earth. The entire south-western corner of Western Australia supports 10,000–12,000 species of plants, with the number of species per square kilometre rivalling those found in the richest rainforests. Most of the world's banksias, sundews *(Drosera)*, and all of its dryandras, to mention only a few, are found in this small region of Australia. Yet it is remarkable that the bulk of these species comes from relatively few families, such as the Proteaceae, the family containing species of *Banksia, Dryandra, Grevillea* and others. Thus many species of rather similar plants coexist. This is all the more surprising as the landscape of the south-west is, superficially at least, rather monotonous. Most of the area is covered by highly infertile sandsheets, and there are few mountain ranges or sharp topographic features to provide microhabitats that might facilitate speciation. Subtle differences in soil type do, however, support different plant communities.

Many species in the region possess unusual adaptations to extreme soil infertility. The Western Australian Christmas Tree *(Nuytsia floribunda)* is a tree-sized mistletoe that gains nutrients by parasitising the roots of grasses and other plants. The carnivorous plants are particularly abundant. They represent well over half of all the carnivorous species found in Australia; and two of our seven genera, as well as the majority of two others, are found only in this small area. More than half the world's species of sundews *(Drosera)* are endemic, as is the Western Australian Pitcher Plant *(Cephalotus follicularis)*, which is placed in its own family. Furthermore the bladderwort genus *Polypompholyx* is entirely restricted to the region as is one of two rainbow plants (genus *Byblis)*. All of these plants have turned to carnivory to meet their nutrient needs (they obtain nitrates and phosphates from insects), and they speak eloquently of the harsh constraints that the infertile soils of Western Australia places upon the flora. They add emphasis to the question of how so many different plant species could have evolved and come to coexist in such an infertile environment. Could the answer lie in the very poverty of the environment itself?

David Tilman of the Department of Ecology, University of Minnesota, suggested in 1982 that, in environments where nutrients such as nitrates and phosphates are in plentiful supply, those species that are best at utilising these nutrients can out-compete all similar species. A prime example of such a species is ourselves. In areas where nitrates,

Most of the world's banksias grow in the south-western corner of Western Australia, including the Acorn Banksia *(Banksia prionotes)*.

JIRI LOCHMAN / LOCHMAN TRANSPARENCIES

ESTHER BEATON

The Western Australian Pitcher Plant is so unique it is placed in its own family. It grows in south-western Western Australia, where the nutrient-poor soils have given rise to many other carnivorous plants. These plants rely on insects for phosphates and nitrates, which the soils cannot provide.

phosphates, water and soil abound, we can destroy almost all other species through intensive agriculture, reducing the environment to a monoculture. In less productive areas, such as those used for grazing, our ability to destroy the species competing with us is less, although with modern technology we are improving that ability. In the most unproductive environments, humans are reduced to just another species among the multitudes, if they can exist there at all.

Tilman referred to such species as 'superspecies', but this term is already in established use in taxonomy where it has quite a different meaning. Perhaps the term 'exterminator species' is more appropriate for, although emotive and used in other contexts, it does adequately describe their effect.

Humans are just one exterminator species among many, and Tilman argues that it is only where exterminator species are excluded that many species can coexist. They do this by becoming specialists, exploiting subtle differences in the levels of the critical resources (such as water and nutrients) in different areas. Thus, in the Western Australian heathlands, one species of *Banksia* may be able to survive in runoff areas where more nutrients are available than elsewhere. Another may survive in sand at the foot of dunes where water may accumulate. Yet another may

GOING WEST FOR WILDFLOWERS

When to go: Early August or late November.

Where to go: The section of the Western Australian coast from Kalbarri in the north to Albany in the south.

What to do: A wildflower exhibition is held annually on the October long weekend in Kings Park, about two kilometres from Perth city centre. The Western Australian Wildflower Society welcomes visitors, meeting on the second Tuesday of each month: (09) 383 1254; PO Box 64, Nedlands 6009.

A variety of Western Australian wildflower tours are available, ranging from a single trip from Perth to five- or six-day botanist-accompanied tours from Perth to Kalbarri. While in Perth, take one of the free guided walks in Kings Park and Botanical Gardens. For information about tours and places to visit, contact the Western Australian Tourist Centre or agency in your State capital.

survive in barren interdune areas because it can exist on very few nutrients. Because of the complex interplay of soils, nutrient levels and water availability, many combinations of resource availability are possible in a nutrient-poor landscape, leading to the evolution of many specialist species.

One further aspect of Australia's heathlands has long puzzled me, and that is the spectacular heathland flowers, some of which are present throughout the year, and most of which drip with nectar. It seems anomalous that such apparent waste of effort should occur in such infertile areas. However, I think I have found a convincing explanation as to why this is so. Because of the diversity of plant species in the heathlands, the nearest potential sexual partner of any individual plant may be a long way off. This means that pollinators, such as insects, mammals and honeyeaters, must be used for effective pollination. Yet in a nutrient-poor environment such organisms, particularly the warm-blooded ones, are likely to be scarce. Thus competition exists between plants for these few pollinators. It takes fewer nutrients for a plant to make nectar, than it does to produce new leaves. This is because only water, air and sunlight are needed to make sugar, while nutrients such as nitrates and phosphates are essential for the production of new plant tissue. Thus, where nutrients are limited, it makes sense for a heathland plant to have blooms that produce lots of nectar to outcompete its fellows for the attentions of the rare pollinators. This is because its ability to produce nectar is not as tightly constrained by low soil fertility. The presence of abundant nectar alone, however, may not increase the abundance of most pollinators. Their numbers in most cases may not be restricted by the amount of nectar but rather by protein, because most species need some protein-rich food such as insects in order to survive. And the number of insects present is probably limited by low primary productivity due to poor soils.

The process can perhaps best be thought of as an arms race; a literal war of the roses, where flower power wins the day. Some species avoid the arms race by flowering at times of the year when few

Specialised pollinators, like this tiny Honeypossum, live off the abundant nectar of Western Australia's diverse heathlands.

WESLEY TOLHURST

other blooms are around, providing a continuous food supply to the pollinators. Thus in a seeming paradox, these very nutrient-poor soils that heaths grow on support an abundance of plant species with the most luxurious flowers. Upon these feed specialised pollinators, including the tiny (ten grams) Honey-possum *(Tarsipes rostratus)*, which is the only non-flying vertebrate to depend totally upon flowers for its food. So rich in nectar and pollen are the heaths of south-western Australia that a Honey-possum can feed virtually every day of the year and, for much of the time, find its food requirements from an area of no more than 40 square metres. And all of this because the environment is so nutrient-poor!

A somewhat different example of great diversity is provided by the Great Barrier Reef. Coral organisms are animals that support photosynthetic algae inside their bodies. Such a strategy is most likely to have evolved in a very nutrient-poor situation, the ancestors of coral animals being unable to find enough food by themselves, and taking advantage of a relationship with plants to supplement their food supply. The relationship remains useful, for coral reefs grow only in the most nutrient-poor warm waters. The reefs provide a home for an enormous diversity of fishes, and it is interesting that the nutrients present in a coral reef environment are cycled through the living animals of the reef very rapidly, with very little loss. Thus a small amount of nutrient is made to go a long way. Unfortunately, the too-rapid removal of parts of the system (such as large fishes) can have disastrous effects. Today, the relatively small commercial and recreational fisheries on the Great Barrier Reef are having a profound impact as predators, algal grazers and other types of fishes are removed from the environment.

What happens if we enrich such a system? We do not need to guess, for we are already carrying out an immense experiment. Queensland sugar cane growers fertilise their fields with large quantities of nitrates and phosphates. During the wet season much of these are washed down rivers and into the sea, eventually finding their way onto the nearer parts of the reef. In consequence, a monoculture of algae takes over from the wonderful reef diversity, much in the way that people and their agriculture take over from heathland with an application of superphosphate.

ALTHOUGH TILMAN'S HYPOTHESIS SEEMS to work well for plants, and perhaps cold-blooded creatures such as fish, there are difficulties in applying it to the larger, warm-blooded creatures such as mammals. This is because these animals have high energy requirements and, in resource-poor environments, there might not be enough resources for them to survive at all. Biologists from the CSIRO studying tree-dwelling marsupials (mostly possum species) in the eucalypt forests around Eden have found that 52 per cent of the forests contain no tree-dwelling mammals at all, and that 63 per cent of the tree-dwelling fauna is found in just nine per cent of the forests. They hypothesise that much of the forest is simply too nutrient-poor to support tree-dwelling marsupials, and that only the forests growing on better soils support large populations. In this case, however, matters are complicated by the eucalypts' propensity to manufacture toxins when they grow on poorer soils. The eucalypts that grow on more fertile soils respond to the presence of leaf-eating possums simply by growing new leaves as the old ones are eaten. Eucalypts that grow on nutrient-poor soils, however, cannot do this because the lack of nutrients limits their growth. Instead they produce carbon-based toxins, especially tannins and phenolics, for much the same energetic reasons that heathland plants produce nectar (that is, they are 'cheap' to produce), and are thus a less expensive way of dealing with leaf loss than by simply growing new leaves. The tannins and phenolics work by disrupting the acid balance in the digestive systems of the leaf-eaters, preventing them from digesting their food.

Despite the fact that the most resource-poor environments may have insufficient resources to support mammals, it may still be that environments with moderate resources might support more species than those with abundant resources, because of Tilman's proposed 'exterminator species' effect. It is difficult

Coral reefs grow only in the most nutrient-poor waters and the reef provides a home for a diversity of fish.

Coral reefs support an amazing diversity of life forms, yet the crystal clear warm waters give testimony to the lack of nutrients found around them. During the wet season, vast quantities of nutrients (from sugar cane fertiliser) are washed onto parts of the Great Barrier Reef, which allows algae to take over from the reef organisms.

ANH

K. DEACON / DIVE 2000

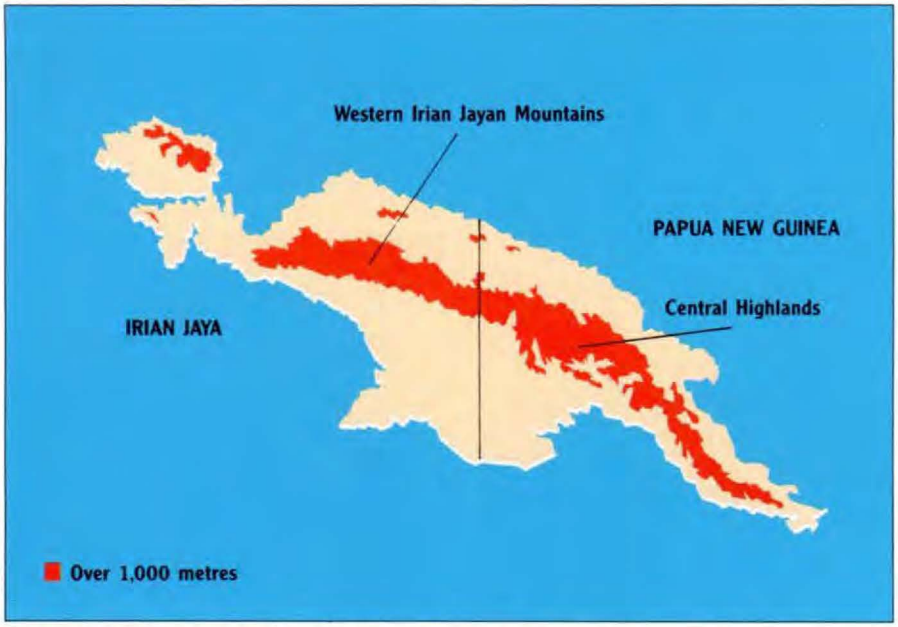
to carry out comparisons of mammal communities in resource-rich and resource-poor environments in Australia because of extinctions (almost a third of Australian mammals have become extinct since humans arrived here) and because of the fact that our few resource-rich environments have been so dramatically altered by Europeans. A better place for such comparisons would be in the highlands of New Guinea, where very few (to date only seven) mammal extinctions have been documented over the past 40,000 years, and the highest diversities of Australian mammals (up to 120 species in a small area) occur. In particular, the areas of western and central New Guinea offer ideal comparisons because, while they are roughly similar in size and still harbour substantial areas of upland rainforest, they differ markedly in their soils.

The soils of the Central Highlands of New Guinea are largely volcanic in origin. They are very fertile and support vast stands of luxuriant mountain forest. In western New Guinea, however, the soils are derived from sandstones and limestones, and are much thinner and poorer. In some places forests give way to a heath-like assemblage of dwarfed rainforest trees. Despite this, our present (incomplete) information suggests that the actual number of plant species is not much greater in the west than the east. But how do the mammal assemblages compare?

The Central Highlands of Papua New Guinea are home to about 77 species of non-flying, forest-dwelling mammal species, while the Irian Jayan mountains to the west are home to about 81 species. Although the difference in overall numbers is small, the actual species that inhabit the differing regions is possibly more informative. The more resource-rich Central Highlands have two large marsupial leaf-eaters—Goodfellow's Tree-kangaroo *(Dendrolagus goodfellowi)* and Doria's Tree-kangaroo *(Dendrolagus dorianus)*—while in the west only Doria's Tree-kangaroo is found. At seven to 20 kilograms in weight, these tree-kangaroos are some of the largest mammals of the New Guinean forests. It may be that there is insufficient productivity in the west to support two species of such large mammals.

The situation with the smaller (100 grams to two kilograms) species is, however, quite different, for among this group there are four species that are found in the west but not in the Central Highlands. These additional species add to the diversity of already diverse groups. Why should more species of all these diverse marsupial groups be able to exist in the less fertile west? At present it is difficult to be sure what these data mean but, on the face of it, they do tend to support the idea that, at least for the smaller mammals, Tilman's hypothesis might apply. The situation, however, is very complex and, until more is known about the distribution, ecology and taxonomic diversity of the mammals of this region, it will be difficult to put forward convincing arguments.

Why should more species of these diverse marsupial groups be able to exist in the less fertile west?



The poorer mountain soils of Irian Jaya support a greater number of medium-sized mammal species than the more fertile Central Highlands of Papua New Guinea.

VARIABILITY IN PRODUCTIVITY ALONE IS insufficient to explain differences in diversity; time is also an important factor. A long period (I suspect more than a million years in most cases) is needed for new species with long generation times (such as the larger mammals) to evolve. Even if plants and fish can evolve faster, it surely would take many tens of millions of years for the diversity of the Great Barrier Reef and Western Australian heathlands to develop. This implies that suitable, low-nutrient conditions have been maintained for a very long time in these areas—through ice ages and the drift of the continent across the face of the Earth. The well-informed reader might now object: "Doesn't recent research indicate that the Great Barrier Reef is only 8,000 years old?" This is not quite true. Indeed, the Great Barrier Reef has only been in its present position for 8,000 years (it moved there in response to sea-level rise at the end of the ice age), but we can be sure that somewhere in the south-west Pacific, similar reef communities have persisted for many millions of years. Likewise floods, fires and climatic changes have disturbed the south-western heathlands for aeons, but no single shock has been large enough to remove them altogether, for fossil floras indicate that Western Australian heathland plants have been in exis-

Goodfellow's Tree-kangaroo is found in the Central Highlands of Papua New Guinea, but not in the mountains of Irian Jaya.

tence for over 40 million years. Indeed, small-scale disturbances such as fire might offer an increased chance for diversity, since some species can make a living as post-fire specialists.

If we could understand more about the determinants of diversity in Australia we might be able to answer some very interesting questions. For example, what is the significance of the differences between the fossil Riversleigh rainforest animal communities and those surviving at present? Why are our desert reptiles so diverse, and how old is this unusual assemblage? Why are the plants of the nutrient-poor deserts not as diverse as those of the heathlands? The arguments developed here also tell us some very interesting things about the future. It has always amazed me that humans (who now utilise about 40 per cent of all the primary productivity of plants on the land surface of our planet) have not caused even more extinctions than we actually have. It is surely, in part at least, because we are 'exterminator species', dependent until recently on the richer parts of the Earth, and not so much on the less fertile regions where most of the world's biological diversity lives.

Our depredations of Australia's more fertile regions have certainly been so great that it is difficult to find a very productive region that has not been grossly altered. Thankfully, we still have those less productive regions. Some humans have dreams, though, of making the deserts bloom and the depths of the seas, and even Antarctica, yield their bounty. As each year goes by, we come closer to developing the technologies that will allow us to realise these dreams. Each year we also feel an increasing need to utilise marginal lands in order to feed our growing populations. But with our dreams fulfilled we will, I fear, see a wave of extinctions so vast as to dwarf anything that has gone before. For we will have become the exterminator species that broke all the rules; the one that could take not only all the resources of rich lands, but of poor ones as well. ■

Suggested Reading

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Tilman, D., 1982. *Resource competition and community structure.* Monographs in Population Biology 17. Princeton University Press: Princeton, USA.

Dr Tim Flannery is a Research Scientist in the Mammal Section of the Australian Museum. He has long been interested in the wonderful heathland flowers of Australia, and why they invest so heavily in spectacular blooms.

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An appreciation of the concept of 'one world' may be a precondition for a more sustainable and secure future.

Many people in the Third World have begun to see in our environmental movement a new and insidious form of colonialism, undermining any real meaning in that cliche 'one world'.

ONE WORLD: THE SCIENCE AND THE POLITICS

W. TOLHURST

BY JONATHON PORRITT

TO LISTEN TO SOME people today, you'd think environmental issues like global warming and depletion of the ozone layer were the products of the overexcited imaginations of people who eat too much muesli, or who don't really know much about science or what's going on in the real world. But debate on these issues is very much science-led—not politically inspired or driven by overzealous environmental organisations.

The Montreal Protocol, for example–the means by which the ozone layer is to be protected against the depravations of industries using ozone-depleting chemicals–stemmed from experiments carried out by scientists in the early 1970s. The scientists showed that chlorine-based chemicals, particularly chlorofluorocarbons and bromofluorocarbons, had a dramatic impact on ozone levels in the upper atmosphere. The protocol–a spin-off from the United Nations Environment Program–is the first instance ever of nations voluntarily agreeing to phase out the use of a chemical that had very significant and signalled benefits to society.

