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Australian Natural History

SUMMER 1989–90 VOLUME 23 NUMBER 3

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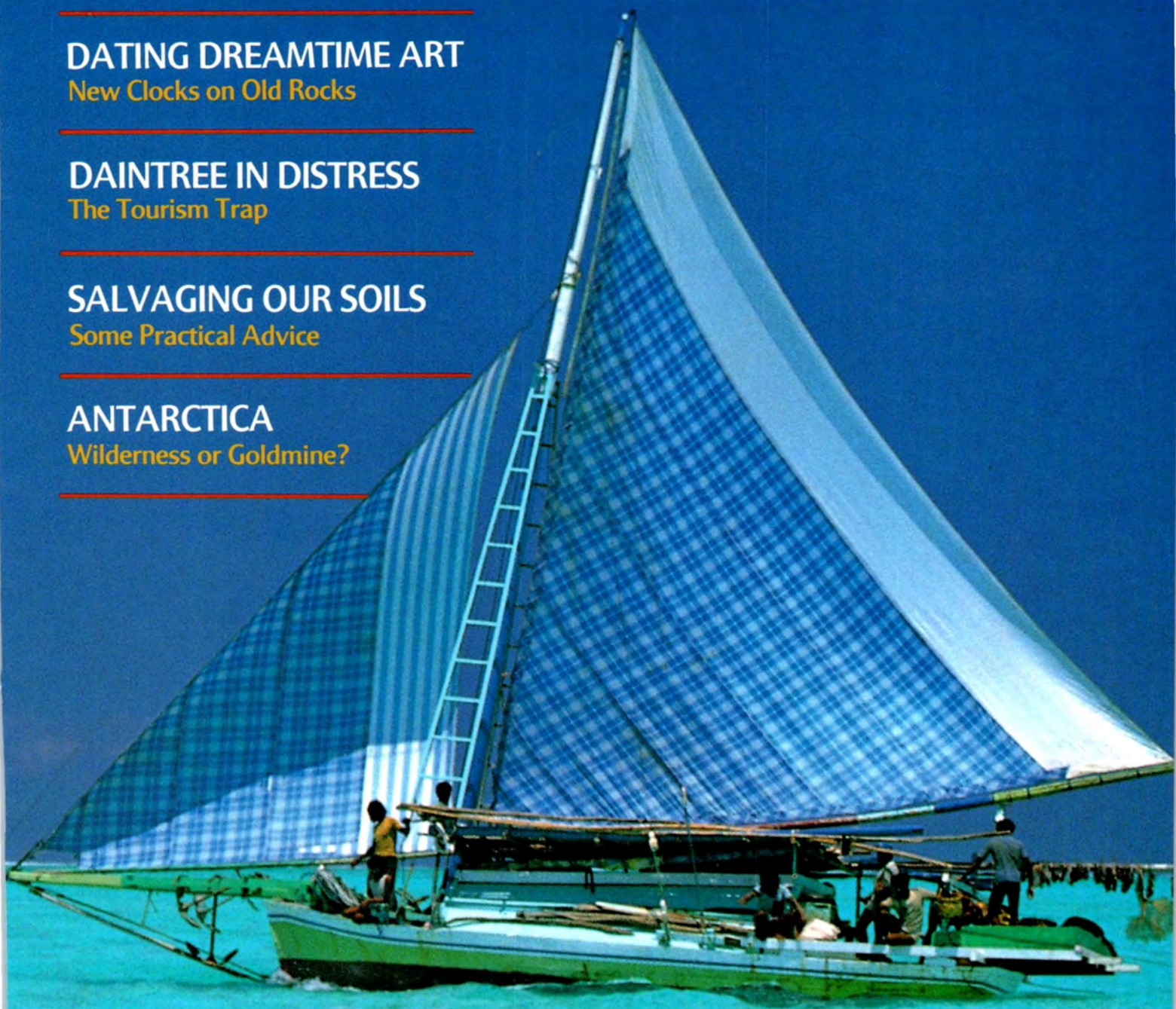

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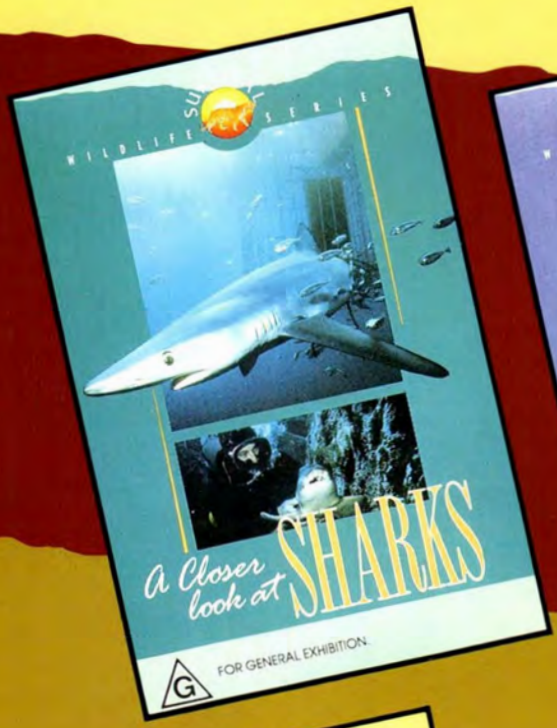

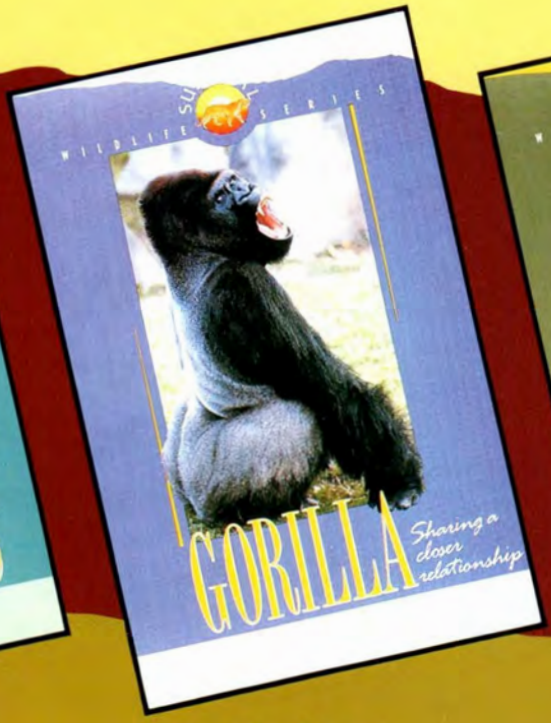

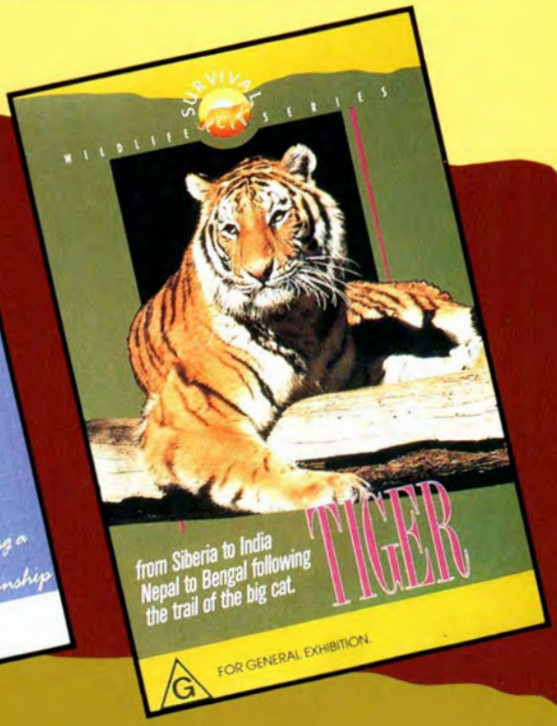

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Front Cover
An Indonesian perahu glides over the turquoise waters at Ashmore Reef, off Australia's north-west coast. Does the practice of traditional fishing harm the reef? See the article on page 210. Photo by B.C. Russell.

WANTED: EXTINCT OR ALIVE?

BY FIONA DOIG
EDITOR

EXTINCTION IS A NATURAL PART OF life. Like death, it is inevitable but its effect on the ecosystem is permanent. It is like turning off a genetic tap. Extinction of one species creates a new niche into which another can evolve. Unfortunately, one singularly successful species, *Homo sapiens*, has been responsible for so many recent extinctions that gaping holes have been created. And many living species are extremely endangered. One would think that, given the current level of concern and support for the environment, work to improve the survival chances for those on the brink is urgent.

Apparently this isn't the case. There are people dedicated to pouring endless money, energy and time into the hope of finding living relics of extinct species. For example, $250,000 was spent on one expedition alone in 1984 in search of the Thylacine, which has been extinct on the mainland for 2,000 years and no confirmed sightings in Tasmania since 1936. Between then and now, many other Australian animals have headed towards extinction, yet remained largely ignored.

Why put so much into rediscovering one species when the same input could have saved so many others? Perhaps there is a greater challenge in the 'impossible'—certainly anyone who had bona fide evidence of a live Thylacine would reap fame and fortune. Or maybe it is through the guilt our ancestors brought to bear on us by eliminating so many species that we feel obliged to rediscover them. Extinction is the end. Final. No curtain calls. Yet we wait with baited breath hoping to lure a species back from its fate. If science hasn't found a way of waking the dead, what hope is there of exhuming the extinct?

At the heart of species salvation is the necessity to maintain biological diversity, in which case each species maintains equal billing, extinct or living. The argument here is not to ignore the extinct, but to look at yield for effort. The money put into the Thylacine searches could have, in the long run, saved many more living species.

The same argument applies to cryptozoology, a branch of research dedicated to finding mythical beasts of rumoured existence, like yetis, yowies, Loch Ness monsters and abominable snowmen. Interesting stuff and maybe they do exist. But again, with many *known* species on the brink of extinction it seems like so much hypocrisy.

Of course there *are* dedicated people intent on creating a better future for these animals. The strength and courage this takes is to be applauded. But somewhere along the way we have lost sight of the play and are concentrating on the star players. Millions of dollars have been poured into Koala research, yet piddling amounts have been relegated to other, more threatened marsupials. What about extremely rare animals like the Bilby, Tuatara, Norfolk Island Owl and Hastings Mouse? Does a tiny rat-like marsupial stand a chance—or will it only be elevated to hero worship once extinct? Are koalas more important than rats? Whales more than fish? Not to say that the species getting money and public attention don't deserve it—I'm questioning priorities. Because if our intention is to salvage the environment so that it can stabilise, then surely our priorities should come from that stand and be set by need, not public interest or commercial value.

Just ask yourself these questions: in the queue for salvation, what takes priority? Do our endangered species have to become extinct before they rate a mention?

Thylacine: let 'dead dogs' lie.

IN THIS ISSUE

GEORGINA HICKEY
SCIENTIFIC EDITOR

ANTHONY FARR

The ANH team with the latest Whitley Award, from left to right: Georgina Hickey, Fiona Doig and Cathy McGahey.

FOR THE THIRD CONSECUTIVE YEAR, ANH has received the NSW Zoological Society's Whitley Award for Best Natural History Periodical (1989). We hope that the great array of articles in this and future issues will help get us a fourth!

Last April, Bert Jenkins came bounding into the ANH office, having just returned from an expedition to the Daintree region. He believes that tourism is one of the most pressing problems for the area. Thousands flock there each year, but often return without getting a good look at the rainforest. And those that do invariably leave some direct or indirect mark on the region. Together with colleagues from the University of New England, they address this problem and launch their concept of 'eco-tourism'.

Another problem, still up north but much further west, concerns the traditional Indonesian practice of fishing in Australian waters. A survey was conducted in the area of Ashmore Reef to study the effects of the fishery. Lyle Vail and Barry Russell from the NT Museum of Arts and Science report.

And soils. The fact that our precious soil is being blown or eroded away is well known. Less well known is how to reverse, or at least halt, the destruction process. Maura Boland, from the SCS, explains how to 'make up for lost ground'.

Also in this issue are articles on the latest methods of dating Aboriginal rock art, the reasons behind the relatively recent extinctions of medium-sized Australian mammals, and rainforest snails. Robyn Williams discusses the trap that historians of science often fall into; Ian Lock the rich story behind a pink bivalve in the Museum's malacology collection; and Mike Archer the view of rainforests as biological warehouses. The complimentary poster in this issue is an 18th-century coloured engraving of an Eastern Blue-tongue Lizard by John White.

Articles

LETTERS

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

Competition: Hard or Soft?

Michael Archer's "Slime Monsters will be Human Too" (ANH, Autumn '89) invites protest on two accounts. Twice Michael has reached conclusions that don't necessarily follow from his evidence—only, presumably, from his own private assumptions.

One: Kamala's behaviour doesn't reveal a subterranean bestiality lurking in us all. Every detail of her complex 'bestiality' was faithfully learnt in the only school she knew—a wolf's pack and family den. From Hitler, and Kamala, to Mother Theresa the evidence supports only the conclusion that early childhood experience has an indelible educational affect on the individual's entire subsequent sociality, nothing about innate bestiality. Among other forms of severe childhood brutality, Hitler was a daily abused child in an era that condoned and widely practised it. In short, foster wolf mothers, neglect and abuse don't allow the 'bestiality lurking in us all' to surface, they only teach their unspeakably tragic victims that wolfism, neglect and abuse are the 'norm'. This is why abused children all too often become abusing parents. They know no way of raising children other than that 'modelled' for them during their own infancy.

Two: there is now absolutely no excuse whatsoever for Michael's attempt to reintroduce Social Darwinism. After a long, reactionary and professionally naive 'for-the-good-of-the-species' era, current Neo-Darwinian biology correctly resurrects a recognition that ruthless competitiveness *is* central to the evolutionary process and to life as we know it. Without competition we'd still be strands of replicating molecules presumably floating in an endless organic soup.

But competition is *not* synonymous with brutality. Accepting Michael Archer's "Slime Monsters will be Human Too" would unconditionally plunge us back into turn-of-the-century Social Darwinism, of which the aforementioned Hitler's brutal Reichs were simply the most logical and consistent expression.

Very early in the history of the biosphere life discovered that 'united we stand divided we fall'. The living phenomenon is so replete with caring, sharing and cooperation, as well as commensalism, mutualism and symbiosis, that it is simply unforgivable for someone in Michael's position to ignore it. Modern biology doesn't. That's what sociobiology is all about. It is about giving a Darwinian (that is competitive) accounting for the apparent paradox of otherwise wholly competitive organisms faithfully helping and caring for one another in each of a thousand million ways, on every level of complexity.

Just because this widespread 'altruism' is always 'selfish', that is, to each participant's mutual benefit, or, more often, simply unadulterated nepotism, it shouldn't blind us to its very real and extensive existence. If 'unselfishly' caring for and risking one's life for one's offspring hadn't been an evolutionarily successful invention, we would all still be squirting our gametes into ocean currents on the happenstance that somewhere, somehow my ova would collide with your sperm and that the resultant embryo would somehow manage to survive on its own!

In short, while caring and sharing do exist only as devices to promote evolutionary success, they are as successful and as entrenched in the living phenomenon as are blood-stained teeth and claws, and are often many times more effective than sheer 'I-win-you-lose' brutality.

Indeed it is now widely considered that every single cell above the bacterial level, including all those making up our own bodies, consists of a most perfect symbiosis between elements that belong to different kingdoms no less. All animals live either directly or indirectly on plants, that is they spend their entire lives devouring, eating and destroying them and are thereby often the mortal enemies of plants. And yet the mitochondria and probably several other cellular elements are symbiotic 'plants' in an 'animal' membrane indispensably helping the 'animal' cell to survive. This relationship is thought to have evolved when the mitochondria learned to survive inside an animal cell after it had been eaten by it!

Every multicelluar organism is a colony of sometimes trillions of individuals, all of which, save the small fraction in the germ plasm, have sacrificed themselves in a most spectacular orgy of communistic 'from each according to his ability, to each according to his need'-unselfish-type cooperation ever imagined. And it works.

One could fill books citing examples of winning through cooperation instead of bashing each other over the head, and in this age where a recognition of the mutual interdependence of us all is universally proclaimed and demonstrated beyond any reasonable doubt, "Slime Monsters will be Human Too" is an unforgivable anachronism. Let's send Michael some Neo-Nazi magazines to give him some idea of where his unmodified dog-eat-dog brutality would logically lead.

The uniqueness of the human adaptation is that we have elevated *non-violent* competition to levels unprecedented in even the other social species. A vast number of other species also compete non-violently. This is how all of the most spectacularly accoutred males developed their finery, by evolving the most attractive set to please the ladies. Human males compete for mates and a place in the social hierarchy by excelling in any one of a thousand non-violently different ways—in art, science, politics, sports, technology, religion, literature, drama, law etc. Just watch your TV set for half an hour. Even when competition becomes one of physical confrontation, under normal (pre-modern) conditions bloodshed was minimal as the

Is it true that humans will be slime monsters too?

fight or war was over the moment the first drop was drawn or the first couple of scalps taken. Get with it Michael!

We love the new magazine and wish you all the best.

—Margaret Austin
Springwood, Qld

Drongo

I refer to page 541 of the Autumn '89 issue of ANH (vol. 22, no. 12) regarding QQC's What's in a Name?: Drongo. When I was a wartime Rookie in the RAAF it was well known that a Drongo was a mythical bird with most peculiar flying abilities. It, also, was brainless.

However, the main purpose in writing this letter regards the scientific name of the Spangled Drongo (*Dicrurus hottentottus*). In Neville Cayley's book *What Bird is That?* (1984 edition, revised by A.H. Chisholm, K.A. Hindwood and A.R. McGill), the scientific name of Spangled Drongo is given as *Dicrurus bracteatus*, with a distribution in north-western Australia to northern Queensland and south to eastern Victoria; accidental to Tasmania; and also occurring in New Guinea.

—F.L. Cunningham
Lindfield East, NSW

The Spangled Drongo was originally described by John Gould, who gave it the name Dicrurus bracteatus. *Later studies after Cayley's book indicated that this species is the same as one found throughout Indonesia and the two should be treated under one name, in this instance,* D. hottentottus *having priority. This is the current state of the name, although even more recent work now suggests that the two forms overlap on the island of Sulawesi and behave as separate species. It appears that the original Gould name will have to be reinstated for the Australian species. This makes sense from the plumage, the*

Original line drawing of the Indonesian form of the Spangled Drongo by Charlies Vaurie, 1949.

Indonesian bird having much more elaborate ornamentation of the head.

—Walter Boles
Australian Museum

Australian Native Plants

The Campus Conference Centre of the University of New England will be hosting a major Conference on the Australian flora to be held from 15–18 February 1990. The Conference, entitled "Australian Native Plants in the 21st Century", will bring together leading professionals from a wide spectrum of government and environmental organisations to predict what the future holds for our native forests and flora. As the 21st century is only 11 years away, trends emerging now are being assessed for their future impact on Australian society. With adequate forward planning, it is hoped that Australians will be prepared to meet major changes with confidence.

—Maria Hitchcock
Consultant (067) 751139

Waves on the Wireless

I listened to the ANH interview on 2BL radio on Sunday 4 June 1989. I have been subscribing to the magazine for the last four years, but if I hadn't I certainly would subscribe after hearing about all those wonderful articles you publish. The magazine gets bigger (!) and better with with every issue. Congratulations to the editors of ANH!

—Elinor Hain
Forestville, NSW

Response to Roxburgh

I am 80 years of age and, when I was 20, bought a two-thirds-acre block way out in the sticks, clear felled it (including a dirty big gum tree) and erected my house. But that gumtree was a sucker for punishment, for 20 years later, during the Depression, two suckers had become trunks equally as huge as the original gum. So I felled them for firewood.

When I was 60, I thought to myself "I had better behead that tree at ground level, otherwise I will spend the rest of my life raking up its bark and leaves" but, as I look out my window, I see five trunks equally as big as that original gum. So Rachel, it is not that the Forestry Commission does not have the expertise to predict what will happen to your 300,000 hectares at Eden—the suckers (in 80 years time) will become their headache (see ANH vol. 22, no. 12, page 532).

Further, let me quote an article I read a few years ago on the overseas use of Australian eucalypts. It is a comment written by railroad author Daniel Behrman and published by Little, Brown & Co. of Boston and Toronto in 1977, regarding Dr Clinton C. Kemp—a chemical engineer interested in using energy derived from the sun:

"He came across the Paulista Railroad in Brazil that had been built in 1903 to serve Sao Paulo and its hinterland. The railroad ran for 200 miles, and six plantations were set up to supply wood along the way to fire its steam locomotives. Dr Kemp thinks this was the first time such a crop was actually planted for energy. In 1900 the railroad sought a suitable tree for its plantations. It had to be straight and without branches so it could be cut into five foot lengths that a fireman could handle. Eucalypts were the species chosen. Five trees can be sprouted from the same stump after the original has been felled. The wood is so dense that it floats with only the top of the log breaking the surface of the water, and it grows quickly in the Brazilian climate. The line's 200 mile lies approximately north and south equally either side of the Tropic of Capricorn and operated on its self-renewing fuel supply until 1958 when the antiquated steam locomotives were replaced by diesels."

Need I add more regarding the self-regenerating properties of eucalypts?

—G.C. Hore
Frankston, Vic.

I noticed in the Autumn '89 issue of ANH (vol. 22, no. 12) a letter by Rachel Roxburgh and a photograph of logging in New Zealand demonstrating the devastation caused by woodchip exploitation. I then noticed that this magazine was printed in Japan by Dai Nippon Printing Co. The magazine and the Museum should put its money where its mouth is and not deal with people who exploit our forests and destroy wildlife.

—W. Ringland
Banglow, NSW

Question: what does Harris Daishowa do with our woodchips? Answer: they are in *Australian Natural History.*

What ANH needed, quite simply, was more good articles—not more gloss, a passing coffee-table appearance, or an increased rhapsody on sex in any shape, form or creature, including ourselves.

My enjoyment from the magazine depended on a feeling that it could be referred to for *facts*—nor for evidence of the worship of science and recommendation of it (The Last Word, ANH, vol. 22, no. 12).

On an economic point, may I suggest an export market in Japan? Just a translation and we could be off! Our balance of trade needs a jog, now that we've abandoned the printing. They [the Japanese], at least, presumably consider this plastic-paged arrangement an appropriate surface on which to present serious, important information. As for the change, I'm sure that newstand buyers will be happy and like it; but then don't they only read 'current', throw-out periodicals?

Hoping for the best that can be hoped for, and anticipating a return to Australian printership and your former distinctively Australian layout.

—David Lynch
Longueville, NSW

QUIPS, QUOTES & CURIOS

COMPILED BY GEORGINA HICKEY
SCIENTIFIC EDITOR

Blushing Flowers

The role of flower colour is to advertise their presence to potential pollinators. Pollinators, in their bid to extract the nectar from flowers, transfer pollen from one flower to the next, enabling pollination and fertilisation to take place. However, problems arise with plants that have numerous flowers—some of which are pollinated, and others that are still to be pollinated. Those that have already been pollinated continue to attract the pollinators (be they insects, birds or whatever). Apart from being a waste of energy for these visitors (there being no nectar to retrieve), they would be more likely to move to another more predictable source of food, thus leaving some of the flowers on the plant unpollinated.

Many species appear to have overcome this problem by evolving a strategy whereby, after pollination has been achieved, the flowers become unattractive to pollinators. The Dune Evening Primrose (*Oenothera drummondii*) is one such plant that may use this strategy. It is a perennial dwarf bush with large, attractive, yellow flowers that open before sunset. Once pollinated (and also after natural senescence) the flowers begin to shrivel and 'blush', through a series of successive 'less yellow' colours, to an orange-red. Hawkmoths and honeybees—the species' main pollinators—are attracted only to the yellow, open flowers and ignore the dark, shrivelling ones. It was this observation that prompted two botanists from Tel Aviv University in Israel to research the matter more closely (*Bot. J. Linn. Soc.* 95: 101–111; 1987). In an attempt to pinpoint just what it was that triggered the petals to change colour and shape, Dr D. Eisikowitch and Z. Lazar simulated insect activity at the flowers and monitored any subsequent change. Activities included touching the petals, stigmata and anthers, removal of pollen, pollination (self- and cross-), nectar withdrawal and simply leaving the flowers alone (the controls).

Flowers were confirmed to change colour and shrivel after pollination, and simulated insect landing and touching of various flower parts without pollination had no effect. Surprisingly, however, removal of nectar without pollination did result in the petals changing colour, and removal of nectar followed by its immediate return had the effect of cancelling the signal for colour change. Before this study, removal of nectar had not been thought of as a significant factor in the signalling process but, if one considers its close interconnection with pollination, perhaps it is not so surprising. All the control flowers eventually 'blushed' and shrivelled, as would be expected with normal senescence in this species.

Whether the change in colour and state *per se* is adaptive, or whether it is just an incidental part of 'adaptively' triggered senescence, is not known. Either way it is clear that both the pollinator and plant benefit. The pollinator's efficiency is improved by not wasting energy probing for rewardless flowers, and other unpollinated flowers on the plant have a greater chance of being visited and thus pollinated.

—G.H.

Petals of the Dune Evening Primrose 'blush' and change shape after pollination.

KATHRYN FOLEY

UV or not UV? The Answer's in the Coral

What do the dashboard of your car, the skin on your back, and the corals of the Great Barrier Reef have in common? They are all exposed to the damaging ultraviolet (UV) radiation in sunlight. Your dashboard may fade and crack and your back may develop skin cancers, but the reef-building corals seem to suffer few ill-effects from prolonged exposure to UV light.

A common belief is that solar UV radiation is stopped within the first few centimetres of the ocean surface, thus explaining the coral's escape from harm. A recent report, however, notes that in clear tropical waters solar UV light has a significant biological effect to a depth of 20 metres (*Aust. Sci. Tech. Newsl.* 1(6): 1; 1989).

Drs Walter Dunlap, Bruce Chalker and Wickramasinghe Bandaranayake, of the Australian Institute of Marine Science, have now shown that corals in shallow waters protect themselves from synthesising UV-absorbing amino acids. They have isolated three of these compounds from the Staghorn Coral (*Acropora formosa*) and shown that, in combination, the three compounds provide a broad-band filter against UV radiation at wavelengths capable of damaging or even killing the corals.

As it happens, those wavelengths fall within the range considered responsible for sunburn and skin cancer in people. Other researchers at the University of Sydney have shown that you don't have to suffer sunburn to get skin cancer, adding to the concern that sunscreen creams may not be providing enough protection against skin cancer. A joint development between AIMS and ICI Australia Ltd has shown that the coral compounds hold out hope for more effective sunscreens to be developed—ones that will stop sunburn as well as warding off skin cancer. The unlocking of the coral's secret may also pave the way for better protection against the damaging effects of UV light on synthetic materials such as plastics, paints, varnishes and, yes, car dashboards.

—B.B.

M. CUTHILL

Staghorn Corals are protected against UV radiation by a broad-band filter. Analysis of the compounds involved may shed light on more effective sunscreens for humans.

Record Dives for Elephant Seals

A respectable amount is known about what Southern Elephant Seals (*Mirounga leonina*) do on land, when these blubbery giants come ashore to moult and breed near southern waters. But their activities at sea, where they spend the majority of their time, have been a virtual mystery until recently. The emergence of reliable instruments for recording the behaviour of diving vertebrates, however, is changing all that.

A spectacular example of the technology's potential has been demonstrated by Mark Hindell, a Queensland University zoologist, and David Slip and Harry Burton, both biologists with the Australian Government's Antarctic Division (*ANARE News* March 1989: 8).

At sub-Antarctic Macquarie Island in early 1988, they attached time-depth recorders (TDRs) to six adult males (weighing in at about three tonnes each) and to 13 adult females (about 400 kilograms each). The seals were near the end of their annual moult.

Eight months later, when the seals returned to Macquarie Island to breed, the scientists were able to recover nine TDRs, six of which had functioned perfectly. The instruments can record depth every 30 seconds and water temperature every five minutes, for up to 70 days. They recorded as many as 4,130 dives for each animal, providing major new insights into the seals' behaviour and feeding habits at sea.

The seals spent 90 per cent of their time under water, making them the most 'aquatic' of all the seals. On average, their dives lasted 30 minutes, although some went as long as two hours. Up to 40 per cent of dives were deeper than 500 metres, although they showed a marked preference to dive shallower at night. But the record went to one animal that achieved a 1,198-metre dive, deeper than had been reliably recorded for any other diving vertebrate.

Astonishingly, the seals spent an average of just two minutes on the surface between dives, even after very long periods of what would have been anaerobic diving. That discovery suggests they have developed unusual physiological ways of coping with oxygen-debt problems.

They may also be dependent on deep-water food resources not available to any other vertebrate predators or human fishing activities. Knowing more about those resources may be a key to understanding why Southern Elephant Seal populations have declined by about 50 per cent in the last 30 years.

—B.B.

JOHNATHON CHESTER/WILDLIGHT

Southern Elephant Seals currently hold the record for the deepest dives. Deeper dives have only been *estimated* for the other species, but never accurately recorded.

Bob Beale, Sydney Morning Herald's science writer, is a regular contributor to QQC.

Control of the Curse

The European weed *Echium plantagineum* became established in Australia in the 1850s, both by accidental and deliberate introduction. Although a priority for biological control since 1971, several hitches had first to be overcome.

The common names of the plant—Paterson's Curse and Salvation Jane—reflect its inherent controversy as a weed. Most people consider it a weed because it is poisonous and, at certain stages of its development, kills grazing animals; it reduces the value of pasture by crowding out more beneficial species, invades natural areas and interferes with native vegetation, and causes allergic reactions in some people. On the other hand, some beekeepers and a minority of others consider it to be beneficial because it flowers very early in the spring, produces a high-quality pollen that increases the quality of the hive, is used to produce honey and summer grazing fodder in some areas (despite being poisonous), and contributes to the beauty of the rural landscape.

The CSIRO investigated the natural enemies of *Echium* in Mediterranean Europe. Four of the first eight insect species found to be safe for introduction were imported in 1979–80. Releases of the leaf-mining moth *Dialectica scalariella* began in mid-1980 in New South Wales, but drought and grasshoppers prevented establishment. Then, in July 1980, two beekeepers and two graziers obtained an injunction from the High Court that prevented further releases of the insects. Thus began the most intense conflict in the history of biological control.

Repeated unsuccessful attempts were made to resolve the conflict, and CSIRO was forced to accept a perpetual injunction in June 1983. This meant that no further work on biological control of *Echium* could be undertaken in Australia until such time as the injunction was lifted.

Meanwhile, the world's first biological control legislation was passed in 1984 and, under the legislation, the Industries Assistance Commission (IAC) conducted an inquiry into whether *Echium* should be a target of biological control. There were over 600 submissions, most supporting biological control, and public hearings were held to get additional input. The inquiry lasted 11 months.

The IAC Final Report (March 1986) recommended *Echium* be declared a target for biological control, the eight insect species as agents, and the program to be managed by government agencies and supported by public funding. The IAC concluded that the program would have total potential benefits of $30 million per annum. (As this figure was based on the easily identified components, it is certainly an underestimate.) All States and territories then passed complementary legislation and made similar declarations.

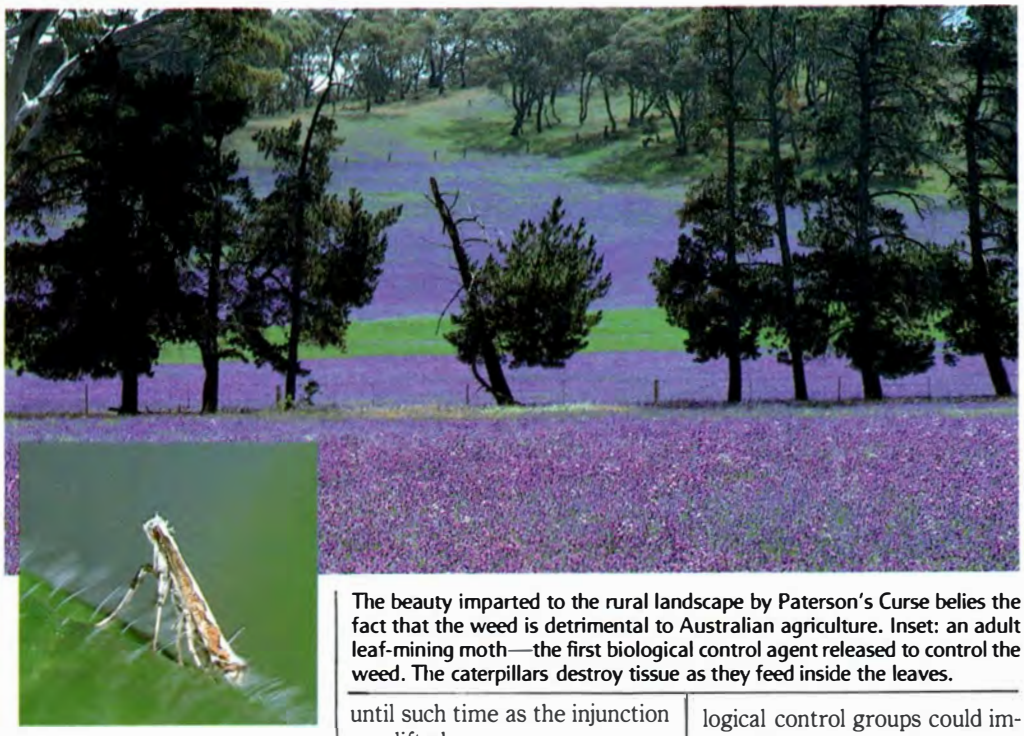
In late 1986 CSIRO was at last able to apply for lifting of the perpetual injunction, which had halted the program for over six years at a cost of some $180 million to the country. However, legal debate continued for another two years, during which the legislation—challenged by the beekeeper and grazier plaintiffs—was declared valid. (The validation of the legislation meant that other approved biological control groups could import *Echium* biological control agents, although the CSIRO was still blocked. The Keith Turnbull Research Institute, Victoria, imported and released the leaf-mining moth in mid-1988, and made colonies available to New South Wales, South Australia and Western Australia for their own release programs.)

Finally in October 1988 the Court decided unanimously in CSIRO's favour and awarded all costs against the original four plaintiffs. Thus, after more than eight years of legal consideration, biological control of *Echium* was approved. The injunction was formally lifted in November 1988 and CSIRO immediately began importing the leaf-mining moth and one of the root weevils (*C. larvatus*).

Who pays for biological control of *Echium*? The IAC identified the livestock industry as the greatest potential beneficiary of successful biological control of *Echium*. Thus, after application by CSIRO to the Australian Meat and Livestock Research and Development Corporation and to the Australian Wool Corporation, funding for the program was approved.

Biological control is the only long-term economically and ecologically satisfactory strategy for management of *Echium*. The plant is an annual, reproducing only by seed, and seed banks exceed 100,000 per square metre! Seeds can also live in the soil for many years. It will therefore take several years for the agents to build up to levels at which they reduce or stop seed production over a widespread area but, because agents attack the critical life stages of *Echium*, the program should be successful. In addition, and importantly, there is now a fair mechanism to resolve conflicts in biological control.

—E.S. Delfosse
CSIRO Division of Entomology



ERNEST DELFOSSE WA PHOTO INDEX

The beauty imparted to the rural landscape by Paterson's Curse belies the fact that the weed is detrimental to Australian agriculture. Inset: an adult leaf-mining moth—the first biological control agent released to control the weed. The caterpillars destroy tissue as they feed inside the leaves.

INSECT SPECIES APPROVED FOR BIOLOGICAL CONTROL OF PATERSON'S CURSE

Species	Common Name	Plant Part(s) Attacked
Dialectica scalariella	leaf-mining moth	leaf and stem epidermis (caterpillar)
Longitarsus aeneus and *L. echii*	flea beetles	leaf (adult) and root (larva)
Phytoecia coerulescens	stem-boring beetle	leaf (adult) and stem (larva)
Dictyla echii and *D. nassata*	cell-sucking bugs	rosette and stem (adult and nymph)
Ceutorhynchus geographicus and *C. larvatus*	root weevils	leaf (adult) and root (larva)

Monotremes Still have Some Shocks in Store

When European zoologists first set eyes on the Platypus, they couldn't believe what they saw. With an odd combination of traits not normally associated with mammals, including egg-laying, a single reproductive and excretory passage, and venomous spurs, the monotremes (Platypus and echidnas) were certainly thought to be a strange bunch. And even today they are still springing surprises on us.

Now, in the 1980s, has come the discovery that the monotremes share with some fishes the ability to detect electrical currents through special nerve receptors. Two West German anatomists, Karl Andres and Monika von Düring, described the electro-receptors they found on the bill of the Platypus in 1984, and speculated that the animal might use them to detect water flows (see ANH vol. 21, no. 11, p. 485). A team led by Uwe Proske of Monash University, in Melbourne, later determined that the Platypus could sense both steady and alternating voltages in their environment (fish respond to one or the other), such as those generated by the activity of shrimp and other prey.

More recently, Proske's team has found similar receptors at the tip (only) of the snout of the Short-beaked Echidna (*Tachyglossus aculeatus*). Proske suspects that the echidna's favourite food (ants and termites) may give off weak electrical signals but as yet this has not been proved. He believes that such a sophisticated sensing system would be unlikely to exist simply as an evolutionary hangover. One clue towards its use as an electrical detector may come from the fact that echidnas continually have runny noses. Proske believes the nasal secretions may provide an electrically conductive medium that can carry tiny currents.

An article detailing these recent discoveries will be included in the next issue of ANH.

—B.B.

COURTESY UWE PROSKE

Dr Uwe Proske holds an electrosensitive echidna.

To Cast a Stone

Stone-throwing behaviour of Egyptian Vultures to break into Ostrich eggs is well known. Once an egg is spotted, the vulture will fly down to it, pick up a stone in its beak, straddle the egg, cast the stone repeatedly until the shell cracks, and then eat the contents.

Ostriches (*Struthio camelus*) and Egyptian Vultures (*Neophron percnopterus*) are both widespread in East Africa. Although other opportunistic scavenging birds also live in the area, stone-throwing behaviour appears to be unique to these vultures.

Interest in stone-throwing by the Egyptian Vulture stems from the fact that any form of tool use in non-human animals is relatively uncommon, and it represents one of the very few examples of tool use observed in wild birds (see article on Palm Cockatoos, ANH vol. 22, no. 5, 1987). In addition, there remains some debate about the origin of stone-throwing behaviour in birds. It had previously been presumed that the behaviour of stone-throwing to break open Ostrich eggs was culturally transmitted; that is, by young birds observing and imitating experienced adults. This was largely based on the observation of a captive-reared bird that, when presented with an Ostrich egg, sat on it, rather than throwing stones at it. Little evidence exists to support this view and other explanations are possible. Individual Egyptian Vultures could, either by trial and error or perhaps through some degree of insight into the relationship of moving stones, cracked shells and food, learn to do it independently. Alternatively, the behaviour may be innate with vultures being selected according to their ability to throw stones at and eat the contents of Ostrich eggs.

In order to address the controversy surrounding the origin of this stone-throwing behaviour, C.R. Thouless, from the Large Animal Research Group in Cambridge, and colleagues carried out experiments on wild and hand-reared Egyptian Vultures in Kenya (*Ibis* 131: 9–15; 1989). By offering varying numbers, shapes, sizes and combinations of fibreglass eggs and stones, the authors were able to observe preferences of both stones and eggs, and stone-throwing abilities. Indeed they found no evidence to support the idea that the birds learn to break eggs with stones by copying other individuals. Observations on hand-reared vultures showed that young birds can develop the technique in isolation. Although stone-throwing behaviour can develop without cultural transmission, it does apear to require triggering at some stage in the bird's life. The trigger appears to be the realisation that an Ostrich egg equals food. The hand-reared birds, although interested in the eggs (as they were with other novel objects) showed no interest in stoning them. It was only after being shown the 'contents' of an Ostrich egg that they started stoning whole eggs. In the wild, opportunities that reveal the link between Ostrich eggs and food would be numerous. The young, which remain with their parents after fledging, may observe their parents breaking into eggs or they may observe eggs already broken into by other scavengers, such as hyenas.

A large variation in the stone-throwing abilities of wild birds was observed. This, the authors suggest, may reflect a critical stage in the young bird's life, during which they may or may not have experienced the Ostrich egg–food association. If a bird was born in a year when Ostrich eggs were few, for example, that bird may never learn the association. And even though vultures appear to have a natural propensity for throwing objects, young deprived of knowing the egg–food association would also fail to associate stone-throwing behaviour as a means to obtain food.

But how would stone-throwing behaviour to break into Ostrich eggs have evolved from an ancestor that had no tendency to throw stones? In 1970 J. Alcock from the University of Washington suggested that the throwing of small eggs (for the purpose of breaking them) may have been redirected when an Egyptian Vulture came across an Ostrich egg (*Ibis* 112: 524). Finding the egg too big to pick up, the bird may have reverted to other objects such as stones to break the egg. If aimed stone-throwing did evolve from unaimed egg-throwing behaviour, one would expect an inherent preference for egg-shaped missiles. Indeed, in Thouless *et al.*'s experiments they found that rounded stones (as opposed to jagged ones) *were* preferred by both wild and naive hand-reared birds (even in their earliest throwing attempts); and wild birds, when presented with small eggs, threw them proficiently.

—G.H.

Vultures often cast stones at Ostrich eggs to break them open.

BARON HUGO VAN LAWICK © NATIONAL GEOGRAPHIC SOCIETY

Spiders that Smell

When answering public inquiries one is sometimes forced to open jars containing very dead spiders. The smell that emanates is quite incredible (although not, perhaps, in the same league as the odours that occasionally emerge from the Bird Room down the corridor). Of course, one expects dead things to smell off, so it comes as rather a surprise to find a spider that smells as bad alive as dead.

Two such spiders from northern Queensland were collected recently by wildlife film producers Densey Clyne and Jim Frazier. I identified the spiders as *Phrynarachne decipiens* (Forbes), a crab spider of the family Thomisidae that also occurs in the tropical areas to the north of Australia. Most *Phrynarachne* species have squat, dull-coloured bodies. They sit motionless on leaves and look like pieces of detritus or bird droppings. *Phrynarachne decipiens*, however, is the nonpareil of the bird dung mimicking fraternity. Not only is the spider coloured creamy white and dark brown–black but it sits upon a pad of silk onto which it places its own runny faeces. The spider forms the solid, lumpy cream and brown flecked centre of the 'dropping', while the rather messy faecal silk pad provides the watery, greyish cream outer parts. Seen in a natural setting upon the broad leaf of a rainforest plant the spider's bird dropping disguise is very convincing. Indeed, H.O. Forbes, the original collector and describer of *P. decipiens* (in the 1880s from Sumatra), was so deceived that he accidentally placed a finger on a 'bird dropping' and only realised it was a spider when "it. . .flashed its falces into my flesh" (*Proc. Zool. Soc. Lond.* 1883: 586–588). Forbes described the dung-mimicking habit of the spider (with some arresting inaccuracies) but made no reference to faeces being associated with the silk pad or to any smell.

Resemblance to a bird dropping, although seemingly unflattering, does have its advantages. It provides such spider mimics with the valuable benefit of not being eaten, especially by birds—a nice irony. Consider then what additional advantages might accrue if one not only looked like a 'turd' but smelt

DENSEY CLYNE/MANTIS WILDLIFE

Phrynarachne decipiens **not only looks like a turd but smells like one too.**

like one too.

The odour given off by *P. decipiens* is difficult to describe other than as fetid and faecal. Observation and inference suggest that the spider uses its scent to attract certain sorts of insect prey that are attracted to decaying matter. One *P. decipiens* specimen in northern Queensland was observed eating a cockroach; and others kept on shrubs in a greenhouse were seen to capture blowflies. In this regard Forbes' original observations in West Java are particularly interesting because he noticed that one spider had captured a dung-feeding butterfly. These butterflies probably use a chemical sense of 'smell' to locate faecal matter in the dim rainforests, and clearly *P. decipiens* takes full advantage of this.

It seems, then, that this remarkable spider has evolved both a protective and a prey-catching strategy based upon dung mimicry. A number of other spiders also mimic dung but, to my knowledge, *P. decipiens* is the only species that has taken the further adaptive step of developing a fetid prey-attracting odour to go with its dung-like appearance.

The only other spiders known to emit prey-attracting odours are a few araneid spiders (relatives of the orb web weavers) that specialise in catching male moths (see ANH vol. 23, no.2). In these cases the spider's scent lure mimics that of certain female moths and can only be 'smelt' by the appropriate male moths.

Just where the fetid smell of *P. decipiens* comes from is uncertain. The faeces-impregnated silk pad remains smelly long after the spider has been removed and, once off its pad, the spider no longer seems to smell. This suggests that the spider's silk or faeces may contain the smelly substance. Equally, the spider may simply turn off its body scent production mechanism when it is disturbed. Whatever the answer, this spider's down-market combination of looks and perfume has provided it with a unique and successful lifestyle.

—Mike Gray
Australian Museum

P.A. COCHRANE

If global warming occurs, Snow Gums, which typically occur at the top of the tree-line, could increase their altitude considerably.

Growing Gums in the Greenhouse

As a group, the eucalypts have shown themselves to be plants that are able to survive and prosper in an amazingly diverse range of habitats, from the cool, wet coastal rainforests to the parched heat of central Australia.

One of the most adaptable individual species is the Snow Gum (*Eucalyptus pauciflora*). It has the largest altitudinal range (from near sea-level to the top of the tree-line in the Australian Alps) and one of the largest latitudinal ranges (from Queensland to Tasmania) of any eucalypt.

Ecological studies by a team at the Research School of Biological Sciences at the Australian National University have shown recently that the Snow Gum has the potential to extend its altitude range even further. The team has shown that, in the right conditions, Snow Gums can germinate from seed and grow to reproductive maturity up to 200 metres above the present tree-line in the Snowy Mountains.

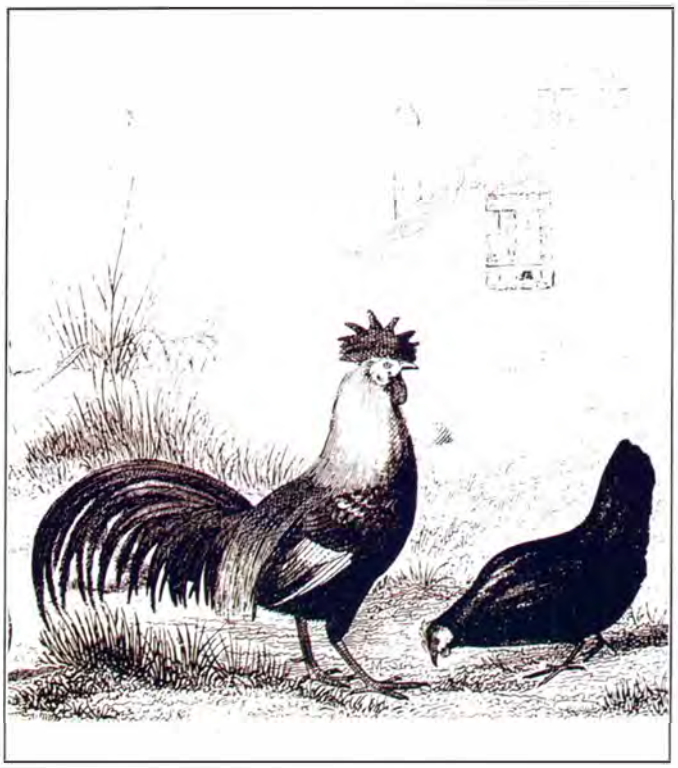
If global warming occurs, as predicted by the greenhouse effect theory, Snow Gums could advance considerably in altitude. That would probably happen only slowly, however, notes Jann Williams (*Ascent* 17: 24–25; 1989), a member of the team. Viable seeds would have to find their way upslope.

At the lower end of the Snow Gum's present range in the highlands, Williams has shown that transplanted seedlings will grow quite successfully downslope from their current limits. If they can grow at lower altitudes, why don't they? The answer lies not in climate, but in competition from other eucalypts.

In the case of the sub-alpine forest of the Brindabella Range near Canberra, Snow Gums are typically replaced downslope by Broad-leaved Peppermint Gums (*Eucalyptus dives*) at about 1,240 metres above sea level. Peppermint Gums seem unable to advance higher due to environmental factors. But, if global warming occurs, the climatic barrier that now inhibits the Peppermint Gum's advance into Snow Gum territory may be lifted, allowing it to climb higher upslope as well.

If nothing else, the studies illustrate the complexities of trying to predict how flora and fauna in any given area would be affected by climatic change.

—**B.B.**



When and where were chickens first domesticated?

Chicken Vindaloo or Sweet and Sour?

Most archaeologists have, until recently, agreed that people first domesticated chickens in the Indus Valley (Pakistan) about 4,000 years ago, and that they spread through Mesopotamia and Greece, and, with the help of the Celts, throughout Europe. But new evidence suggests that people have been breeding better drumsticks for much longer than that, and that chickens reached Europe by quite a different route.

Barbara West, of the British Museum (Natural History), and Ben-Xiong Zhou, of the Institute of Archaeology in Beijing, suggest that chickens were first domesticated 4,000 years earlier in South-East Asia (*J. Archaeol. Sci.* 15: 515–533; 1988).

Radiocarbon dating estimates show the oldest chicken bones to have come from Cishan, in north-eastern China. The bones were longer than those of the ancestral Red Jungle Fowl (domestic form *Gallus gallus*) and smaller than modern chickens, and they were too far north for any naturally occurring species of wild jungle fowl. West and Zhou believe it would have been unlikely for the birds to arrive in what were then freezing conditions (as now) without human help.

Both believe the domestic chicken originated further south than China, but they differ on how it reached Europe from there. Zhou favours the old Silk Route through Turkistan, while West favours a more northerly route through the steppes of the Soviet Union.

—**B.B.**

First Lord Howe, then the World

Ten years ago there were just 22 Lord Howe Island Woodhens (*Tricholimnas sylvestris*) left on Earth. Only three healthy breeding pairs survived and the Woodhen seemed destined for oblivion. Thanks, however, to an amazingly successful captive breeding and wild release program (not to mention $300,000 worth of funding from the National Parks and Wildlife Foundation), it appears that there are now more than 220 Woodhens alive and clucking.

Apart from the extermination of feral pigs and goats from Lord Howe Island, the underlying reason for the Lord Howe Island Woodhen's ten-fold increase in a decade has, undoubtedly, been the changed attitude of the 300 Lord Howe Island residents.

From the earliest days of human visitation to Lord Howe, the Woodhen was primarily looked upon as an easily attainable source of food. One of the first sightings of the Lord Howe Island Woodhen occurred on 16 May 1788 when the *Lady Penrhyn* stopped at the island. At the time, ship's surgeon Arthur Bowes wrote in his journal about "...a curious brown Bird abt. the size of the Land Reel in England walking totally fearless and unconcern'd in all part around us, so that we had nothing more to do than stand still a minute or two and knock down as many as we pleas'd with a short stick...they never made the least attempt to fly away".

Lord Howe Island was a convenient resting-place for ships sailing between Sydney and the penal colony on Norfolk Island. It was eventually settled in 1834 because it afforded water and a plentiful supply of food (Woodhen being very much part of the menu).

Unfortunately, the settlers got carried away with the bush-tucker, to such an extent, in fact, that to date no less than nine species of endemic land birds on Lord Howe have become extinct. Many, such as the White Gallinule (*Notornis alba*) and the Lord Howe Pigeon (*Columba vitiensis godmanae*), were literally eaten out of existence. Others, such as the Lord Howe Parrakeet (*Cyanoramphus novaezelandiae subflavescens*), were exterminated because they fancied the settlers' orchards and crops.

The Woodhen would have disappeared in a flurry of feathers, too, but for a creeping awareness of the Woodhen's plight in the late 1960s when the first Woodhen survey by John Disney of the Australian Museum and Peter Fullagar of the CSIRO showed that the bird was on the downhill slide to extinction. Responding to the growing concerns of the outside world, the Lord Howe residents finally began to develop a new protective feeling towards the Woodhen.

As each year passed that feeling intensified—so much so that visitors to Lord Howe today are struck by the extraordinary degree to which a rather drab-looking, olive-brown rail has taken on what one tourist suggested was "virtually the status of a fertility God". The locals let Woodhens scurry around their yards, feed them cheese and biscuits, give them nicknames and call up the authorities if any of them go missing.

According to Cameron Leary, National Parks and Wildlife Service Ranger on Lord Howe, the residents have grown so fond of the Woodhen that they would be "running and knocking down doors if something was happening to the Woodhen".

From being down and almost out, the Lord Howe Island Woodhen now apparently faces bright days ahead. Apart from owls who take a fancy to Woodhen chicks and a rumoured sole-surviving pig on the loose, the bird no longer has any serious (that is, species-threatening) predators to confront. Even domestic cats and dogs on the island do not seem to trouble the Woodhen. The cats are either too old or too lazy and the dog population remains distinctly cautious (the meanest dog on the island, a bull-terrier called Marvin, was seen running from a Woodhen, having suffered a crushing blow to his canine ego).

With the continued respect of the locals—indeed, loving attention—it is hard to imagine anything interrupting the Woodhen's onward march, except perhaps an unforeseen natural calamity.

—Toby Jones
National Parks and Wildlife Foundation

KATHIE ATKINSON

Residents of Lord Howe Island treat their woodhens like children. This one is being hand-fed a beetle larva.

MYSTERY PHOTOGRAPH

MIKE GRAY

Does anyone know what this photograph may illustrate? Why not write down your suggestions and send them in to us? The answer will be published in the next issue of ANH.

"Returning at the appointed time, Hill was met by the Aboriginal collector who told him Strange had been speared and the others waddied to death."

A STRANGE TALE

BY IAN LOCH
MALACOLOGY SECTION, AUSTRALIAN MUSEUM

AMONGST THE SPECIMENS HELD IN the Australian Museum mollusc collections is a pink bivalve, *Nemocardium bechei* (Reeve, 1840) named for Sir Henry de la Beche, Director of Ordnance Survey and President of the Geological Society in London. This specimen has a poignant history, for it was the last find of Frederick Strange, collected the day before he was killed by Aborigines at Percy Island off central Queensland in 1854.

Strange was one of a notable group of professional collectors of natural history specimens (a respectable Victorian occupation), intimately involved in the exploration of Australia. Like many of his contemporaries, he was to find that the cost of novelties could be high. Born at Aylsham in Norfolk, England, Strange came to South Australia in about 1836. In 1838 he accompanied a party led by Charles Sturt to Stranges Creek near Gawler, and another in 1839 to the north-west corner of the Murray River near present-day Morgan, during which one man died and others had to drink horse blood to survive thirst. Strange then moved to New South Wales, married Rosa Prince, started a family and settled down to business as a collector around New South Wales. His wife kept a boarding house near the Rocks, known as the Naturalist's Home. Various naturalist collectors of the period, such as John Gilbert, John Macgillivray of HMS *Fly*, and John Gould stayed there when in Sydney. Strange continued to supply John Gould in England with specimens and, when Leichhardt's party was overdue at Port Essington and presumed lost, proposed that he replace Gilbert as Gould's collector. Gould demurred in the hope that Leichhardt would return, which he did but without Gilbert who had been speared and killed by Aborigines. Strange carried on collecting, visiting New Zealand (mainly the South Island) in the late 1840s on HMS *Acheron*. By 1850 he had extended his collecting to Moreton Bay (then still part of New South Wales) and in 1852 returned to England with his expanding family and large natural history collections. These consisted of plants, insects, birds' eggs and mollusc shells. The shells were purchased *en masse* by Hugh Cuming, a London collector-turned-dealer whose large collections formed a major part of the British Museum collections when purchased for the nation subsequent to his death. Strange's name is liberally scattered through the species described in many genera from Cuming's collection.

Frederick Strange was speared by Aborigines at Percy Island shortly after collecting a new species of pink bivalve.

With extensive contacts made in England, Strange and his family returned to Sydney in 1853, starting a naturalist's shop in Bridge Street. Then in 1854 he entered into a share agreement with J.C. Rossiter and G. Korff for a collecting and trading trip to the islands off the north-east of Australia. This was one of the earliest privately funded scientific voyages in Australia. The ketch *Vision* was purchased and, together with George Maitland (master), Walter Hill (later first Colonial Botanist in Queensland), Richard Spinks (Strange's assistant), William Spurling (mate and conchologist), Gittings (the cook) and two seamen, Strange sailed from Sydney on 4 September 1854. Just prior to departure he donated "some rare shells" to the Australian Museum where his friend George French Angas was then Secretary.

On 29 September, the *Vision* sailed from Moreton Bay with an Aboriginal collector added to the crew, ready to start the real work of the cruise. After a brief stopover at a small island off Cape Capricorn, the *Vision* anchored at No. 2 Percy Island on 14 October. The Percy Islands (21°42′ S, 150° 20′ E) are north-east of Shoalwater Bay, central Queensland, about 50 kilometres from the nearest point on the mainland and 25 kilometres from the nearest islands. They are continental islands, not coral cays, and had already become established as a convenient anchorage for ships using the inner route through the Great Barrier Reef. A string of islands along the north Queensland coast were favoured because of easy anchorage and/or permanent water. The mainland coast was as that time largely unexplored on a local scale, the harbours of all the present large towns not having yet been discovered. The central Queensland area was then referred to as the Wide Bay district, the furthest north European pastoral expansion had reached. Rockhampton was not established until the following year. Over this decade the effectiveness of Aboriginal resistance halted and even turned back pastoral expansion.

A small party went ashore and made friendly contact with the Aborigines on Percy Island. Returning on board, dredging by Strange yielded the specimen of *Nemocardium bechei*. On the morning of 15 October, Strange, Hill, Spurling, Spinks, Gittings and the Aboriginal collector went ashore to collect, Strange being the only one armed with a double-barrelled gun. The party separated, Walter Hill going inland to botanise. Returning at the appointed time, Hill was met by the Aboriginal collector who told him Strange had been speared and the others waddied to death. The pair hid amongst rocks until after dark when they managed to get back to the *Vision*, which then limped its way to Brisbane.

When the news reached Sydney, Angas composed the following valedictory verses (only the first and last of nine included):

Australia! for thine onward march
How many a son of science fell.
Shall not thy bards of future years
Their deeds of noble daring tell?

Alas, poor Strange! 'tis will to know
Australia hath a heart to feel;
To wipe away thy orphans' tears—
Thy widow's broken heart to heal.

As for the pink bivalve, "regarded at the time as unique", the Governor, Sir William Denison (himself a Trustee of the Australian Museum) and Angas tried unsuccessfully to purchase it for their private collections. Eventually the Curator,

W.S. Wall, persuaded Strange's widow to present the specimen to the Australian Museum. Unfortunately, no record of this donation can be found today.

In the best colonial tradition, a gunboat HM *Torch* (a paddle steamer) called at No. 2 Percy Island in February 1855 and arrested ten Aborigines (three males, three females and four children) who were brought before the Water Police Court in Sydney. Problems arose when no-one could be found who could communicate with the accused. Their subsequent fate is unknown. The trip was not completely wasted, however, as Lieutenant Chimmo R.N. collected what became the type specimens of *Helix mucida* Pfeiffer, 1856 (= *Ramogenia mucida*, a chloritid land snail).

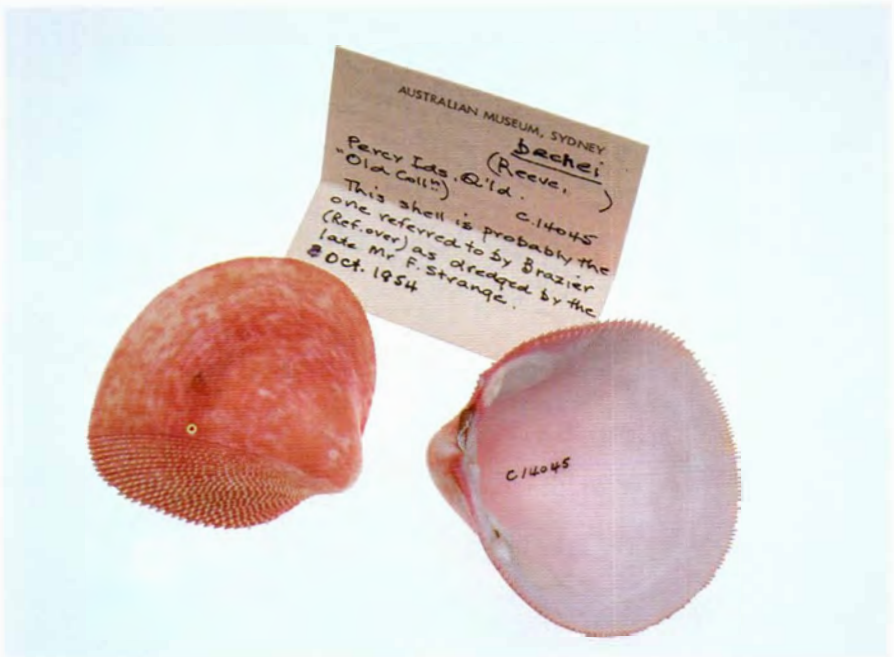
Things became quiet for the bivalve, "affixed to a card tablet" in the Museum. A power struggle between the Curator Wall and Secretary Angas saw first Wall and later Angas 'retired' after conflict over the smell of Wall's dog faeces in the basement, the accusation that Angas was painting on Museum time, and the theft of shells. Angas returned to England where he started publishing extensively on Australian shells, many of which were sent to him in the 1860s and 1870s by John Brazier, a Sydney conchologist, son of a sea captain and husband of Sophia Rossiter, the daughter of Thomas Rossiter who years previously had providentially saved Edward John Eyre on the Great Australian Bight. Strange's silent partner, J.C. Rossiter, was a brother or a son. A long amiable correspondence arose between Brazier and Angas until, in 1877, Brazier published "Notes on *Laevicardium Beechei*" recording the presence of this still rare species from the Torres Straits, Cape Grenville and (from his brother-in-law R.C. Rossiter) New Caledonia, and mentioning at the end "there were two fine living specimens in the Australian Museum some years ago, dredged by the late Mr. F. Strange at Percy Island; one specimen was purloined by a gentleman who at one time held an appointment in that institution".