International efforts to reduce global warming were also set in train after some of the world's most eminent scientists presented their reports at the Second World Climate Conference in Geneva in November 1990. But it was at that point that the politics really started. People began to put slurs on scientists, suggesting their findings were driven by their need for funding for further research programs. They suggested the level of uncertainty in the debate was so great that no responsible politician could take action.

SYDNEY FREELANCE

There is an international trend towards cooperation, evidenced by the demolition of the Berlin wall in 1990.

Politicians should not be tempted to wait for Armageddon to arrive before they act.

I do not by any means wish to dismiss the difficulties for politicians in dealing with these enormously complex global issues. I believe, however, that they should not be tempted to wait for Armageddon to arrive before they act. The decision of the scientific 'jury'–the Intergovernmental Panel on Climate Change–is that global warming is occurring and will continue to occur unless we do something about it.

Politicians, however, tend to be preoccupied with the achievement of economic goals which, in their conventional form, are not compatible with a consistent approach to global environmental issues. Most economists are totally out of touch with the natural sources of wealth on which all our man-made wealth depends –clean air and water and healthy soils and forests, for example. They have very few ideas about resource accounting, developing alternative indicators to gross national product, or any of the other things we need to do to bring environmental issues into our economic framework.

When discussing these issues, politicians love to refer to the concept of 'one world'. They speak enthusiastically of the 'global village' of which we are all citizens and the power of telecommunications binding us all together. But it would be more appropriate for them to refer to a global *supermarket* because, as far as most of them are concerned, the only togetherness they're interested in is the speed with which the entire planet can be turned into one great big heaving hypermarket to flog off the products of our consumer society to unwitting nations that have as yet not benefited from them.

Beneath that slightly cynical interpretation of 'one world' is an important issue with which politicians do not often deal. It concerns our understanding of our relationship with each other and with the Earth itself.

In sharp contrast to the Darwinian notion of survival of the fittest, the evolution of human species is as much about cooperation as it is about competition. It's useful to look at the evolution of our species, starting from the very earliest days when we were concerned primarily as individuals to ensure our own survival. From that kind of vicious individualism we progressed to a hunter-gatherer society where families and tribes coexisted, to sedentary agricultural communities in which people were able to cooperate much more closely in order to win surpluses from the soil. From these agricultural communities came towns and cities in which it was possible to achieve ever greater complexity through ever greater levels of cooperation. And from there developed regional loyalties, which led in turn, in much more recent history, to the development of a nation-state and eventually, in the 20th century, to aggregations of nation-states such as the Eastern and Western blocs, the European Community, NATO and, wider even than that, to the prototype League of Nations and today's United Nations.

Our evolutionary history demonstrates a clear direction that is continuously underestimated by some politicians and free marketeers who wish to see the development of human species purely in terms of conflict and competition. One need look back no further than the last few years, to the breakdown of the Iron Curtain and the dissolution of some tensions between East and West, to see that the trend towards greater cooperation is continuing.

While politicians' approaches to global environmental issues are easy to criticise, environmentalists themselves are not beyond reproach. I believe they are in danger of slipping into a disgracefully narrow view of the challenges confronting them. As far as the Third World is concerned, the issues are not global warming, depletion of ozone, tropical deforestation, or toxic waste disposal, but whether people have enough food to stay alive, access to clean water, and are able

to provide basic education and health care for their communities.

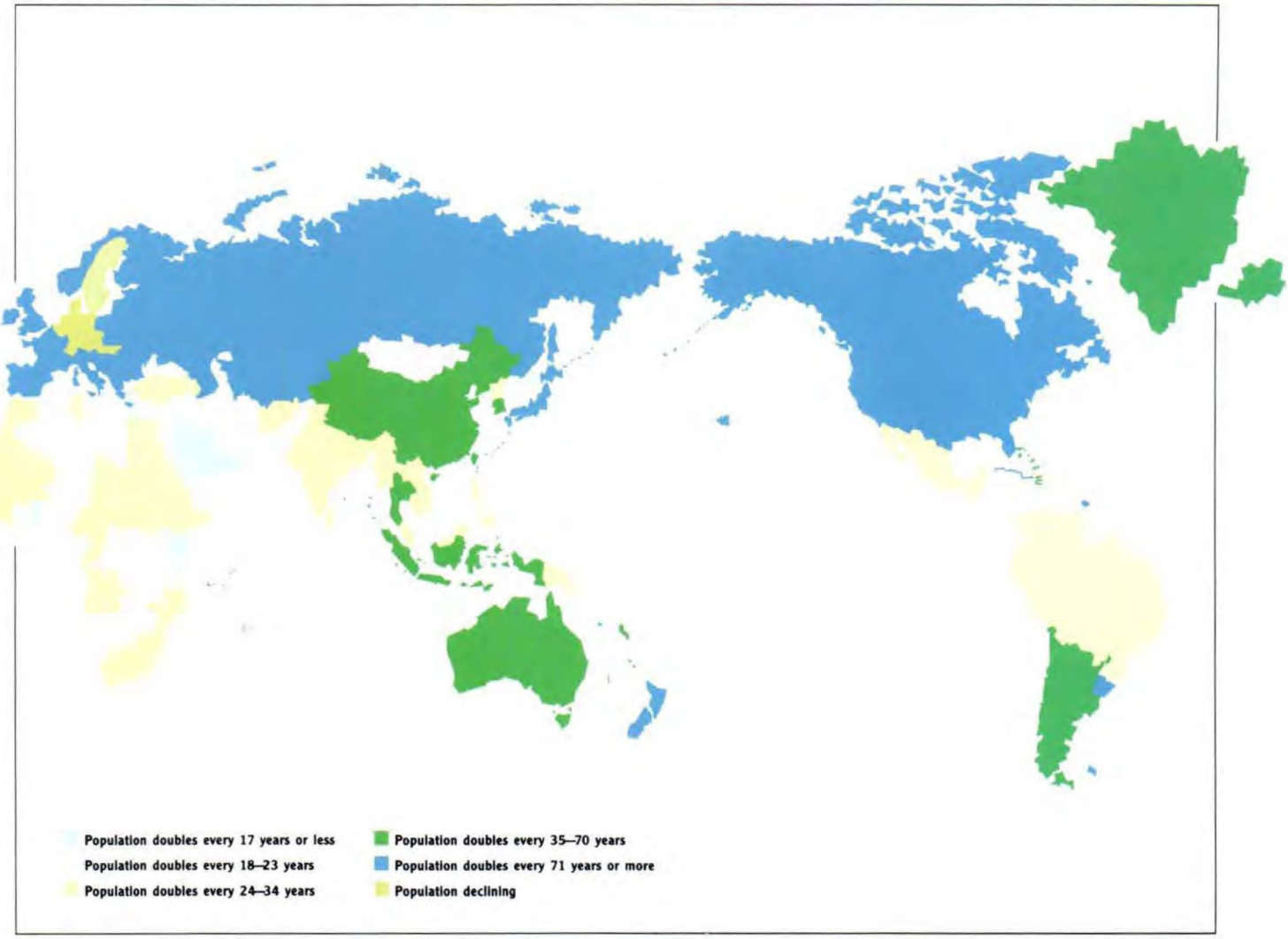
Indeed, many people in the Third World have begun to see in our environmental movement a new and insidious form of colonialism, undermining any real meaning in that cliche 'one world'. There is deep anger that a new agenda is emerging, where the interests of two thirds of humanity are largely being set to one side. The ozone layer and its depletion provide a very telling example of precisely that imbalance in power politics.

THIRD WORLD COUNTRIES HAVE CAUSED a minute proportion of the damage done to the ozone layer to date. Yet when you read some of the literature, it is almost as if India and China were already being blamed for the ozone depletion to come from the projected increase in their use of chlorine-based chemicals as their populations grow and become more industrialised.

At the 1990 Montreal Protocol Review Conference in London, Mrs Maneka Gandhi, then India's Environment Minister, made clear what would be acceptable to her country if it was to respond equally to the ozone depletion problem. She concentrated on nations like Australia, understandably concerned about increases in skin cancer and the thousands of people who will die as a consequence of increased exposure to ultraviolet radiation. She sympathised with the human grief and suffering it would cause, but said that India, with hundreds of thousands of deaths each year from preventable causes, had more important issues on its doorstep. Until those issues could be put right, India would not pay the price of the pollution we had caused.

One can see similar dilemmas looming even more dauntingly when we consider the global warming agenda. India and China have one third of the world's population, but account for no more than a thirtieth of total world pollution and resource consumption. So, in as far as keeping the world in balance, we owe them and other developing nations a massive debt. Because they produce only a relatively small amount of pollution, it is up to more developed nations like ours to clean up our act. However, we cannot protect the atmosphere from carbon dioxide and other greenhouse gases unless it is done in every single country on Earth. So we have no choice *but* to persuade developing countries to work towards the same goal of controlling carbon dioxide emissions. Environmental organisations in developing countries suggest that this can only be achieved by a strict interpretation

Population growth rates vary from country to country. Although average world population growth was 1.7 per cent per year between 1985 and 1990, some developing countries grew at a rate of four per cent per year, doubling their population in just over 17 years.



of the 'polluter pays' principle.

If we calculate the amount of carbon dioxide emitted every year (approximately 31 billion tonnes) and subtract the amount absorbed by Earth's natural sinks (oceans and vegetation, for example), the difference is the excess carbon dioxide that we somehow have to clean out of our system. It amounts to approximately 13 billion tonnes a year.

Third World environmental organisations say we should allocate access to the natural sinks available to us on a per capita basis. They argue that every person on Earth has equal access to those natural sinks, regardless of where they live, their level of industrial activity, or the amount of carbon dioxide they currently produce. The collective 'sink access' would determine each country's permissible carbon dioxide emissions.

A country like India, then, which has 16 per cent of the world's population, would theoretically be allowed to produce more than three times as much carbon dioxide as the United States, which has only five per cent of the world's population. Yet India is responsible for only about six per cent of world carbon dioxide emissions, while the United States accounts for 28 per cent. Under a strict interpretation of the polluter pays principle, a country like India would be able to trade permissible carbon dioxide emissions with the United States.

If a $15 charge were made to all countries for every thousand tonnes of carbon dioxide emitted in excess of their permissible quota, the United States would have to fork out $6.3 billion every year, and India would receive $8.3 billion. If we go even further and fine countries that still don't come within their limits, things begin to look very interesting indeed. Say you take a nominal sum of $25 per tonne of carbon dioxide, then the United States ends up being fined $38 billion every year and the world benefits to the tune of $90 billion going into some global climate protection fund.

As radical as the proposal sounds, it represents natural justice to a tee. If the polluter pays principle has any merits, then those kinds of mechanisms are going to have to be negotiated over the next two or three years, and that will be the minimum condition on which countries like India will agree to start addressing global warming concerns.

But there is a challenge beyond even that. Better technologies, greater energy efficiency, and the ability to minimise wastes will all help to achieve social and political goals on a constrained planet. But no amount of new technology, new 'internationalism' or people opting for quality of life rather than crude materialism, are going to bring about the kind of transformation that is necessary. A radical philosophical shift is also needed.

Scavenging a rubbish tip in the Philippines: Third World countries have more pressing problems than global warming.

RON GILING / PANOS PICTURES

WAYNE LAWLER / AUSCAPE INTERNATIONAL

The problem of global warming must be handled at an international level. The only way to achieve international cooperation is by a strict interpretation of the 'polluter pays' principle.

That is where the wonderful Gaia theory comes into play—a compellingly simple idea that the Earth's climate and environment are controlled by the plants, animals and microbes that cover it (see ANH vol. 23, no. 1, 1989). The Earth is seen not as some inanimate lump of molten rock accidentally capable of sustaining life by a sequence of arbitrary geological processes, but a biological superorganism capable of regulating its conditions to optimise the chance of survival.

While scientific hypotheses have all too often been inappropriately used as metaphors for the human condition, I think there is something we can learn from the Gaia theory. Its proponents are putting before us an alternative to the notion that humans are central to the universe. They offer a totally new way of viewing the origins and meaning of life on Earth. And instead of conflict, they stress cooperation. Perhaps the final stage in the evolution of human awareness will come when we realise that the interests of our species can only properly be met by working to protect the interests of *all* species. That will move us away from the prevailing anthropocentrism of industrial societies (a context in which even the best efforts towards change often amount to little more than enlightened self-interest) towards a more biocentric ethic in which *all* creatures are recognised as having value, regardless of their usefulness to us.

For some, of course, Gaia has become a religion. But it need not be frightening to scientists. The word religion means to bind again. As far as the human species is concerned, that is the overwhelmingly important priority facing us today—to bind ourselves again to the workings of life on Earth. Whether we come to it by religion, by politics, or science, doesn't really matter. With the best will in the world one cannot really claim that either politicians or scientists yet understand the nature of the challenge that now confronts them. A firmer grounding in the workings of the Earth, and a less rhetorical appreciation of what 'one world' really means, are preconditions for achieving a successful transition to a more sustainable and secure future. ■

Suggested Reading

Porritt, J., 1984. *Seeing green: the politics of ecology explained*. Basil Blackwell: Oxford.

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Jonathon Porritt—environmentalist, author and broadcaster—is Special Adviser to Friends of the Earth International. The topic of this article was part of the Australian Museum's Science Super Series lecture in March 1991, and is also covered in more depth in his latest book Save the Earth.

DAVID J. BEDFORD

Xanthorrhoea thorntonii is one of only two grass tree species that occur in arid Australia.

ANH

A common misconception about grasstrees is that individual plants are thousands of years old.

AUSTRALIAN GRASSTREES

BY DAVID BEDFORD

GRASSTREES OR, IN SOUTH AUSTRALIA, yaccas, are common names for some very distinctive Australian plants. Many may know them better by their earlier common name of blackboys, so named for their supposed resemblance to an Australian Aborigine holding a spear, but this name is less used these days because of its racist connotations. The common name of grasstree describes the

In many species, whole populations bloom together following a fire.

JOHN W. KELLY

ANH

Grasstrees have been used as adhesives, lacquer, and to treat both diarrhoea and constipation.

distinctive skirt of grass-like leaves found on the species that develop a trunk. *Xanthorrhoea*, the botanical name for grasstrees, is derived from the Greek *xanthos* meaning yellow, and *rhoea* meaning flowing, describing the yellow resin exuding from the trunks of the first species to be described.

Throughout history, grasstrees have been put to various uses. Aborigines used parts of them for tools, weapons and medicines. The resin was used both as an adhesive to attach axe heads or spears, and as a lacquer to seal some surfaces. The long, smooth section at the bases of the 'spears' of some species made ideal spear shafts, and the dry old leaves and leaf bases were used as kindling.

European settlers learned some uses of grasstrees from the Aborigines, and also invented new uses. In 1894 Joseph Maiden (who was later to become Director of the Botanic Gardens Sydney) recorded 16 uses for the resin, including as medicines (for both constipation and diarrhoea!), as an alternative for shellac, and in perfumery. The fibrous trunks also came in handy as brake blocks for the steel-tyred wagon wheels in use throughout last century. Earlier this century large quantities of resin were extracted (primarily in South Australia, especially Kangaroo Island) and sold for use in the chemicals and explosives industry. The resin is a phenolic compound that can be converted into picric acid, which is used in the manufacture of gunpowder. It is said that Germany imported a considerable amount of resin to make explosives prior to World War I.

GRASSTREES WERE AMONG THE PLANTS to take the interest of the first Europeans to arrive in Australia. For example, Joseph Banks and Daniel Solander collected grasstree specimens on Cook's voyage to Australia. Indeed, the earliest use I have found of their botanical name, *Xanthorrhoea*, is on Solander's labels for the plants collected on that trip.

The first major survey of the group was by Robert Brown, the eminent botanist who visited Australia in the early 1800s to collect for Joseph Banks. Brown travelled extensively around Australia and collected new species of grasstrees that he described upon his return to England (in his *Prodromus* of 1810). Until the 1960s there were only sporadic botanical studies of the group, and few discoveries of additional species. Then Alma Lee, a botanist at the Royal Botanic Gardens Sydney, produced an improved treatment of the group for New South Wales, and in the mid-1980s I revised the group Australia-wide for the *Flora of Australia*.

There are 33 different kinds (28 species and five subspecies) of grasstree currently recognised. Features used to separate the species include the presence or absence of a trunk; the leaves; the 'spear', which is divided into two sections—the spike (flowering section) and scape (bare stalk below the spike); the flowers and small bracts (specialised leaves) that cover the spike; and their distribution. Grasstrees grow only in Australia and are found in all States and mainland Territories. Most species are very limited in their distribution, growing over a fairly small geographic area and often in isolated clumps.

Our image of grasstrees is usually of tree-like or arborescent plants, but many species never develop trunks. In fact, grasstrees range from trunkless, long-leaved plants with elegant bottlebrush-like spikes atop long slender scapes (such as *X. macronema* and *X. gracilis)*, to massive trunked plants up to six metres tall with 'spears' up to 150 millimetres in diameter *(X. semiplana* or *X. glauca*, for example).

Grasstree stems grow upwards from one main active growth centre or apex. When it grows above the ground the stem is called a trunk. The apex produces both the leaves and the stem (trunk) tissue. At flowering time this apex stops producing

DAVID J. BEDFORD

Globules of red resin that have exuded from the base of the trunk of the grasstree *Xanthorrhoea johnsonii* after a fire. Each species has a different resin, found throughout the trunk and in the old leaf bases. The resin seals wounds in the trunk and is often found on the trunk after fires.

TRUNKS AND FAMILY TREES

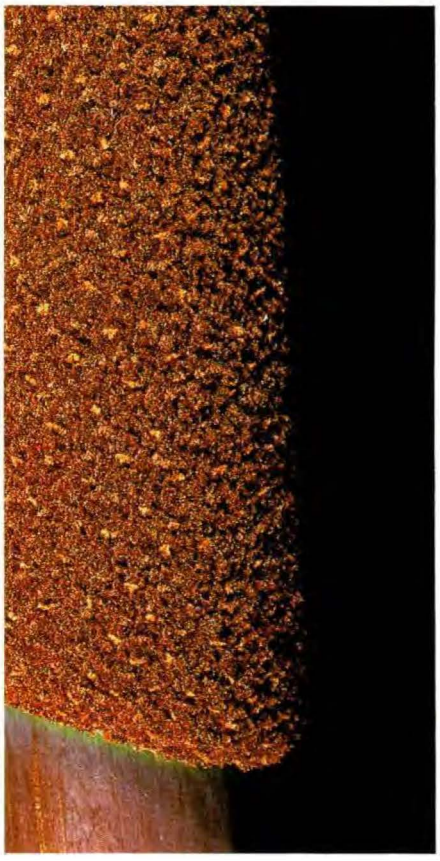
Cross section through the trunk of a dead grasstree. The centre section now rotting, contained the vascular (water- and food-conducting) tissue, and the outer radiating structures are the old leaf bases.

JOHN W. KIELY

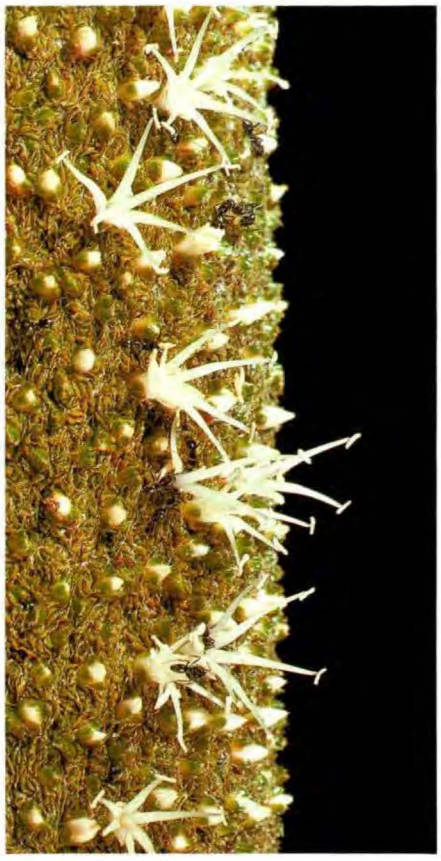
Because of their superficial resemblance to certain ancient plants, such as cycads and treeferns, there is a popular misconception that grasstrees too are an ancient group of plants. However, this is now not believed to be the case. Rather, grasstrees seem to be a very advanced and rapidly evolving plant family.

Flowering plants are divided into two main groups: the dicotyledonous plants (named for the two seed-leaves or cotyledons produced when they germinate) and the monocotyledonous plants (one seed-leaf on germination). The dicots include most of our tree and shrub species, while the monocots include plants such as the palms, grasses and lilies.

The trunks of dicotyledonous plants increase in thickness with time through the addition of layers of water- and food-conducting tissue onto the outside of the wood. This growth often occurs in distinct growth seasons, producing the familiar 'growth rings'. The process is called secondary growth. Monocotyledonous plants have a different structure. Their water- and food-conducting tissue is in discrete bundles rather than in layers. Also, with a few exceptions, once the stem is formed it retains the same number of bundles across the stem for the whole of its life. Some palms do become thicker at the base with time, but this expansion is usually through swelling of existing cells or roots growing out of the base of the trunk. The number of bundles across the trunk does not increase. Only a small group of monocotyledonous plants—including grasstrees, *Dracaena* and its allies, as well as the agaves and aloes—have the capacity to produce more bundles in their trunk once it has been formed, and these have a type of secondary growth different from that found in dicotyledonous plants. This process is called dracaenoid secondary growth—named after *Dracaena draco*, the Dragon Tree, the first plant in which it was described—and involves the development of additional bundles of both water- and food-conducting tissues, rather than development of separate layers of these tissues as in dicots. The few monocotyledonous plants whose trunks grow thicker by the addition of new cells are thus considered close relatives.



DAVID J. BEDFORD



Left: surface of a young spike of the grasstree *Xanthorrhoea resinosa* before flowering. The distinctive brown, velvet-like bracts (leaf derivatives) are characteristic of this species. Right: early flowering stage of the grasstree *Xanthorrhoea johnsonii*. The green sepals, only just visible at the bases of the flowers and young buds, are very small in most grasstree species.

Grasstrees are among the first plants to resprout after fires.

stem tissue and changes to produce the flower spike. Following flowering and fruiting the apex dies. The continued growth of the stem is from one or more of the previously inactive axillary buds, which sprout after the main apex dies. When more than one such bud survives, as regularly happens in some species, the plant forms multiple branches.

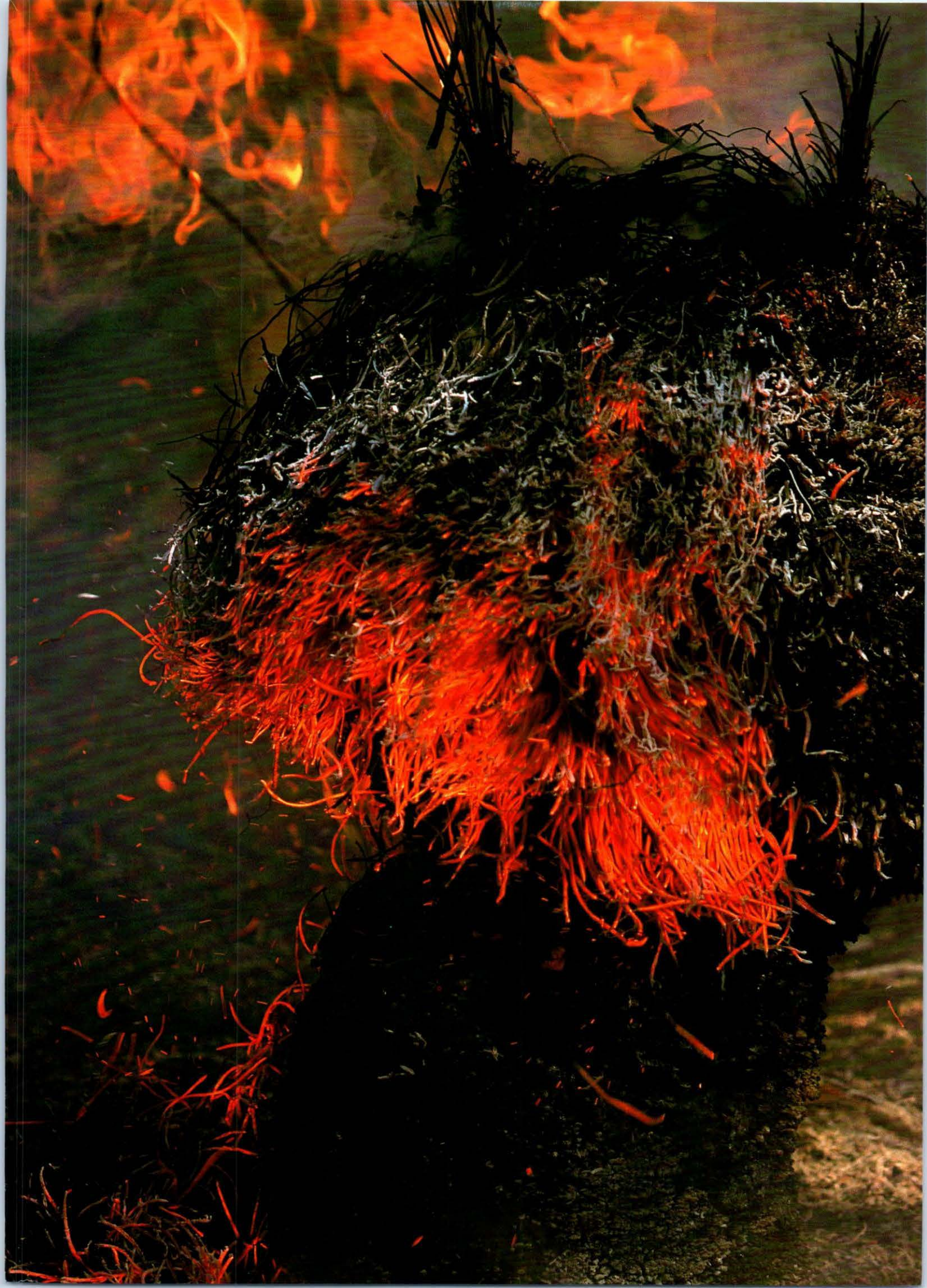
Trunk development partially depends on how many leaves are produced each year. Grasstrees that do not develop trunks produce fewer leaves each year than those with trunks. These small species grow larger by developing several branches underground and at the base rather than continuing to grow upwards.

A common misconception about grasstrees is that individual plants are thousands of years old. This probably arose from both grasstrees' superficial resemblance to primitive plant groups (see box), and a paper published in 1955 by one amateur naturalist, C.F. Lewis, who proposed that some plants could take over 5,000 years to emerge above ground level, and that they grew at about 300 millimetres every 120 years thereafter. Lewis primarily based his estimates on his observation that young plants produce only about 2.5 leaves per year. In fact, Malcolm Gill (CSIRO Division of Plant Industry, Canberra) and Frank Ingwersen (Conservation and Agriculture Branch, Department of the Capital Territory) found in a study published in 1976 that mature specimens of one of the tallest, and therefore most probably fastest growing, trunked species of grasstree increase in height about 20–25 millimetres per year, and my own observations are that trunked species produce about 150–250 leaves per year. It is also possible that, without realising it, Lewis was counting seedlings of a species of grasstree that never develops a trunk. In any case, Lewis' calculations gave ages 50–100 times longer than recent scientific calculations on the rate of growth and age of these plants. This is not to say that grasstrees do not grow relatively slowly; they do. After germination they have an establishment phase of at least six to ten years during which time they develop their root system, which consists of numerous fine roots radiating from an underground inverted cone at the base of the stem. This phase is followed by (for trunked species) the gradual development of a trunk at approximately 10–25 millimetres per year. A plant two metres high can therefore be over 100 years old, and could be up to 200 years old.

Grasstrees are part of the hard-leaved, fire-adapted vegetation type in Australia, and mostly occur on soils low in nutrients. The tree-like species are well insulated from fires by the closely packed old leaf bases covering the trunks. Grasstrees also have roots that contract as they grow, and thus pull the vulnerable stem apex of young plants and trunkless species below soil level, allowing the plants to survive all but the fiercest fires. Because grasstree leaves grow out from special growing points at the base of each leaf, close to the stem, and the leaves themselves protect the growing point, grasstrees are among the first plants to resprout after fires. Although the obvious leaves are burnt off by the fire, the growing points can quickly produce more leaf tissue. The flowering of many, but not all, species of grasstree is synchronised or coordinated by fire so that whole populations may bloom together in the flowering season after a fire. Flowering after a fire has many advantages in Australia's low-nutrient

Grasstrees survive all but the fiercest of fires. Although the outer leaves are easily burnt, the growing points at the leaf bases are protected and so quickly resprout after fire.

JOHN FIELDS / AUSTRALIAN MUSEUM



Grasstrees transplanted from the bush generally do not survive more than a couple of years.

ecosystems. The fire releases nutrients from the accumulated leaf litter, and plants that resprout or seed quickly can take advantage of the open conditions after burning.

Because grasstrees are often amongst the first plants to flower after a fire, there has been a view that grasstrees *always* flower immediately after a fire. This assumption is incorrect. Grasstrees do not necessarily flower every year, but when they do each species flowers at the same season in any year. Therefore, if a fire takes place after the flowering season, it could be almost a year before the plants flower again. Also, some species grow naturally in areas where the soil is quite moist, and so cannot or need not rely on regular fires. These species flower in season, often all together, without any apparent prompting. Another factor is that grasstrees only flower when they have adequate stored food reserves so, if they have depleted reserves, even those species that would normally do so are not always found to be in flower after a fire.

Although many people associate grasstrees with arid landscapes, they are mostly found on the higher-rainfall fringes of the continent with only two species *(X. thorntonii* and *X. nana)* found in true arid or semi-arid regions. Most species of grasstrees like well-drained soils, although four of the species will grow in periodically waterlogged soils, and all are very sensitive to *Phytophthora* root rot. This condition is caused by a number of introduced soil-borne fungus species (*Phytophthora* spp.) and is spread by humans (feet and on vehicles), animals and in the watertable. As well as being a disease in home gardens, *Phytophthora* is killing large areas of native vegetation in parts of Australia, especially Western Australia. In fact, the advance of this disease through natural areas can sometimes be monitored by observing the distribution of dead and dying grasstrees.

MANY GARDENERS WOULD LIKE TO GROW grasstrees but have been deterred by their reputation for slow growth or a bad experience with transplanted examples. However, grasstrees are readily grown from seed and, if this method is chosen, it is much more feasible to grow grasstrees in the garden than most people think.

Currently the main source of grasstrees for the garden is plants transplanted from the bush and sold through nurseries. However, I do not recommend these for a number of reasons: they have been 'ripped off' from the bush instead of purpose-grown; they are expensive (often hundreds of dollars each); and many of them do not survive more than a couple of years.

As plant lovers we are all concerned about the conservation of Australia's natural bush areas, and realise that not all vegetation types or species are protected or adequately conserved in national parks. It is therefore important that a hobby of growing Australian plants is not to the detriment of natural areas, whether they be publicly or privately owned. I argue that the removal of grasstrees (or any other plants) from natural areas for resale is an undesirable practice and should not be encouraged.

Support for this view comes from the fact that most such transplanted grasstrees live for no more than three to four years. Because they have a wide, relatively shallow root distribution, grasstrees suffer massive root loss and disturbance when dug up and put into nursery-size plastic buckets. As for many other native plants, such root disturbance and loss usually results in the death of the plant. Grasstrees can live up to four years after such treatment because they have considerable reserves of food stored in their trunks. But when these reserves are exhausted the plants die. Their susceptibility to *Phytophthora* root rot also makes transplanting less successful. Obviously the plants are much more likely to be infected when they have been dug up with unsterilised earth-moving equipment and have suffered from root damage.

Grasstrees grown from seed, on the

Old flowers and developing fruit on the grasstree *Xanthorrhoea resinosa*. Although only a small proportion of the flowers develop into fruit, each spike will still generate a massive 1,000–2,000 seeds. A Tree Dragon *(Amphibolurus muricatus)* may be using the spike as a vantage point.

KEN GRIFFITHS

DAVID J. BEDFORD

This specimen of *Xanthorrhoea glauca* was photographed when it was 13 years old. It was grown from seed in 1978 and planted out three years later into this Brisbane garden, which belongs to the author's parents.

GROWING GRASSTREES

Many native plant nurseries sell grasstree seedlings or seeds. However, some also sell the transplanted trunked grasstrees, which have been dug up out of the bush. These should be avoided.
Grasstree seeds can also be bought by mail order from the Society for Growing Australian Plants. Write to Seed Sales, PO Box 378, Miller, New South Wales, 2168 for a price list. Packets of native seed plants are available from $1 upwards.

other hand, become attractive plants within only a few years. Even though they do not develop tall trunks quickly, the fastest growing species will have a noticeable trunk (100–150 millimetres high) in 10–15 years, and many species will flower after only five or six years.

Grasstrees produce prolific quantities of seeds that remain viable for a few years if sensibly stored. Seed can easily be collected from most species. Wait until the fruit are fully open but still holding the black seeds in the capsules, and take only a few seeds from each plant so as not to reduce their chance to reproduce in the natural environment.

Sow the seed into a well-drained mix of new soil or into new, washed, coarse river sand in a good-sized pot (not less than 150 millimetres deep). Most fresh seeds germinate within about two weeks (older seeds can take longer) and quickly put down a root to the bottom of the pot, before much shoot develops (which is why small pots and trays are best avoided). Seedlings can be grown in large pots for one to three years before planting out in well-drained, *Phytophthora*-free soils.

Growing grasstrees can be a very gratifying experience, as they give a longer-term interest and uniquely Australian flavour to a garden. They are particularly interesting because they have evolved only here and are a distinctive part of the Australian bush. Because they have few easily visible characters to distinguish them, many species are quite cryptic. As we learn more about grasstrees it is likely that we will be able to distinguish additional species or subspecies, which could be important to the conservation of Australia's biodiversity. Indeed, recent work has found two undescribed species of grasstree, quite close to major cities. Grasstrees are homes to many Australian animals, some of which are uniquely associated with them. They also attract a wide range of birds, mammals and interesting insects when they flower. And you can be sure they will never drop leaves in your gutters! ■

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PHOTO INDEX

Water Buffalo thundering across the Top End.