This being brought to Angas' attention in England, his letter of 15 September 1878 frostily changed from the usual "My dear Brazier" to "Dear Sir" and condemned the "anonymous imputation of a very serious kind affecting the honour and character of several individuals, myself among the number, who have from time to time held office in the Australian Museum". This was the same conclusion I had come to prior to reading Angas' correspondence held in the Mitchell Library. Angas described the acquisition in detail, stating there was only ever one specimen and demanding Brazier's source of information. Unfortunately Brazier's reply of November 1878 cannot be traced here or in England, but the reply from Angas in May 1879 accepts his explanation that reference to Angas was not intended and lets the matter drop, "although the statement apparently pointed to me rather than to others, my being so well known as a collector of shells". Nor can any record of accession be found to indicate if Brazier had been misled into his libellous statement.

In a final footnote, there is a specimen of *Nemocardium bechei* from the Percy Islands in the Museum of Victoria, which was donated by the Reverend J.E. Tenison Woods in 1880. It would be interesting to know from whose hand the Reverend acquired his specimen and whether this represents the phantom second specimen "purloined by a gentleman". ■

Mr Ian Loch is the Collection Manager of Molluscs at the Australian Museum. Care of these historical collections has stimulated his interest in colonial science.

The pink bivalve, *Nemocardium bechei*, collected from Percy Island, Queensland, by Frederick Strange in 1854.



ANTHONY FARR

"Alice's brief descriptions of such foods are important ethnographic data, for they are among the few records of the diet of Channel Country Aborigines."

OUT MOORABERREE WAY

BY TIM LOW
NATURE WRITER

EARLIER THIS YEAR I TRAVELLED through the famous Channel Country of south-western Queensland—an extraordinary stretch of desert steeped in Aboriginal and colonial history. I was just leaving the township of Betoota, on the Windorah to Birdsville dirt highway, when I passed a turnoff that made me jump. A rough dirt road, wending north over a stony gibber plain, bore the signpost "Mooraberree".

Mooraberree Station was the home of Alice Duncan-Kemp, a pioneer who wrote several books about outback life, the best-known being *Our Channel Country* (Angus & Robertson, 1933). Alice's books hold great interest to me, for they vividly recount the ways of the Channel Country Aborigines early this century, including descriptions of many of their foods.

At Mooraberree, as at other stations, Aboriginal men worked as stockmen and the women as domestics. Food and clothing were the only wages and the workers slept in gunyahs close to the homestead. Yet away from the house, Aborigines still maintained their traditions; they gathered foods in the desert and camped in large groups at all the permanent waterholes. Alice often encountered these people while mustering with her husband. Here is her account of one such meeting:

"The tattered tribal remnant before us carried little in the way of food and no blankets or covering of any description. They relied on the plants among the flats and sandhills to provide them with food for their journey, supplemented with the small game which infested the plains and gibber country. . .

"They would find *kooni*, the red rosy Pigweed spread over gravelly flats or about sandhills; *curda*, another fleshy plant of the Portulaca order. . .Gins scraped the sands for the *witooka*, a brittle, radish-like root, or dug for sweet onion bulbs called *tallculli*."

Alice's brief descriptions of such foods are important ethnographic data, for they are among the few records of the diet of Channel Country Aborigines. In 1943, anthropologists T.H. Johnston and J.B. Cleland attempted to identify the plants. They bravely identified *witooka* as a tarvine (*Boerhavia* species) and *tallculli* as bulbine lily (*Bulbine* species), and gave many other names, some of which are almost certainly incorrect.

Some of Alice's most notable observations concern the storage of grain. Once she was out with two Aboriginal stockmen, Bogie and George: "Looking hard at a notch on a smooth round stone, Bogie lifted it and dug beneath, unearthing some *pattis* or seed-cakes; these were marked on the upper surface with a circle and criss-cross of red ochre. Bogie placed them hastily in the hole again, covering them with the stone. Not satisfied, he went off in another direction and found another cache; these must have been the desired brand for Bogie and George both seemed to enjoy snapping them with their poor teeth. The *pattis* are hard flinty slabs made by the gins from grass-seeds found in black-ants' nests and baked to chips in primitive ovens."

This anecdote is one of the most signifi-

The '*witooka*' of Aborigines at Mooraberree was probably tarvine (*Boerhavia* species). These small creepers sprout after rain on sandy soils and produce small brittle taproots that can be cooked and eaten.

PHOTOS: TIM LOW

cant accounts ever written of how Aborigines stored grain. Although Alice was evidently unimpressed by the "hard flinty" *pattis*, she reveals that some Aboriginal foods were relished by the whites. Note her account of the native Bauhinia trees (*Lysiphyllum gilvum*):

"When rains draw near, the old gins about the homestead wander up and down the creeks scoring or cutting the bark with a tomahawk. After rain they visit the scored trees and gather the *minni*, a thick sweet sap which exudes from the cuts like jellied honey-coloured gum; a great delicacy among the blacks, who eat it straight from the tree.

"White children consider *minni* an excellent substitute for sweets, when cooked in a baking-dish with a little sugar and water for a couple of hours, and sprinkled with roasted nuts or Mungaroo from the roots of the nut-grass [*Cyperus bulbosus*]."

Alice also told of Aborigines making semi-intoxicating drinks by mixing the pounded flowers of the Bauhinia with native honey or honeypot ants, the liquid being left to ferment for eight or ten days.

Alice's writings illustrate that Aborigines, contrary to popular belief, brewed alcohol, and stored and mixed foods. Her observations complement those of other authors (such as Leichhardt and Petrie) about Aboriginal practices in other parts of Australia. Unfortunately, her books have long been out of print and are largely forgotten, and Mooraberree today is just another Channel Country beef station. As for the Aborigines—the Murranudda, Ooloopooloo, Karanya and other tribes—their culture has been all but obliterated. ■

Tim Low B.Sc. is a full-time nature writer. He is the author of three wild food books, the latest being Bush Tucker, *which includes articles reprinted from his ANH column.*

Treat from a trunk: toffee-like gum oozing from the wild Bauhinia tree was eaten by Aborigines and colonists alike in outback Queensland. This specimen is as big as a plum.

At the edge of Betoota Billabong in far western Queensland stands this fine Bauhinia tree. Alice Duncan-Kemp lived not far north of here and spoke of the tribes that inhabited this bleak desert region.

PHOTOS: TIM LOW

"If scientific history is no more than a succession of heroes, then most of us can do little but watch in awe and some despair."

WHIGGERY

BY ROBYN WILLIAMS
ABC SCIENCE SHOW

HISTORY IS OF VITAL IMPORTANCE TO the good health of science. If we know what our predecessors did and why, then we can ourselves proceed with greater purpose. The trouble is that the history of science is often depicted as a series of heroic events. You remember the grandiose verse about the two titans of modern physics?:

> Nature and Nature's laws lay hid in night,
> God said "Let Newton be!" and all was light.
> It did not last. The devil, crying "Ho!
> Let Einstein be!", restored the status quo.
> —Alexander Pope

Well, that's all very well but it does presume, like so much of what's been called a 'whig' interpretation of history, that the Newtons and Einsteins are there waiting in the wings, as Churchill appeared to be in 1940, for the great moment to arrive. When Einstein published his Theory of Relativity in 1905, it was all but ignored. Only one response came, in the first year, to indicate that anyone had read it at all. It was only when Sir Arthur Eddington, 14 years later, observed the eclipse of the sun and managed to detect the slight bending of light from a star that Einstein became world famous. Relativity itself remained of little practical consequence until the 1950s, but the man who proposed it had become legendary because he seemed to have shown the world to be quite different from the way we once pictured it.

Whiggery is accused of stepping over such inconvenient details, of leaving out the failures and blind alleys, of setting aside the smaller players, of presenting the heroes as if they dominated an era. We don't do that with our present-day scientists though, because we assume quite naturally that research is teamwork, that even the greatest mind may have its blemish and that science simply doesn't operate that way. I mean, just ask yourself, can you name anyone in any branch of research today who's equivalent to the Einsteins and Newtons of yesteryear? The scientific heroes of our age are more likely to be the communicators like David Attenborough or David Suzuki. Try naming three of those in any field who've won a Nobel Prize in the last ten years. John Bardeen and Fred Sanger have two each in one subject. Are they popular heroes like the Curies once were?

We are nonetheless still prone to see science as unfolding in an almost inevitable progression. One breakthrough follows the next and failures are forgotten. But failure is the essence of science: we set up ideas to test them, supposedly to knock them down and be left with only one survivor, The Truth. That's the ideal. But even scientists are reluctant to forsake their favourite theories, however battered they become in the critical onslaught.

"how will history record Sir Fred Hoyle's brief appearance in the scientific firmament? Will he have a mixed but still noteworthy inscription? Or shall we erase his awkward memory because his ideas were too often wrong?"

Consider Sir Fred Hoyle. His place in the hall of fame should have been automatic and straightforward. He, with three colleagues, had worked out where the elements come from, how they are 'cooked' in stars to become the larger atoms like carbon, nitrogen and iron from which living things are made. A fundamental insight, no question. Yet Sir Fred had also proposed two other theories of more questionable merit.

First, on the origin of the universe, he suggested that hydrogen atoms are continuously 'created' in emptiness and that space goes on, more or less for ever, with little change in appearance. Then, the Big Bang theory, beloved of Sir Fred's then Cambridge rival, the late Sir Martin Ryle, became widely accepted as astronomical observation seemed to confirm it beyond doubt.

The second, more recent in promulgation, is Sir Fred's concept of organic 'seeding' from outer space. He cannot accept that the evolution of living things can have taken place on Earth in the time available. Therefore, he says, we must be willing to countenance viruses or similar entities coming to Earth on bits of comets or meteorites and, with their new genetic material, giving evolution a 'push', even changing its direction profoundly. In this way he explains sudden leaps as one line in the fossil record appears to give rise to another. Sir Fred has even told me that he sees diseases like the influenza outbreak of 1918 as coming from deep space!

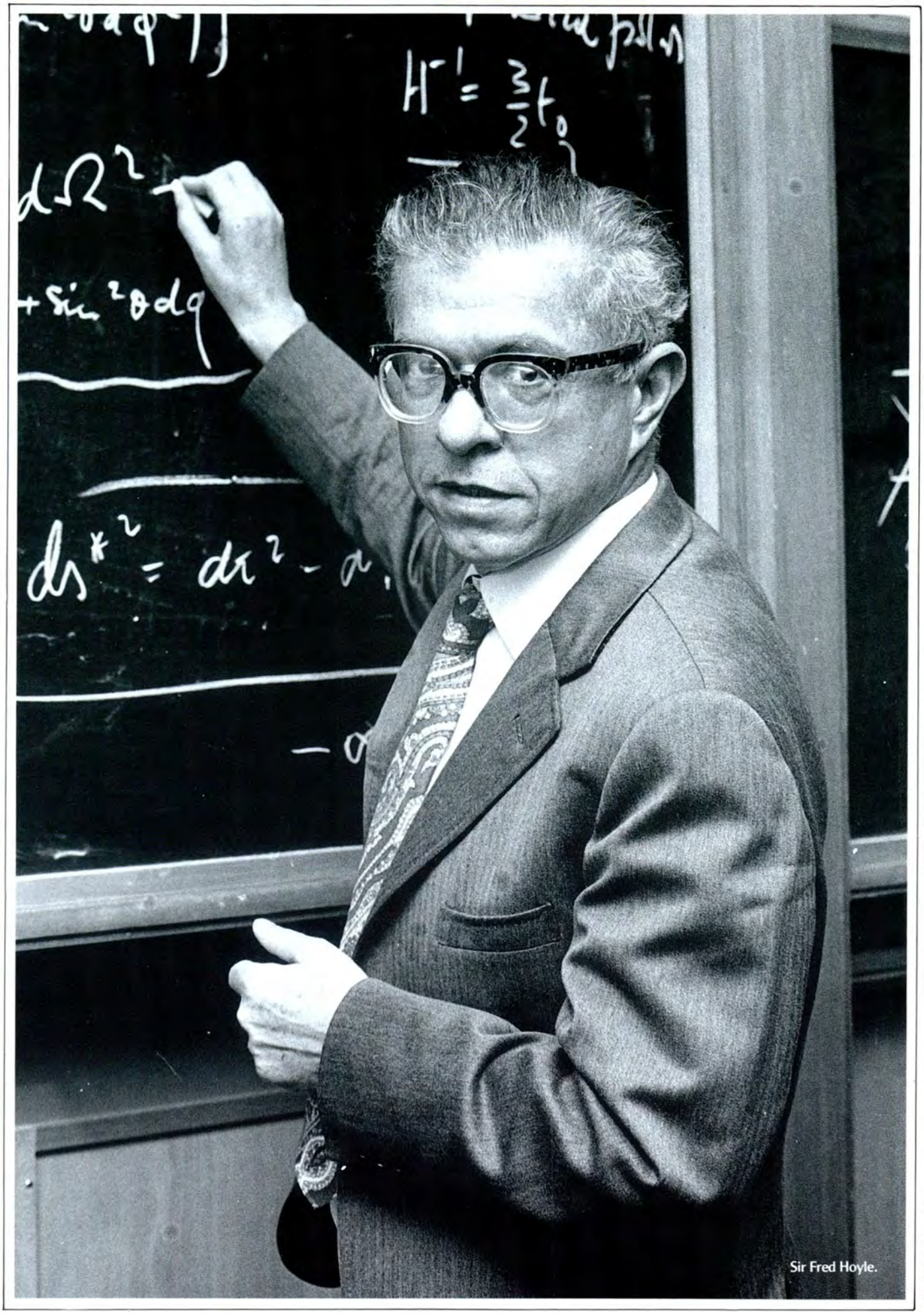
All good juicy stuff. But sufficient to lose Sir Fred a Nobel Prize in physics. Others were recognised for the work on element formation to which he had contributed no small amount.

But how will history record Sir Fred Hoyle's brief appearance in the scientific firmament? Will he have a mixed but still noteworthy inscription, rather like Lord Kelvin (who was daft on radiation but solid on much else)? Or shall we erase his awkward memory because his ideas were too often wrong?

Whiggery is unfortunate because it presents science as a less human activity. If scientific history is no more than a succession of heroes, then most of us can do little but watch in awe and some despair. But if we recognise the imperfections and the dead ends, the peccadilloes and the hiccups, then science becomes something for all of us, whether we want to join in or not.

In terms of social history it is also valuable to view the Newtons, Darwins and Hoyles as true products of their age, doing work that fits the preconceptions of life at that time. Newton's astronomy was in many ways in tandem with the era of British naval exploration and Darwin's evolutionary theories were clearly influenced by 19th-century capitalism. Seeing science in this way, as much a product as a force of change, enables us to choose the kind of science we want. If we are allowed to. ■

As Producer of the ABC Radio Science Show, Robyn Williams has the opportunity to interview many interesting people in science.



Sir Fred Hoyle.

KEITH BYRON, SMH 1971

"A concept of eco-tourism must be developed by which visitors can be both entertained and educated and yet leave the area with more or less the same wilderness value it had when they entered it."

THE DAINTREE DILEMMA

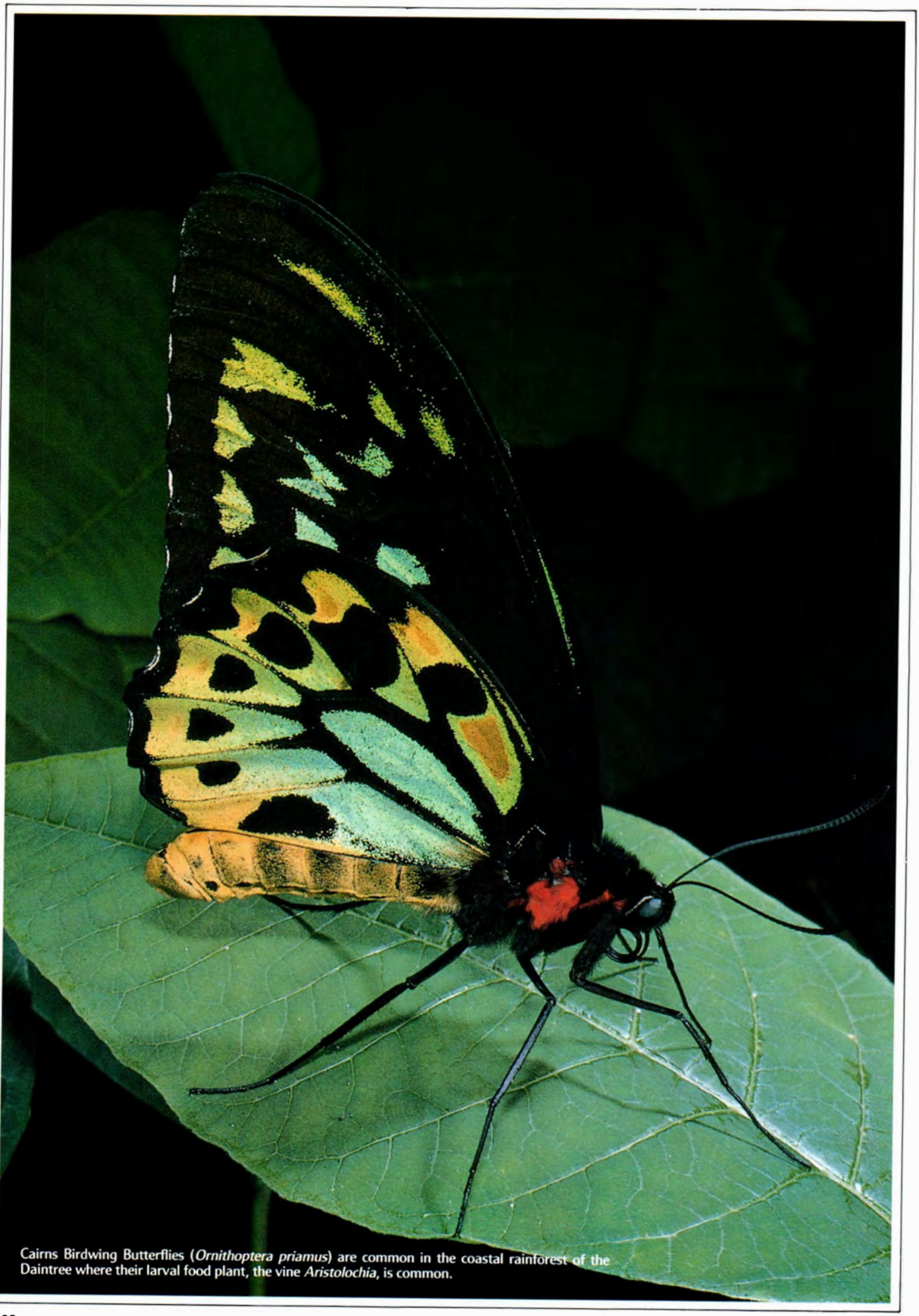
BY SUE McINTYRE, BERT JENKINS & ROSEMARY LOTT

DEPARTMENT OF ECOSYSTEM MANAGEMENT, UNIVERSITY OF NEW ENGLAND

HERE THE RAINFOREST MEETS THE sea. Vast *Calophyllum* trees writhe out from the forest's edge often resting with huge woody 'elbows' on the beach itself. *Taeniophyllum* orchids, visible only as a tapeworm-like green root embedded within the tree's bark, join the epiphytic ferns and vines so characteristic of Australia's tropical rainforests. Looking up from the beach edge, layer upon layer of green, each subtly different from the next, rise to the canopy and beyond until they are lost in haze on the ridgeline of the coastal

The Daintree: where the rainforest meets the sea.

LEO MEIER/WELDON TRANNIES



Cairns Birdwing Butterflies (*Ornithoptera priamus*) are common in the coastal rainforest of the Daintree where their larval food plant, the vine *Aristolochia*, is common.

PAVEL GERMAN

mountains. This green continuum is the backdrop for animal activity. The butterflies—Birdwings, Ulysses', Leafwings, Orange Lacewings—drift across the green curtain as brilliantly coloured specks. Metallic Starlings squabble over the flowers of an Umbrella Tree and the Orange-footed Scrubfowl shouts 'doctorr' as if all around were stone deaf. The mammals are more secretive: an evening glimpse of the Northern Brown Bandicoot as it slips across the dirt road, mosaic-tailed rats using the camp as a storage place for palm seeds, and strange tube-nosed bats appearing as beige ghosts in the twilight.

These are the forests of the Daintree and we were there as part of a wet-season expedition from the University of New England. Our team of six carried out two major research projects during our five weeks in the field. The botanists studied the survival and fate of palm fruits and the entomologists studied the intricacies of the animal community living in aquatic container habitats. We had come to this region for a number of reasons in addition to the pursuit of new scientific information. In particular, we wished to see for ourselves the World Heritage area declared in December 1988 and so hotly contested by the Queensland Government. As ecologists we wished to assess the present impacts and likely future developments in the region. In particular we wished to know how these changes will affect the ecological integrity of the rainforest ecosystem. It is what we observed on this front that prompts the present article.

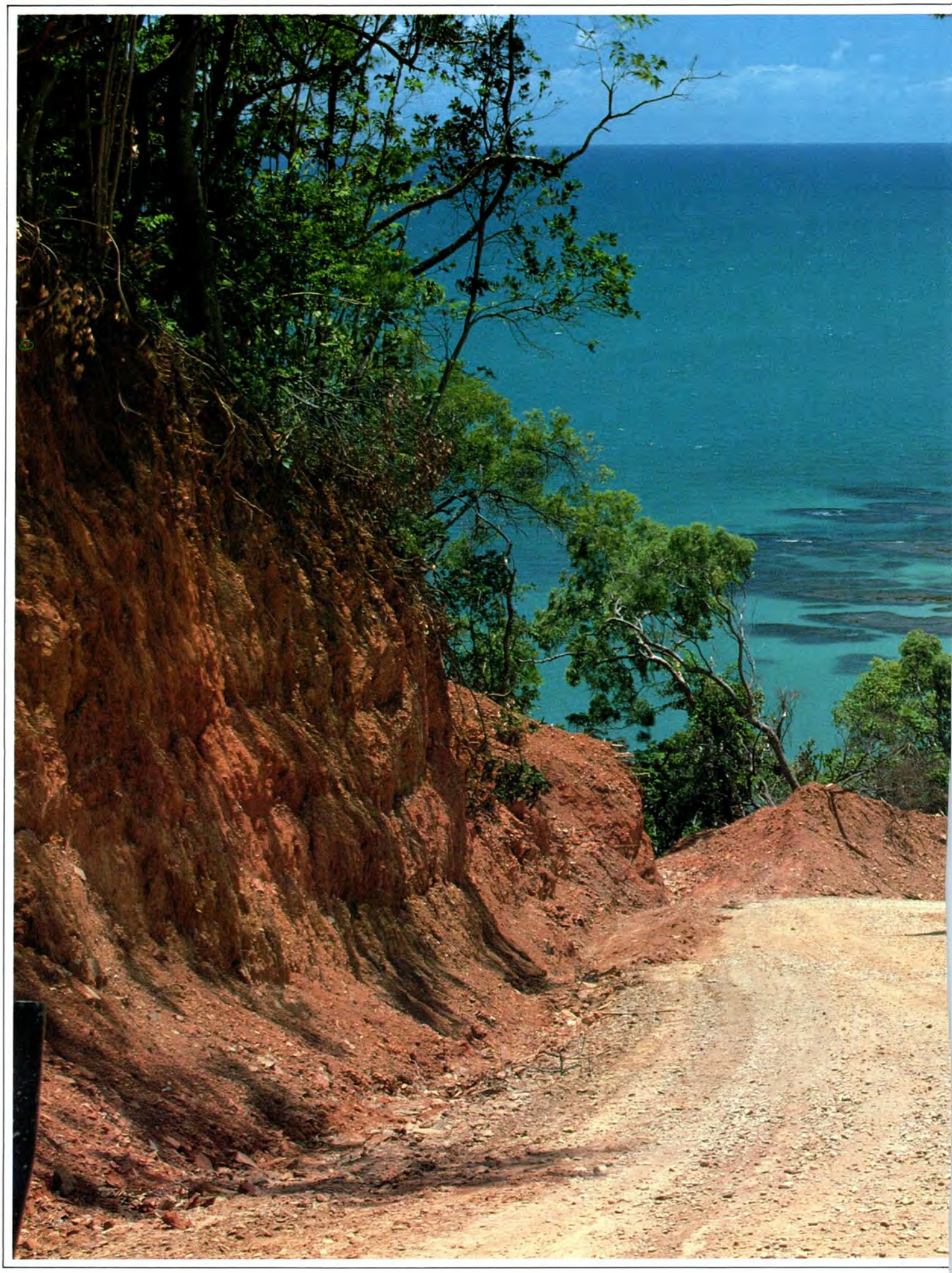
IN THE BAR OF THE JUNGLE LODGE AT CAPE Tribulation the Eurhythmics belt out of the loudspeakers. The open-work timber of the bar overlooks the Lodge's swimming pool, tastefully surrounded by palms and ferns. The dance floor is packed. It's actually hard to catch an Australian voice—here we met Germans, Swiss, Danes, Americans, Irish, Brits and so on—almost all under 30 and all part of the immense tourist influx that the Daintree region has seen since its very special qualities were recognised and 'rainforest' became, quite rightly, an impassioned catchcry for the young of the developed world. These people did not come here to rage, although they do it well; they could as easily have stayed in Cairns to do that. They came because the rainforest is here. And yet, whenever our expedition members came down to the Lodge for a little 'rest and recreation', we were besieged by questions about 'the forest'. Now bear in mind that this forest starts at most 200 metres from the door of the Jungle Lodge. The questions repeat themselves: 'How can we see the forest?', 'What is so special about its ecology?', 'What are the local issues surrounding the World Heritage listing?', 'What are you up to in your research program?', and so on. Not trivial questions and ones that deserve answers—and yet, but for our presence, go

Susan McIntyre and Rosemary Lott measure one of the Fawn-footed Melomys (*Melomys cervinipes*) captured using seeds of the Black Palm (*Normanbia normanbyi*) as bait. This study of seed predation was one of the projects carried out during the Daintree expedition.

ROGER KITCHING

Mosaic-tailed rats are among the commonest consumers of rainforest seeds. The Fawn-footed Melomys (*Melomys cervinipes*) is one of five species of Mosaic-tailed rats that live on Cape York.

PAUL GORERT



LEO MEIER/WELDON TRANNIES

largely unanswered (by professionals anyway), leaving the energetic visitors no choice but to rage every night.

Most of them have heard vague stories of stinging trees, fire vines, poisonous snakes and, of course, Saltwater Crocodiles. Without proper advice many of them are simply afraid to penetrate the forest wall that surrounds the Cape Tribulation settlement.

This vignette points out perhaps the most important immediate environmental problem facing the region—tourism. This is one of the most beautiful and special spots on the face of the Earth. The nomination of substantial parts as World Heritage was not simply a political whim on the part of the Hawke Government; it is fully worthy of recognition as part of the heritage of all the world's people. Indeed as Australians we should be specially proud that it has been so recognised and very conscious of our responsibilities with respect to it henceforth.

So, that the area attracts tourists is neither surprising nor undesirable. Not only do such tourists, potentially anyway, get to experience a unique and exciting ecosystem, they also leave behind them dollars, pounds, marks and kroner which, in this age of economic rationalism, is judged to be important too. This economic input, of course, enriches the local tourist operators but, through the direct and indirect taxation processes, also benefits Queensland and the country as a whole. However, without a visionary approach to the management of tourism, two highly undesirable things will happen. The tourists themselves will go away unhappy and the very environment that attracts them will be damaged or even destroyed.

Such management of tourism is not occurring.

Two things that have happened in the last few years underpin any understanding of what's happening. In 1984 the Queensland Government, against much opposition and informed advice, completed the road north from Cape Tribulation, connecting it to the road that already existed and that runs from the Bloomfield River to Cooktown. This new section of road perches on steep hillsides and cuts through soft lateritic soils. Its role as a degrader of the environment is hard to deny. We noted that after rain the creeks below the road ran red and the plumes of sediment were clearly visible in the shallow waters offshore. The dilapidated remains of the protest camp, left in place as a misguided attempt at some sort of monument, were an additional eyesore, as were the abandoned car bodies and other miscellaneous junk that littered the roadsides. Other events during our stay highlighted this immediate impact even further: a jeep, abandoned in motion after its hiring by a group of overseas tourists, rolled over into one of the finest creeks in the district. Local wreckers 'souveniring' the fuel tank emptied its load of diesel into the creek to lighten their task!

But in the present context the primary result of the road's completion has been

FRITHFOTO

Stinging trees, together with fire vines, are among the plants to be wary of in the north Queensland rainforests. Contact with the leaves of this tree lead to painful and persistent stinging. *Dendrocnide moroides*, the fruit of which is shown here, although one of the smaller species, is reputed to have the most severe sting.

In 1984, after much opposition, the road north from Cape Tribulation was completed. Now, after rain, creeks east of the road run red with displaced sediment.

C. TRUELOVE

Dilapidated remains of the 1984 protest camp do nothing to help the environment that the protesters set out to protect

that this whole region is now accessible—not following a special, arduous journey to it but as an alternative 'scenic' route from Mossman to Cooktown. Regular bus services run daily and any number of four-wheel drive 'wilderness tours' are to be seen hurtling up and down the road. Much larger numbers of people now enter the region and they do so at little personal cost—either in terms of money or, more importantly, effort. This easy access has led to an easygoing attitude towards the preservation of environmental values. It has also led to increased demand for services and that inevitable correlate, an escalation of land values.

The World Heritage decision itself has played a major part in exacerbating the situation by drawing world attention to the glories of the area.