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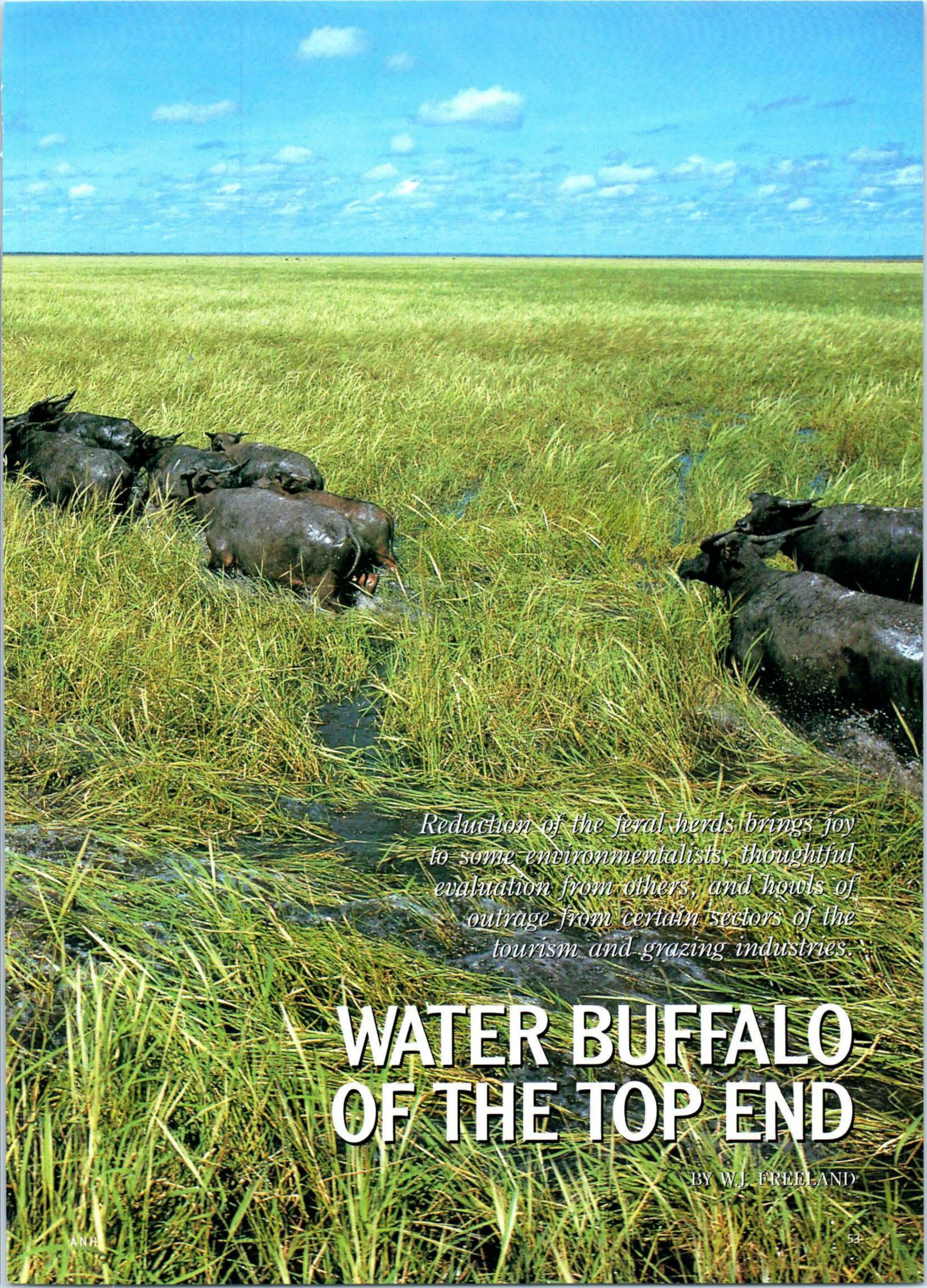


Reduction of the feral herds brings joy to some environmentalists, thoughtful evaluation from others, and howls of outrage from certain sectors of the tourism and grazing industries.

WATER BUFFALO OF THE TOP END

BY W.J. FREELAND

IN 1828 WATER BUFFALO *(BUBALUS BUBALIS)* were introduced to northern Australia from Asia as potential food and beasts of burden. They made their debut at the ill-fated settlement of Fort Wellington (Melville Island, Northern Territory), with an encore appearance at the equally ill-fated Victoria Settlement (Cobourg Peninsula, Northern Territory) in 1838. In 1843 Captain I. Everard Home wrote from Victoria Settlement that he had seen two herds of approximately 50 each feeding near the neck of the peninsula. Two years later Ludwig Leichhardt saw them, and ate one, as he made his way through the flats of what is now called Murgenella Creek.

The next known introductions were between 1864 and 1866 when the schooner *Beatrice* made several trips to Timor, returning with yet more buffalo for the temporary settlement at Escape Cliffs, near the mouth of the Adelaide River. It is reported that in 1885 one E.O. Robinson found feral buffalo sufficiently numerous in the flood plains of the Adelaide River to begin commercial shooting of buffalo. Over 100,000 hides were exported between 1886 and 1911.

Despite the abandonment of most of the early human settlements in the Top End, the buffalo continued to thrive. Although the hide, and later the meat industry, had some impact on the feral populations, it was not enough to thwart the burgeoning numbers or the damage they were causing to the wetlands. In 1978, in response to calls from environmentalists and the meat industry, the Government of the Northern Territory established a Board of Inquiry to develop recommendations on the Water Buffalo, and the Territory's other feral species. The report was produced in 1979, and focused attention on widespread environmental deterioration caused by the feral buffalo.

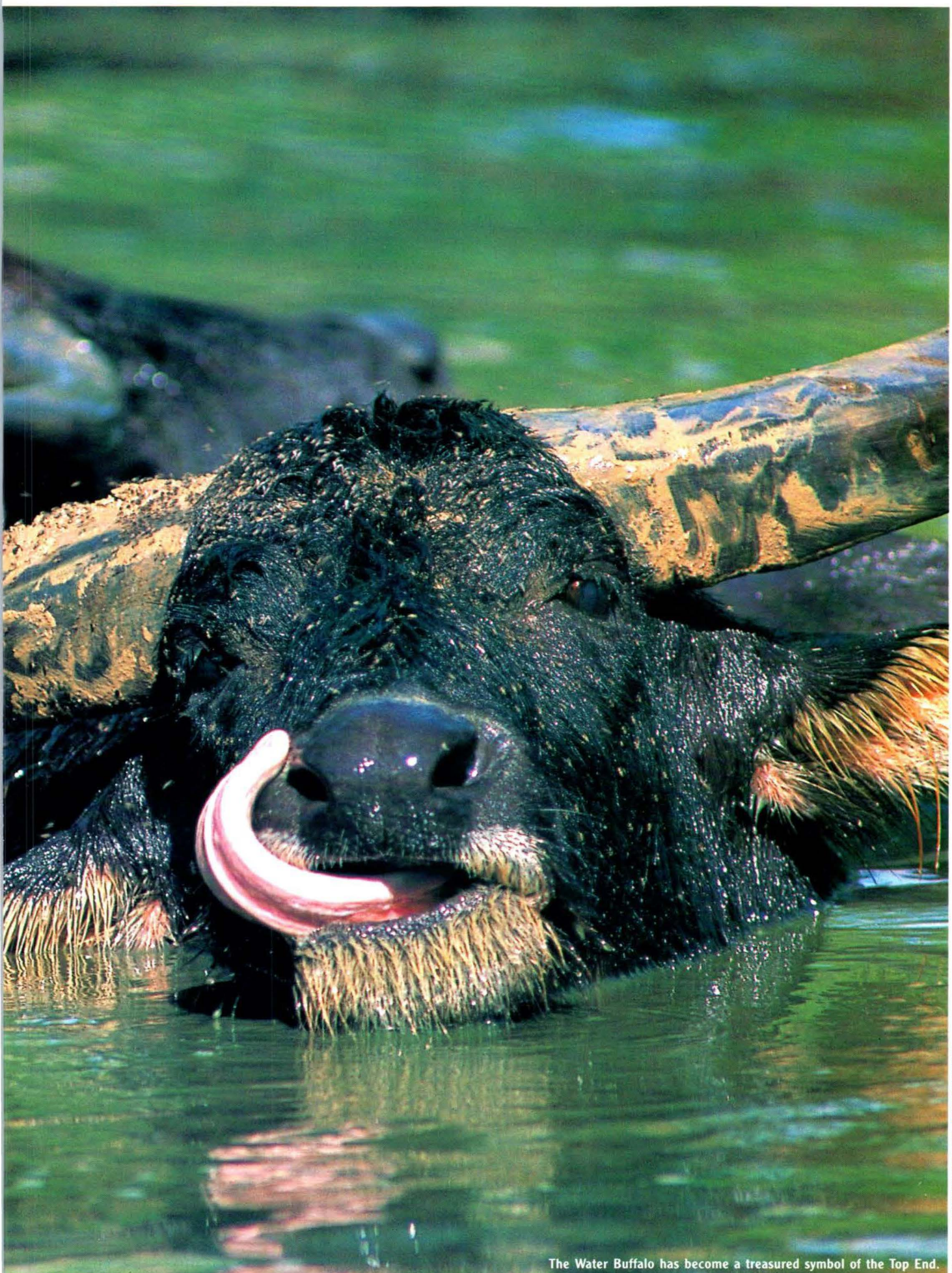
Impacts from buffalo included overgrazing with marked damage to monsoon rainforests, palm forests and the wetlands. The most apparent damage resulted from buffalo making swim-channels that allowed seawater to penetrate into and kill hundreds of square kilometres of paperbark swamp forest. It is only in the past few years that this damage has been mitigated at great expense by the erection of embankments to hold back the sea. Other major impacts included loss of stands of the reed *Phragmites*, diminution of perennial grasses in the flood plains and eucalypt forests and woodlands, and erosion of soils once the vegetation had been damaged. The report called for reduction of buffalo populations in areas of conservation importance, and the establishment of domestic herds.

Despite the formation of domestic herds and control measures on parks and reserves, by 1985 there were approximately 340,000 feral Water Buffalo spread over an area of 223,672 square kilometres of the Northern Territory. The distribution extended from Melville Island (survivors of the original introduction) and Cobourg Peninsula in the north, to the Victoria River district and Gulf of Carpentaria lowlands in the south. Highest densities were recorded from the major flood plains of the north.

Since 1985, as part of the National Brucellosis and Tuberculosis Eradication Campaign (BTEC), the feral populations have been significantly reduced. Many former populations now consist of only a few individuals. Domestic herds remain in

The buffalo hide industry began in the late 1800s when they were used locally for industrial leather. Today they are mainly exported to Asia.

F. WOERLE



The Water Buffalo has become a treasured symbol of the Top End.

JEAN PAUL FERRERO / AUSCAPE INTERNATIONAL

F. WOERLE

The construction of fences clearly prevents the movement of buffalo into areas of conservation importance.

the wetlands to the south-west and east of Darwin, and in Kakadu National Park. Feral populations on Melville Island and in some parts of eastern Arnhem Land have been declared tuberculosis-free and are being used as foundation stock to develop domestic herds.

Reduction of the feral herds brings joy to some environmentalists, thoughtful evaluation from others, and howls of outrage from certain sectors of the tourism and grazing industries. There is much to learn about what the elimination of buffalo will mean, but already it has resulted in and will continue to bring major changes to flood plain habitats. Many of the changes are little understood, and some may be of concern. One potential problem is the apparent growth of perennial grasses at the expense of Wild Rice *(Oryza rufipogon)* and the spikerush *Eleocharis dulcis*, critical foods for the Magpie Goose *(Anseranas semipalmata)*. Although the massive populations of the past are unacceptable, future results may indicate that controlled, low-density populations provide an effective means of managing some wetland habitats. Reduction of the buffalo populations has also created difficulties in gaining breeding stock for the domestic herds; it has reduced the significance of the pet meat industry; and it has removed one of the Top End's major tourist attractions.

Over the past 50 or so years the Water Buffalo has become a treasured symbol of the Top End. It was and is a part of things Territorian, and its apparent demise something many regret. While noting that, yes, it had a negative impact on the environment, there is something sad about the current status of the buffalo population. The Top End's Water Buffalo, in a sense, provided a substitute for our lost marsupial megafauna. Nowhere else in Australia could you see vast herds of

Reduction of the Top End's buffalo herds has removed one of the major tourist attractions.

large herbivorous mammals (large horns and all) thundering across the plains—an unusual sight for Australia. Unfortunately, however, something went wrong and, as well as a megafaunal replacement, we ended up with a major environmental problem.

Before the eradication campaign, Water Buffalo in the Top End existed at exceptionally high densities. Average population density over much of their range was 3.3 animals per square kilometre. This compares with 1.08 per square kilometre for similarly sized animals in their native habitats, and 0.83 recorded from Water Buffalo in their native habitat. Given that maximum densities in the Top End have been recorded at 25.2 Water Buffalo per square kilometre, it is clear that the introduced populations were far from natural. It is the impact of these unnatural densities that results in environmental damage, rather than an inherent inability of the Australian landscape to cope with some attribute (such as large size or cloven hooves) of individual buffalo.

An understanding of the cause of the extraordinary densities of Top End buffalo populations may provide a basis for developing controls that eliminate the threat of future environmental damage. In the absence of control, the populations will inexorably return to their former proportions.

WATER BUFFALO GIVE BIRTH THROUGHout much of the year, with peaks occurring during the wet season. Approximately 95 per cent of sexually mature females give birth each year, with females first giving birth during their fourth year and continuing to reproduce until at least 20 years of age. In most years there is remarkably little mortality, and a population can increase at rates of up to 27 per cent per year. Growth of undisturbed populations continues when dry-season (May to October) rainfall exceeds 50 millimetres. At Darwin this level of rainfall is achieved during 73 per cent of years, with the maximum rate of buffalo population growth (27 per cent) achievable during 69 per cent of years. During years when monsoonal rains are delayed and dry-season rainfall is less than 50 millimetres, many Water Buffalo succumb to thirst and starvation, or die bogged in mud in a hopeless quest for moisture. The late Don Tulloch (who conducted the majority of the work on feral buffalo) reported a 60 per cent decline in one buffalo population (1,266 buffalo to 503) as a result of late rains.

The rapid growth of feral populations of Water Buffalo, combined with massive mortality occurring approximately once every seven years, results in populations that vary erratically from low densities to densities that are exceptionally high. The rapid growth, apparent sensitivity to adverse conditions and high density of the feral populations appear due to the absence of stabilising mortality. When we brought the buffalo to the Top End we failed to bring with it its predators. There are no Tigers in the Top End. There are Dingoes and Saltwater Crocodiles, which can and do take some buffalo, but they do not affect feral populations as much as would the wild dogs, crocodiles and Tigers of the buffalo's native habitats.

Similarly, the Top End's buffalo are relatively healthy. Many of their natural parasites and diseases do not exist in Australia. It is the absence of major bovine diseases that gives Australia its 'edge' in international trade in livestock and livestock products. It is this 'edge' that is protected with strict quarantine laws, and is imperilled by the possible spread of exotic disease via contamination of the Top End buffalo herds. Disease spreads most rapidly through high-density populations. High densities of buffalo, together with their remote location, make monitoring for and control of exotic disease a difficult undertaking.

So the Top End buffalo population is a population that has left its regulatory control mechanisms in its country of origin. The lack of such mechanisms results in the high densities that cause environmental damage, imperil the livestock industry with its potential for rapid spread of exotic disease, and makes their control so difficult.

Controls used to date are based on a combination of utilisation for commercial purposes, and culling by shooting. Commercial harvest involves mustering for transport to abattoirs for human consumption, or shooting for pet meat. Following harvest, populations are subject to shooting without use of the carcass.

Damage caused by buffalo include saltwater intrusion into paperback swamp forest.

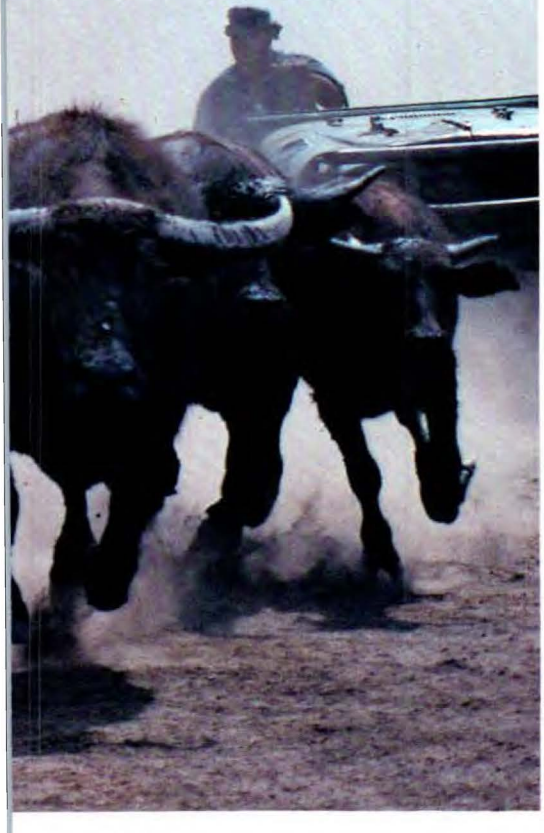
F. WOERLE

Helicopters are essential for managing Water Buffalo populations. They are used to muster the herds into pens, and also as vantage points for shooting.

F. WOERLE

F. WOERLE

Late rains in 1972 resulted in the deaths of thousands of Water Buffalo.



Shooting from helicopter is the only practical form of control in areas where terrain or isolation prevents commercial harvest. Compared to shooting on the ground, shooting from helicopters is very rapid and cost-effective. It is also extremely humane. All shooters are highly skilled, and continually subject to training. Death of a buffalo is swift, and the kills assured and checked.

Unfortunately the rapid growth of buffalo populations means that costs of control are prohibitive. Simulations of control exercises reveal that, if a population of 50,000 buffalo is subject to an effective shoot, the cost of reducing the population from 311 per 100 square kilometres to 7.33 per 100 square kilometres would be at least $1.35 million. Although a density of 7.33 per 100 square kilometres might sound like extinction, in the absence of further control the populations will rapidly return to former levels. Long-term reduction of the buffalo's environmental impacts depends on costly recurrent control.

There is no easy solution to the buffalo problem. Although the population is currently low and widely dispersed, in 20 years time it will be well on the way to recovery. At that time we might have an effective, humane and low-cost control method. One possibility is the introduction of a biological control agent such as the round worm *Toxocara vitulorum*, which in Asia can destroy up to 30 per cent of new buffalo calves. The worm is transmitted to the calf in the mother's milk and takes up residence in the calf's intestine, causing disturbances that, in severe cases, result in death. The worm is absent from the Top End but present in cattle in northern New South Wales. It is not a serious pest in cattle, and can be controlled in domestic buffalo.