So the combination of much easier access and a sort of international guarantee of attractiveness to tourists and their money has led to a surge in land values along the coastal strip (most of which is just outside the boundaries of the World Heritage area). And this, as elsewhere, has attracted that most dangerous of environmental pests, the coastal developer, aided and abetted by willing councils. Patches of virgin rainforest have been re-zoned from rural to high-

C. TRUELOVE

density residential! The recent sale of a nine-hectare block in Cape Tribulation for almost two million dollars points out the rampant escalation in land values in response to the 'Gold Coast' development imperative. Elsewhere in the area the Douglas Shire Council has approved plans for a resort on a patch of land totally surrounded by the World Heritage area. So extensive have been the proposals for development that public outcry against the Douglas Shire Council's Development Control Plan has led to it being withdrawn for redrafting.

Overall, then, the talk is of one-hectare residential blocks and condominium developments, of resorts and swimming pools, and the dollar signs light up in the eyes of the speakers. It is likely that the rainforest presence will be reflected only in the fanciful names that these developments adopt—'Crocodylus', 'Jungle Lodge' and the like. The impacts of these or indeed any developments have not been thought through. The impact of siltation on the offshore reef, the nutrient enhancement of forest and reef as a result of primitive sewage arrangements, and the disposal of garbage are just some of the ecosystem-level problems that will arise. More subtle impacts of noise on wildlife, of the many dogs that visitors and residents bring into the area, the transport of seeds of exotic plants, the removal of orchids and ferns from trees, of four-wheel drive and motorcycle enthusiasts thinking that great empty stretches of beach are 'unused' and thus open to them as racetracks, are hardly mentioned let alone taken seriously.

The area has other environmental problems—the amount of damage being done by feral pigs is very conspicuous. A walk along the beach one night was enlivened by a large boar that used the mangrove flats as a regular source of food. He decided that trailing us was good entertainment (we were less convinced!). Inside the forest, enormous areas are ploughed up by pigs as they root for the edible, and pigs may well be displacing the magnificent cassowaries as they drive off the nesting birds and prey upon eggs and chicks. The forest edges are choked with convolvulus and grassy clearings by the introduced sensitive plant *Mimosa pudica*. But these biological problems are dwarfed by the human ones.

The area desperately needs a management authority that will tackle these and other problems in an integrated way. All those concerned, whether paid by federal or State governments must, sooner or later, set aside petty differences and work together so that the values of the region are retained in perpetuity. But 'later' may be too late.

BOTH HERE AND ELSEWHERE A CONCEPT of eco-tourism must be developed by which visitors to an area of great natural heritage value can be entertained and educated and yet leave the area with more or less the same wilderness value it had when they entered it. There are models both in Australia and elsewhere for this sort of tourism. A proportion of the tourist use in the Kakadu National Park, Northern Territory, is both controlled and orchestrated by informed interpreters aided by the National Parks Service. In North America 'educational tourism' is both very popular and a great money spinner. Those members of the public with an interest in the outdoors and natural history have proved more than willing to pay to be educated about segments of the natural world while holidaying. Nowhere is more ready and more suitable to this sort of development than the northern rainforests. At the same time the depredations of the developers and speculators

Even in this moist warm environment, abandoned car bodies constitute eyesores for many years.

along our coasts must be modified to comply with the idea of 'sustainability'—the notion that bigger profits and more physical development go hand in hand with increased quality of life must be shown to be the nonsense that it is.

So what form might such eco-tourism take? Well, for a start, the whole Daintree region is accessible on a day-trip basis from Mossman or Cooktown. It is hard to see how any further development of facilities for accomodation is justified within the forest itself. The impact of such projects during construction and on-going use is inevitably great. A modern, well-funded and well-staffed interpretation centre is desperately needed as are selected well-developed, signposted walking trails. Lastly, central coordination of access would moderate environmental impact by controlling the pressure placed on the environment and facilities during 'peak' times. On the Australian scene, measures such as these may seem draconian yet every one of them is commonplace in the United States National Park System—acknowledged as one of the best in the world.

At a time when the greenhouse gases in the atmosphere are increasing daily as a result of rainforest clearing (principally in Amazonia), we have a deep-seated responsibility to conserve our own tropical forests so that they continue to remove carbon dioxide from the atmosphere, offsetting, in part, the inputs we put into it by use of fossil and other fuels and chemicals. To have any credibility in the global environmental debates that have already begun and that will, without doubt, be the key political issues over the next decade Australia must do the right thing in its own forests. The conservation and proper management of our tropical rainforests are our particular responsibility. They remain an inseparable part of a global responsibility to maintain the health of the planet. As an atmospheric cleansing agency, rainforests are second to none; as a biological treasure house, source of future pharmaceuticals and genetic stock, they are unparalleled; as a provider of inspiration and intellectual rejuvenation, they are superb; and on top of all this they are beautiful in the extreme.

All the signs are there in the Daintree, of the tarnishing and, ultimately, loss of this unique and humbling phenomenon—the tropical rainforest. In so far as this impact is due to increased tourist use and the uncontrolled development that this is producing, the forests are being 'loved to death'! So far nothing done is irrevocable but in a matter of months it may well be so. It takes a week to clear a patch of mature rainforest; it may take 700 years for it to recover to the state it was in at the beginning of the week! Propaganda photographs showing trees and dense vegetation on land recently logged must not be taken as evidence that the rainforest regenerates and restores itself quickly. A few such highly disturbed areas are a natural feature of any forest but they are ecologically tolerable only when they form a small proportion of the whole. Large tracts of mature, undisturbed forest are characterised by structural features of the trees and other vegetation, and the habitat mosaic they form for the multitude of animals that live within them. This is what we have in the rainforests of the Daintree. They are part of the heritage of all of us and we should treasure the chance to see them and have our children and their children see them.

This remains a possibility right now: but for how long? ■

Suggested Reading

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Dr Sue McIntyre is a research fellow at the University of New England. A Melbourne graduate, she is a plant ecologist with special interests in seed and weed biology. Mr Bert Jenkins and Ms Rosemary Lott are PhD students in the Department of Ecosystem Management at UNE. Both are graduates of Griffith University, Brisbane. Bert is studying the factors determining foodweb complexity in aquatic container habitats and Rosemary the dynamics and regeneration of rainforest remnants in northern New South Wales. She is particularly interested in the ecology of seeds and fruits of rainforest trees.

MARK HEARNDEN

Feral pigs (*Sus scrofa*) are an exotic intrusion into the northern rainforests. They plough up large areas of ground interfering with normal germination and plant replacement processes, and may also prey upon the eggs and chicks of ground nesting birds such as Scrub Fowl and cassowaries.

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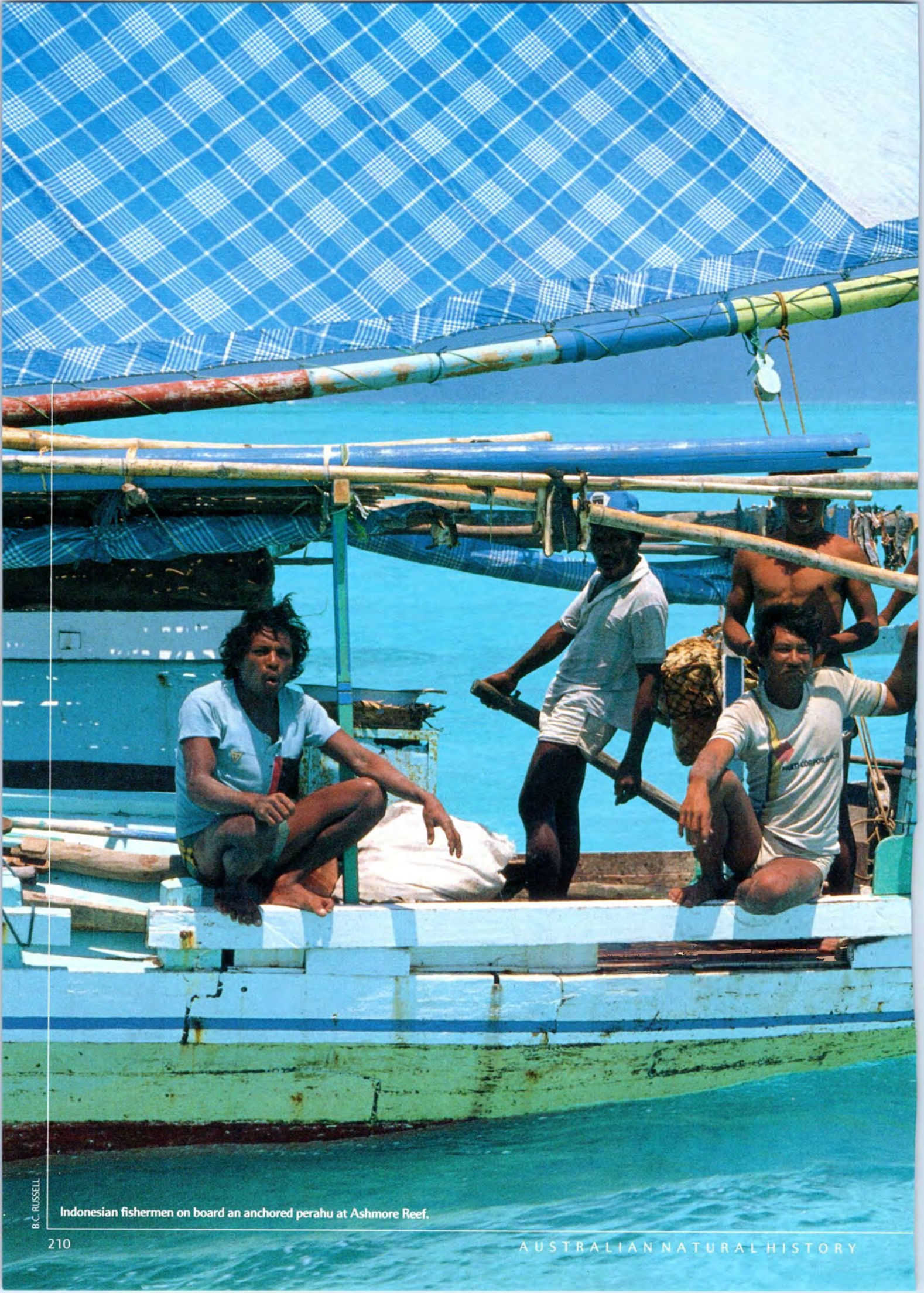
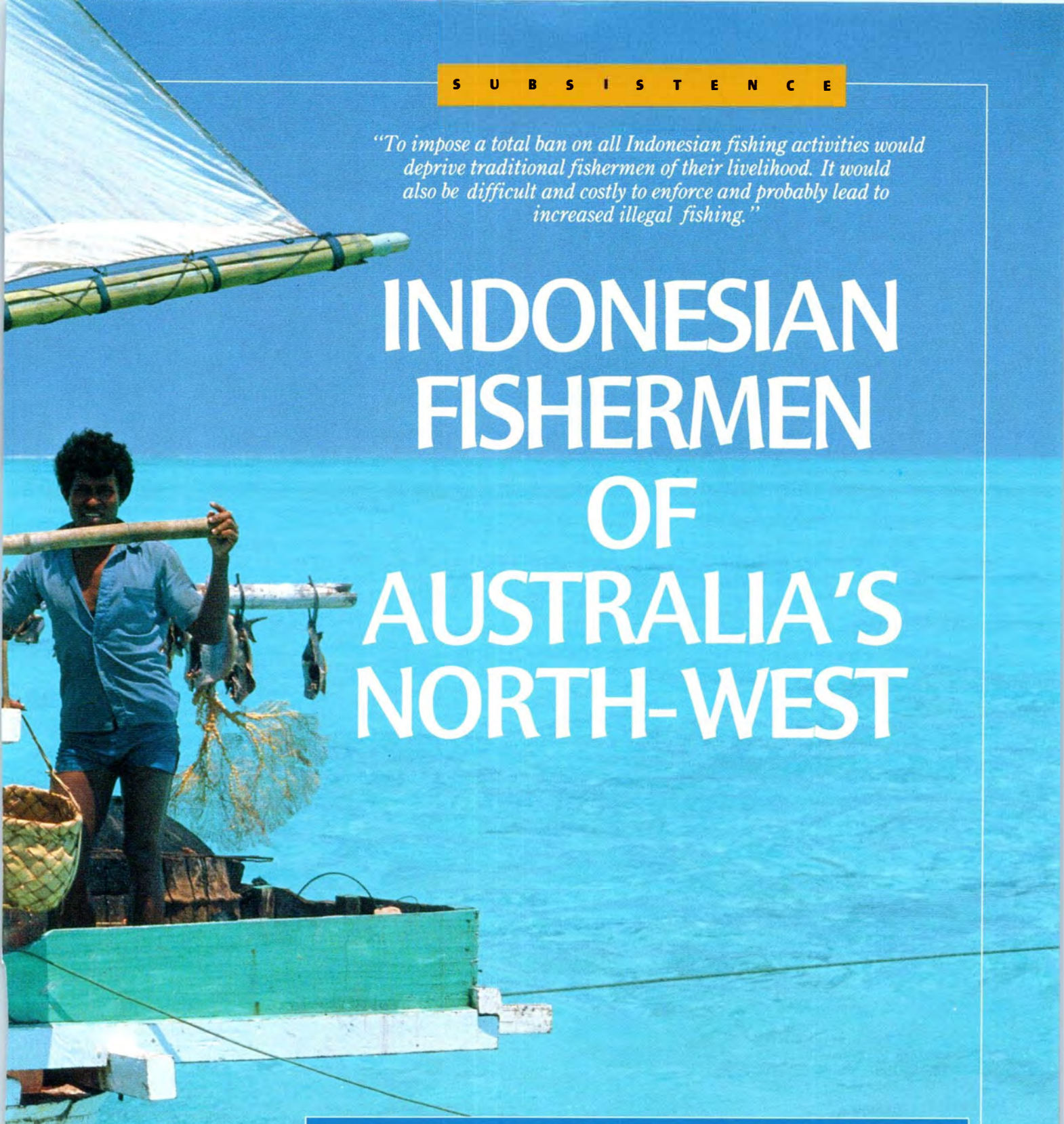


Indonesian fishermen on board an anchored perahu at Ashmore Reef.

B.C. RUSSELL

"To impose a total ban on all Indonesian fishing activities would deprive traditional fishermen of their livelihood. It would also be difficult and costly to enforce and probably lead to increased illegal fishing."

INDONESIAN FISHERMEN OF AUSTRALIA'S NORTH-WEST



BY LYLE VAIL & BARRY RUSSELL
NORTHERN TERRITORY MUSEUM OF ARTS AND SCIENCE

THE INDONESIAN PERAHU *RASA Sayang* had been sailing a full day and night from Roti, one of the southernmost islands of Indonesia. A battered compass was all that the captain and his six crew had to navigate by. On the morning of their second day from home, they noticed low-lying clouds with a greenish hue. This was the first indication that they were nearing their destination, Ashmore Reef, known to the Indonesians as Pulau Pasir.

Ashmore Reef and other off-shore reefs, as well as the northern and north-western coasts of Australia, have been fished by

Indonesians for several centuries, making it the oldest foreign-based fishery in Australia. The earliest reported contact with traditional Indonesian fishermen comes from the narrative of Matthew Flinders who described an encounter with a fleet of about 60 perahus near Cape Wilberforce, at the north-western corner of the Gulf of Carpentaria, in February 1803. The crew on the perahus, about 1,000 men, were fishing for trepang (edible holothurians of the phylum Echinodermata). Upon his arrival in Coepang (Kupang), Flinders inquired about the trepang fishermen and was informed that the natives of Makassar (Ujung Pandang) had long been accustomed to fishing for trepang amongst islands near Java and on a dry shoal lying to the south of 'Rottee' (Roti), presumably Ashmore Reef.

In recognition of this long tradition, the Australian and Indonesian Governments signed a Memorandum of Understanding in 1974, allowing traditional fishing by Indonesians to be continued in the Australian Fishing Zone around Ashmore and Cartier Islands, Scott Reef, Seringapatam Reef and Browse Island. In 1983, Ashmore Reef was declared a National Nature Reserve to protect nesting seabirds and turtles, although fishing by traditional methods was still permitted. In July 1988, however, the Australian Government unilaterally introduced new regulations, banning all fishing activities in the Nature Reserve, except for some areas outside the reef crest. Although fishing is now prohibited in most areas of Ashmore Reef, Indonesian fishing vessels still shelter in the lagoon during their voyage to nearby Cartier Reef and to more southern reefs.

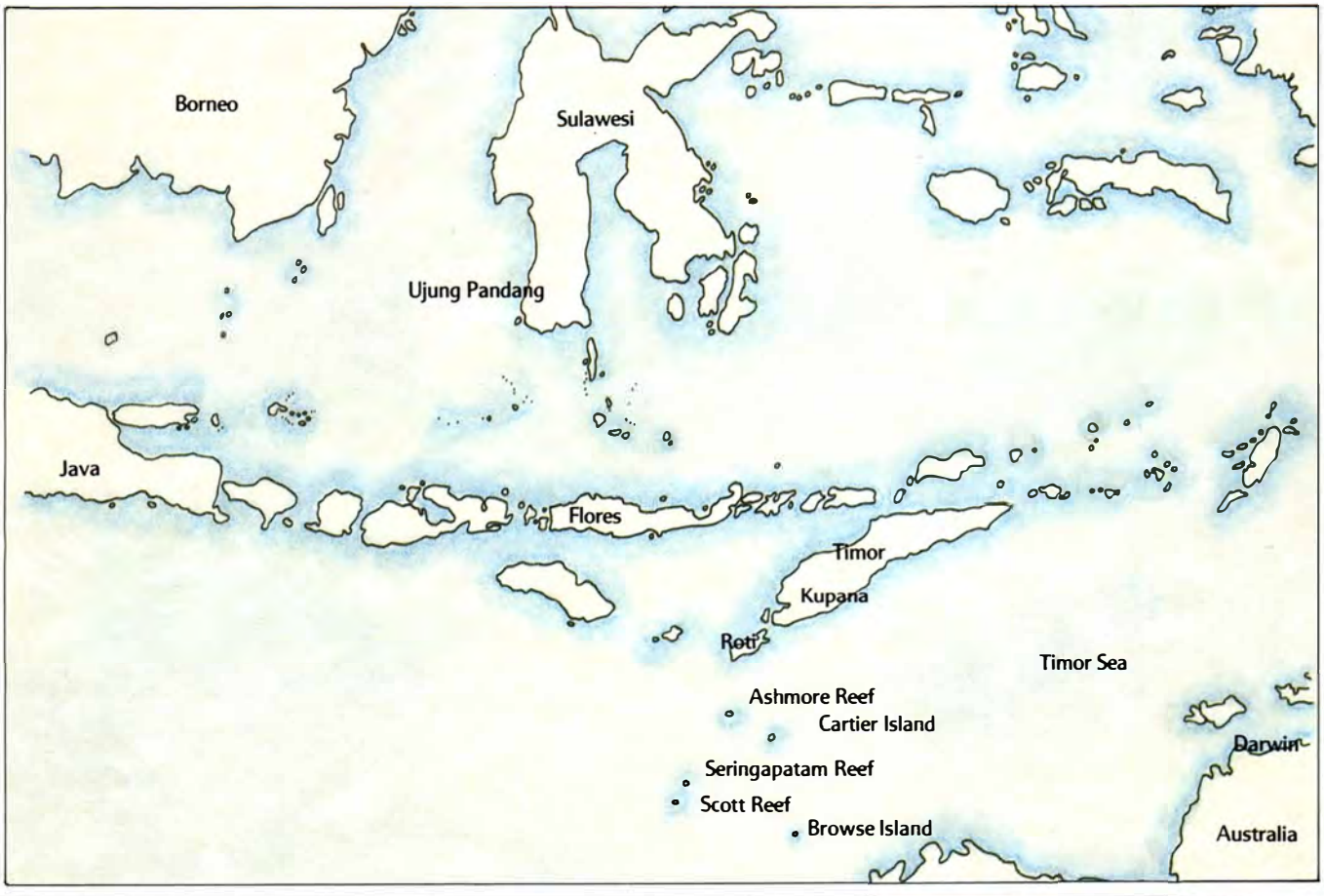
Much publicised recent arrests of Indonesian fishermen in Australian waters have highlighted the problem of illegal fishing. The majority of these illegal vessels are non-traditional, motorised perahus, capable of making more extended voyages than sailing craft and operating largely outside the area reserved for traditional fishing under the Memorandum of Understanding. Two apparent reasons for the recent upsurge in fishing by Indonesian craft outside the traditional fishing zone are increasing market values for fishing products, particularly Trochus shells and sharks' fins, and a serious decline in fisheries stocks in Indonesia.

In 1986, the Australian National Parks and Wildlife Service, which administers the Ashmore Reef National Nature Reserve, commissioned a consultancy with the Northern Territory Museum to undertake a survey of the marine resources of Ashmore Reef. The main objective of the study was to assess the impact of traditional Indonesian fishing activities upon the Nature Reserve. In the course of this work we visited Ashmore Reef twice in 1987 and carried out field surveys in three habitats (reef flat, lagoon and outer reef slope) to determine the distribution and abundance of trepang, Trochus shells, giant clams and fishes—the main products exploited by Indonesian fishing vessels. On the basis of these surveys, we attempted to estimate the level of exploitation of the reef animals by comparing results from the surveys with

L.L. VAIL

the catch we observed on perahus, and also with the reported abundance of some of the same species on reefs elsewhere in the Indo-Pacific region. We also conducted, through an interpreter, interviews with the crews of 13 perahus to learn about the traditional fishing methods employed, the importance of the fishery and patterns of use of the reef over the past 10–15 years.

ASHMORE REEF LIES ABOUT 180 KILOmetres south of the Indonesian island of Timor, on the edge of the Sahul Shelf of north-western Australia. It is a roughly elliptical-shaped reef about 30 kilometres long and encloses a shallow lagoon with extensive reef and sand flats, covering an area



CATHY McGAHEY

Interior of the main cabin of a perahu where the crew's possessions are kept and where they sleep. Drinking water and firewood are stored under the floor boards.

of 239 square kilometres. Three permanent islands—East, Middle and West Islets—are important rookeries for many species of sea birds and nesting grounds for turtles.

The majority of perahus come to Ashmore Reef during the dry season (April–November) primarily because of the favourable sailing winds and suitable weather conditions for drying their catch. From April 1986 to June 1988, 151 perahus visited Ashmore Reef (boarding records supplied by the Department of Arts, Sports, the Environment, Tourism and Territories). Most of these were from Roti. Many visited twice a year, some fished in successive years, and others visited only briefly en route to other reefs.

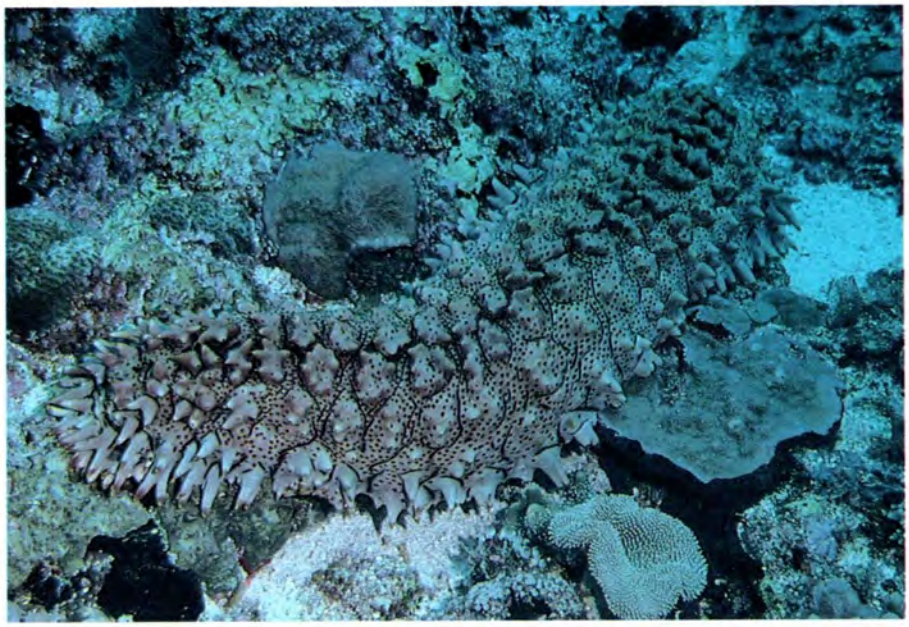
Perahus generally begin to arrive at Ashmore Reef in March, their numbers reaching a peak in April, then declining to a minimum in June–July. Numbers again peak in September before declining in October–November. These two peaks constitute two distinct fishing seasons, the length of each (four to six weeks) being largely determined by the food and water supplies carried on the perahus.

Life is generally hard for the crews of the fishing perahus, although most do not consider their occupation particularly dangerous. Heavy weather is the main hazard to the small perahus and is of greatest concern to crews. Crews of at least two perahus were lost when Cyclone Kay crossed over Scott Reef in 1987 and many fishermen drowned when a perahu foundered near Cartier Island in heavy seas whipped up by Cyclone Orson in April 1989. As traditional Indonesian fishing vessels do not carry radios, the number of perahus lost at sea in Australian waters is not known. Other hazards these fishermen face are malaria and cholera, illnesses that are endemic to their home villages, as well as exposure caused by diving, and wounds acquired while collecting animals on the reef. Few perahus carry any medicinal supplies and fishermen who have died at Ashmore Reef are buried in shallow graves on the reef's islands.

L.L. VAIL

Trepang, mainly *Actinopyga* spp., drying on the deck of a perahu.

The *Rasa Sayang* and its crew typify those coming to the reefs off north-western Australia. This sailing perahu is made of wood, is 9.5 metres long and has a cargo-carrying capacity of ten tonnes. When not in Australian waters, it is used as a cargo vessel carrying goods between Roti and Sulawesi. The *Rasa Sayang* carries an all-male crew of seven whose ages range from 18 to 25. Living conditions on the perahu are basic and crowded. In the main and only cabin, headroom is sufficient only for sitting and there is barely enough sleeping space for all the crew. Drinking water is stored in several 44-gallon drums under the floor of the main cabin, along with firewood. Cooking is done on the cramped rear deck over an open fire contained in a steel pan. Staples are rice, sugar and tea, supplemented by reef fish.



L.L. VAIL

The large and valuable trepang, *Thelenota ananas*, commonly called the 'prickly red fish', on the outer reef slope.

L.L. VAIL

The most valuable species of trepang, *Holothuria (Metriatyla) aculeata*, is usually found on the reef flat.

Rubbing trepang (*Holothuria (Metriatyla) aculeata*) with sand to remove the skin. These specimens had been buried in the sand for 24 hours in order to loosen their skin.

The primary catch on the *Rasa Sayang* was trepang, with smaller amounts of Trochus shells and sharks' fins. Reef fish, giant clam meat, squid and octopus were also taken, but mainly for consumption by the crew or dried for later use by their families in Indonesia. Helmet, pearl and baler shells are also collected and used for trading or bartering and occasionally the red alga *Gracilaria* is taken to be dried and used in cooking.

TREPANG ARE CONSIDERED A DELICACY with aphrodisiac properties in certain parts of Asia. The trepang collected at Ashmore Reef are eventually sold to Chinese buyers in Ujung Pandang who in turn export the product overseas, mainly to China.

Nine species of trepang were collected and processed at Ashmore Reef. They were taken while reef walking or diving. Diving, using only a pair of homemade wooden goggles, was regularly done to depths of at least ten metres. A weighted spear with a line was sometimes used to collect valuable species from deeper water.

The processing of trepang varies, depending on the species. In general, trepang are gutted, boiled and then air-dried on board the perahu but sometimes drying and removal of the skin is done on sand cays exposed at low tide. After boiling, the skin of some species is removed either by vigorous rubbing with an abrasive material, or by burying the animal in sand for about 24 hours, after which time the skin is easily removed. Although individuals of some trepang species may weigh up to one kilogram, 90 per cent of this is water. One kilogram dry weight therefore represents about ten of these large specimens. On the perahus we boarded, the maximum dry weight of trepang collected during a trip was about 800 kilograms.

The market value of trepang varies between species and is dependent on both size and quality. At Ashmore Reef, the most valuable species was *Holothuria* (*Metriatyla*) *aculeata*, up to 13,000 Rp ($A9.30) per kilogram dry weight. The most commonly collected species was *Holothuria* (*Halodeima*) *atra*. This species comprised at least 80 per cent of the trepang caught, although it is worth only about 500 Rp ($A0.36) per kilogram dry weight. Ten to 15 years ago, only the more valuable species, such as *Actinopyga* spp., *Holothuria* (*Microthele*) *nobilis* and *Thelenota ananas*, were collected. However, the expanding demand for trepang and the decline in numbers of the more valuable species has meant that some trepang such as *Bohadschia marmorata*, usually not considered to have a market value, are now sometimes collected.

A comparison of the abundance of trepang found during field surveys with those on perahus suggests there is indiscriminate collecting of lower-priced species such as *Holothuria* (*H.*) *atra*. But this may not be the case for higher-priced species such as *Actinopyga* spp. and *Holothuria* (*M.*) *aculeata*, since the proportion of these found on perahus was slightly higher than in the field.

The Trochus shell (*Tectus niloticus*) is the most valuable mollusc collected at Ashmore Reef; it is taken by diving on the outer reef slopes. The shell is in demand for use in the button industry and in specialised paints. Fishermen eat Trochus meat and the dried meat was often seen hanging from the perahus' rigging. The price received for Trochus shell can be up to 6,000 Rp ($A4.35) per kilogram. During interviews, most crews said that the abundance of Trochus at Ashmore Reef had declined in the last 10–15 years. We found only two Trochus shells in our study sites, thus confirming the relative scarcity of this species.

The most commonly collected species of trepang, *Holothuria (Halodeima) atra*. Small individuals of this species are commonly covered with sand, except for some bare spots along each side of the body. This species is found in many habitats but is particularly numerous on the reef flat.

B.C. RUSSELL

L.L. VAIL

B.C. RUSSELL

L.L. VAIL

A well-camouflaged Trochus shell on the outer reef slope. The shell is covered with coralline algae.

Giant clams were relatively common at Ashmore Reef with *Hippopus hippopus* being the most abundant and commonly collected species. Crews usually only collected the meat and not the shell. Since clams were abundant in shallow water, most could be collected by reef walking, although some were also taken by diving. The number of clams gathered by crews of some perahus was considerable, with up to 1,000 pieces of meat (one piece per clam) drying on some perahus. Interestingly, few crew members thought that the number of clams had declined over the last ten or so years. Our field surveys supported this impression for *H. hippopus*, which occurred at Ashmore Reef at densities many times greater than has been reported for some Pacific Ocean reefs. The abundance of other species of giant clam such as *Tridacna gigas*, however, was low compared to that on some other reefs. During our field surveys, we found 80 per cent of *T. gigas* shells to be those of dead animals. The continued exploitation of this species would probably lead to its extinction at Ashmore Reef, as has already occurred on so many reefs in the Indo-Pacific.