Whether the worm could be an effective control for populations of feral Water Buffalo is not known, and is the subject of current computer simulations. *Toxocara vitulorum* is an example of the type of natural control that may provide our most cost-effective solution. A successful, natural agent of control would reduce population densities, slow the rate of population increase, and hopefully minimise the inhumane starvation and thirst imposed by the Top End's erratic rainfall. And the special appeal of a biological control agent is that it would be density dependent—that is, the intensity of its regulation would depend on the abundance of its buffalo host.

Should natural biological control prove effective, the feral Water Buffalo may become an effective means of managing wetland habitats, and once again become a spectacle for visitors, Australian and otherwise. It may also be the only effective means of returning the buffalo to the status of cultural icon in the Top End. ■

Suggested Reading

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Dr Bill Freeland is the Head of the Wildlife Division of the Conservation Commission of the Northern Territory. Over the past nine years his research has concentrated on the management and impacts of the Territory's large range introduced animals, including Water Buffalo, Donkeys and Cane Toads.

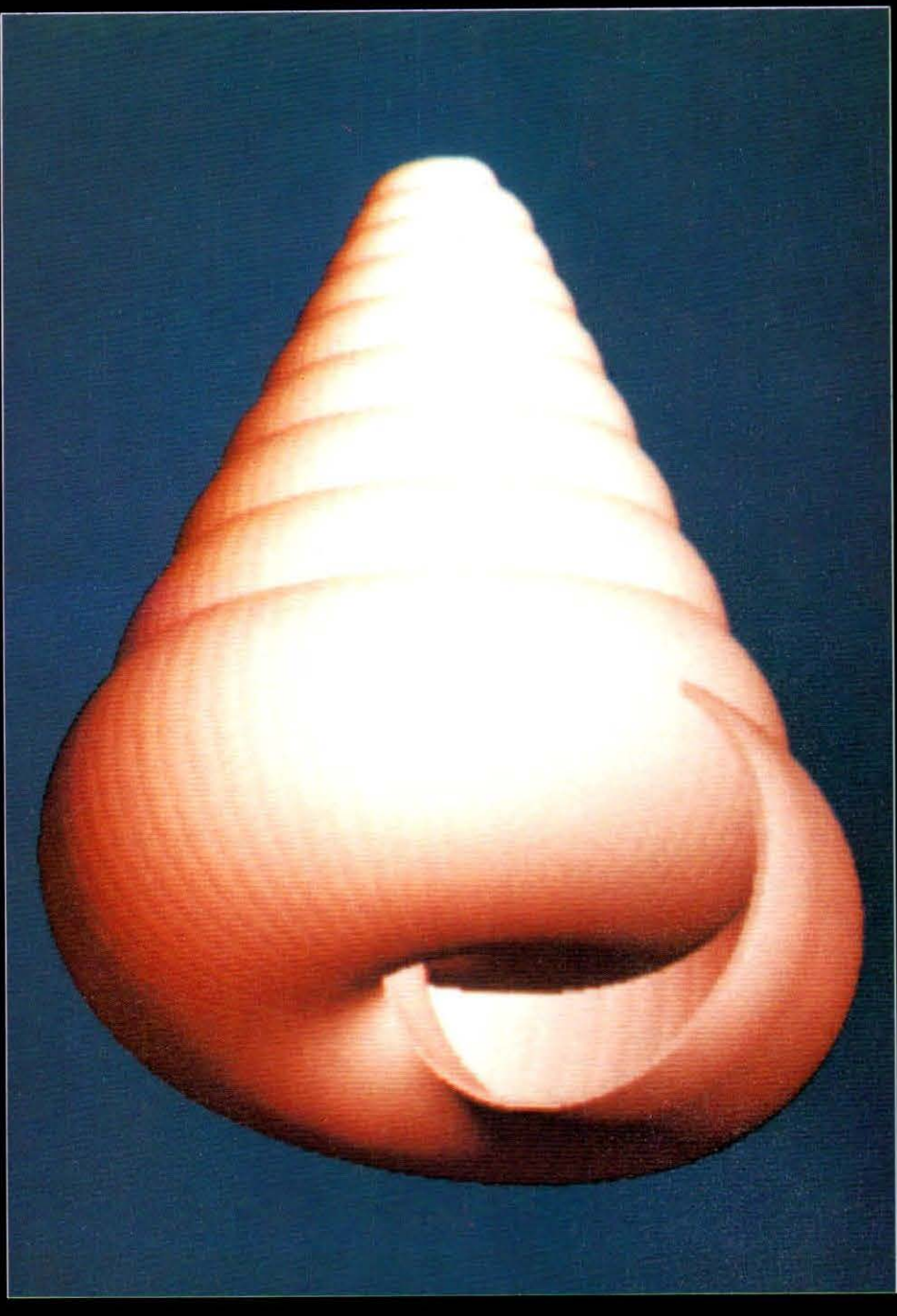
COMPUTER RESURRECTION

BY
CHRIS ILLERT

Only during the last decade or so has it been appreciated that seashells obey amazingly precise and important mathematical and physical laws. Using my mathematical equations, Clifford Pickover of IBM New York was able to produce full-colour supercomputer images of long-extinct Cretaceous ammonites. These are as fresh and clear as if they had just been plucked from the sea. Even the surface texture, reflectivity and reddish brown striped pattern is probably close to the original shells.

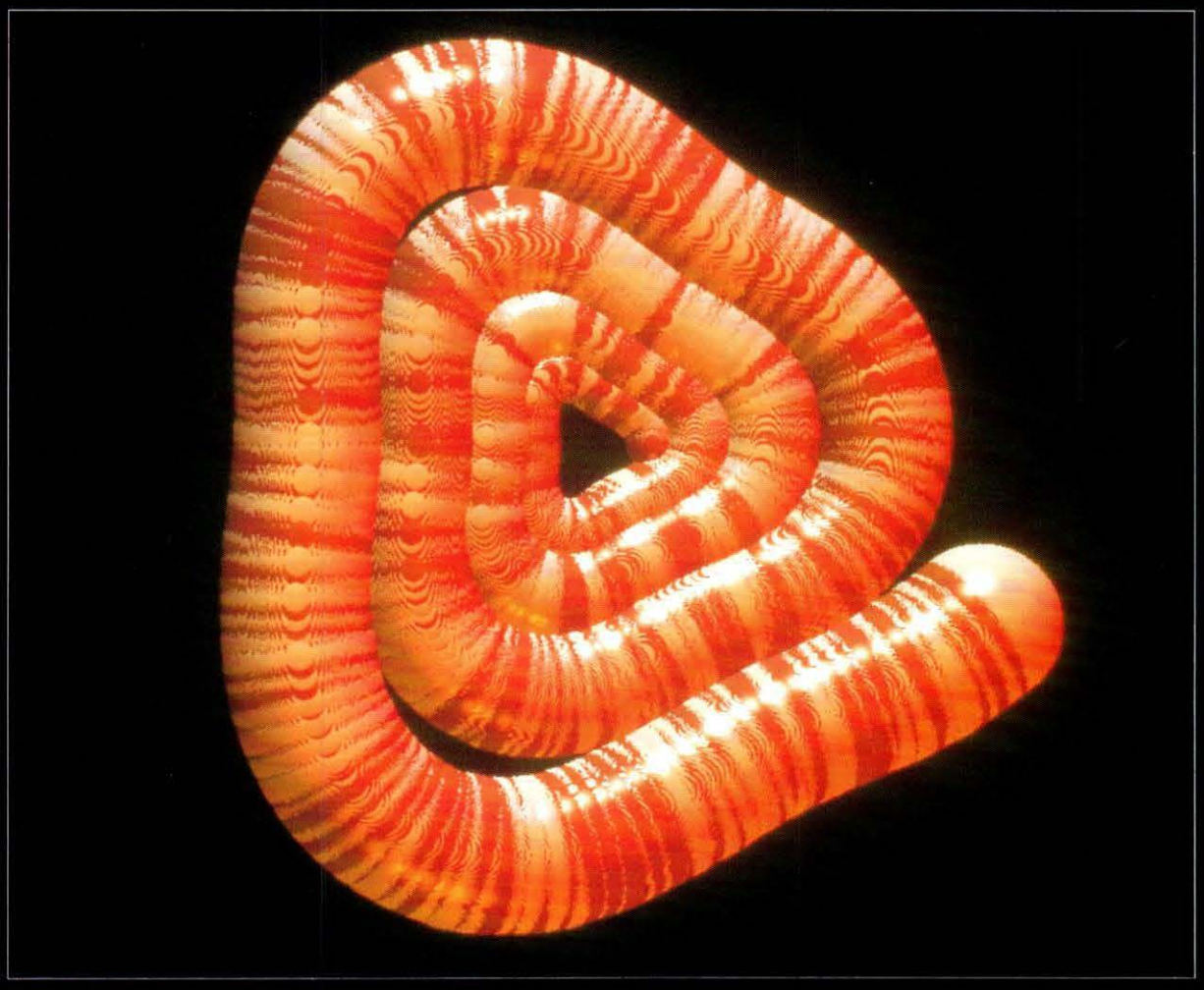
Clifford has developed various complex programs for supercomputers, which generate shell images individually, or sequences of images from different angles, enabling us to produce movies of spinning and growing shells.

The individual computer-generated 'snapshots' are created by a slowly expanding sphere, which moves increment by increment along a trajectory through space. We can approximate the molluscan soft body to an expanding solid object for the purposes of predicting shell growth. As the computer-generated solid 'sphere' expands and moves through space, it leaves behind a 'trace' of where it has been (rather like a time-lapse photo), thereby imitating the way real molluscs deposit shell



W. BRONSVOORT / DELFT TECHNICAL UNIVERSITY

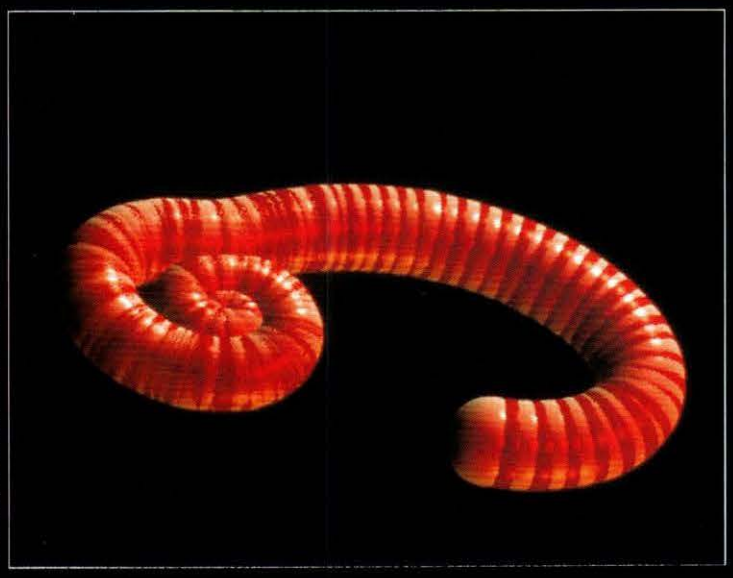
Supercomputers created these fossil gastropod shells with familiar turbinate spires.



C. ILLERT, D. REVERBERI & C. PICKOVER

The peculiar triangular shape of *Soliclymenia paradoxa* is yet another form of shell coiling.

PHOTOART



C. ILLERT, D. REVERBERI & C. PICKOVER

Macroscaphites ivani found in early Cretaceous strata from Africa and the European alps. Initially regular, spiral coiling becomes elongated.

material during their growth.

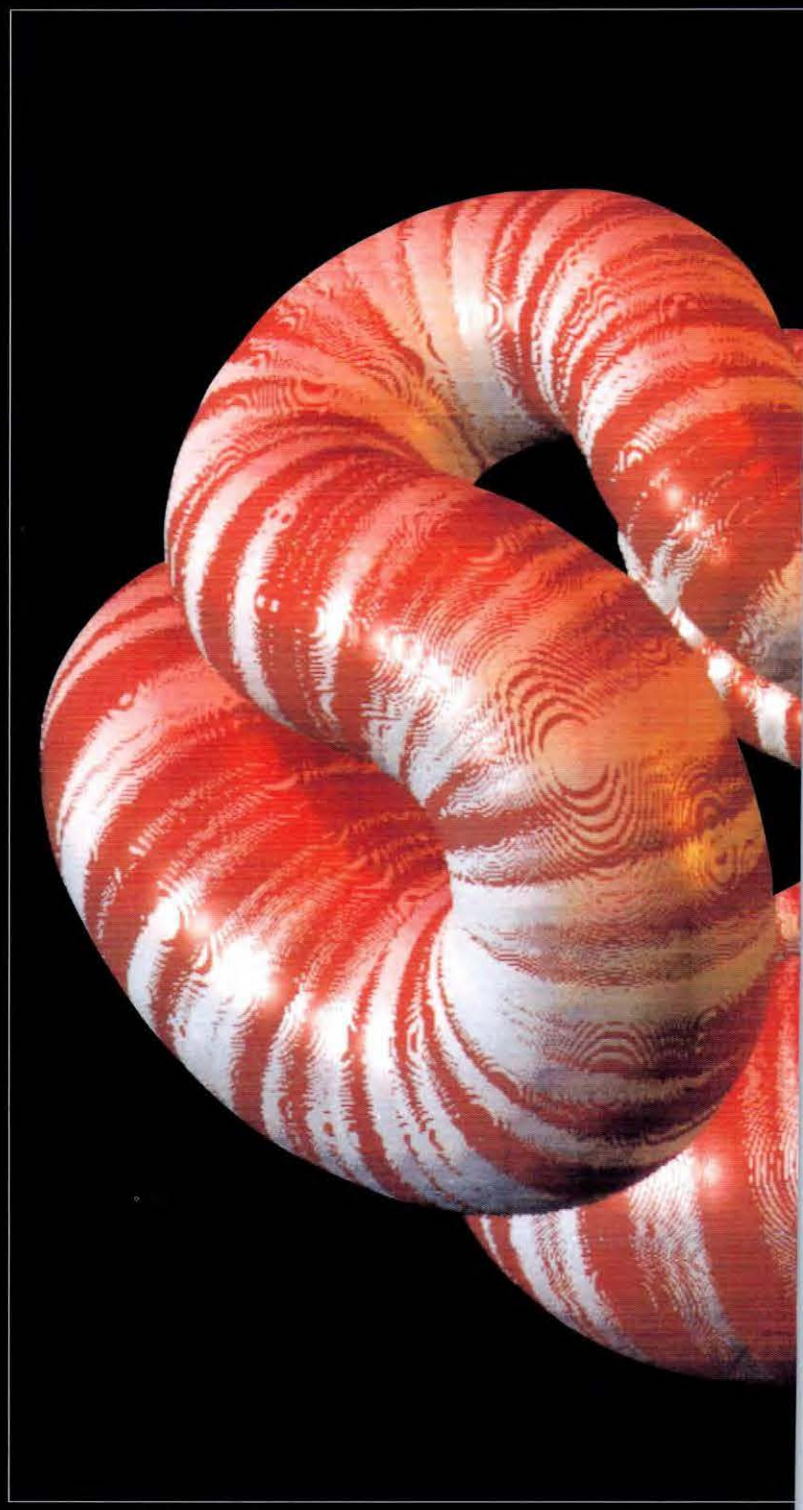
Of course, care must be taken to accurately imitate the growth rates of real fossil shells. If successive 'spheres' are too close together, the shell's ribbed effect is lost; if too far apart, the shell tube looks beady and discontinuous.

Willem Bronsvoort, Koen van Ginkel and Rudi Way of Delft Technical University in the Netherlands have used a different approach to generate computer images of gastropod shells with conical-looking spires. They generate the whole shell surface, before actually 'shining' the light onto it using a mathematical process called 'ray-tracing'.

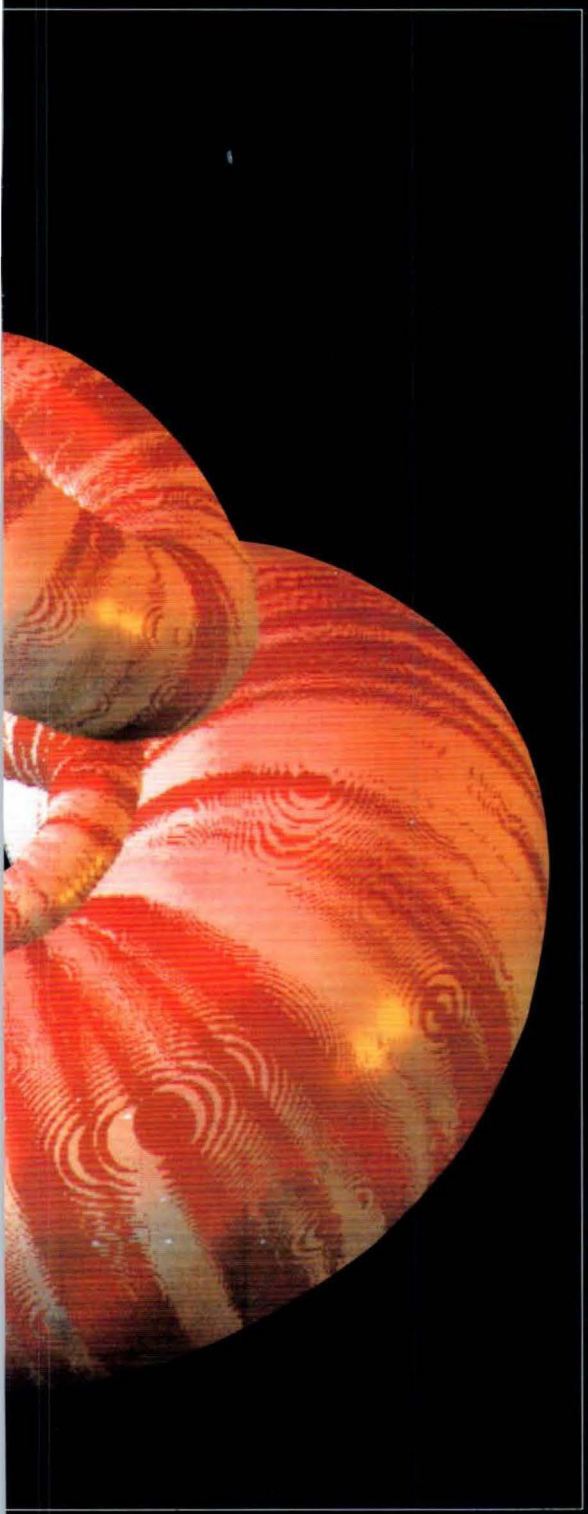
Whichever approach is used, the results are visually pleasing and realistic. And, as some shells change their shapes during the course of growth or evolution, our computer-animated geometrical movies provide insights into nature and help us make sense of the vast array of naturally occurring shell geometries.

C. ILLERT, D. REVERBERI & C. PICKOVER

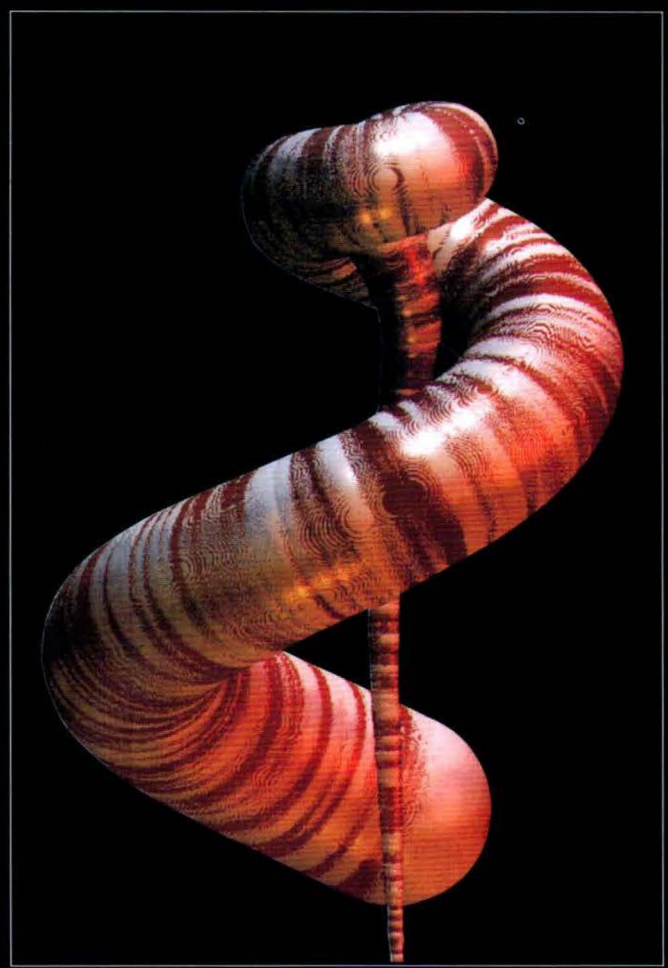
A juvenile *Nipponites* sp. that starts off coiling in a serpentine fashion right from the start.



***Nipponites mirabilis:* by adulthood 'chaos' seems to have set in, with outermost whorls meandering in a serpentine fashion, like the suture-line on a tennis ball.**



C. ILLERT, D. REVERBERI & C. PICKOVER



C. ILLERT, D. REVERBERI & C. PICKOVER

The extinct fossil shell *Madagascalites ryu* starts growing along the axis of symmetry then reverses its direction of growth and starts coiling about itself.

COMPUTER RESURRECTION

The War of the Kingdoms has produced some impressive tactics.

SANDWICHES AND SANDWICH EATERS

BY MICHAEL ARCHER

THE INSTANCE I SAW THE BOX OF prickly pear fruits, sweat beaded on my forehead, my eyes narrowed and my shopping trolley swerved out of control. Mumbling a confused apology to the winded lady sprawled in the aisle before me, I knew I would never get over my fear of these awful plants.

It all went back to an afternoon spent digging fossil bones in a cave north of Perth. At the entrance was a huge prickly pear dotted with swollen yellowish green fruits. "They're really great with ice cream!" someone encouraged. Although the fleshy leaves of this introduced tree-sized cactus were covered with conspicuous spines, the fruits bulging obscenely from their ends looked safe enough. But as each was knocked into a waiting shirt (mine of course), it became obvious that even the fruits were covered in tufts of needle-like hairs. After the first and only attempt to pick one up without the wretched hairs innoculating my fingers, I lost all interest in the exotic desert. That night I washed my shirt thoroughly but, when I put it on the next day, my whole torso shrieked with the jabs of thousands of tiny hypodermic needles. I logged this experience with childhood memories of poison ivy and stinging nettles under 'Really awful green things to be avoided like the plague'.

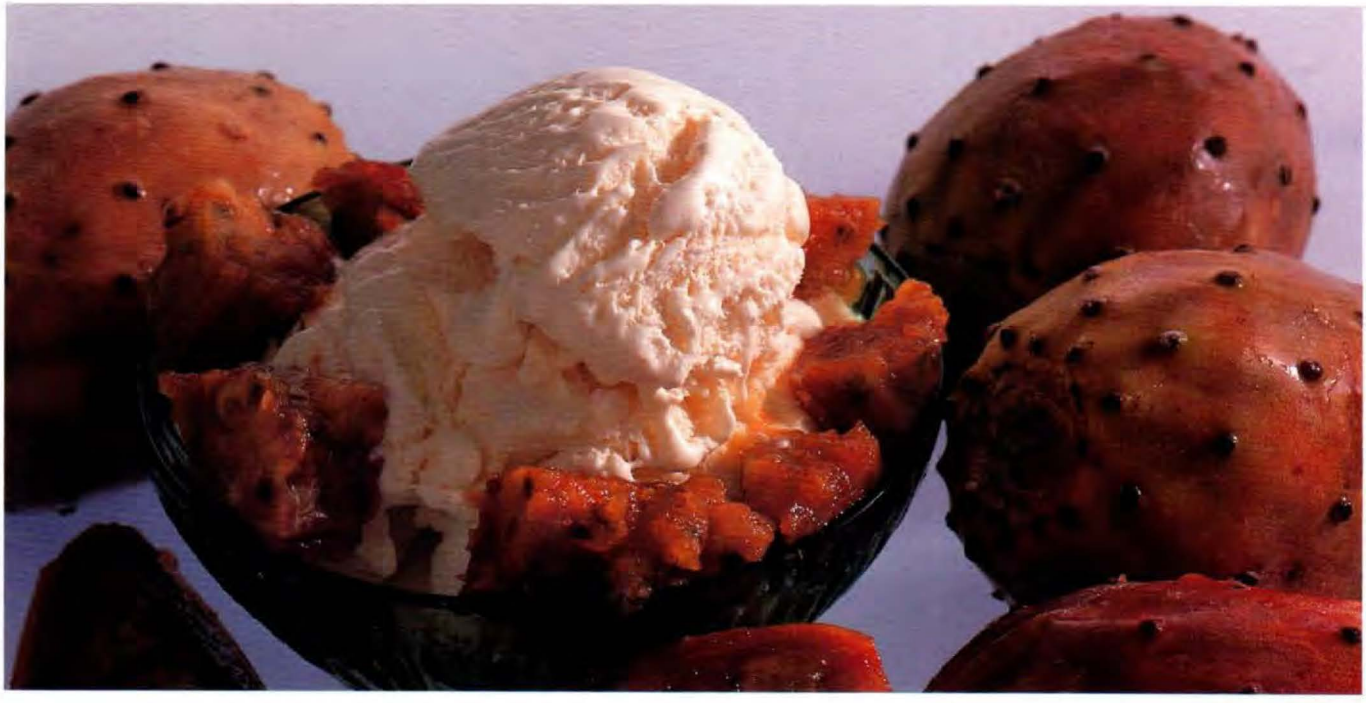
As animals, we tend to regard plants as defenceless blobs of mindless biota whose purpose is to be laid down on a plate before us. And for a few cultivated plants like cabbage and corn, this may well be true, but for the 150 billion tonnes of plant material consumed annually by non-human animals, the consumer–consumee relationship is rarely so peaceful.

For billions of Earth's early years, chemical-consuming and food-manufacturing prokaryotes (bacteria and blue-green algae) dominated the world. Then, sometime about two billion years ago, a devious single-celled species, sick to death of munching mud, turned its covetous sense organ onto one of its self-reliant neighbours. Thus were born the first vampirish, insatiable cell-suckers, stars of the world's first nightmares.

The consequences of this prehistoric savagery were manifold–including a steep rise in biodiversity. In these newly parasitised communities, any overly successful producer would have become a more frequent target of the predators and in its decline in abundance would have enabled more kinds of species to share its environment's resources. Of course it didn't take long for the brutalised eatees to explore evolutionary strategies for frustrating the feeding frenzies of the eaters. Thus began the now ancient War of the Kingdoms, savage amoeba *versus* gentle bacteria, cow *versus* grass, sandwich-eater *versus* sandwich.

After more than a billion years of battle, this bestial war has produced some impressive tactics. Among the better-known is the development by plants of an indigestible cellulose fortress to secure their intracellular goodies from animals that lack the magic key: the enzyme cellulase. Animals, not to be outdone, 'borrow' cellulase manufactured by undigested bacteria to dissolve the walls of the cellulose fortress. Sharpened stakes such as the seven-centimetre long horns of African acacia trees would seem an impenetrable, let alone indigestible, defence for its foliage but, as they lengthened, so did the height and resilience of the teeth and gums of savanna mammals. Even the capacity to increase the length of these

Although visually appealing, prickly pear cactus fruits use tiny, irritating hairs to guard against indiscriminate munching.



CARL BENTO / AUSTRALIAN MUSEUM

thorns following initial attacks has failed to remove these trees from the table.

Overt ploys and counterploys such as these, however, pale in comparison with campaigns of chemical warfare. For example, cycads, an ancient group of botanical battlers that successfully (in the long run) matched their green bits against the appetites of the dinosaurs, lace their seeds and tempting greenery with gruesome and yet almost tasteless poisons. De Vlamingh, an early explorer of Western Australia, reported his hapless herbivorous crew was violently sick and "crawled all over the earth and made ungovernable movements" following a side-order of cycad (see ANH vol. 23, no. 6, 1990).

When under siege by ravenous caterpillars, some plants pour cauldrons of poisonous chemicals into their veins. Stinging nettles use hypodermic 'syringes' (trichomes) loaded with painful toxins and increase the number of these weapons if the original armada fails to deter an attack (see ANH vol. 23, no. 12, 1992). The Bursera tree in central America actually shoots a horrible brew of sticky terpene chemicals into the face of any creature inexperienced enough to nibble a leaf.

Other plants lace their tissues with tannins, chemicals that reduce the plant's digestibility as well as stunt the growth and damage the intestines, liver and kidneys of animals foolhardy enough to eat them. Going one step further, some African acacias, which produce enough tannin to kill their tormentors (3,000 South African kudu antelopes were found dead after being forced to dine on this indelicacy), release ethylene gas into the air if they are attacked. This is tree-talk for 'danger!' Their air-sprayed siren warns nearby acacias to top up their lethal loads of toxic tannins before the beast with teeth arrives.

But this is a two-sided war. Eventually the hungry eaters must try to outwit the defences of the eatees. In the case of the toxic acacias, Giraffes have learned to munch every tenth acacia and avoid trees downwind from those previously sampled. In the case of the Bursera's squirt-gun, one group of beetles has developed the trick of biting through the leafstalk before dining on the then disarmed leaf. In Australia, Aola Richards and Wyn Filewood (University of New South Wales) have found a ladybird beetle that engages in trench warfare to avoid the potentially toxic leaves of pumpkins and marrows. Cutters not quitters, the adults isolate the area chosen for dinner by excavating curved trenches and sometimes even trenches within trenches. These cut the supply lines that the plant would otherwise use to race noxious chemicals into the besieged part of the leaf.

Skirmishes closer to home in this War of the Kingdoms are perhaps even more curious. Consider that 'plague of the porcelain', fruit diarrhoea. Yesterday, as I greedily popped the twelfth date during a shameless fruit pig-out, I did so despite being fully aware of the inevitable consequences: a growling tummy within hours and, an amazingly short time afterwards, a marathon race for the loo.

Most of us tend to look upon this culinary masochism as a small price to pay for a good feed of fruit. We are unlikely to consider a connection between the interests of the brainless date embryo, secure within the seed whose tasty birth shrouds we ravage, and the rapidly discovered need to be within sprinting distance of the dunny. Yet, isn't it possible that the rapid onset of diarrhoea is part of the date's 'strategic plan', ensuring that any seed that rocketed down the gullet before the tongue could catch it would not be resident in an animal's guts long enough to be digested? In our case, before the days of porcelain bowls and ocean outfalls, the date's precious children would have ended up swaddled in a life-nourishing coat of nitrogenous fertiliser, somewhere just out 'there', a greater distance from the parent tree than simple seed-fall would have allowed.

Could the rapid onset of diarrhoea be part of the date's 'strategic plan'?

As animals, we may well be able to outwit, in a neurological sense, a bowl of dates. But if date palms are more common now than they have ever been in their evolutionary history, who really used who? ■

Suggested Reading

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

QUESTIONS & ANSWERS

COMPILED BY
JENNIFER SAUNDERS

Wild Art

Q. On a recent trip to America I was impressed by the popularity of accurate wildlife art. An annual American Duck Stamp, which features the winning illustration from the most important of all the US wildlife art awards, is issued for hunting licences and has grossed more than a third of a billion dollars towards wetlands funding. In this way, both artist and wildlife benefit. Could you tell me if we have anything similar in Australia?

—E. Guinn
Huntleys Point, NSW

A. The trend to use wildlife art for conservation is indeed still in its infancy in Australia. However, you will be pleased to learn that we have followed the USA's example and introduced an annual Australian duck stamp, which is used to gain entry to Kakadu National Park. There is also an inaugural James Hardie Wildlife Art Prize that last year offered $70,000 worth of prizes. The general popularity of accurate wildlife art seems to also be on the rise. The Australian Museum hosts an annual WIRES (Wildlife Information and Rescue Service) exhibition (13 to 29 July 1992) that attracts donations of works from well-known Australian artists and has proven to be a very popular event. For Victorian residents, Eltham Wireglass Gallery is at present busy setting up its fourth annual wildlife exhibition (at 559 Main Road, Eltham, from 30 June to 19 July 1992). This show also attracts many talented Australian artists and is well worth a visit.

In supporting such an art form, we are not only encouraging the artist, but are helping to conserve our native wildlife by promoting its existence.

—J.S.

Sea-sculpt

Q. I was fascinated by the photoart article (ANH vol. 23, no. 9, 1991) about tafoni, the honeycombed formation or type of erosion caused by the combination of rock, air and water. Could you please tell me where these photos were taken, and does this phenomenon occur anywhere other than the coastline?

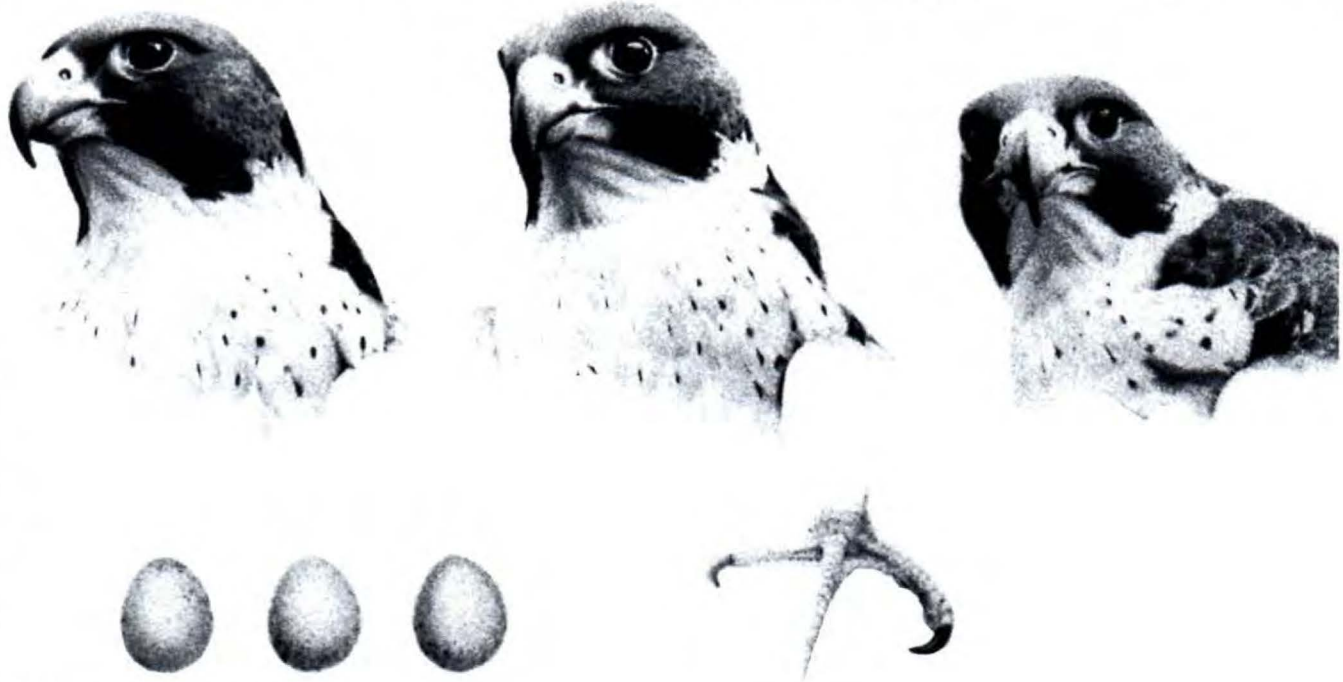
—J. Schuman
Drumoyne, NSW

A. Tafoni, or the honeycomb weathering pattern, is also found on rocks in deserts as well as along the coastline. It is regarded as being typical of tropical and subtropical semiarid to desert areas, although small-scale tafoni features are found in the cold, arid areas of Asia and the polar regions. Tafoni formations are rare in the most arid parts of the world's deserts, but are found in some humid areas that experience a variable climate, suggesting that water plays an important role in their development.