Reef fishes were caught by all the perahus and formed an important part of the fishermen's diet. The main method of fishing was by hook and line, using octopus or clam meat as bait. Emperors and snappers comprised the bulk of the catch, with a single species, the Orange-striped Emperor (*Lethrinus ramak*), constituting

An Indonesian fisherman hunting reef fish with a hand-made speargun.

nearly half the total number of fish caught.

The fish are eaten fresh, used as bait, or salted and sun-dried. Considerable numbers of dried fish (over 300) were counted on some boats. Dried fish has a low market value, about 150–500 Rp ($A0.10–0.36) per fish, and is usually sold only if there is an excess, with most of the fish being consumed by the fishermen and their families. An estimated annual fish harvest of nine tonnes, compared with a potential annual harvest of 320–400 tonnes, indicates that reef fish stocks at Ashmore Reef are not being overexploited.

Fish (*Lethrinus* sp.) being sun-dried on the cabin of a perahu.

B.C. RUSSELL


B.C. RUSSELL

Sharks were also caught by most perahus but a few concentrated on shark-fishing alone. Sharks were caught both inside and outside the reef, using hand-lines with single hooks or long-lines up to 100 metres long with five to seven large hooks. Many of the shark fishermen attracted their catch with shark rattles (*goro goro*). These consist of a length of bamboo split and spread into a fork at one end. Across this end is a short piece of bamboo onto which several half coconut shells are threaded. The shells create a rattling noise when shaken in the water and the vibrations attract the sharks. Strict ritual is observed when using the *goro goro*: a headband is worn and the fishermen must not spit, urinate or otherwise contaminate the water—actions considered to render the *goro goro* ineffective.

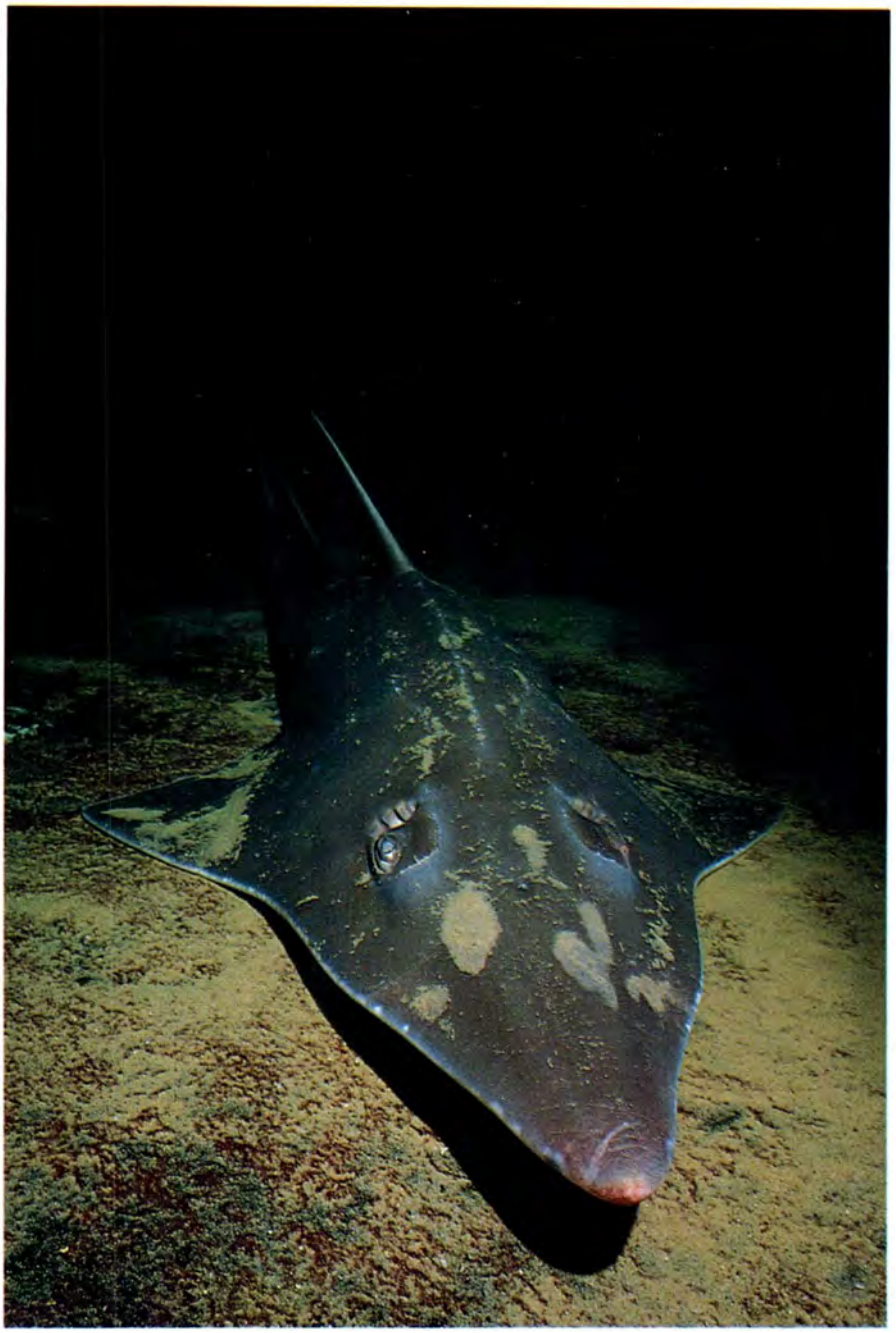
All types and sizes of sharks are taken, but larger sharks and other large cartilaginous fishes are preferred. Usually only the fins are kept for sale, but some meat is cut into strips, salted and sun-dried. The market value for the fins ranges from 3,000–20,000 Rp ($A2.17–14.50) per kilogram, with the fins of the Giant Guitarfish or Shovel-nosed Ray (*Rhynchobatus djiddensis*) fetching up to 50,000 Rp ($A36.25) per kilogram.

OUR SURVEYS AT ASHMORE REEF AND discussions with fishermen show that pressure on the marine resources of the reef have increased over the last 10–15 years and that exploitation of Trochus and some species of trepang, clam and possibly sharks are reaching high levels. For other groups such as fishes, however, exploitation in relation to potential yield still appears to be low. Similar levels of exploitation probably apply to other Australian reefs within the traditional fishing zone, and it is clear that some conservation measures are called for.

Management options are either a total ban on all Indonesian fishing activities in Australian waters, or a continuation of traditional fishing but under carefully managed conditions in the area covered under the Memorandum of Understanding. To impose a total ban on all Indonesian fishing activities would deprive traditional fishermen of their livelihood, and cause hardship and economic disruption to Indonesian communities such as on Roti where conditions already are severely depressed. Furthermore, a total ban on fishing would be difficult and costly to enforce and would probably lead to increased illegal fishing.

Management measures would preserve the existing traditional fishery while ensuring conservation of resources. One measure, already implemented, has been the banning of all non-traditional, motorised fishing vessels within Australian waters. Other management practices might include strictly limiting fishing activities to traditional gathering and processing methods.

Indonesian fishermen demonstrating the use of shark rattles (*goro goro*).



DEACON PUBLISHING SERVICES

The Shovel-nosed Ray or Giant Guitarfish is hunted by Indonesian fishermen at Ashmore Reef.

There is a need also to restrict exploitation of some species, especially Trochus and the giant clam *Tridacna gigas*. In future, the number of perahus fishing in Australian waters might need to be limited by allowing only perahus from areas such as Roti to fish, or by a selective licensing system. A permit system might be one way of ensuring that conditions of fishing in Australian waters are clearly spelt out, and that numbers of visiting perahus are controlled.

Whatever measures are adopted, proper and adequate communication with Indonesian authorities and fishermen is required. Unless the control of Indonesian fishing is tackled at its source—at the Indonesian village or port of origin—Australia will face continuing and escalating problems of illegal fishing. ■

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Dr Lyle Vail, Curator of Echinoderms at the NT Museum, is interested in the taxonomy, biology and ecology of tropical echinoderms, particularly crinoids and holothurians. Dr Barry Russell, Senior Curator of Fishes at the NT Museum, is interested in the taxonomy and ecology of tropical demersal fishes, especially those of coral reefs.

They would especially like to thank their interpreter Luciana Nicholls, Andy Bartells of the Department of Arts, Sports, the Environment, Tourism and Territories, and Captain Laurie Sexton of the Ocean Reaper *for their assistance with this study.*

The camaenid snail *Hadra bellendenkerensis* is only known from the wet tropics from Tully to Cooktown in north-eastern Australia.

MARK HEARNDEN

"They may not be as ostentatious as a bird-of-paradise or as awesome as a Jaguar, but there's more to our rainforest snails than meets the eye."

FABIANS OF THE FOREST

BY BRONWEN SCOTT
ZOOLOGY DEPARTMENT, JAMES COOK UNIVERSITY

TROPICAL RAINFORESTS ARE INHABITED by some of the world's strangest and most spectacular animals. Africa has its Gorillas and Okapis, Asia its tapirs and flying snakes, South America its sloths and toucans, and Australia its cassowaries, tree-kangaroos and snails.

Snails? Why not. Our land snails are remarkable, a mixture of locally derived, Asian and Pacific elements. Most Australian snails are endemic at species level, a few are shared with New Guinea or are introductions from Europe or nearer ports. At least 25 families are represented in this country, 22 of which are found in the tropics. They may not be as ostentatious as a bird-of-paradise or as awesome as a Jaguar, but there's more to our rainforest snails than meets the eye.

The snail fauna of the wet tropics is very diverse, but it is dominated by two families: the Camaenidae and the Helicarionidae. Both are widespread in South-East Asia and New Guinea but are absent from the Pacific Islands.

THE HELICARIONIDAE IS A STRANGE FAMily of snails and semi-slugs. The most obvious members are the terrestrial and semi-arboreal species of *Helicarion*, which are found in wet forests all over the east coast. *Helicarion* is a portmanteau name, describing an animal halfway between a snail (*Helix*) and a slug (*Arion*). The body of a helicarionid is long and slug-like, usually ending in a jaunty little up-turned tail. The shell is thin and glassy, and sits on the animal's back like a howdah. The veins of the lung cavity are clearly visible beneath. Most helicarionids are too bulky to withdraw into the shell and rely on camouflage to keep them out of danger. If this fails, they thrash their tails around, trying to draw the predator's attention from the vulnerable visceral mass. In *Helicarion* the normal role of the shell is reversed, with lobes of tissue from the mantle protecting it from mechanical damage and keeping it moist. The mantle lobes are cryptically coloured in earth tones and bear a sculpture of ridges and papillae. They completely cover the shell at rest. Only when the animal is moving is the shell's highly reflective surface visible.

Why are the helicarionids heading for a shell-less existence? There are advantages and disadvantages in having a shell. Certainly it is useful to have an impermeable, mobile shelter to prevent predation and reduce water loss, but such an inflexible attachment can sometimes be a liability, cutting down the number of places a snail can go. A slug can burrow or crawl through cracks in rocks and logs—something a snail of similar body weight would find impossible. Water loss is a major concern to soft-bodied animals but the problem is reduced in rainforests where the humidity and temperature fluctuate very little. Unable to withdraw into the shell, helicarionids resist desiccation by secreting a thick mucus that cloaks the body and cuts down evaporation when the animal is active. Australian rainforests are not always wet and, when the air dries out too much, helicarionids retreat to damp hiding places beneath logs and under bark until it's safe to come out again. The skin of the body is thick and tough, but the thin-walled visceral mass is shielded, first by the shell and then by the mantle lobes. This arrangement obviously works for the helicarionids for they are very common in rainforests all over the east coast.

A snail's armour casing isn't always impregnable. Pittas, ground-dwelling birds of subtropical and tropical rainforests, relish the larger snails, smashing the shells open on rock anvils. Camouflage does not seem to help these snails, judging by the number of cryptically coloured shards of shell around the feeding sites. Rats and carnivorous marsupials take a share, biting through the apex to get at the softest tissue beneath. Even glow-worms get in on the act, the larvae of some species feeding exclusively on small snails. So, although a shell can be useful (think how many shelled forms there are), it's not entirely foolproof and can be dispensed with in favourable habitats. The helicarionids are doing all right.

There are several groups of snails within the Helicarionidae. The *Helicarion* complex is probably the most familiar. Anyone who has ever wandered along the Palm Walk at Eungella National Park in central Queensland, has undoubtedly sent one or two huge *Helicarion superbus* to an early grave. During the wet season it is difficult to walk anywhere without treading on mating pairs. This semi-slug is the largest in Australia, surpassed only by an undescribed grey and black species from far northern Queensland.

Two other forms exist in Australia: *Parmacochlea* and its allies, in which the shell is reduced to a flat plate, and the *Nitor* group, in which the shell is conventionally coiled and exquisitely fine and crystalline. Helicarionids may be found on the ground, on tree trunks, or on the undersides of leaves. The subtle colouration makes them hard to pick out at first but once the snail-hunter has the search image established they can be found everywhere!

THE CAMAENIDAE IS BY FAR THE LARGEST family of snails in Australia. Its members are found throughout the mainland in all habitats from desert to rainforest. Particularly numerous in the north, the number of species decreases as you travel south, so only one species, *Austrochloritis victoriae*, is found in southern Victoria and none occurs in Tasmania.

Rainforest forms are often quite large and handsomely patterned, making them popular with shell collectors. Snails belonging to the *Sphaerospira* complex, for example, are well represented in both private and museum collections, but confusion over the names still exists. The camaenids are notorious for their variability in shell shape and colour. Within one population there

A snail's shell or camouflage is not always foolproof. Some snails rely on defensive 'frothing' to ward off predators.

The shell of *Helicarion* species is thin and glassy. When at rest, lobes of mantle tissue protect the shell from mechanical damage and drying out.

DENSEY CLYNE/MANTIS WILDLIFE

DENSEY CLYNE/MANTIS WILDLIFE

may be blond, dark or banded forms with rounded or keeled shells. Early workers, provided with small samples and incomplete locality data, gave each form a different specific or, at the very least, subspecific name. Consequently, just about every island in the Whitsunday Group was thought to have an endemic species of large camaenid. In his 1937 revision of the Australian land snails, Tom Iredale listed over 60 names that he considered valid for the *Sphaerospira* complex. The true number is probably closer to 15.

Australian rainforest camaenids tend to have large ranges, which can be loosely divided into southern, central and northern regions. Each area has its own species, but the richest is in mid-eastern Queensland where there are at least seven species of *Sphaerospira*, mostly confined to rainforest.

The montane forests of Eungella are inhabited by the large snail, *Sphaerospira informis*. At 60 millimetres in height and diameter, this impressive species is commonly encountered on night walks along the park tracks. Individuals from higher altitudes are much larger than those from the lowlands. The extended rainy season on mountain ranges may account for this, allowing snails to continue feeding, and thus growing, while those on the dry coastal plains are forced into aestivation.

Almost all other species found in mid-eastern Queensland occur either only on the mainland or on both mainland and islands. Two species have island-only distributions. *Sphaerospira macleayi* is confined to the wet gullies on the Whitsunday, Lindeman and Cumberland Groups. No reliable records exist for the mainland, which is surprising as the closest occurrence is only a few kilometres from the coast. The shell is also remarkably consistent: pale yellow with a dark lip and dark peripheral band. *Sphaerospira macleayi* is one of the few camaenids that can be soundly identified from shell alone.

QUEENSLAND MUSEUM

Sphaerospira informis **is a large camaenid snail (maximum six centimetres in height and width). Individuals from higher, wetter altitudes grow bigger than their lowland counterparts, perhaps because there is no need to aestivate and stop feeding.**

The other island species is of doubtful status. *Sphaerospira whartoni* is a large striped snail recorded only from Holbourne Island, off Bowen. It bears a strong resemblance to *Sphaerospira saxicola*, which is widespread in the area, but as no whole specimens are available for study the true identity of this snail remains an enigma.

Further to the north, the large stretch of rainforest from Townsville to Cooktown is home to another group of northern camaenids, the *Hadra* group, which is closely related to the more southerly *Sphaerospira* complex. The largest snail in northern rainforests, *Hadra bipartita*, may often be encountered in parks and gardens, where it can be a bit of a shock to southern emigrés. This snail grows to 70 millimetres across, which is enormous when compared with the more familiar introduced garden snail *Helix aspersa*, a midget at 30 milli-

Hadra bipartita **is a generalist. It prefers wetter areas but will also move into less stable environments. Reaching a height and width of seven centimetres, it is Australia's largest northern snail.**

DENSEY CLYNE/MANTIS WILDLIFE

metres. *Hadra bipartita* is easily recognised by its striking colouration—a handsome two-tone, chestnut brown to tawny above, and black below, sharply divided at the periphery. In adult specimens the lip is white and of the nature of porcelain. Wholly yellow individuals have been recorded from many localities. The shell shape may vary from rounded to sharply keeled. The keeled forms are flattened, sometimes almost discoid, and are particularly common on the Atherton Tablelands.

Hadra bipartita is a generalist, as far as rainforest snails go. It prefers the wetter areas but will move into less stable environments, such as monsoon forest, where it appears to be quite successful. It occurs over a huge expanse of eastern Queensland, from Cardwell to the tip of Cape York the Torres Strait Islands and New Guinea. Many names have been given to the various island forms but they are all thought to belong to the single species.

***Rhynchotrochus macgillivrayi*, the single Australian member of a large New Guinea genus, lives high up in the rainforest canopy. Examining them in their natural habitat can be an arduous task.**

QUEENSLAND MUSEUM

Two related species are found in the north-east: *Hadra bellendenkerensis*, which is confined to the wet tropics from Tully to Cooktown, and *Hadra barneyi*, a dry-forest species from Cape York Penisula.

The northern rainforests are also inhabited by animals with New Guinea affinities. Among the more bizarre snails is *Rhynchotrochus macgillivrayi*, which is the single Australian member of a large New Guinea genus. This snail, like many of the northern camaenids, is arboreal, adapted to life high up in the rainforest canopy. The Australian tree snails are poorly known because the canopy is a difficult place in which to collect. They are accessible by helicopter, hoist or ladder but then only to the very brave. Examination of trees newly felled by natural or human agency is the most profitable way to find specimens. Luck seems to play a disproportionate part. The total number of tree snail species in Australia is unknown. A new species was recently discovered at Mt Lewis, near Mossman, by Keith McDonald of the Queensland National Parks and Wildlife Service while he was collecting frogs in forest streams. The snail had fallen out of a tree and into a creek. (Where else would you look for an arboreal snail?)

THE HELICARIONIDAE AND THE CAMaenidae are the most obvious members of the rainforest snail fauna but many other groups are represented. There are more terrestrial prosobranchs (primitive gilled snails) in these forests than anywhere else in Australia. Most are small and difficult to spot but species of the Pupinidae are quite large (up to ten millimetres—big for a land prosobranch) and are often collected in mistake for insect pupae, from which their Latin name is derived.

***Triboniophorus graeffi* is one of the few known true slugs to occur in northern rainforests. They are normally cryptically coloured but populations of scarlet forms also occur. Perhaps this colour acts as a warning to its unpalatability, however no research into this has been undertaken.**

KATHIE ATKINSON

The pupinids, like most other prosobranchs, possess an operculum—a flat plate that sits on the upper surface of the animal's tail and seals the aperture of the shell when the soft parts are withdrawn. The operculum prevents predators getting in and water getting out. It also cuts down gaseous exchange, so the animal must find a way of letting air through or it will suffocate. Pupinids have solved this problem by extending part of the shell lip into two siphons, one either side of the aperture. The configuration of these siphons is usually enough to identify the species.

Although there are a lot of semi-slugs, true slugs are not numerous in the northern rainforests. Only two families are present, one poorly known with a few small and cryptic species, the other represented by only one well-known species, *Triboniophorus graeffi*. This is a large and colourful slug with a discontinuous distribution along the eastern coast from Cape York Peninsula to Royal National Park, south of Sydney. Individuals from the top of Mt Bellenden Ker, near Innisfail, are crimson and hard to ignore. Why should a soft-bodied animal make itself so obvious to predators? No research has been undertaken on the palatability of *Triboniophorus* but it has been suggested that the red colour may be a warning and anything trying to make a meal of the slug might be in for a nasty surprise. Another red form (scarlet) occurs on Mt Kaputar in northern New South Wales. Other populations of *Triboniophorus* are cryptically coloured yellow, olive green or grey and are almost impossible to see.

There are hundreds of species of land snails in our rainforests. Although this article will give you an idea of the range, nothing beats getting out there with a hand lens and an indomitable will. You will need the former to examine the smallest species and get a close-up on the larger ones. The latter you will need to keep you going through the rain, ants and leeches. No wonder the rainforests are Australia's last unknown wilderness. ■

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Ms Bronwen Scott is a technical officer at the Queensland Museum's North Queensland Branch and a post-graduate student at James Cook University, Townsville, where she is studying the systematics and biogeography of the camaenid land snails of eastern Queensland.

You can learn a lot about the history of Macquarie Street just by looking at the pavement.

Macquarie Street's Sydney Hospital hasn't always enjoyed such an established and conservative title.

Last century, the site was occupied by a hospital which was named after the preferred liquor of the day, namely, Rum.

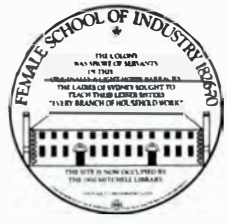
In 1810, three Sydney businessmen built the city a magnificent hospital in exchange for the coveted monopoly over the city's Rum trade.

This became the Rum Hospital, and stood complete until 1876, when the central block was demolished to build the present Sydney Hospital.

Further down the street you'll find the site where the Female School of Industry once stood.

In 1826, before anybody had even heard of 'Feminism,' the colony ran short of servants.

Accordingly, the ladies of the colony set up the Female School of Industry in order to teach their lesser sisters "every branch of household work." The site is more appropriately occupied now by the Mitchell Library.



The fact is, Macquarie Street is more than just another city street.

It is Sydney's, if not Australia's, most interesting thoroughfare.

In an effort to pay tribute to this, Caltex, in association with the NSW Public Works Department, has laid twenty commemorative footpath plaques along Macquarie Street, each marking a historical site.

So if you want to find out what Sydney was really like in the early days, look out for the Caltex Commemorative Plaques on your next stroll down Macquarie Street.

You could learn a lot simply by watching where you walk.

THE COMMEMORATIVE PLAQUES SPONSORED BY CALTEX

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"In their innocence, these pioneers left behind a trail of destruction in a country susceptible to land degradation. They were not to know of terms such as salinity and acidity, of woody weeds or soil structure decline."

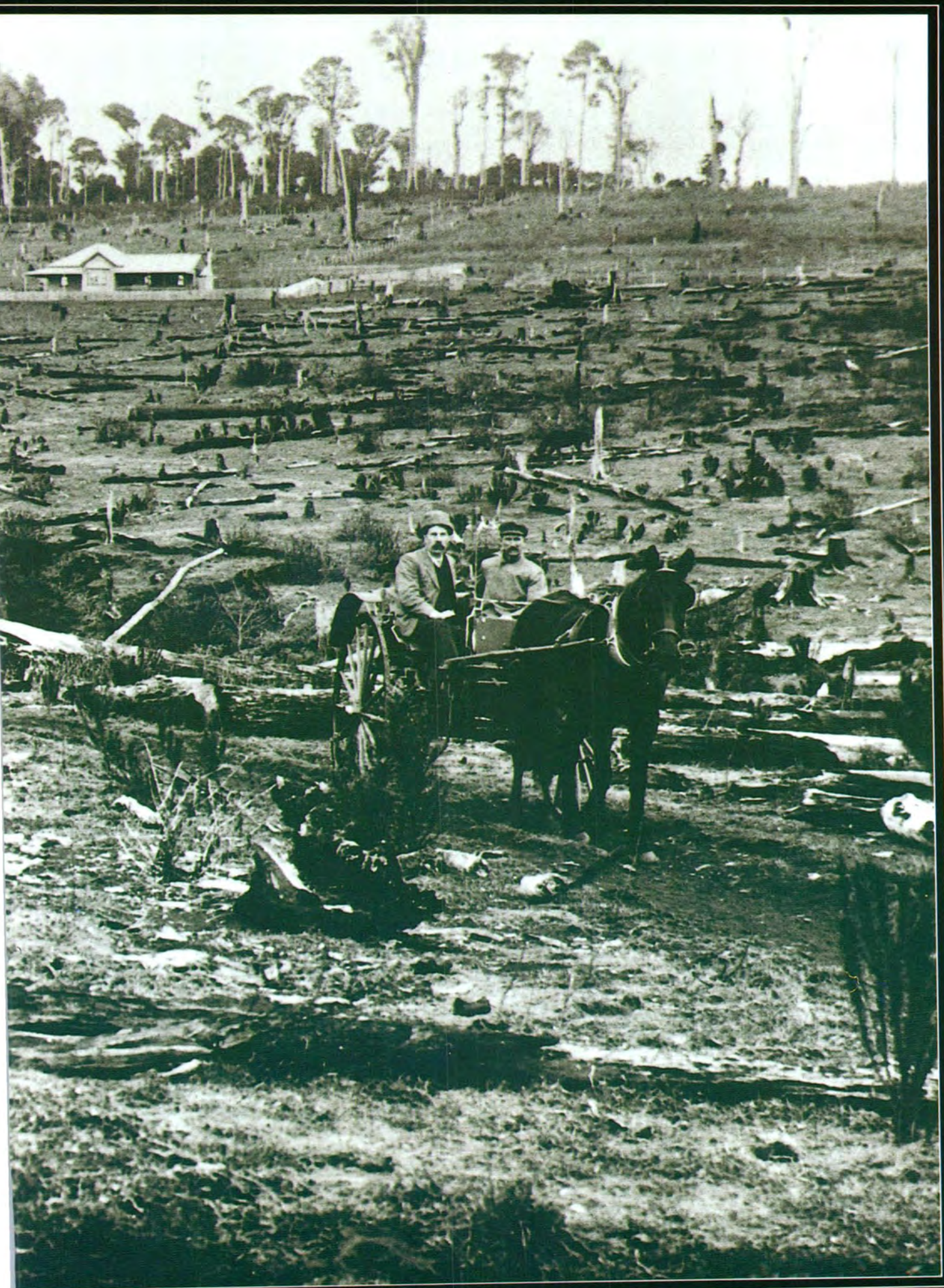
MAKING UP FOR LOST GROUND

BY MAURA BOLAND
SOIL CONSERVATION SERVICE OF NEW SOUTH WALES

JUST OVER 200 YEARS AGO, CAPTAIN Cook described a new well-forested land offering promise and hope. Following settlement, work began to establish a self-sustaining colony. Almost immediately the available land around Sydney was cleared and planted for cultivation. When the resulting meagre harvest disappointed the settlers, they looked westward. They found some encouragement in the Hawkesbury region, near the footslopes of the Blue Mountains, but the pressures of a growing population forced a move further inland to the Western Slopes. There they cleared the sclerophyll forest so typical of early Australia, for fuel and building materials and to make room for crops.

It soon became obvious that Australia was not a land with the rich fertile soils of Europe. Ever-decreasing crop yields forced many settlers to search further. Overgrazing, by stock and introduced vermin such as rabbits, compounded the problems. Thus, a cycle of clearing, planting and moving on was established. In their innocence, these pioneers left behind a trail of destruction in a country susceptible to land degradation. They were not to know of terms such as salinity and acidity, of woody weeds or soil structure decline, or even of gullies.

In their innocence, Australia's early pioneers left behind a trail of destruction in a country susceptible to land degradation.



TYRELL COLLECTION/ACP

IT IS WIDELY ACCEPTED THAT THE MOST urgent and difficult environmental threat facing Australia is not the greenhouse effect nor the destruction of the ozone layer—it is land degradation. Australia's soils are fragile and shallow. Without a protective covering more problems than could ever have been imagined are beginning to surface. This is particularly true for New South Wales, where a recent Statewide survey on the extent of land degradation by the Soil Conservation Service of New South Wales (SCSNSW) revealed some frightening and startling figures.

Land degradation is a decline in the quality or condition of the land. It arises as a consequence of misuse of that land—and this can be as simple as planting the wrong crops. Land degradation affects us all, both in terms of consequence and solution. The people of New South Wales are paying the costs of land degradation through decreased production yield and increased production costs. However, horror stories of devastated land aren't important now. What matters is halting the problem and, more importantly, doing what is necessary to avoid future problems.

Erosion is the best known and most visible form of land degradation. Most people, whether urban or country dwellers, will have at some time seen the sinister beauty of a gully, deeply etched into the land, or the choking intensity of a severe dust storm. Soil erosion takes many forms, the most common being sheet, rill and gully erosion by water, and wind erosion in drier areas. What they all have in common is their basic cause—removal of the binding vegetative plant cover.

Sheet and rill erosion both start when water flows across bare, unprotected country. Rain loosens the surface soil particles and then runoff washes them away. In the case of sheet erosion a fairly uniform layer of topsoil is lost from the land surface. By contrast, rill erosion occurs when the soil loss results in the formation of many smaller channels, similar to tiny gullies. Rill erosion often occurs in recently cultivated or disturbed lands. Both of these types of erosion cause problems because it is the fertile topsoil that is lost. To compound the problem this same topsoil silts up streams and water storages. What little fertile soil we have is literally going down the gurgler.

The most important thing to do in areas affected by sheet and rill erosion (which account for just over ten per cent of the State) is to stabilise the soil. This is best done by establishing and maintaining a good ground cover of grasses, shrubs and leaf litter. If cultivated lands are affected, reducing the speed of surface runoff or diverting it to a safe disposal area by building soil conservation structural works, such as contour banks, will reduce soil loss. Changes in management practices are also necessary. For example, using reduced or no-till systems, which involve minimum tillage and stubble retention after crop harvest, will ensure that there is always a protective ground cover. On grazing lands, this type of erosion can be minimised by adjusting stocking levels so that ground cover is not overstressed, or by installing more watering points so that stock are more evenly distributed.

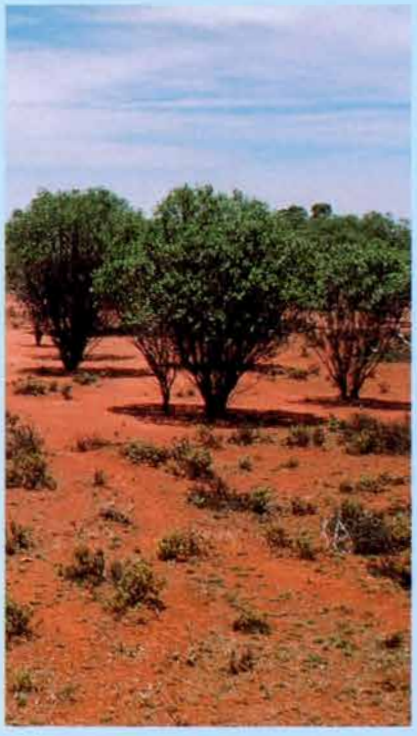
Gullies are possibly the most dramatic reminder of the way our land has been misused. Those deep channels that cut their way through otherwise productive land affect to some extent almost 25 per cent of the State. Gullies form along areas of concentrated surface water flow. Like sheet and rill erosion, the effects of gully erosion are far-reaching: they carve up areas of farming land, making associated production costs higher; they destroy roads and railways, as well as other farm improvements, by undercutting or burying them; and they remove the fertile topsoil layers, depositing them as sediment in creeks, rivers and other water supplies.

Where gully erosion is only minor, soil conservation earthworks can be constructed to treat the problem. These are successful when used in conjunction with the crop, pasture and soil management practices appropriate for the land. However, if the gullying is severe, there is no alternative but to change the land use to one of a lesser intensity. For example, if lands are currently used for cropping, they might be converted to grazing. If particu-

WOODY WEEDS

Plants are not always desirable for soils. Plants such as woody weeds are regarded as the single greatest menace threatening the pastoral lands of western New South Wales. These inedible native plants are rapidly invading large areas of the semi-arid and arid regions of the State. Only 33 per cent of the Western Division remains free from infestation. Their distribution and density are increasing due to favourable environmental conditions and a lower incidence of fire. Unfortunately, woody weeds flourish under the same environmental conditions as more useful trees and shrubs.

Few of the native trees and shrubs that grow in the Western Division have become a problem. Those that do include Turpentine (*Eremophila sturtii*), Budda (*E. mitchelii*), Broadleaf and Narrowleaf Hopbush (*Dodonaea viscosa* var. *arborescens* and *D. attenuata*), Punty Bush (*Cassia eremophila* var. *eremophila*) and Silver Cassia (*C. artemisioides*). High densities of these native plants have not just resulted from normal regeneration but also because a changed environment works in their favour.



Bare ground at the base of clumps of woody shrubs is an erosion hazard.

Once established, woody weeds severely restrict the growth of surrounding pastures due to competition for moisture and light. Beneath dense stands of mature plants, ground cover is virtually absent. The bare ground is exposed to wind and water, and sheet, rill, gully and wind erosion result. The reduced feed available on susceptible land forces livestock and native animals onto unaffected areas, where they graze heavily. Consequently, these areas become more susceptible to degradation and woody weed invasion. To the grazier, the effects don't stop there. High densities of woody weeds make stock mustering longer and less efficient. They also lead to overgrazing, less drought resistance for the property, greater losses during periods of fly strike, lower lambing rates and lower land values. Economically, they are a disaster for the landholder.

Controlling the spread of woody weeds is not easy. Developing a method of biological control is unlikely since they are native species and have no known significant diseases or predators. The most efficient and economical time to control woody weeds is before they form dense mature stands. This way, pastures are maintained, management difficulties are avoided and the bare ground that leads to soil erosion never eventuates. When young, plants can be controlled by prescribed burning. This is also a useful treatment for scattered shrubs. If treatment is very selective, chemical control by point application can be appropriate. Mechanical control, including pushing, chaining and root ploughing or using 'land imprinting' rollers (which restrict wind and water erosion), can control more densely infested areas. Cropping is another alternative but is limited to areas of reliable rainfall.

A combination of treatments is often the best solution. It is also usually necessary to have several follow-up treatments to completely rid an area of woody weeds. Some of these controls can be quite costly, but the cost is small compared to the cost of not removing them. By controlling woody weeds now, future costs and losses of production will be much lower over many years and land values will be maintained and improved.

OWEN GRAHAM

Replanting of natural vegetation on eroded land near Alice Springs.

WA PHOTO INDEX

larly severe, they should be rested completely and allowed to revert to native forest. Unfortunately, six per cent of the State suffers from severe to extreme gully erosion.

GULLIES, SHEET EROSION AND RILLS ARE all problems with well-researched answers. But there is a new generation of threats to the soil emerging from our tree-felling past: salinity, acidity, soil structure decline—even the names sound complex. And so are the problems. Many of these new problems take up to half a century to emerge. Hopefully they won't take that long to subdue.

Latest research suggests that soil structure decline costs more than any other form of land degradation; an estimated $144 million per year in the Murray–Darling Basin alone. Over 18 per cent of the State is moderately to severely affected by soil structure decline, most of it on lands used for cropping. This is only too understandable when the causes of soil structure decline are known.

A stable soil structure is the basis of good, healthy soil. When the arrangement of soil particles and the air between them is stable, an optimal amount of water can infiltrate, roots can grow unhindered and well aerated, and plant growth is vigorous. Well-structured soils are also more resistant to erosion.

Cropping practices are responsible for many unwanted changes in soil structure. Heavy machinery used in tillage can destroy soil aggregates and compact the soil, forming a dense layer known as a plough pan at the base of the cultivation layer. Land practices incorporating tillage reduce the amount of organic matter that can contribute to soil fertility. Stock trampling can also contribute to soil structural decline particularly when cultivated soils are grazed in wet weather. Ultimately, conventional tillage can result in reduced crop yields; the very opposite of the desired outcome!

Land management practices hold the key to arresting the degradation problem. The quickest and most efficient way to reverse soil structure decline is to establish a good pasture of fibrous-rooted grasses. On cropping land, conservation farming techniques can mean the difference between pasture that is good for only a few years and that which is sustainable. It is essential to incorporate pasture leys, when only grass is grown, for a sufficient length within cropping rotations. In addition, practices that involve machine-sowing seeds directly into the soil (direct-drilling) with little or no-tillage reduce the chance of compaction. If these methods are used, grazing, burning or herbicides are advisable to minimise competition with weeds. Green manure crops, such as lupins or peas, can also be used to increase the organic matter content of some soils.

In the search for ways to improve on poor soil productivity, fertilisers were widely applied. Ironically the nitrogen and superphosphate fertilisers that are used to 'boost' the production of New South Wales' relatively infertile soils are now proving yet another burden, being a major cause of induced soil acidity. Nitrogen-fixing bacteria convert nitrogen in the form of ammonium salts to nitrates and nitrites—forms that plants can use. Significant acid levels may be generated in the process with negative effects in the longer term. And even more complex chemical reactions lead to the acidification of soils subject to superphosphate application. Other land

Sheet, rill and gully erosion on the eroding lunette at 'Walls of China', Willandra Lakes National Park.

OWEN GRAHAM

Poor land practices can result in topsoil being blown away in dust storms such as this one near Bourke.

REG MORRISON/WELDON TRANNIES

COURTESY SOIL CONSERVATION SERVICE

Before and after: a gully is treated by levelling and using straw mulch to encourage plant growth.

uses that introduce excess amounts of nitrogen into the soil, such as nitrogen-fixing legume pastures (clovers), also contribute to soil acidity.

Once present, induced soil acidity can affect the soil's delicate chemistry. Available aluminium and manganese may reach toxic levels if increasing acidity liberates these elements from normally insoluble compounds. Induced soil acidity leads to reduced pasture growth and crop production. As with so many environmental imbalances, the effects don't just end there. The resulting decreased ground cover increases the susceptibility of the soil to erosion.

Like many other land degradation problems, changes to land management practices are needed to reclaim acidic soils. These can include liming, altering fallowing practices and using deep-rooted perennial species. Fertiliser use can continue if it is ammonia-based, while in the legume-dominant pastures, grass levels should be increased. In the short term, acid-tolerant plant species can be used to stabilise the soil while it is being managed back to health.

Salinity is one of the recently identified land degradation problems that has attracted the most attention. Many hectares of Australia's food bowl, the Murray–Darling Basin, are threatened by this insidious form of erosion.

The schemes to irrigate south-western New South Wales by controlling vast amounts of water from the Murray and the Murrumbidgee Rivers have had some unforeseen and unwanted consequences in some areas. Where the newly irrigated areas have been located above ancient salt beds, irrigation salinity has resulted. Too often, this is intensified where poor management practices mean that more water than a crop could possibly use is applied. The excess water filters through to the watertable. As more water accumulates in the soil, the table rises, bringing with it the ancient salts. Eventually the salt accumulates at the surface, stifling trees, crops and pastures. Ironically, it is the horticultural crops of citrus, vine and stone fruits, which the scheme was designed to promote, that are the worst affected.

If the watertable in these areas is not lowered, New South Wales may find that its 'garden' will become barren. Unfortunately, it is far easier to prevent irrigation salinity than to treat it. Prevention can be achieved by choosing the right soils and carefully planning the irrigation program so that only enough water for the needs of the crop is applied. Timing of water application should be based on soil moisture levels. For areas of flood irrigation, the slope needed for optimum water flow is very small. Laser levelling can be used to obtain the exact slope, thus reducing water wastage. For areas already affected, mechanical systems such as deep drainage can be used to lower the watertable. But as with all types of land degradation, prevention is better (and cheaper) than cure.

Away from the irrigated areas of south-eastern New South Wales, dryland salinity wreaks its own insidious form of havoc. Who of the pioneer settlers would have thought that beneath the gently sloping hills they cleared for pasture lay millions of tonnes of salt? The shallow-rooted grasses and crops that replaced the deeper-rooted dry sclerophyll forest move far less water though transpiration. As with irrigation salinity, the excess rainfall intake causes the water levels to rise. Where the watertable intersects the land surface, often at the footslopes and drainage depressions, saline water seeps out—hence the name saline seepages. Water evaporates from these

Conservation farming: no tillage. Here a wheat crop is growing from stubble.

COURTESY SOIL CONSERVATION SERVICE

COURTESY SOIL CONSERVATION SERVICE

OWEN GRAHAM

Irrigation salinity: the saline watertable has risen above the surface in a local depression.

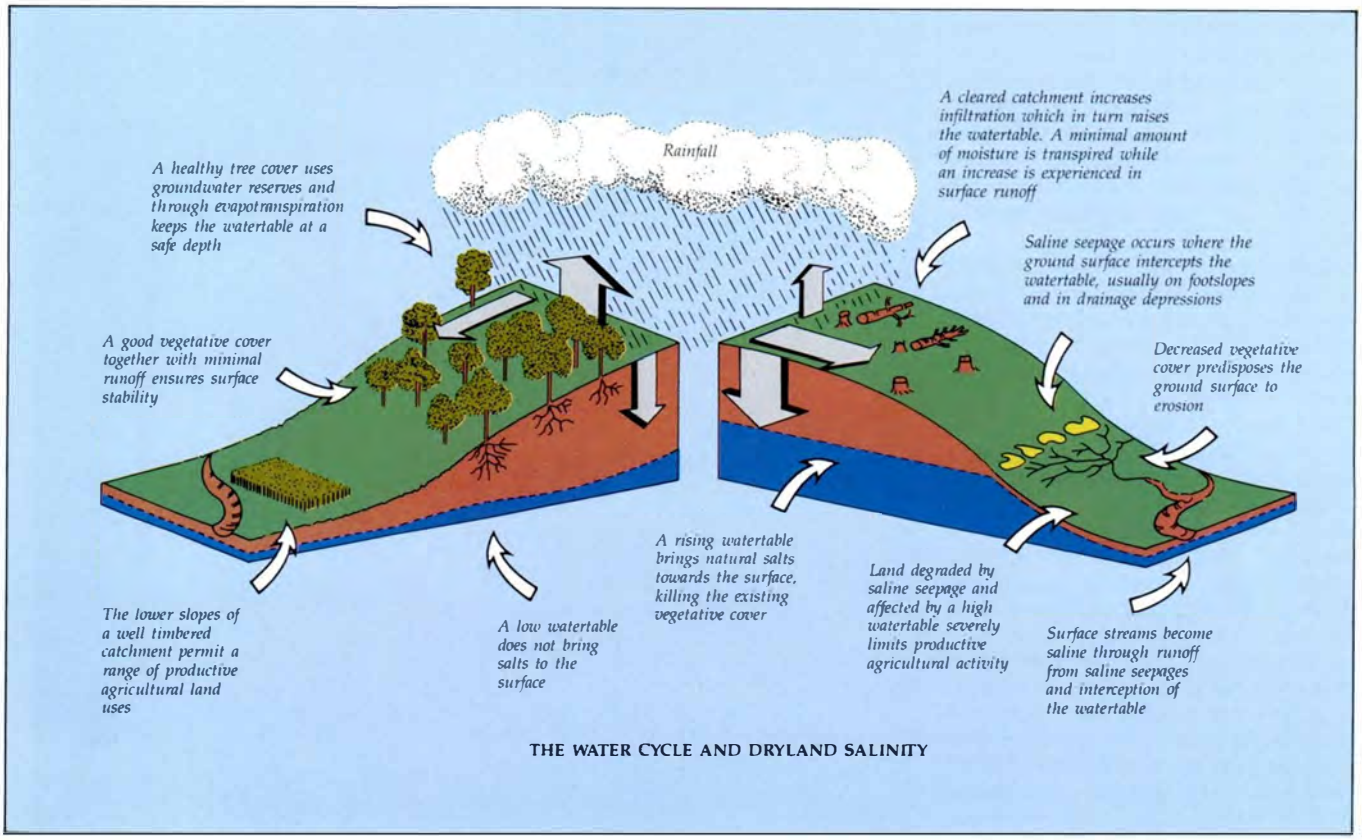
areas, leaving salt crystals. Normal vegetation is unable to grow and only the most salt-tolerant species survive. Stock often congregate on the bare areas to lick the salt and their trampling leads to further erosion.

Dryland salinity is one of the most difficult problems to treat. This is not because the solutions aren't known. Rather it is because most of the problems are remote, in both time and distance, from the source. Often this means that land owned by many different people is affected. And where the creek and river water becomes saline, thousands of people can be affected. But the problems are often not apparent at the source.

Nonetheless, there are many things that can be done to ease the problem of dryland salinity. Treatments must involve both the point of water entry (the 'groundwater re-

Drawing up a farm plan is a necessity for every landholder.

COURTESY SOIL CONSERVATION SERVICE



THE WATER CYCLE AND DRYLAND SALINITY

charge zone') and the point of water exit (the 'groundwater discharge zone'). Most importantly trees must be re-established on the groundwater recharge zone. Ideally, a dense stand of deep-rooted trees should be established, to increase evapotranspiration and ultimately lower the watertable. A good growth of deep-rooted gum trees can lower the watertable within as little as four or five years—a short time when compared to a possible 50 or 60 years for the problem to emerge!

At the point of saline water discharge, a number of things can be done to improve the situation and to minimise further damage. Revegetation with salt-tolerant grasses, herbs, shrubs and trees can stabilise the soil and stop the salt-laden particles washing into streams and other surface-water systems. This can be helped by ripping the site and applying surface mulch to encourage germination. Keeping stock out of the area means the land doesn't have the added strain of hoofs to cope with. Soil conservation earthworks can be constructed to divert runoff and deep drainage systems can be installed. And, more significantly, land management practices must adapt so the land is not abused—albeit often in ignorance.

Perhaps more than any other form of land degradation, dryland salinity requires a total community response. Many have claimed that it isn't 'fair' to ask landholders to bear the cost of fixing problems that are often not of their making, but that have been developing for many years. This is particularly true for salinity, where those who hold land at the point of cause don't see a problem. However, it also isn't 'fair' to ask the Government only to bear the costs of saline seepage. Because the problem can affect such a wide area, the best solution seems to involve whole communities.

One whole community in the Yass River Valley is now doing just that. In a project developed and implemented by the SCSNSW and financially backed by the National Soil Conservation Program (NSCP), the Yass Valley Community are fighting their own battle against salinity.

This is the future in the fight against land degradation. The New South Wales State Soils Policy has stated that the New South Wales community as well as individual landholders have a responsibility for preventing and mitigating land degradation. Recognising the importance of widescale involvement in trying to save the land, the NSCP has made financial assistance available to community groups who aim to encourage the control of land degradation, and to promote and demonstrate sustainable land use practices.

It is important for individual landholders to remember that they can and must act. Treatment can be expensive and sometimes results aren't seen in the short term. These disincentives are significant to a farmer who is barely making a profit. But even a little change in land management may be enough to make some difference. Having a farm plan drawn up to determine optimal farm layout and necessary improvements is a start. Even if only some of the features are incorporated immediately, it can form the basis for future works. Plant trees. Trees are one of the most necessary and useful features of any property. They can act as windbreaks, shelter for livestock, and eventually serve as food or timber for furniture. All these actions can accumulate. And remember that expenditure on approved soil conservation work is a cost that is tax deductible for a primary producer.

The soils of Australia took many thousands of years to form. We have managed to damage 80 per cent of these soils in just under 200 years. Soils are not renewable. Failure to protect them could see us suffer the same fate as Egypt and Babylon, swallowed by the sands of time. We know how to contain land degradation. All that is now required is for us to act responsibly. ■

Suggested Reading

Australian Soil Conservation Council, 1989. *National Soil Conservation Strategy.* ASCC, AGPS: Canberra.

Soil Conservation Service of NSW, 1988. *Soil Conservation.* SCSNSW: Sydney.

Soil Conservation Service of NSW, 1989. *Land Degradation Survey, NSW 1987–88.* SCSNSW: Sydney.

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FARM TREES

It is almost impossible to overestimate the importance of trees in treating land degradation. No other treatment can be used as an antidote to so many problems. Excessively steep slopes can be protected, degraded or eroded areas reclaimed and problems with salinity alleviated with tree retention, regeneration or the planting of new trees.

The advantage of using trees as a treatment for land degradation is that they also serve so many other purposes. Rows of trees planted as windbreaks can reduce cold stress in livestock, by minimising the heat-stripping effects of cold, strong winds. Clumps of trees can provide shade for livestock in hot weather, lessening heat stress. Windbreaks also protect pastures and crops, since they reduce the moisture stress caused by strong winds, an especially important consideration for horticultural crops. They can also reduce the speed of fire advance to less than ten per cent of that in open grassland, an advantage if used at strategic points. In droughts, emergency fodder can be found in trees, while they also provide a habitat for a diversity of wildlife. And at the same time as the root system and leaf litter provides soil with a structural stability, they aesthetically improve the landscape.

Large-scale farm tree-planting is the easiest method of soil treatment. There are no general rules for the best location to plant trees. This should be worked out on the basis of the specific property, since it is dependent on land capability, soil type, rainfall distribution and frost severity as well as other climatic factors. It also depends on the purpose for which the trees are intended. When trees are being used to stabilise and treat problem areas, special attention should be paid to species selection, soil preparation and care of trees. Such sites are often particularly fragile and trees may need special attention for satisfactory growth.

As an alternative to tree-planting, fencing and stock management can be considered, encouraging natural regeneration to take place.

COURTESY SOIL CONSERVATION SERVICE

Windbreaks protect crops from moisture loss due to high winds.

The planning stage of any effort to improve tree numbers is probably the most important stage. Once it has been established why and where trees are needed, it is then important to prioritise which parts of the plan are most important. For example, it could be urgent to stabilise an area affected by saline seepage, while less important to establish a wildlife habitat. Once prioritised, planting can then proceed at a pace appropriate for financial and other constraints. But at least a small number of trees should be planted every year in an effective program. As well as spreading the financial burden, this results in a diversity of age classes, an important consideration where few trees already exist.

MEEHAN-JONES COLLECTION

"It now seems likely that these extinctions are ominous signs of an environmental collapse that began 40,000 years ago and is continuing unabated at present."

WHO KILLED KIRLILPI?

BY TIM FLANNERY

HEAD OF MAMMALS, AUSTRALIAN MUSEUM

KIRLILPI, AS THE WARLPIRI ABORIGINES knew the Desert Bandicoot (*Perameles eremiana*), is just one of 20 mammal species to have become extinct in Australia since European settlement. Tragically, many of these extinctions have occurred in the last 30 or so years. This string of extinctions ranks among the most catastrophic in the world, accounting for just under a third of all mammal species to have become extinct worldwide in the last 500 years. A decade ago just about everyone was certain about the cause of this extinction event. The standard line went that the 'primitive' marsupials had given way to the 'superior' placental predators and herbivores, such as the fox and rabbit, that Europeans had introduced to the country.

Evidence that has been accumulating over the past two decades (and that led to the argument put forward here) shows that

AN EXAMINATION OF AUSTRALIAN EXTINCTIONS

this simplistic assessment was wrong. It now seems likely that these extinctions are ominous signs of an environmental collapse that began 40,000 years ago and is continuing unabated at present.

But before abandoning the old theory it is worth establishing just why it doesn't fit the facts. Perhaps the most telling evidence concerns the peculiar specificity of the extinction event. Almost all the mammals to have become extinct were of medium size (between 150 grams and five kilograms in weight) and inhabited the arid and semi-arid zones. Central Australia still supports the most diverse lizard fauna on Earth and, although distributions may have altered, not a single extinction has been confirmed among its many reptiles, birds, or its large or very small mammals. Yet hardly a single medium-sized mammal species survives there today. The effects of hard-hoofed stock and the predation of foxes and cats should surely have affected far more than just the medium-sized mammals. Indeed, in other parts of the world cats alone have been responsible for the extinctions of a wide range of vertebrates, from wrens to crested pigeons. Furthermore, it was not just the 'primitive' marsupials that were affected; over half the extinct species were native rodents of the family Muridae. This family of eutherian mammals contains, among the most successful of the world's mammal species, the Black Rat (*Rattus rattus*) and House Mouse (*Mus musculus*). Also, the medium-sized marsupials of Australia's wetter areas have survived with hardly a single extinction. But the *coup de grace* to the old theory was finally delivered, to my mind at least, by work carried out by Dr Ken Johnson and his team at the Alice Springs Arid Zone Research Institute (see also ANH vol. 21, no. 12: 544–546, Autumn 1986). They have shown that mammal extinctions occurred in areas where stock never reached and where fox and cat predation was minimal. They also demonstrated that Aboriginal firestick farming (a management practice first elucidated in this magazine in 1969 by the eminent archaeologist Dr Rhys Jones, Australian National University) was an important factor in maintaining suitable conditions for the medium-sized mammals. Before moving to settlements and other communities in the early days of European colonisation, Aborigines regularly burned the landscape, and Johnson and others put forward the idea that this maintained an elevated level of plant diversity and enhanced availability of food and shelter

Anbarra women and children burning floodplains in Arnhem Land during the late dry season.

This mihrung (*Genyornis newtoni*) was one of Australia's largest birds. It became extinct during the late Pleistocene.

over time. In such conditions the fauna is better able to withstand the effects of drought, predation, competition for resources etc., and large-scale fires are prevented from destroying everything in their path.

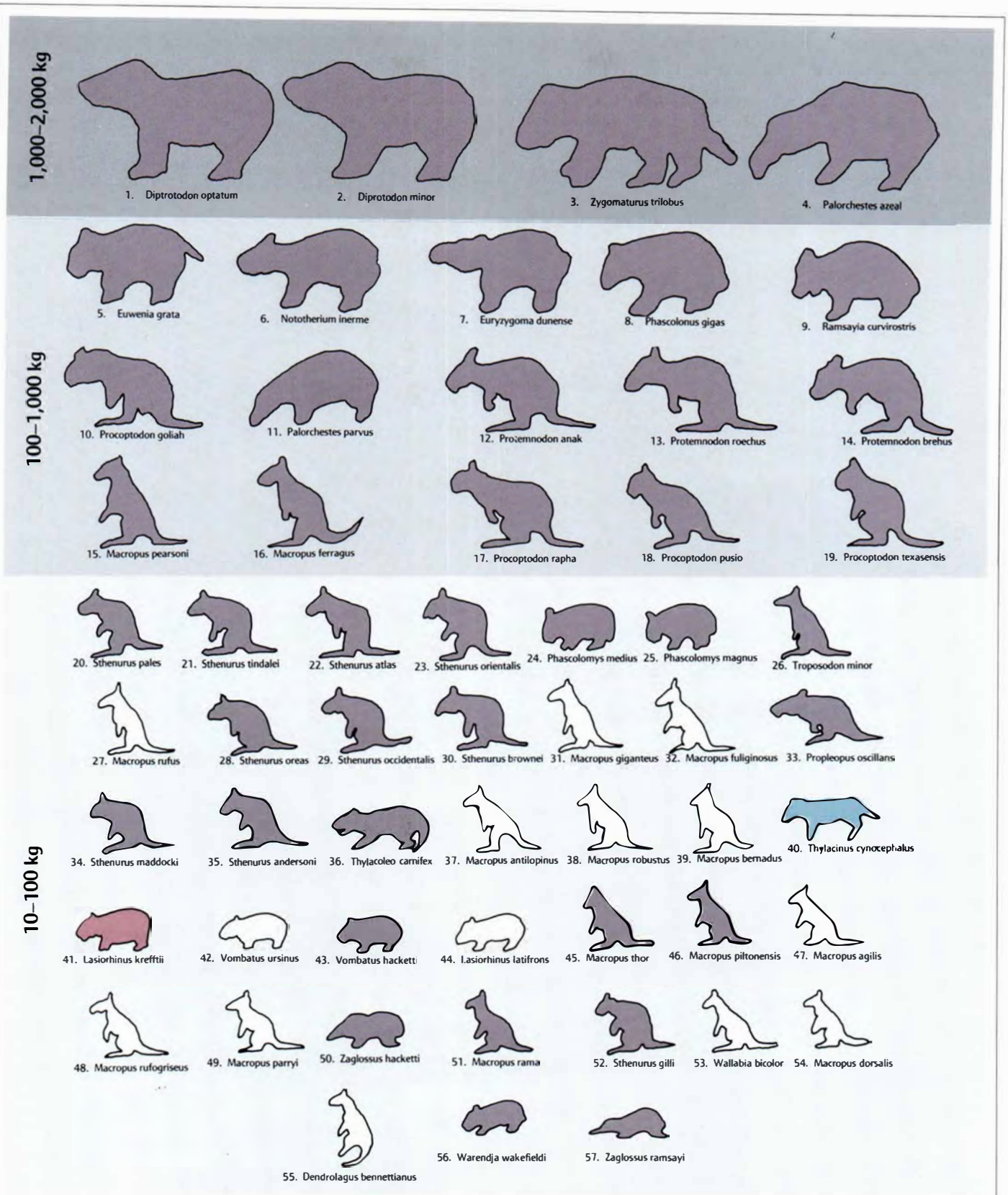
But even this important breakthrough failed to provide a fully satisfactory explanation. Being trained in palaeontology, I have always wondered how, if firestick farming was so important, did the medium-sized mammals survive before the coming of the Aborigines? An understanding of this, I think, is the key to the whole puzzle. Pre-Aboriginal Australia was a very different place to what it is today. Forty thousand years ago, large numbers of very large birds, reptiles and marsupials roamed the landscape. Australia at that time was like Africa is today, with its complex savanna ecology and abundant large mammals. Because of the numerous large plant-eaters, it seems likely that there was rarely enough vegetation to support constant or vast blazes. We know, however, that these great animals disappeared from Australia. Could the development of Australia's fire-prone ecosystem date from the time of their demise? I am convinced that the first Aborigines were, through hunting, responsible for these extinctions and that the extinction event greatly altered the Australian environment. In central Australia most of the vegetation had been within reach of the extinct plant-eaters and, once released from the browsing and grazing pressure, the bushes, grass and low trees must have grown enormously, as in a paddock left unstocked for a number of years. Soon enough vegetation would build up to enable enormous wildfires to ravage the landscape, burning millions of hectares. The medium-sized mammals simply couldn't cope with this. Unlike reptiles they are unable to burrow and fast until the plant growth returns; and unlike the large mammals they cannot bound off to new areas and return in a few months when green pick is available. The small unburned patches that fires always leave behind would have been sufficient to support the smallest mammals, but their medium-sized relatives were doomed, for the large fires simply leave insufficient resources for them. Hungry, they would have foraged in ever-more dangerous and open places, until predators or malnutrition finished them off. By the time replacement animals could migrate from distant areas, fire would have destroyed their refuges too.

If this admittedly speculative hypothesis is correct, then why didn't medium-sized mammals follow the path of extinction 40,000 years ago, along with the Pleistocene giants? I suggest that this

AUSTRALIAN MUSEUM

HANS & JUDY BESTE/AUSCAPE INTERNATIONAL

Birds like these Brolgas are less affected by fire than medium-sized animals because they can easily move to the most suitable areas.



MAMMALS MARKED FOR EXTINCTION

Schematic representation of Australian mammals that weighed more than ten kilograms before the arrival of humans. Species coloured grey became extinct some 30–40,000 years ago, those in blue became extinct in historic times, and those in pink have suffered drastic range reductions. This impoverishment of Australia's large animals must have affected plant communities and thus fire regimes.

SHANLEY MORRIS

C. & S. POLLITT/ANT PHOTO LIBRARY

Reptiles survive fires and their aftermath because they can readily find shelter and can exist for long periods without food.

'trophic cascade' of extinctions was arrested by the Aborigines' practice of firestick farming. Really large fires must have struck at the core of Aboriginal existence, for the loss of the medium-sized mammals, which were an important food source, could have spelled disaster following the loss of the megafauna. Thus it was crucial for Aborigines to halt the extinction cascade. Whether deliberately or through trial and error, they apparently found that if they continually burned the landscape, small fires—not large ones—resulted. Small fires do not affect the medium-sized mammals and, because of insufficient fuel, really large blazes could not threaten the animals' resources. Thus was born the important management technique of firestick farming. Of course at present such management is not given as a reason for lighting fires, but it is inevitably a result.

It appears that things went well for 40,000 years or so, until Europeans came along and removed both Aborigines and firestick farming from the landscape. In the series of gigantic blazes that have erupted periodically in Australia's arid regions in historic times, that tragic extinction cascade was allowed to flow again, and finally it consumed our beautiful bandicoots, wallabies and native mice.

ALREADY I HEAR CRITICS SHARPENING their knives at my scenario, so perhaps it is best to meet their questions head on and tackle the really difficult issues. They are, to my mind, the following.