The beautiful shots in the photoart feature you refer to were taken by freelance photographer Anthony Farr along Sydney's northern beaches.

—Armstrong Osborne
Sydney University

Tafoni, or honeycomb weathering, so common on the coast is also known to occur in desert regions.



ROB FREEMAN / COURTESY ELTHAM WIREGLASS GALLERY

This exquisite pencil drawing by Freeman will hopefully benefit both artist and subject.

FARRIGHT PHOTOGRAPHY

Australian Crawl?

Q. I have been told that kangaroos and Koalas can actually swim quite long distances. Is this true?

—G. Wilson
Audley, NSW

Questions for this column may be sent to Jennifer Saunders, Australian Natural History, P.O. Box A285, Sydney South NSW 2000.

A. Like most mammals, kangaroos and Koalas can swim if forced to—although whether they do so by choice is debatable. Sightings of kangaroos swimming are far more common than sightings of Koalas, although the latter would appear to be better suited to this form of locomotion. Taking to the water, for most mammals, is usually a means of escape from predators or harassment by dogs. The distances covered while taking a dip vary but there are confirmed reports of wallabies being seen a kilometre or so off shore.

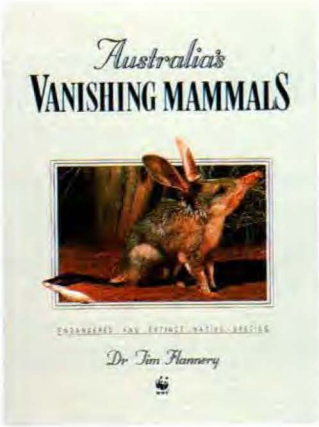
—Linda Gibson
Australian Museum

Answers to Quiz in Quips, Quotes & Curios (page 13)

1. A bird
2. 1859
3. Agoraphobia
4. Adrienne Clarke
5. Tethys
6. Five
7. Whale Shark
8. Australia
9. Seismic activity or earthquakes
10. Uluru National Park

REVIEWS

COMPILED BY
JENNIFER SAUNDERS



***Australia's Vanishing Mammals**
By Tim Flannery. Reader's Digest Press, Australia, 1990, 192pp. $50.00.

Like most recent works that have dealt with the status of Australian mammals, I expected *Australia's vanishing mammals* to be a depressing account of species destruction and impoverishment. The facts are bleak. Twenty species of mammals have become extinct since the arrival of Europeans to this continent and perhaps twice that number is currently at risk from disturbance in the future. Yet, this gloomy situation is alleviated somewhat in *Australia's vanishing mammals* by the colourful, glossy format; the skilful weaving of historical fact and anecdote; and by the conviction of the author that our recognition of the extinction problem is itself a sign of hope.

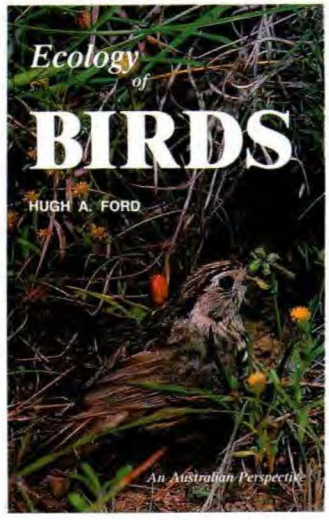
The first third of the book provides summaries of the biology of ten species of extinct mammals. Basic notes on the size, appearance, collecting localities, habitats and behaviour are given when known, and the most likely causes of extinction are discussed. Because 'extinction' is defined as no sightings for more than 50 years, first-hand accounts by early naturalists, such as John Gould and Gerard Krefft, are often all we have to go by. In addition to bringing valuable insights to the biology of vanished mammals, we learn that Krefft's appetite for his specimens "more than once over-ruled [his] love for science", and that T.T. Flynn, an early but lonely champion for the Thylacine, was father of the swashbuckling Errol.

Reproductions of Gould's prints are provided for most of the extinct mammals, as well as watercolour paintings by Karen Wynn-Moylan. I found the paintings mostly well executed, although the Eastern Hare-wallaby *(Lagorchestes leporides)* seems a little too gaunt, and the open plains setting shown for the Crescent Nailtail Wallaby *(Onychogalea lunata)* does not square with the apparent preference of this species for woodland and scrub. Although the dates and collecting localities of all extinct mammals are discussed, distribution maps would have helped to emphasise the vast geographical areas over which some species have disappeared.

The last two-thirds of the book describe the appearance and biology of 20 species of mammals whose prognosis is vulnerable, endangered or critical. The format of this section follows the species-by-species accounting of the first, but presents the most recent (and often unpublished) information available on the biology of each species, along with excellent colour photographs. The accounts are very readable, spiced once again by historical recollections and personal acquaintance with the animals or their habitats. Distribution maps are shown for extant but threatened species. However, these would have been more informative if they had contrasted the former known range with the current range to illustrate the magnitude of decline in many species.

There are a few small errors, such as incorrect distribution maps for the Dibbler *(Parantechinus apicalis)* and Greater Bilby *(Macrotis lagotis)*, and some likely excesses, such as a suggestion that we may one day clone a Thylacine from preserved specimens. The ordering of species accounts is somewhat idiosyncratic, with marsupials, rodents and bats jumbled together in no apparent order. For five species, there is also a discrepancy between their designation of 'critical' status in the main text and 'endangered' in an appended list of threatened species. But these are quibbles. The book is intended to increase public awareness for the beleaguered state of our mammalian fauna and to highlight the need for proper conservation. This it does, and admirably too. In pointing out that some species have been rediscovered after being declared extinct, often as a result of information volunteered by the public, the book also affirms that we all have something to offer. At $50.00, *Australia's vanishing mammals* is a good buy, and I would recommend it for specialists and non-specialists alike.

—Chris Dickman
Sydney University



***Ecology of Birds: An Australian Perspective**
By Hugh A. Ford. Surrey Beatty & Sons, Sydney, 1989, 287pp. $36.90.

The standard texts on general ornithology have been written by Northern Hemisphere authors and the bias towards North American and European studies is evident. Australia, with its unique assemblage of unusual birds, does not receive the depth of coverage it deserves or that Australian readers require. *Ecology of birds: an Australian perspective* is not a substitute for these more general texts and it does not attempt to cover those topics that are common for birds of all countries. Its emphasis is on the Australian avifauna and its interactions with the environment and between species.

Opening chapters like "The Australian Environment" and "The Origin of Birds" set the background for what is to come. "Food and Foraging Behaviour" emphasises some of Australia's outstanding research on the feeding habits of select species of birds. "Community Ecology" looks at the different interacting members of an avian community, showing clearly and succinctly the ways in which seemingly similar species partition the resources to avoid excessive competition. Several chapters are also devoted to breeding biology, as the diverse array of approaches to breeding found among Australian birds is one of the avifauna's most fascinating features.

Recognition of the extinction problem is a sign of hope.

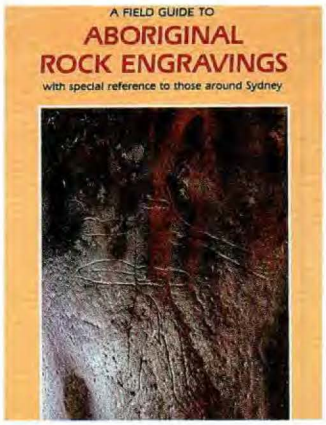
The chapter on migration presents an overview of our current understanding of these annual movements that include simple shifts in altitude from season to season, to massive intercontinental journeys. Equally important in the Australian context is nomadism, the unpredictable and irregular movements that characterise some arid-zone species.

Two important chapters of particular interest are "The Ecology of Rare, Endangered and Extinct Birds", and "Habitat Destruction and Modification in Australia". Anyone wishing to become acquainted with the causes detrimentally affecting bird populations, particularly those of human origin, will find an excellent introduction here.

Ecology of birds: an Australian perspective will remain a valuable reference for many

years. It is attractively produced and I recommend it wholeheartedly for institutions and personal collections alike.

—Walter Boles
Australian Museum



***A Field Guide to Aboriginal Rock Engravings with Specia Reference to Those Around Sydney**
By Peter Stanbury and John Clegg, Sydney University Press, NSW, 1990, 163pp. $19.95.

One of the most pervasive forms of human expression is rock art. Rock paintings and engravings can be found on every continent that humans have inhabited, and their production has occurred over many thousands of years. The earliest forms are thought to be at least 25,000 years of age, while the most recent in North America and Australia date to this century. Australia, in particular, has one of the richest rock art traditions in the world with large concentrations of sites in the Pilbara, Kakadu and Sydney regions. The Sydney area is especially well known for its engraved sites and at last a comprehensive, portable guide to their locations has been produced.

The authors of this pocket field guide have produced a well-illustrated, well-organised and readable handbook that really is portable and practical. Furthermore, they have incorporated many poems inspired by the sites and this helps establish, in the mind of the reader, the charged atmosphere associated with these powerful spots in the landscape.

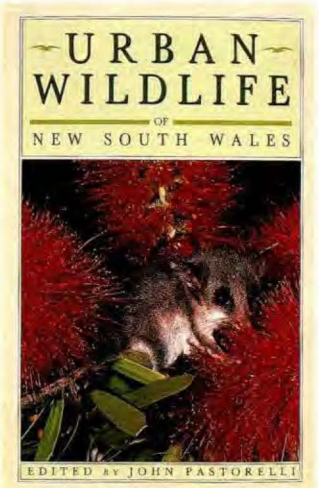
The field guide is divided into three main sections and appendixes. Chapter one provides basic information about Aboriginal rock engravings, such as how and why they are made, where they may be found and the best way to view them. Chapter two lists 23 selected sites, including some of the most outstanding and accessible. Each site is described in terms of location, number of engravings, size and quality. Published references are also listed, along with brief detailed descriptions and comparisons of various interpretations. Chapter three goes into detail about engraved sites in general and discusses them in relation to Aboriginal religion, conservation and management, and the ways in which Europeans attempt to gain meaning from the sites through scientific study. It is informative and straightforward but suffers from being somewhat out of date.

The appendixes attempt to place the Sydney engraved sites into a larger regional context but in many ways they confuse the reader. Appendix C, for instance, is supposed to be a list of selected rock engraving sites throughout Australia but most of those listed are actually rock painting sites and the list should more probably be described as selected rock art sites, which includes both. Furthermore, the division of rock art forms into panaramittee, simple figurative and complex figurative is not only outmoded and problematic but also confusing as the same terms may be used to describe totally different styles, unrelated temporally or culturally. Most contemporary rock art researchers avoid these terms where possible and their brief description on pages 9–10 of chapter one does not really inform the reader about the current debate on this matter.

This book is particularly valuable as a site guide but perhaps the authors should have left it at that. Some of the interpretation sites, for example, are contentious (see Figure 30) and much more recent research has not been included. The most glaring omission is the extensive work of Josephine McDonald, from the Australian National University. She has recorded over 1,500 sites on a systematic basis over the past few years and offers the most balanced and current interpretations on the subject. It is true that this book is not intended as an academic reference and originally was to be published over a decade ago, but it would have benefited from a more recent revision.

Despite the guide's shortcomings, I would recommend it as a site handbook. It should raise the general public's level of awareness and hopefully instill in visitors the need to protect them. Rock art of any form is a most important cultural resource as it represents a fragmentary record of past peoples thoughts, beliefs and experiences. By preserving it for the future we are able to pass on a legacy that is a testament to human creativity and awareness.

—Paul Tacon
Australian Museum



***A Review of the Urban Wildlife of New South Wales**
By John Pastorelli. Angus & Robertson, NSW, 1990, 166pp. $14.95.

This attractive little book began as a bicentennial project. Hundreds of volunteers were provided with a guide book to urban wildlife and data sheets, and sent out into the wilds of Sydney and Wollongong to observe and record. They were guided by several well-known naturalists, who provide notes on the group's findings, and the results were tied together by John Pastorelli. The observations lasted from September 1977 to February 1988, and a large number of them were made at night. In addition, more formal nature walks through urban bushland were arranged for groups.

It was a good idea, and doubtless drew many people into a new pursuit, but if the aim was to base the whole book on the results of the survey, it didn't quite work. Frank Haddon, for example, lamented that only four kinds of freshwater fishes were seen in the survey (he doesn't say which, except for *Gambusia*) and consequently had to flesh out his fish with species that can be found in New South Wales waterways. Hence the inclusion of the Murray Cod.

Apparently observers noted grey kangaroos at large in urban New South Wales.

Densey Clyne obviously faced the problem that every entomologist or arachnologist knows–identifying an insect or spider from a lay person's description–and had to include 'long-horned' and 'short-horned' grasshoppers.

The observers did best with mammals, birds, frogs, reptiles, butterflies, beetles and spiders, but ignored bushflies, bull ants and cockroaches. There were, apparently, grey kangaroos at large in urban New South Wales (George Street?), but no Galahs or House Sparrows.

This book tells as much about the interests of the public as about the biology of New South Wales, but it is still well worth reading. There are excellent photographs and drawings, a useful guide to urban bushland areas and advice on countrifying your bit of urban New South Wales.

—Arthur Woods
University of NSW

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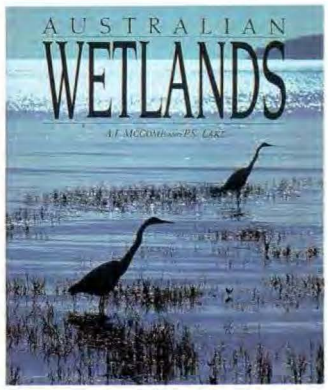


***Australian Wetlands**
By Arthur McComb and Sam Lake, Angus & Robertson, NSW, 1990, 258pp. $49.95.

All life needs water. Perhaps more than any other biological resource, water must be looked after and managed carefully. Sadly, when it comes to the management of this resource, Australia has its fair share of skeletons in the closet. By world standards, Australia is not well off for water, being the second driest continent to Antarctica. Although the semi-arid and arid inland is the main reason for this, we still need to be concerned about our water and it is refreshing to see a book about water conservation. The basis for such a treatise is the land on which water sits or flows–the wetland.

I liked this book. It is the second book to originate from a workshop on wetland conservation held in Sydney by the World Wide Fund for Nature.

Australia is the second driest continent to Antarctica.

Australian wetlands achieves what both books promised–an interesting, readable overview of wetlands and their conservation in Australia.

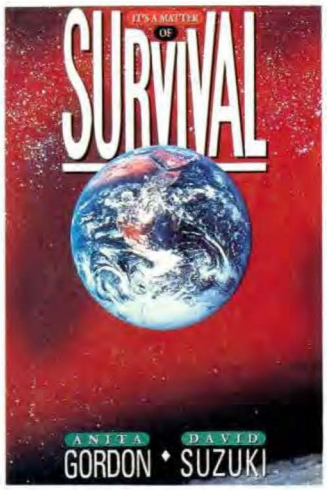
The book begins with wetlands of the high country and ends with the sea. Chapters on heritage and the future round the book off nicely, and the style of writing is refreshingly direct.

Excellent colour photographs convey some of the atmosphere of wetlands and their inhabitants, and occasional black-and-white photographs, which recall past events, are particularly interesting. A photograph of "the strikingly coloured Corroboree Frog" to match the paragraph devoted to its conservation would have been preferable to the one of Verreaux's Alpine Tree Frog.

Only two criticisms can be made of this book. As a scientist, I found the absence of comprehensive referencing frustrating. Sometimes I would have liked to find out more about a subject but there were no leads. A book with this much information would have benefited from the added investment of more references to original scientific work.

I was also a little disappointed that the book dived into the sea at the end. Marine conservation is really a separate province covered in more depth by books devoted to this ecosystem. Such criticisms are minor. This book is well worth reading and, something that cannot be said of many such books, it can be easily read. I recommend this book highly.

—Richard Kingsford
NSW National Parks
& Wildlife Service



***It's a Matter of Survival**
By Anita Gordon and David Suzuki. Allen & Unwin, Sydney, 1990, 278pp. $16.95.

This book arose from the 1989 CBC radio series of the same name. Dealing with environmental issues, the broadcast spanned five hours and incorporated over 100 interviews with scientists, politicians and other experts. It elicited written responses from more than 13,000 listeners, most asking "What can I do?" The stated aim of this book is to address that question. The first author, Anita Gordon, is the originator, executive producer and co-writer (with David Suzuki) of the radio series. David Suzuki is Professor of Genetics at the University of British Columbia and a well-known author, lecturer and broadcaster with a focus on environmental concerns.

The book is organised into three parts; Toward The Year 2040 (apocalyptic scenarios for 2040 by various people), Sacred Truths (environmentally damaging socioeconomic paradigms that go unquestioned) and Toward The Year 2040 (ways of ameliorating damaging impacts, both technological and behavioural). Most of the 278 pages are devoted to attacking six 'sacred' truths, namely 'nature is infinite', 'go forth and multiply', '...and dominate the Earth', 'that's the price of progress', 'growth is progress', and 'there at our disposal'. This is an accessible way of exposing the cultural, behavioural and value-based underpinnings of our burgeoning environmental problems.

Such scenarios shock people into realising that fundamental changes are needed.

In my view, the 'sacred' truths are well chosen and represent fairly the dominant Western values that are relevant. Numerous statistics detailing our environmental ills are given and placed in the 'sacred' context. The news is worse than bad (but not hopeless) and gives rise to the alarming title. Not surprisingly, the authors assert that fundamental changes in these 'sacred' areas are necessary for sustaining human economies and diverse, healthy ecosystems.

Of course, a central problem when interpreting complex issues still undergoing scientific debate is that the authors have to make contentious judgements on the severity of problems. There is no simple, precise way of answering the question 'How bad (or good) are things?' Further, the tactic of presenting scenarios for 50 years hence may cause readers to misinterpret them as confident predictions. Rather, the real value of such scenarios is to shock people into the realisation that advance planning and immediate, fundamental changes are needed to evade dire consequences.