The fact that much of the Australian vegetation is highly adapted to fires indicates to some people that fire has been part of the landscape for millions of years and thus could not have caused the extinctions. I suspect that fire has *not* been

The Latest Lost List

Species	Habitat	Last Recorded
Thylacine (*Thylacinus cynocephalus*)	Tas.	1936
Desert Bandicoot (*Perameles eremiana*)	centre	1931
Pig-footed Bandicoot (*Chaeropus ecaudatus*)	south, centre	1907
Lesser Bilby (*Macrotis leucura*)	centre	1931
Broad-faced Potoroo (*Potorous platyops*)	dry south-west	1875
Desert Rat-kangaroo (*Caloprymnus campestris*)	centre	1935
Eastern Hare-wallaby (*Lagorchestes leporides*)	dry south-east	1891
Central Hare-wallaby (*Lagorchestes asomatus*)	centre	1932
Crescent Nailtail Wallaby (*Onychogalea lunata*)	south-west, centre	1956
Toolache Wallaby (*Macropus greyi*)	south-east savanna	1924
White-footed Rabbit-rat (*Conilurus albipes*)	dry south-east	1870s
Gould's Mouse (*Pseudomys gouldii*)	south, centre	1860s
Alice Springs Mouse (*Pseudomys fieldi*)	centre	1985
native mouse (*Pseudomys* sp.)	south-east savanna	?
Lesser Stick-nest Rat (*Leporillus apicalis*)	centre	1933
Big-eared Hopping Mouse (*Notomys macrotis*)	dry south-west	1844
Long-tailed Hopping Mouse (*N. longicaudatus*)	south-west, centre	1902
Short-tailed Hopping Mouse (*N. amplus*)	centre	1896
Darling Downs Hopping Mouse (*N. mordax*)	east	1840s
hopping mouse (*Notomys* sp.)	centre	?

Two immature Pig-footed Bandicoots. Like the Kirlilpi, or Desert Bandicoot, and 15 other medium-sized mammals, these animals vanished from Australia after European settlement. Why?

NPIAW

MARTIN COHEN

Lignotubers of mallee eucalypts serve well as a defence against fire, but did they evolve to fulfill that role?

DICK WHITFORD/ANT PHOTO LIBRARY

The Numbat, once distributed throughout much of southern and central Australia, occurs only in the wettest part of its range: the south-west of Western Australia.

HANS & JUDY BESTE/AUSCAPE INTERNATIONAL

Rock wallabies such as *Petrogale lateralis* are the only medium-sized mammals to have survived in central Australia. Their rocky habitat may insulate them from the effects of fire.

overwhelmingly important in the Australian ecosystem until people arrived. Many of the features that we think are adaptations to fire (such as the lignotubers of mallee eucalypts) may have developed in response to other factors, such as low soil nutrient levels (as suggested in 1968 in a paper by N.C.W. Beadle of the University of New England). Thus our flora may be pre-adapted to fire, and 40,000 years of intense fire selection may have greatly benefitted such pre-adapted species, but it is as yet far from clear that our flora evolved in a fire-dominated system. Furthermore, analysis of pollen cores taken from Lake George near Canberra and other locations makes it clear that there *has* been a marked increase in fire and a change in vegetation type. However, this did not occur on Lake George some 120,000 years ago as previously thought, but perhaps around 50–60,000 (or maybe even 40,000 years ago), as suggested by Dr Richard Wright of Sydney University in 1986 using direct correlation. I suspect that this fire change will eventually be found to coincide with the megafaunal extinction event.

Other people, no doubt, will feel that the introduced fox and cat should be given more credit for the extinctions. After all, the offshore islands where these predators never reached have acted as refuges for many species that became extinct on the

The Thylacine became extinct on the mainland 2,000 years ago and in Tasmania by the 1940s. (Photo taken at Beaumaris Zoo, Hobart, in the early 1930s.) Inset: the rarely photographed Desert Rat-kangaroo was last recorded in 1935.

mainland. It is true that many medium-sized mammal species still survive on island refuges. However, I suggest that multiple factors are responsible for this. By their very nature these island refuges are not susceptible to supporting enormous fires. The vegetation is salt-pruned and, in many cases, topography prevents all-encompassing fires from taking hold. Even if they are burned, an important part of the extinction equation is missing: there are *no* mammalian predators on the refuge islands. Animals can therefore forage in exposed positions without being eaten. Although, of course, times would be lean after fires, some animals would survive. Thus it is not the lack of cats or foxes *per se* that is important in maintaining these refuges, but the lack of *any* form of mammalian predation, as well as diverse topography.

And why should only the mammals of the arid zone suffer, and not those of the wetter areas where fire is also important? Species such as the Brush-tailed Bettong (*Bettongia penicillata*) and Numbat (*Myrmecobius fasciatus*) survive today only in the wettest parts of their former ranges. Indeed, rock-wallabies, in their fire-insulated rocky ranges, have survived even in central Australia. Clearly something is different in these places, even though foxes and cats are present. I suspect that the fires themselves are different. Because of the increased moisture and steeper topography of the eastern and south-western coastal regions, larger unburned areas survive to act as refuges for vulnerable species.

If correct, this new view of Australia's mammal extinctions should sound a note of warning. Already these historic and prehistoric extinctions are the greatest seen in Australia since the age of the dinosaurs, and there may be more to come. Trees live hundreds of years. How are they, particularly their seedlings, faring with the new fire regime? And perhaps our plague species, such as rabbits, need to be re-evaluated in the light of this hypothesis. Are they really part of the same catastrophe, with those megafaunal extinctions of long ago 'opening' the land to them, creating an ecological 'gap' in which they could proliferate? Finally, extinctions of large mammals have happened in other parts of the world in the last 40,000 years. Are other nations also suffering ongoing ecological collapse? Whatever the case, it is clear that we need to understand much more about our distant past in order to manage the present. ■

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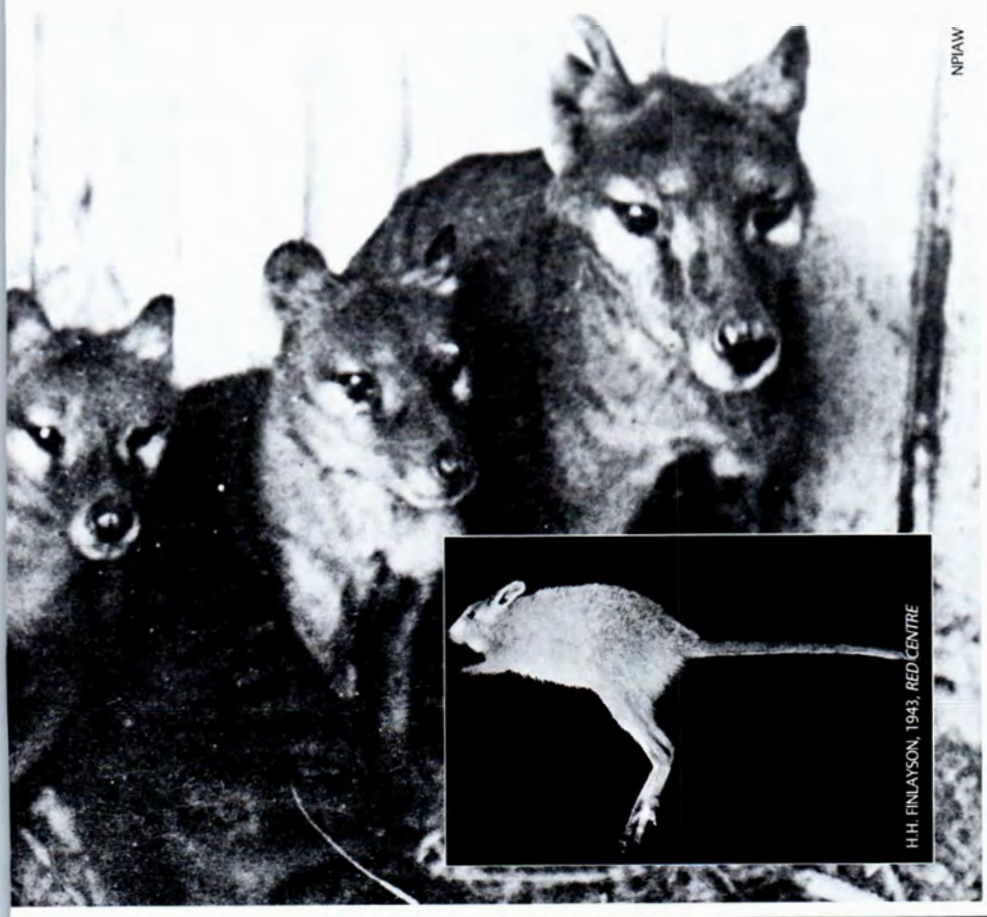
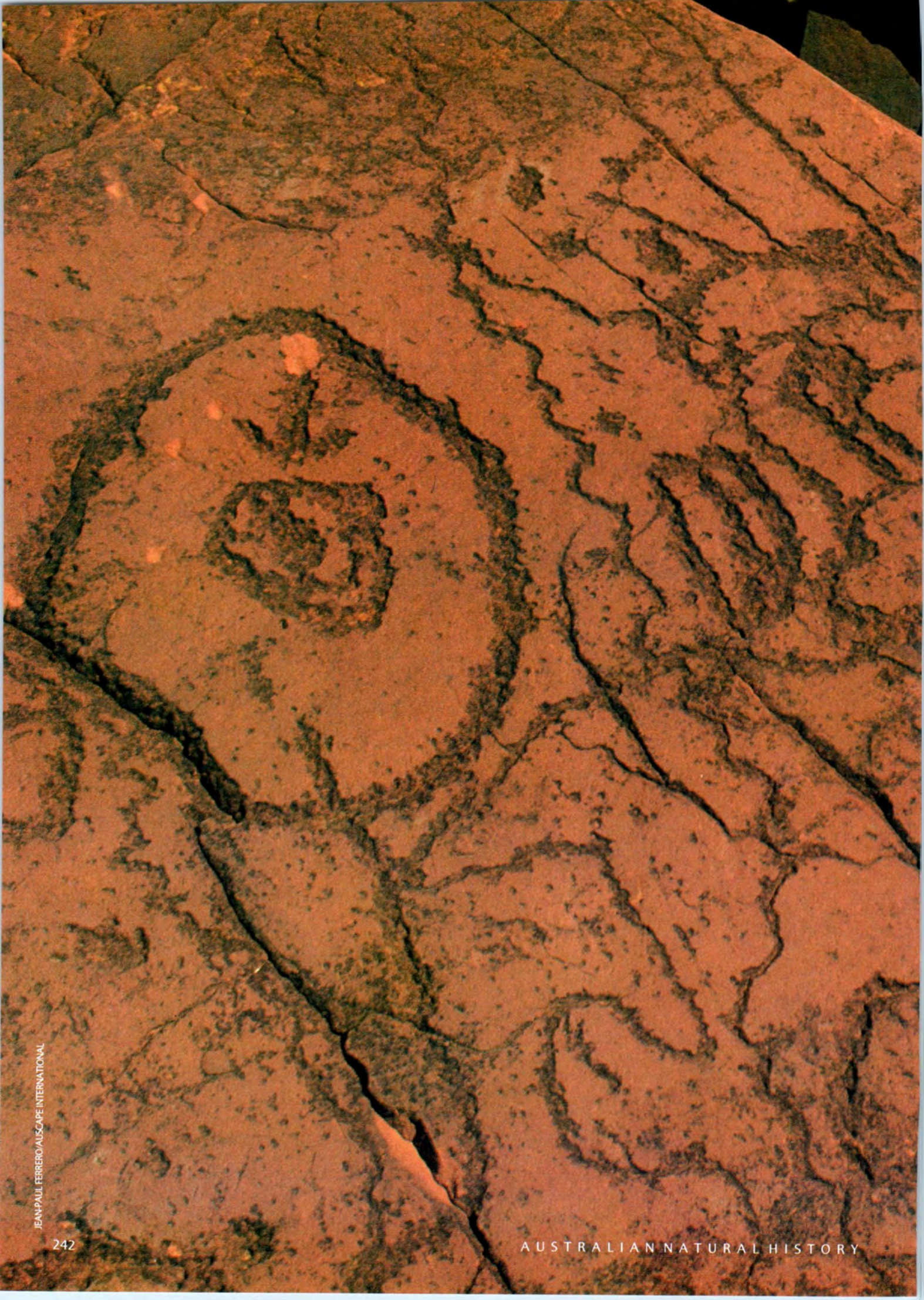
Dr Tim Flannery began his scientific career studying palaeontology. He later became involved with studying Australasia's living mammals and has long wondered how the dramatic events of the distant past have affected the present fauna. The admittedly speculative hypothesis he develops here has wide implications for wildlife management.





JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

"Finding the accurate age of Dreamtime art has been, and continues to be, an exciting challenge."

NEW CLOCKS ON OLD ROCKS

DATING DREAMTIME ART

BY ALAN WATCHMAN
SCHOOL OF APPLIED SCIENCE
CANBERRA COLLEGE OF ADVANCED EDUCATION

AUSTRALIAN ABORIGINAL LEGEND links the origin of rock art with the Dreamtime. The legend holds that, during the Creation Time, all things, such as yams, birds and snakes, lived and walked around like humans; then in the Dreamtime (thought by scientists to be the time of the last ice age—about 20,000 years ago), all things changed into Wandjina, Mimi or other spirit figures, which left their images on the rocks.

The deep significance of rock art to Australian Aborigines is underlined by the fact that it has continued to be reproduced as part of traditional ceremonies over hundreds, if not thousands, of years. Finding the accurate age of Dreamtime art has been, and continues to be, an exciting challenge.

ESTIMATES OF THE GREAT ANTIQUITY of rock art have been based on the advanced state of weathering of the engravings or the faded appearance of paintings. Often speculative ages have been given to many painted and engraved sites without sufficient scientific justification. In the past paintings and engravings have been dated by using the archaeological context in which they were found. Evidence for the age of rock art has rested with recovering either fragments of ochre or fallen pieces of engraved rock surfaces associated with charcoal from excavated occupation shelters. (Charcoal in the deposits can then be systematically dated using the radiocarbon method.) For example, in 1929, abraded grooves found on the back wall of Devon Downs rock shelter in South Australia were dated at about 3,500 years on the basis of their probable links with associated carbon-dated archaeological layers in the deposit. A number of smooth and scratched ochre fragments were found in an excavation at Keniff Cave in southern Queensland and, as dates of 19,000 years had been obtained for the deposit, it was assumed that the ochre drawings on the walls were of the same antiquity.

In 1966, engraved fragments of rock were found associated with charcoal in an excavation on Willeroo Station in the Northern Territory. Dating of the charcoal revealed an age of 7,000 years for the deposit in which the fragments were located, and a date of slightly more than this was given for the creation of the engravings. Charcoal collected from near dense concentrations of wall markings in the Koonalda Cave in South Australia has been dated at about 20,000 years. The charcoal was presumed to have originated from wooden torches, carried into the cave for light by Aborigines in search of flint nodules. It was therefore proposed that the wall markings were of the same age as the charcoal.

Examples of archaeologically dated ochres are from Cape York Peninsula in Queensland (6,870 years), Warburton Ranges in Western Australia (7,000 years), Graman (5,000 years) and Cloggs Cave (18,000 years) in New South Wales, and the Alligator Rivers region (22,000 years) and Deaf Adder Creek (19,960 years) in the Northern Territory. These dates suggest that Aboriginal artists

Estimates of the age of rock engravings have been based on the degree of weathering or archaeological associations. Recent research into the surface varnishes that form over the engravings may give more accurate minimum ages for the art.

FORD KRISTO

Paintings of extinct fauna, such as this Thylacine at Ubirr, Kakadu, have been dated using their association with known, specific extinctions. The white deposit that covers the rear quarters of the animal is a mixture of gypsum and polyhalite salts deposited from surface water flowing across the rock.

were at work throughout Australia for many thousands of years.

Paintings of ships, guns and human figures on horseback have been used to date the so-called contact period with Europeans—that is, over the last few hundred years. Similarly, extinct fauna and other animals and plants depicted in paintings have been used to estimate the age of some art styles because of their association with specific extinctions, or past geomorphological and climatic regimes.

People have also attempted to place art styles into time frames based on past environmental conditions. Categories of art styles, developed from arrays of motifs or subjects depicted in the paintings in rock shelters in Kakadu National Park, have been used to create chronological sequences for the art. In Kakadu, the styles and motifs have been linked to geomorphological events, such as pre-estuarine, estuarine and freshwater phases of coastal evolution, over the last 20,000 years. For example, X-ray descriptive paintings of barramundi, mullet and estuarine catfish are thought to have been painted during the period when estuaries developed on the shoreline, between 1,000 and 9,000 years ago. Thrown objects, such as boomerangs, throwing sticks and spears, and hand and grass prints are believed to have been painted in a much drier period, about 30,000 years ago, when grasslands dominated the landscape.

Interpretation of the motifs and styles depends on personal feelings and impressions obtained from the art. Because different people view artistic objects in a variety of ways, the time frames allocated to particular styles and objects will also vary. For example, there are two views on when stencils of boomerangs in Kakadu were first painted: one view estimates an age of 20,000 years; the other 9,000 years. The dates put forward depend on how one interprets the effects of climatic change and environmental conditions on Aboriginal society, particularly on the development of boomerangs as weapons and hunting implements. The older date is suggested because at that time the northern part of Australia was much drier and cooler than today, and a thrown stick or boomerang was developed as a hunting implement to kill birds and other scarce animals where there were fewer trees. The younger date is suggested by those who believe the wetter conditions about 9,000 years ago caused rapid flooding of the river valleys and created great stress on the inhabitants, forcing social and hunting practices to change in response to the environmental conditions. Wetter conditions meant greater numbers of birds and a new method of catching birds needed to be developed in order to exploit this abundant resource. The conflicting dates for the introduction of boomerangs means that the age of their art remains a mystery.

ALL THESE METHODS GIVE ONLY VERY approximate ages for the art, for they do not date the art itself, the weathered substrate on which the art was painted or engraved, or the process by which it was produced.

Organic binders, thought to have been mixed with earth ingredients to increase their adhesion to the rock surface, have not been reported in the paintings. If organic substances, such as resin, blood and plant extracts, had been used to bind the paint to the rock, then it may be possible to date the art using carbon isotopes. Australian Aboriginal painters either did not mix any binding agent with the ochres and clays but applied the finely ground, coloured earth materials directly onto the rock face, or any previous organic binder has been oxidised and has now dissipated from the ochre.

Dating the weathered rock surface on which the art has been painted or engraved may yield more direct information about the antiquity of the art. Engravings have been made into weathered rock and either infilled by weathering products or have been partly covered by later deposits of varnish. Paintings are found above weathered rock, as layers within thick multi-layered crusts, and also beneath thin siliceous films. Dating layers beneath art gives a maximum age for the art whereas dating surface coatings above art establishes a minimum age for the art. The ideal situation is to find an ochre 'sandwich' where a layer of ochre lies between a surface coating and a bottom crust, both of which can be dated. Recent research into the formation and age of the surfaces and layers on weathered rock art sites is providing hope for more accurate dating of rock art.

Engravings, chipped and pecked into hard doleritic and quartzitic rock pavements and boulders, have been dated by using the surface varnishes that have formed over them. Smooth, shiny and dark-coloured varnishes are generally

FORD KRISTO

Sailing ships were painted during the 'contact period' with Europeans—about 150 years ago.

In Kakadu, X-ray paintings of fish have been linked to the period when estuaries developed on the coast, between 1,000 and 9,000 years ago. The paintings have been highlighted with Reckitts Blue during repainting in the 1960s for the benefit of photographers.

LEO MEIER/WELDON TRANNIES

found on exposed rock surfaces in semi-arid climatic regions. They consist of finely dispersed clays, iron, titanium and manganese oxides, quartz and traces of organic chemicals. Thin laminations have been deposited and cemented by natural weathering processes, including micro-organic activity, which catalyses the interactions between the scarce water, dust particles and the underlying rock. Metabolism of inorganic chemicals by microbes that live on and in the weathered rock leads to the production of organic

Hand and boomerang stencils were made by spraying paint from the mouth. Estimates of the age of boomerang stencils vary greatly according to how one interprets the effects of climatic change and environmental conditions on Aboriginal society. Dating the weathering surfaces that form below and above the art should resolve the problem.

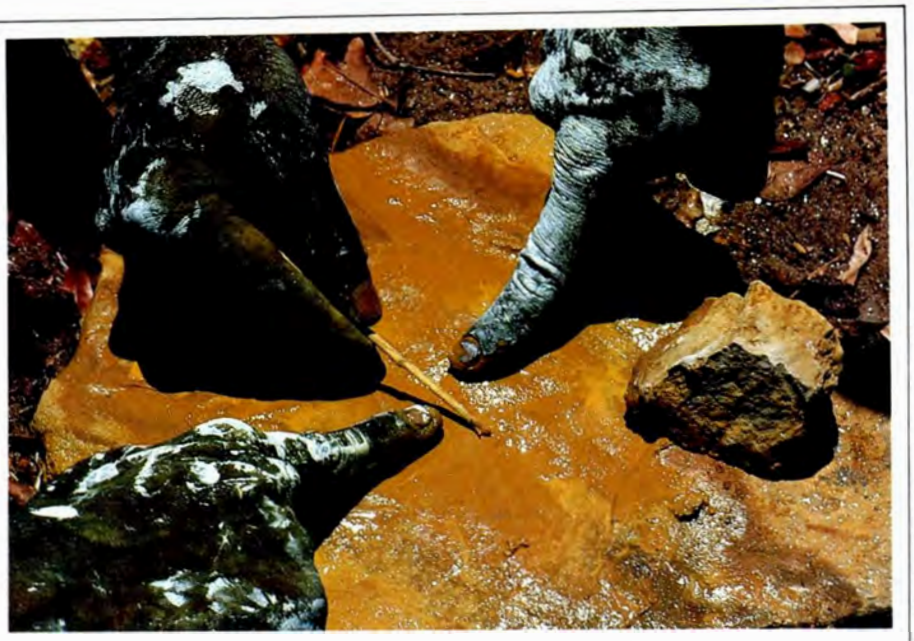
HANS & JUDY BESTE/AUSCAPE INTERNATIONAL

compounds and to the formation of complex mineral assemblages in the surface crusts. If we assume that varnish begins to form soon after the surface has been engraved, determining the age of the rock varnish establishes the minimum age for exposing the underlying surface during the engraving process, and hence gives an approximate age for the engraving.

Varnishes containing underlying materials that can be radiocarbon-dated have been found in the Broken Hill district of New South Wales. An age of 7,000 years was determined for carbon in the calcium carbonate that partly coated a varnished, but not engraved, rock surface. Younger carbonate layers, about 3,500 years old, have been found on engravings; it is probable that other older carbonate layers contain some engravings that are now below the ground.

A revolutionary technique, which uses the ratio of selected cations (positively charged particles such as potassium, calcium and titanium) leached from the weathered rock, has recently been developed to date rock engravings. This 'cation-ratio' method was used in the Olary province of South Australia to date engravings on patinated, fine-grained carbonate rock. For the cation-ratio method to be effective in dating engravings, a 'calibrated cation leaching curve' must first be established. This is done by calibrating the ratios of potassium and calcium to titanium in the varnish, against a known time scale. Potassium–Argon, radiocarbon or some other geochronological method of dating must then be used to produce numerical ages for samples that can be analysed for their cation elemental concentrations.

One problem with this dating method is that the techniques used in the calibration process are unreliable and can result in significant errors. The calibration curve determined for samples from Olary was obtained by using accelerator mass spectrometry (AMS) to date organic particles in the crusts. The AMS dates obtained for organic matter in the weathered crusts presume that micro-organic and other weathering processes have not significantly affected the calibration samples. Sources of the carbon-14 atoms in the organic matter of the crusts are unknown and contamination from other possible organic processes is highly likely in the desert environment. Another problem with the cation-ratio method is the size of the analytical errors. Minute inaccuracies during measurement of cation concentrations will lead to significant variations in the calculated age. It is also doubtful that the cation leaching curve will remain constant over long periods of time, especially during periods of climatic change. Although potassium and calcium are added continuously to the surface crust from dust, rain and aerosols, they are also lost through weathering processes. Another assumption of the cation-ratio method is that titanium is immobile; that is, it does not move in or out of the weathered rock. However, when complexed with other chemicals, such as occurs under the groundwater conditions that leach potassium and calcium, titanium becomes mobile and can be lost from the crust.

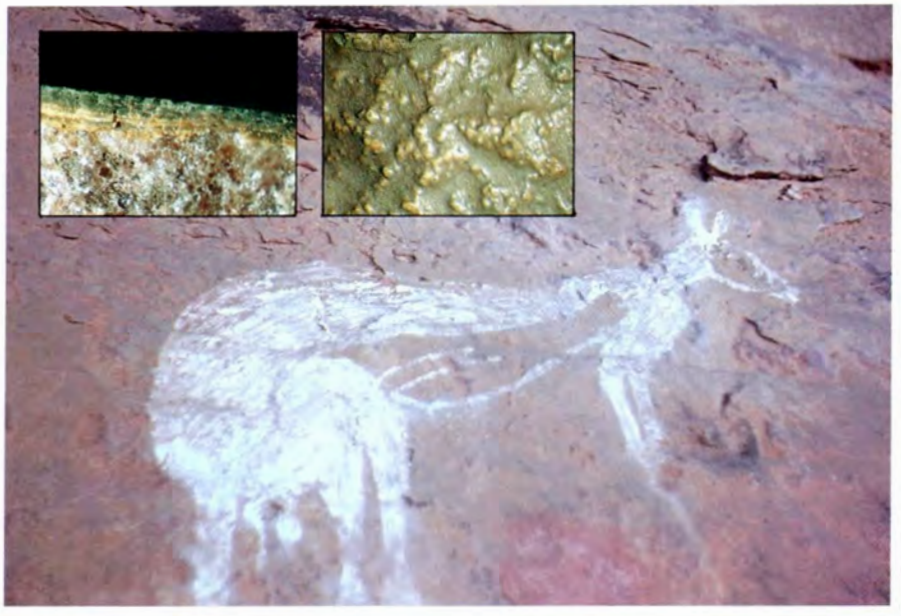


JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Traditional Aboriginal paintings, composed of clays, ochres and other natural earth substances, were applied with grass, pliable twig brushes, fingers or hands.

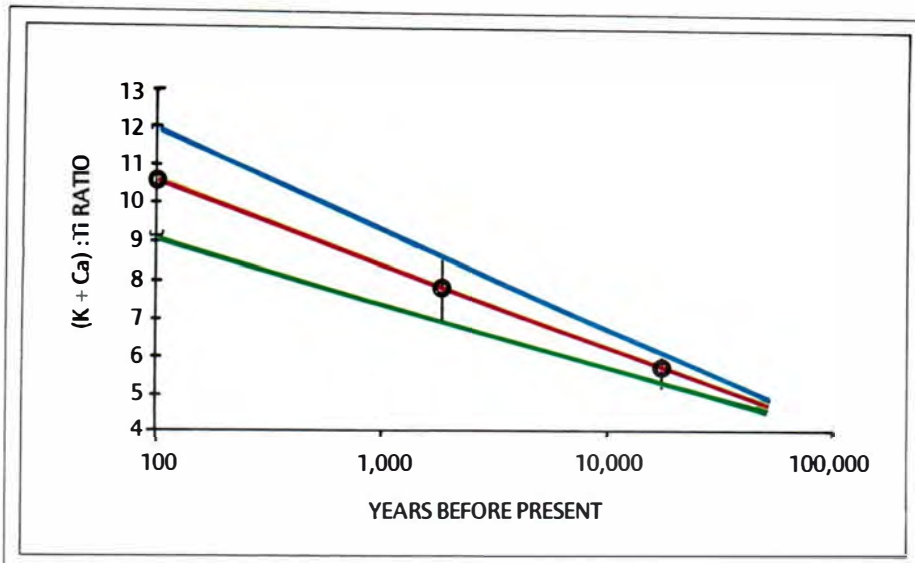
FORD KRISTO

Smooth, shiny, dark-coloured varnish forms over exposed rock surfaces in semi-arid climatic regions. The varnish is made up of fine clays, iron, titanium and manganese oxides, quartz and organic chemicals, which can be dated to establish the minimum age for exposing the underlying surface during engraving processes.

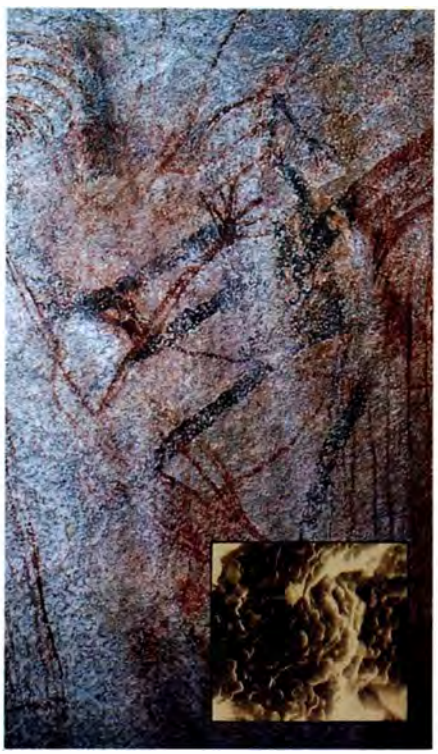


ALAN WATCHMAN

A painted dusty surface in a rock shelter at Anbangbang, Kakadu. Beneath the surface dust layer is a thick, multi-layered crust composed of calcium oxalate, salts, quartz grains and clay particles (cross-section inset). In some rock shelters the oxalate minerals are green-black and shiny (inset).



The cation-ratio method of dating rock art relies on the establishment of a calibrated cation leaching curve (red line), whereby the ratios of potassium (K) and calcium (Ca) to titanium (Ti) present in the varnish covering the engraving are calibrated against a known time scale. This method of dating is in its early stages of development and there are currently several sources of potential error (blue and green lines). (Redrawn from Nobbs and Dorn 1988).



DEHNE McLAUGHLIN ALAN WATCHMAN

White silica skin covering finely painted figures (Jim Jim) in the Northern Territory. Inset: SEM of part of a silica skin. The bubbly texture is caused by the fossilisation of micro-organisms by a thin film of amorphous silica.

ALAN WATCHMAN

Dr John Head of the Radiocarbon Dating Laboratory, ANU, extracts carbon for carbon-14 dating from the oxalate mineral whewellite found in a multi-layered crust in Kakadu National Park.

Using the cation-ratio method, minimum ages of up to 30,000 years have been reported for engravings near Olary. Once the micro-geochemical and analytical problems are overcome, the procedure may have potential for many rock surfaces where samples from thick-patinated engravings can be readily collected and analysed without defacing the site.