With the Suzuki message being unacceptable and threatening to many, attempts to discredit him and the environmental movement at large are gathering force. Some of Suzuki's previous work has drawn criticism on the grounds of "exaggeration, distortion and intimidation" and "ignoring compelling evidence" and failing to provide "practical solutions" (see for example articles in *Quadrant* June 1990). This book will no doubt attract similar criticism but responsible critics will focus on the crucial issues including sustainability, carrying capacity, long-term management and global management.

The growth and market-orientated economists and analysts who are Suzuki's main detractors would do better by proposing their own solutions. After all, they do admit that problems exist. If economic growth is part of their solution, they need to demonstrate how it can be sustained on a finite planet.

Gordon and Suzuki reserve a good deal of criticism for those who advocate growth in human population size and the economy. They ask what sort of a world it would be with twice the present population, when humans already appropriate about 40 per cent of all the products of photosynthesis. What would be left for other species and how would our life support systems react? The issue of growth and international equity is also addressed. The authors quote statistics showing that the recent decades of high economic growth have benefited the Third World little in terms of income. Moreover,

their environmental assets are being sacrificed in order to service their massive debt.

While the authors do not develop detailed alternative socioeconomic models, they do suggest energy solutions. In particular, energy efficiency promises the quickest reduction in carbon dioxide emissions (three billion tonnes a year according to Worldwatch). Various actions are recommended and optimistic local examples are given (Osage, Iowa has made consumption cuts approaching 50 per cent). The development of renewable energy technologies is also favoured with Worldwatch claiming that a solar-run planet could be in place in only 40 years from now. The authors are optimistic about our capacity for rapid democratic change and quote recent dramatic political transformations as examples.

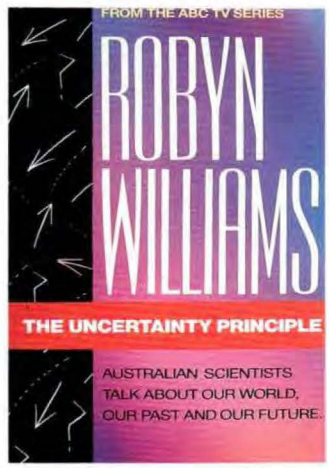
The final chapter, "A Sense of Place", amounts to a lament for lost attachment to nature and an appeal to rediscover true values and priorities. It is only six pages long, scarcely thorough, and seems like an afterthought.

Above all, this book is deliberately opinionated, drawing as it does on numerous interviews. The authors use a catchy, dramatic style designed to sway public opinion. However, key claims are usually buttressed with research-based statistics and the main theses are well supported. The extravagant Suzuki literary style, the attacks on growth, and his effective duality as scientist and advocate will no doubt provide a great stimulus to examine some comfortable, cherished and ultimately disastrous beliefs.

—Alan Jones
Australian Museum

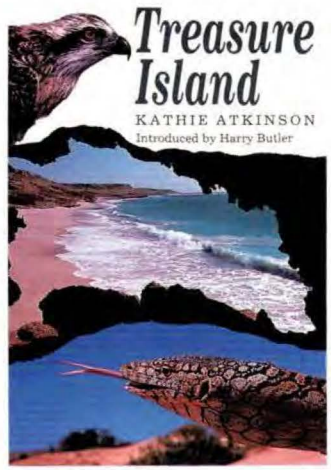
Wildflower Country
Department of Conservation and Land Management, Western Australia, 1991, 104pp. $19.95.

A beautiful guide to exploring the mid-west of Western Australia. The region is divided into five major sections: the northern wheatbelt, northern sandplains, Batavia Coast, Murchison Goldfields and the desert coast. Each section provides comprehensive information about the area, along with detailed maps for travellers. A handy wildflower calendar is included as well as a list of national park recreation areas. The magnificent colour photography of the native flora and fauna from that region will inspire anyone wondering where to travel for their next holidays.



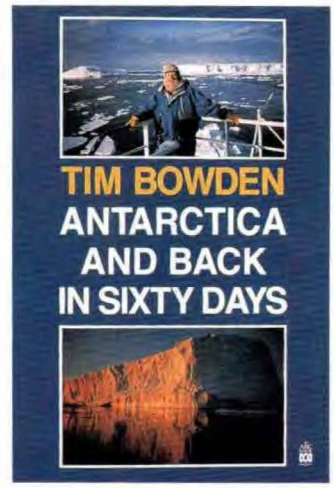
***The Uncertainty Principle**
By Robyn Williams. ABC Books, Sydney, 1991, 307pp. $16.95.

A new and enlarged edition, including seven new chapters, detailing Robyn Williams' fascinating interviews with prominent members of the scientific community. This book provides an insight into their visions for the future and their thoughts on the fundamental problems we face today.



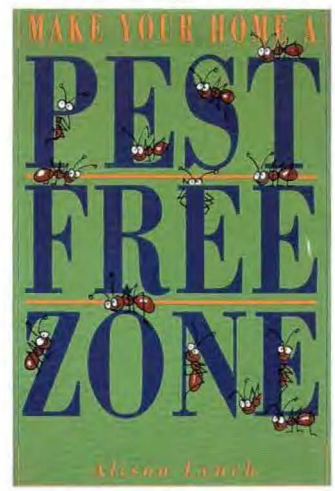
Treasure Island
By Kathie Atkinson. Allen & Unwin, Sydney, 1991, 32pp. $14.95.

A well-written book for young children that explores Barrow Island, off the Western Australian coast. The wonderful photography by Kathie and the easy-to-read text make this book a good way for children to learn about science and nature.



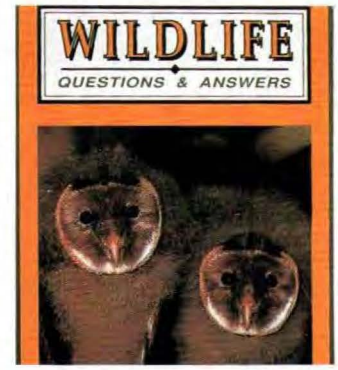
***Antarctica and Back in Sixty Days**
By Tim Bowden. ABC Books, Sydney, 1991, 239pp. $19.95.

Tim Bowden's wicked sense of humour and effortless way with words combine to describe his adventures in Antarctica aboard the *Icebird*. Black-and-white photographs aid in the telling of his tale.



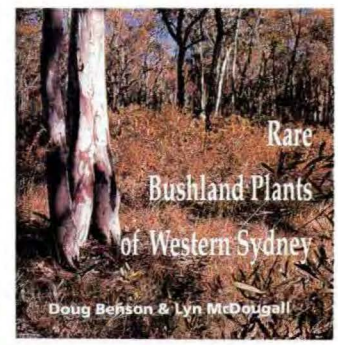
Make Your Home a Pest Free Zone
By Alison Lynch. New South Wales University Press, Sydney, 1991, 115pp. $10.95.

The author identifies all the major pests found in and around the home, along with both the chemical and non-chemical methods of removing them. The black-and-white pictures aid in identifying both the pest and the tell-tale signs they leave.



***Wildlife Questions & Answers**
Ed. by Erna Walraven. Allen & Unwin, Sydney, 1991, 132pp. $14.95.

Each year Sydney's Taronga Zoo receives thousands of queries about wildlife from concerned and curious Australians. This book deals with the most commonly asked questions, providing answers written by zoo experts. A good information source for anyone interested in our native fauna.



***Rare Bushland Plants of Western Sydney**
By Doug Benson and Lyn McDougall. Royal Botanic Gardens, Sydney, 1991, 60pp. $6.95.

This book attempts to improve on the poor recognition so far given to the unique vegetation of western Sydney. The area studied covers the Cumberland Plain from Parramatta westward to the Hawkesbury River, and from Windsor south to Campbelltown. Brief notes on regionally significant species are provided, along with black-and-white line drawings. The final third of the book is dedicated to a table of native plant species recorded in western Sydney. Notes on species that are presently vulnerable to extinction are included as well as the identification of areas that should be protected to guard against further species loss.

—J.S.

There is no sound environmental reason to remove huskies from Antarctica.

THE MAWSON HUSKIES THE CASE FOR RETENTION

BY PATRICK MOONIE

MYKE GERRISH/SYDNEY FREELANCE AGENCY

IN OCTOBER 1991 THE 26 CONSULTATIVE nations of the Antarctic Treaty signed a Protocol for the Protection of the Antarctic environment. Swept up within this Protocol was a clause for the removal of the husky dogs from Antarctica by 1 April 1994. The decision to remove the huskies was based on the concern that they might introduce disease and that they might break free and attack penguin colonies. With respect to the huskies at Mawson—the sole Australian station retaining huskies—there is no evidence to support either of the above concerns.

The Mawson huskies have been isolated in the pristine Antarctic working environment for 41 years and, with no record of acquiring, carrying or transmitting disease, it is ludicrous to suggest that they could start now. Similarly, there is no evidence that they have been a threat to wildlife and, with more stringent controls recently introduced, the incidence of threat is even more remote. For example, the huskies are not only secured to their lines when not working, but protective measures have been put in place to ensure that the inquisitive Adelie Penguins do not wander into the dog lines. Further, the taking of seals for dog food was abandoned in 1984 and all sustenance is now imported from Australia.

The stated reasons for the removal of the huskies from Antarctica are totally devoid of substance. So why the push for their exodus? In 1988 zealous elements of the environmental movement attempted to force the removal of the Mawson huskies with spurious claims similar to the above. A nationwide campaign for retention resulted in an investigation by the then Minister, Senator Graham Richardson, who issued a statement that the huskies were not a threat to the environment and that there were no plans for their removal. The Antarctic Division director, Rex Moncur, also stated that they were far better for the environment than any mechanical vehicle.

The Protocol signed in 1991 was a joint initiative by France and Australia to ban all mining in Antarctica and the issue of the huskies became caught up as a minor element. It is known that the Australian Government pushed very strongly for the Protocol, but it is also known that the same zealots who attempted to remove the huskies in 1988 were present with the Australian delegation at Vina del Mar (Chile) in 1990 and Madrid (Spain) in 1991 when the Protocol was hammered out. As there is no sound environmental reason to remove the huskies from Mawson, I can only conclude that the agreement to do so is a craven placatory gesture to a vociferous but ill-informed lobby group.

Huskies' unique polar instincts for survival were directly responsible for saving my own life.

The present and past Antarctic community, represented by the ANARE Club, supports the preservation of the Antarctic and any environmental agreements necessary to achieve that aim. However, what I find repugnant about the present situation is the sheer hypocrisy of Australia getting into bed with France when the French are exploding nuclear devices in the Pacific and actually bulldozing penguin colonies at their Antarctic station at Dumont Durville to build an airfield! If we were to follow the aims of the Protocol, it is the French who should be removed from Antarctica, not the huskies.

I am told that the Minister, Ros Kelly, has received more mail on the husky issue than any other matter, but she has resolutely remained mute to any entreaties and has refused to respond to, let alone acknowledge, correspondence, phone calls or our requests to meet a delegation to discuss the issue. We would like to see an Environmental Impact Assessment on the activities of the Mawson huskies. On the basis of their 41 years of Antarctic service we are confident that huskies would be shown to be entirely complimentary to the stringent environmental protection measures in the Antarctic, and no threat to the flora and fauna. Furthermore, we wish to present to the Minister some very sound reasons why the huskies should be retained at Mawson.

As a unique means of polar transport, commencing with Sir Douglas Mawson's 1911–1914 Australian Antarctic Expedition, the huskies have contributed immensely to the exploration and scientific expeditions upon which much of our territorial claim to Antarctica is based. For sea ice travel they have been the primary means of transport and an important supplementary means of transport east to the Amery Ice Shelf, west to Enderby Land and south to the vast Prince Charles Mountains. More than anything else, they are the focus of the intrinsic ethos of our polar endeavours and their removal would be short sighted and an act of gross historical vandalism.

The psychological factors of the huskies at Mawson are of great importance. They are the only objects upon which the personnel at this isolated outpost can lavish their affection and, as a result, they contribute much to the well-being and morale of the expeditioners.

More importantly, huskies are unquestionably the safest means of transport over the unpredictable and sometimes treacherous sea ice and heavily crevassed glaciers. During our Antarctic operations a large number of vehicles of all types have fallen through the sea ice and now reside in Davy Jones' Locker. Other Antarctic nations have lost not only vehicles but men's lives also. To this day, we have not lost a dog team or attendant sledges. On the personal level, their unique polar instincts for survival were directly responsible for saving my own life. As we still have a requirement for travel over the sea ice for biological and glaciological programs, the huskies must be retained because of their pre-eminent safety record. What is the price of a human life? Must we put ourselves in the position of having the coroner ask that question when the causes of death are being determined?■

Patrick Moonie was a member of five expeditions to Antarctica and is currently the Director of Contracts at Parliament House, Canberra. He is engaged in the campaign to retain the Mawson huskies in Antarctica.

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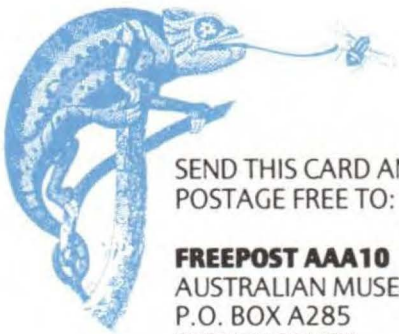

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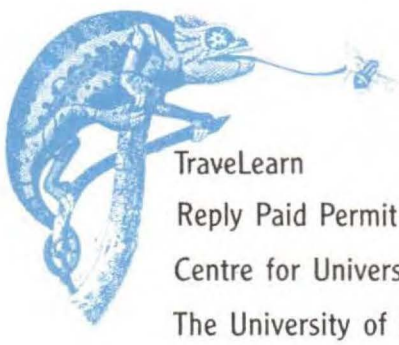

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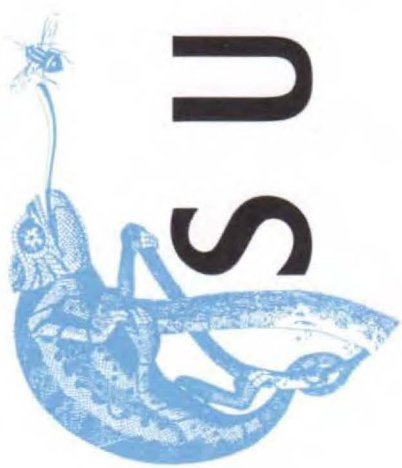

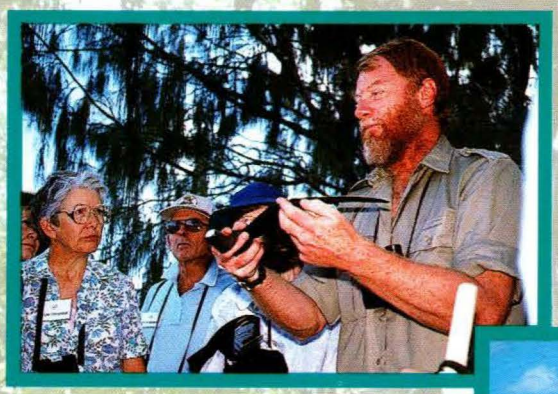

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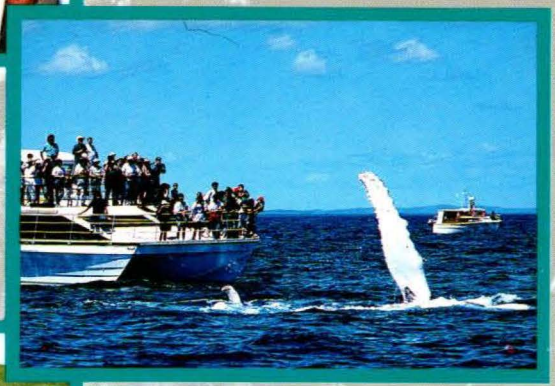

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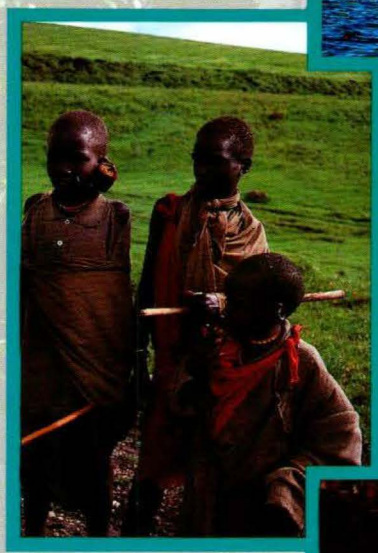

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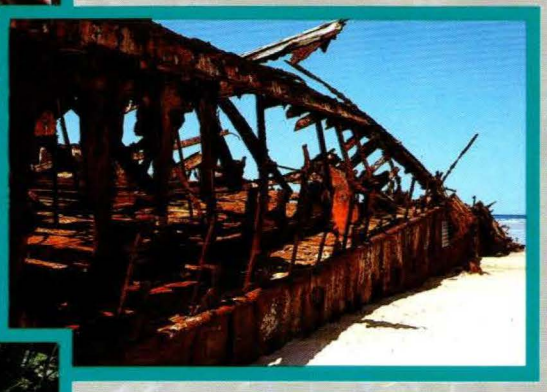

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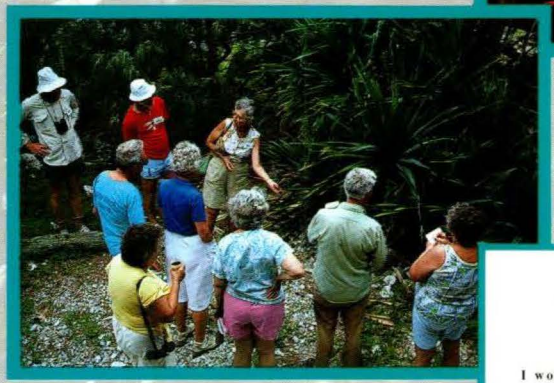

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