Another technique that relies on radiocarbon dating has yielded an age of approximately 9,000 years for thick, multi-layered crusts beneath painted surfaces in Kakadu National Park. The carbon used to date the crusts occurs in an oxalate mineral called whewellite, which has been deposited as a result of biological activity on the rock face. Lichens and micro-organisms produce quantities of oxalic acid as a product of their metabolic processes. Reaction of oxalic acid with calcium and other cations in the weathered rock and in groundwaters results in the formation of the dark laminated coatings on which the art has been painted.

This approach has good potential for dating rock surfaces where oxalate-rich minerals have been deposited. Further refinements of the AMS dating method, such as allowing micro-grams of minerals to be dated, will greatly assist the realistic dating of rock faces on which art has been placed.

On many exposed quartzitic rock faces in Kakadu and in sandstone shelters in New South Wales, Queensland and New Zealand, thin siliceous films have formed over art. The clear to translucent milk-white films generally protect the art from weathering and are thought to form under specific environmental conditions over relatively short time spans. Examination of these silica skins has revealed a close association between their composition and formation and the activities of micro-organisms. Mineral-laden groundwaters, which flow across the quartzitic substrates, not only contain dissolved silica but also carry nutrients that support microbiological activity. Metabolism of the nutrients in the water changes the chemistry of the remaining liquid to such an extent that the silica is no longer soluble and it precipitates onto the rock surface and, in the process, fossilises the micro-organisms.

Researchers are currently looking for a way of dating the traces of organic matter that may be trapped in the siliceous film. Chemical extractions of minute quantities of remnant organic substances in the fossilised microbiological structures are being used to obtain trace amounts of carbon-14 for AMS dating. The dates obtained will provide ages for the formation of the silica deposit, which enclosed the art. For some rock paintings, such as the Mimi-style in Kakadu, these recent advances should allow the discovery of very old ages, perhaps as much as 30,000 years old. In the sandstone shelters in coastal New South Wales, dating silica skins over art should confirm recent ages for the charcoal drawings. As yet these recent advances have not been tried on samples from previously dated (archaeologically or other methods) rock art sites and it would be fascinating to see how the different dating methods compare.■

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Mr Alan Watchman is a senior lecturer in rock art conservation at the CCAE. He is currently researching crust formations and the age of various weathered rock surfaces, with a view to developing techniques to conserve rock art.

COMPOSITION IN BARK

Old bark dries and cracks on the trunk of a Smooth-barked Apple (*Angophora costata*) to reveal the new layer underneath.

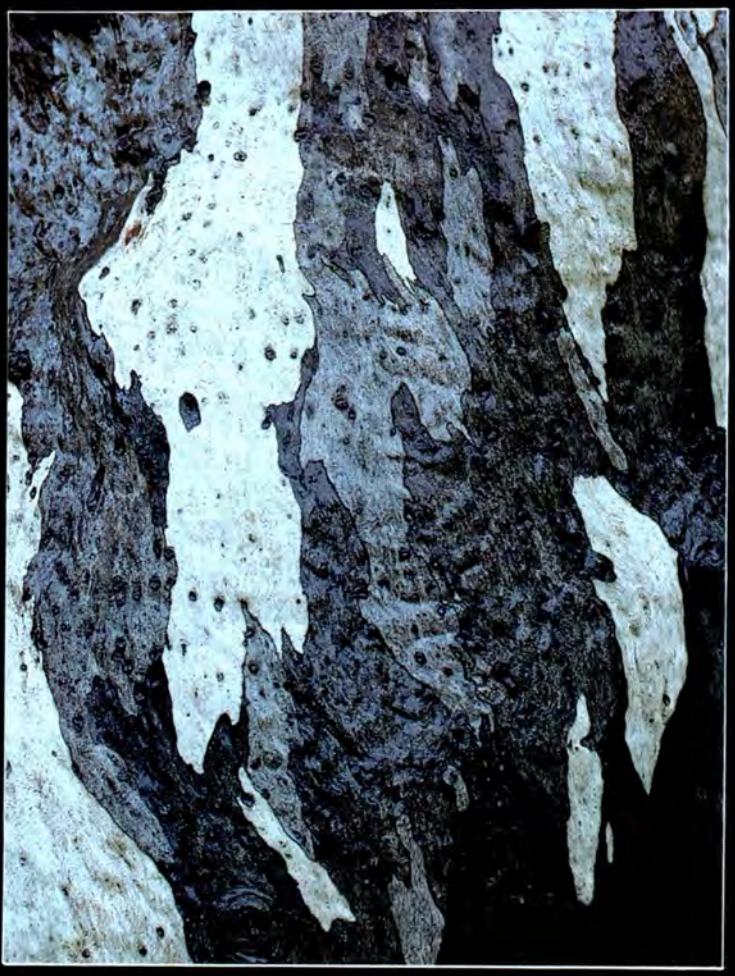
Australian forests don't go through dramatic displays like the annual leaf-falls of their Northern Hemisphere relatives but the bark of many eucalypts goes through regular changes with a subtlety rewarding to the frequent observer. Bark is shed or changes in a seasonal rhythm, lending colour, variety and a rich harvest of detail to our bushland.

BY IAN BROWN
NATIONAL PARKS AND WILDLIFE SERVICE

In the drying heat of summer, old scribbly gum bark peels to expose the clean flesh beneath.

During summer the bark of the Mountain Gum (*Eucalyptus dalrympleana*) seems to bleed when washed with rain.

Sheets of discarded bark festoon the lower trunk of a Blue Mountains Ash (*Eucalyptus oreades*). Bark is shed in long strips as the tree expands.



In the rains of mid-winter the trunk of this scribbly gum (*Eucalyptus rossii*) gleams in a tonal symphony.

The fibrous and furrowed bark of this Sydney Peppermint Gum (*Eucalyptus piperita*) provides a perfect host for a variety of lichens in the moist Blue Mountains' climate.

COMPOSITION IN BARK

The random writings of scribbly gums (*Eucalyptus* spp.) are caused by the larvae of a moth burrowing and feeding below the bark. As the old bark falls away, the scribblings of the grubs are revealed on the new bark.

Orange flakes of Smooth-barked Apple (*Angophora costata*), dampened by rain, pile up at the feet of the trees to add a spark of colour to the forest floor.

"If Microstrobos *is consistent with some other podocarps that have very slow growth rates, the largest specimens could be up to 1,000 years old."*

LIVING ON THE EDGE

BY IAN BROWN
NATIONAL PARKS AND WILDLIFE SERVICE

UNDER THE COLD SPRAY OF A FEW waterfalls in the Blue Mountains west of Sydney, there lives a most remarkable plant. *Microstrobos fitzgeraldii* has no common name, probably because it is not at all common. In fact, it is one of Australia's rarest and most interesting conifers.

Microstrobos fitzgeraldii is only found beside waterfalls where the 200-metre sandstone cliffs face southwards into the Jamison and Megalong Valleys, forming the abrupt edge of the Blue Mountains plateau. Here, well shaded and with a constant supply of water dripping or blowing over them, they can survive in the conditions for which they are adapted.

Microstrobos is forced to live teetering on the edge, quite literally, as it cannot tolerate drying out or too much competition from other plants. Colonisation of the waterfalls themselves is not possible. Some seedlings may survive a year or two but eventually a battering flood scrapes them away. Even where they can grow to maturity, the geological instability of the waterfall zone places them at risk. Rockfalls can occur and whole ledges of matted vegetation have been seen to peel off the cliff.

Squeezed into the narrow zone between drought and flood, there are a mere six locations where *Microstrobos fitzgeraldii* can be found. The plant's earlier distribution is unknown but it is likely that it was more widespread during the wetter and cooler climatic periods. It is now a relict species, forced almost to extinction by the relatively recent drying out of the Australian continent.

The first systematic study of the distribution and conservation status of *Microstrobos* was carried out by local researcher Jim Smith in 1980. He surveyed potential sites, finding at least one new location and a total of 203 plants. At that time all sites were largely unprotected. However in 1987, about 3,000 hectares of the escarpment country were added to the Blue Mountains National Park, including five of the falls where *Microstrobos* occurs.

Branchlets of *Microstrobos fitzgeraldii.*

Mr Wyn Jones of the New South Wales National Parks and Wildlife Service has been undertaking a major research program into *Microstrobos.* His first task is to establish how many plants there are, where they are and what sort of condition they are in. This has involved many days of cold and unpleasant work; many plants can only be reached by abseiling down the dripping cliffs.

The rewards for these efforts are the spectacular environment and the essential data that are being obtained as the basis for regular monitoring of the population. At this stage it looks as if there are about 300 plants. Although some may be new seedlings, the difference between the two surveys is due to well-hidden and inaccessible individuals that were previously overlooked, or as part of a clump considered before to be only individual plants. It is difficult to determine where one plant stops and another one starts, due to their often creeping habit. Even separating roots from stems can be difficult as both can have green foliage.

It is crucial to find out whether the population is stable, growing or declining, and to understand the processes involved. Already it is evident that many mature plants have large amounts of dead foliage. The plateau above the falls supports the urban areas of the City of Blue Mountains, and runoff from the plateau drains over the falls. At five of the six *Microstrobos* sites, the water spraying over the plants is polluted by this urban runoff. Unfortunately, the one site with clean water and about 25 per cent of the total population is unreserved and unprotected. This site is obviously the most important for the continued survival of the species. Jones suspects that the high levels of salts and other nutrients in the polluted waters may be causing accelerated growth of algae on the foliage of the plants, resulting in the dieback. Or the pollution might be having a more direct toxic effect. The research program will eventually resolve whether these fears are justified; meanwhile the proximity of urban development will always present a threat to the species.

Microstrobos holds many mysteries, including how it achieves sexual reproduction. Answers are needed on this if we are to ensure its survival. Like many other conifers, individual *Microstrobos* plants are either one sex or the other, with either male or female cones. So the scattered distribution of the plants raises the issue of how the sporophylls produced by the male cones get together with the ovules of the female cones. Wind is unlikely to be an efficient disperser in the constant wetness but water could be effective. This would require the male plants to grow above the female plants at the same location. Because only a small proportion of plants have cones at any time, a long period of observation will be necessary to determine the distribution of male and female plants.

Animal agents may be another possibility, but as yet no evidence exists. The plant also regenerates readily from broken pieces that lodge in favourable sites, and cuttings are the only known method of propagation.

Also mysterious is the age of the plants. If *Microstrobos* is consistent with some other podocarps that have very slow growth rates, the largest specimens could be up to 1,000 years old even though their trunks are less than 20 centimetres thick. Jones hopes to find out by drilling a core from a large individual and studying the growth rings.

Although at first I didn't think much of it, *Microstrobos* grows on you as knowledge increases. This tenacious and specialised plant has survived for thousands of years through climate changes and the vagaries of its precarious habitat. It now remains to be seen whether it can endure the pressures of civilisation. ■

Mr Ian Brown is a ranger with the NSW National Parks and Wildlife Service in the Blue Mountains. He is also a photographer, naturalist and outdoor enthusiast.

IAN BROWN

"The world is filled with creatures like the leap-fish, with one foot poised on a threshold, unknowingly waiting their big chance; rabbits in nature's hat."

AS LONG AS LIFE'S HAT HAS RABBITS

BY MICHAEL ARCHER
SCHOOL OF BIOLOGICAL SCIENCE
UNIVERSITY OF NEW SOUTH WALES

YESTERDAY, INTENT ON PALAEONTOlogical business, I dangled from the jagged edges of limestone blades 50 metres above the base of Western Australia's Napier Range, searching for remnants of cave deposits that might have filled prehistoric cavities in these gargantuan stone teeth. Three hundred and sixty five million years ago, during late Devonian time, this limestone first accumulated as a barrier reef at least 300 kilometres long. It guarded the southern margin of the Kimberley region from the open ocean that then filled the Canning Basin to the south[1]—just as the Great Barrier Reef today grows and crumbles off Queensland's coast. Where I clung to the limestone pinnacles high above a hot 'sea' of red sand and domes of yellowing spinifex, massive heads of bright coral were once awash in serging waters lanced by strange fish.

The ocean waters have long since gone to lap on brighter reefs in younger places; the strange Devonian fish metamorphosed through time to become even stranger things like me. As the spawn of their urge to adapt and reproduce, I return to gaze at the remnants of myself in former lives: discarded head shields that protrude from the eroding rock like rusted armour, aging photos in a family album of life. In younger cavities in the archaic stone, bones of wallabies, bats, rats and even humans accumulate, waiting to be cemented into new time capsules, to jut provocatively at our successors from limestones yet to be formed. Relentless, purposeless, collossal cycles of reefs, erosion, life and more life.

Today we visited the Derby jetty—an eerie centipede-like construction that at low tide stands high and dry, a sentinel waiting for an air-ship from the Twilight Zone. I watched mudskippers dance like deranged frogs at the leading edge of the rushing sea as it streamed in across the vast mud flats. Presumably they were looking for food scraps left behind by the previous tide or perhaps avoiding predators in the deeper brown waters that 'boiled' up behind them.

Watching their frog-like behaviour, I had to remind myself that these creatures were *fish*. Yet they seemed to *avoid* the water, springing into the air with their strong arm-like fins ahead of the rush, sometimes resting on the trunks of reclining mangrove trees or lumps of rock along the shore, perhaps like the first rambunctious Devonian fish that teetered on the brink of an inviting shore and the dawn of amphibianhood.

Sure, these modern mudskippers are knocking much too late on the edge of the land because the first fish–amphibians crossed that threshold over 360 million years ago and their descendants, in the form of frogs, reptiles, birds and mammals, would be all too pleased for a meal of incautious leap-fish. No, that door into the future is probably closed—but perhaps only for the moment.

What if something utterly devastating were to happen to the back-boned animals of the land? Perhaps total destruction of the ozone layer would, at least temporarily, make life on land intolerable for its current occupants. Then, after the last smell of rotting sunburned flesh blended with the new balance of atmospheric gases, perhaps this

JOHN GURCHE

Muscular fins and the ability to breathe air enabled some Devonian fish to survive on land. (From *The Rise of Life* by John Reader, 1986, Collins.)

ED MURPHY

If something utterly devastating were to happen to land vertebrates, perhaps mudskippers, 'teetering on the edge', could renew the cycle of vertebrate conquest of dry land.

little leap-fish, filled with great expectations and potential, could renew the cycle of vertebrate conquest of dry land.

Fortunately for Life's future, the world is filled with creatures like the leap-fish, with one foot poised on a threshold, unknowingly waiting their big chance; rabbits in nature's hat. What, after all, are Sugar Gliders if they are not also pre-pouched 'bats' or legless lizards if they are not potential 'snakes' or otters potential 'seals' or 'whales'? All creatures are blends of adaptation and unplanned potential.

Far from the mangrove muds and fossil reefs of the Kimberley Region, in the red sands of the centre, are Emus and Red Kangaroos—like me, the evolutionary great grandchildren of the fish that swarmed over the Napier Range's Devonian reef. In these vast arid lands (which fill a respectable 44 per cent of our continent—3.3 million square kilometres), live 126 species of mammals, 51 per cent of Australia's total. To most of us, these desert species, like the Red Kangaroo and Emu that decorate Australia's coat of arms, symbolise this continent. Flies, sun and sandy animals just seem as naturally Australian as Vegemite.

To anyone who understands that the present is an illusion of stability in a continuum of change inexorably converting the past into the future, it's not so much the contemporary diversity of living things in our ecosystems that matters; it's understanding how that diversity originated and developed as a means for best-guessing probable changes to come. In practice, ecosystems cannot be fully understood or protected without information about how and why they are changing through time. Can we, for example, really understand the role played by humans in outbreaks of the Crown of Thorns Starfish without knowing if such outbreaks occurred before humans arrived in Australia?

But, like mudskippers, the desert animals are in fact rambunctious upstarts, in this case descendants of rainforest ancestors that have *successfully* colonised new 'vacant' habitats in Australia. Like the arid lands they thrive in, most are much less than ten million years old. Between their time and those of the first successful fish–amphibian colonists on Australia's shores have been many millions of years of dark forests. The *real* home of the emus and kangaroos, as well as of almost all other Australian animals, was the vast, ancient Gondwanan rainforest that once stretched in a continuous belt from South America to Queensland—lush, tropical, lowland, spectacularly rich and at least 45 million years old, the time when Australia severed its last ties with Antarctica.

We are discovering the extent to which this is true from our studies of 25 to 15 million-year-old fossil rainforest deposits at Riversleigh in north-western Queensland[2]. Here we have found, among hundreds of new kinds of animals, pre-grazing kangaroos, pre-koalas, pre-wombats, pre-moles, pre-brushtail possums, pre-platypuses and even pre-emus. In these lowland rainforests there were representatives of 34 families of mammals. Surely this was the wellspring for the first colonists of arid Australia? Today there are still 21 families represented in the remnants of Australia's rainforest but only 13 in Australia's arid lands. Without a doubt, rainforest has been in the past and continues to be in the present, hectare for hectare, this continent's richest reservoir of biological diversity.

Just as mudskippers wait at the edge of our waterless world, restrained for the moment by evolutionary events of the distant past but willing and probably able to colonise the land if its present occupants vanish, the plethora of diverse creatures peering from the edges of our diminishing rainforests, like rabbits in a green hat, may be Australia's most important warehouse for renewal of life on this continent. They did it magnificently once before; presumably they could do it again. Unfortunately, our lack of care for this magic hat of genetic wealth belies its importance and affronts our intelligence.

The widespread indifference many politicians and business folk show for the welfare of rainforest is more than a threat to the viability of nature's hat of renewal: it's a kind of biological matricide. Like the first rainforest kangaroos and emus, the first tremulous steps of our own ancestors were upon the dappled floor of an African rainforest. Rainforests were the mother of what has been and, barring our avaricious stupidity, may be the mother of all that is to be, as long as the green hat stays full. ■

Suggested Reading

[1] Ritchie, A., 1985. The Gogo Fish. Pp. 102–108 in *Kadimakara: Extinct Vertebrates of Australia*, ed. by P.V. Rich and G.F. van Tets. Pioneer Design Studio: Melbourne.

[2] Archer, M., Godthelp, H., Hand, S.J., Megirian, D., 1989. Fossil Mammals of Riversleigh, Northwestern Queensland: Preliminary Overview of Biostratigraphy, Correlation and Environmental Change. *Aust. Zool.* 25: 29–65.

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

"We should recognise species by recognising if they recognise themselves!"

BESTIALITY & THE RECOGNITION OF SEXUAL MATES

BY GLEN INGRAM & RALPH MOLNAR

VERTEBRATE ZOOLOGY, QUEENSLAND MUSEUM
VERTEBRATE FOSSILS, QUEENSLAND MUSEUM

Dramatis Personae

The Biological Species Concept

The opinion that species are groups of individuals that breed among themselves but are reproductively isolated from other such groups.

The Recognition Concept of Species

The opinion that species are groups of individuals, both male and female, that share a common fertilisation system.

Reproductive Isolating Mechanisms

Characteristics of organisms that ensure different species either don't mate or, if they do, the mating is unsuccessful or the hybrids are infertile.

Fertilisation System

Characteristics of organisms that contribute towards fertilisation.

The Important Act

In a densely vegetated park, a Koala hugged a thick branch while wedged in the fork of a tree. This would not have been unusual except for a Baza, which is a Crested Hawk, that was perched close by. But what was most unusual was what they were doing. Unaffected by their close proximity to each other, both stared intently at the ground below. Beneath them different species of rainbow skinks glinted and shone as they dashed through the litter of a garden. Every now and again the lizards met and presented their colours to the full. Heads bobbed and throat colours of reds, blues, blacks and yellows were displayed; red or orange tails were hoisted to curl up and down and forward with the tips wagging over their backs. Summer was near and some of the males had their full breeding colours of bold red, orange, pink or blue stripes on their backs and sides.

In his haste to capture a moth, one male with vivid pink sides and blue throat careered into a dull brown and white female. She, too, had been intently pursuing the moth. They had not seen each other till they crashed and, at first, they were a flurry of feet, bodies and tails. Then, after moving apart with short sharp movements, the male stopped, faced the female and began to bob his head. The female watched and the male bobbed more vigorously. Suddenly she whipped around and sped off into the leaves leaving him standing at the start.

Koala: Damn!
Baza: What's wrong this time? If you complain about your fork again, I shall close my ears. You chose this spot, not me.
Koala: I am comfortable, thank you. But my eyes are not what they used to be. Did you see that female lizard well?

"The Recognition Concept does not need another species to define a species. . .they are self-defining."

Baza: Quick little devils aren't they? There one minute and gone the next. And so plump!
Koala: You promised me you would eat before we came. We are not going to settle our disagreement over the nature of species if you fly down in the middle of our experiment and eat the subjects.
Baza: I have kept our bargain and stuffed myself with phasmids. I was merely expressing the sentiments of a gourmand. I am just as keen as you to observe these sexual dichromatic skinks. Indeed, they are ideal for our purposes. Our observations should help us decide on the correctness of either the Biological Species Concept or the Recognition Concept of Species. And I will be right.
Koala: Well?
Baza: Well what?
Koala: What species was that female? I could see the displaying male was a Pink-sided Rainbow Skink but those wretched females are so similar and difficult to identify with my poor eyes.
Baza: I am not going to tell you.
Koala: So you were not paying attention! Your bird-of-prey eyes are capable of seeing the minutia of their scales at this distance. Obviously you were thinking of your belly in the middle of our empirical observations. I am disappointed.
Baza: I am not going to tell because of the experiment! Those lizards were irrelevant to our question. What we saw were two individuals that did not recognise each other as mates. They played no part in helping us to recognise a shared fertilisation system for a particular species.
Koala: Don't be silly. That they did not recognise each other suggests the possibility that different species were involved in the encounter. And, even if it was just a case of a conspecific female not being in breeding condition, it is still important that we identify both individuals.
Baza: It is not.
Koala: It is. And you are just trying to win our argument by exploiting my poor eyesight. It is typical of you Recognition Concept supporters—you just don't like to be proved wrong.
Baza: And you are a typical supporter of the Biological Species Concept. You won't accept that the information you seek is governed by your restrictive concept of a species. The question you asked contained your answer. Fancy asking me "What species is the female?" when we are here trying to gather raw data from which to decide "What is a species?"
Koala: What's the fuss? So I slipped up.
Baza: I do not think so. Answer me this: why are those male skinks so brightly and distinctly coloured?
Koala: The colours and patterns are species-specific—they are species advertisements. They inform a female that the correct male is signalling. This ensures that females and males of different species do not mate. The colour patterns function as pre-mating isolating mechanisms.
Baza: What you say is only true in part. Certainly the male colour patterns are signals to a receiver, the female, but these are only part of the overall fertilisation system. In reacting to the male colours, the female does not say to herself "This male is the correct species and let's get into it." She simply responds to stimuli that lead to mating. There is no 'choice' on her part nor does she 'recognise' the species. It is the fertilisation system that leads to positive, assorted mating.
Koala: What on Earth are you trying to say? You are very obscure.
Baza: Have you ever thought of having it off with a possum?
Koala: I beg your pardon??
Baza: Well, have you?
Koala: I have never been more insulted in all my life.
Baza: No, you haven't chased possum. And you know why? It is not because you say to yourself "That animal is brown. That is a

possum. It is the wrong species. I will not have sex with it." In fact, you don't react at all. But when you see a Koala that is a potential mate you experience a positive sexual reaction. You don't 'know' the species.
Koala: Well, if you put it that way. . .
Baza: I do and I rest my case. It is the fertilisation system that leads to positive, assorted mating.
Koala: You are being dramatic. I have always contended that our opinions did not differ. Your 'fertilisation system' functions to isolate the different species anyway. It is an isolating mechanism—your argument only quibbles about semantics.
Baza: Have you ever been sexually attracted to cockatoos?

"It is not what we think species are but what the species think they are."

Koala: Your crudeness is not seeming. But two can play this game. So what if I was attracted to a cockatoo? Our species would not be violated. We could not interbreed because we do not have the necessary secondary sexual characteristics to successfully engage. It would be like trying to put a square peg into a round hole.
Baza: You're disgusting!!
Koala: Even so, it is a good metaphor for a pre-mating isolating mechanism. But, for the sake of the discussion, suppose the cockatoo and I did manage it. Either fertilisation would not take place or, if it did, the embryo would die; or if the embryo developed, it would be infertile and a 'mule'. These post-mating isolating mechanisms would ensure the integrity of our species.
Baza: It wouldn't be a 'mule'; it would be a 'Cocky-Kola'!
Koala: How dry. But the joke does portray your preoccupation with words as your whole argument has been preoccupied with semantics.
Baza: Our dispute has never been about semantics. Isolating mechanisms *are* silly notions. If you and a cockatoo recognised each other as mates, then you would be the same species. Further, that the reproductive process goes awry after you mate would be especially irrelevant. If the 'integrity' of species were dependent upon this failing, then there would be species all over the place sharing each other's fertilisation systems. But there aren't!
Koala: Now that *is* interesting.
Baza: Even further, your Biological Concept defines species with respect to other species: species are groups that are reproductively isolated from each other. Note—and this is very important—the Recognition Concept does not need another species to define a species. To put it loosely, they are self-defining. They are the most inclusive population that shares a common fertilisation system.
Koala: Yes, that is *very* interesting.
Baza: Don't tell me I have at last managed to get something into your eucalyptus-addled head? This is a moment to savour!
Koala: I *do* see. We should recognise species by recognising if they recognise themselves!
Baza: I suppose so.
Koala: Thus it is not what we think species are but what the species think they are.
Baza: I give in.

With that the Baza flew down and ate the rainbow skinks. ■

Suggested Reading

Coyne, J.A., Orr, H.A. & Futuyma, D.J., 1988. Do we Need a New Species Concept? *Syst. Zool.* 37: 190–200.

Paterson, H.E.H., 1985. The Recognition Concept of Species. Pp. 21–29 in *Species and Speciation*, ed. by E.S. Vrba. Transvaal Museum Monograph No. 4. Transvaal Museum: Pretoria.

Paterson, H.E.H., 1988. On Defining Species in Terms of Sterility: Problems and Alternatives. *Pac. Sci.* 42: 65–71.

Dr Ralph Molnar is Curator of Palaeontology at the Queensland Museum. His research has been directed towards filling the vast gap in knowledge of Australian vertebrate history between the Devonian and Miocene. Dr Glen Ingram is interested in evolution and the philosophy of science. In 1987 he received a special commendation from the BBC Wildlife Nature Writing Awards.

QUESTIONS & ANSWERS

A regular column where *your* questions about our natural world are answered by experts.
Readers are invited to submit brief questions.

A Question of Gender

Q: Do hermaphrodites, like slugs and snails, take turns to be the male?

—J. Meurer
Townsville, Qld

A: No. Hermaphrodites produce both sperm and eggs. This means that during copulation both partners are fertilised, each acting as a female recipient and male doner. They have a hermaphroditic duct, which is a tube running from the ovotestis (an egg and sperm producing organ) to the area of fertilisation. Both eggs and sperm travel via this tube.

Some molluscs, which are *not* hermaphrodites, do play both sex roles at different times during their lives. The Common Sydney Rock Oyster (*Saccostrea commercialis*), for example, starts adult life as a male, and later changes to a female. This story is repeated many times in the molluscan world, and is a phenomenon shared by other phyla—certain fish species, for instance.

—Phil Colman
Australian Museum

An Ill Wind

Q: If cows give off so much methane that it contributes significantly to the greenhouse gases, why can't this gas be trapped and somehow converted into a useful energy source? Surely such quantities would provide the world with an enormous amount of energy!

—M. Kenrick
Glebe, NSW

A: Depending on its diet, the average cow expels approximately 100 litres of methane into the atmosphere daily. If it was possible to extract all the methane that cows expel, this would create a significant reduction in our dependence on other energy sources, such as coal. Indeed, cows in Australia annually produce methane equivalent in energy to that in millions of tonnes of coal.

Methane, a major constituent of natural gas, is an efficient, clean source of energy and does not produce the dust particles and lead created by coal. It does produce carbon dioxide, another major greenhouse gas, but since methane absorbs more ultraviolet energy than carbon dioxide, the overall greenhouse effect is reduced. (The absorption of UV energy creates the greenhouse 'blanket' around the world that causes the global temperature increase.)

The logistics of trapping the gas produced by cows make the likelihood of such a task extremely remote and would certainly be very costly. (Even the very thought of attempting to trap and store it is enough to put the most dedicated scientist off!) But you are right about the quantities—it would probably take only a few cows to heat and light the average family house.

Some major advances in reducing the emission of this gas by cattle have been developed by CSIRO scientists, Drs Ralph Laby and Keith Ellis, and Elanco Products Company Ltd. With the intention of reducing bloat in cattle, they have produced a pill that improves the efficiency of the digestive system and is claimed to reduce a cow's methane production by up to 20 per cent. One estimate suggests that, if every cow in Australia were to be given this pill (which is a slow-release capsule lasting six months), it would be equivalent to burning 2.6 million tonnes less coal annually.

—F.D.

DENSEY CLYNE/MANTIS WILDLIFE

Slugs mating: the best of both worlds.

Recycling Paper

Q: Much has been said recently about conservation of our limited resources. But are such things as recycled paper readily available in Australia? I haven't been able to find any. What guidelines are recommended in setting up a paper recycling–collection project in my office?

—S. Winter
Surry Hills, NSW

A: The paper industry has always had a considerable interest in recycling paper and paperboard for one very good reason—it is cheaper than new pulp. Recycled pulp has been used where it is most cost effective, that is in paperboard for packaging and in moulded fibre products. Have a look at the grey layers inside your cornflakes box or egg cartons.

Most domestic waste paper recovered is not suitable for recycling into fine writing paper as it usually contains a high proportion of newsprint, which is made from it. It is only recently that sufficient high quality waste has been available in Australia to produce higher grade paper from 100 per cent recycled fibre. Associated Pulp and Paper Mills makes recycled paper (available in either 100 or 80 per cent recycled stock; the 100 per cent stock has no further bleaching and is not de-inked). Australian Paper Manufactures (APM) also produces 100 per cent recycled and unbleached paper, called 'Re-Right'.

AUSTRALIAN MUSEUM

Waste not, want not. . .the recycling saga.

Proportions of recycled and new pulp create a stronger product with wider applications because, when paper is repulped, it gives a weaker product than the pulp from which it was originally made. Although it is ideal for general stationery, the lack of tensile strength in 100 per cent recycled paper means it cannot cope with many new office machines, which are designed to run at high speeds.

Setting up an office paper collection–recycling program starts with staff education. The actual process is quite simple: to separate paper from other garbage. But to get everyone to do this takes a little more effort. Most offices already have a waste collection system that is capable of removing waste paper for recycling, but it's best to check first and find out what

they do with it. It isn't always sent for recycling into paper products. Ask them whether it is useful to segregate the various types of office waste paper, such as printed matter, computer paper etc., for final conversion to different recycled products. White paper has a much higher value and better properties for recycling, but this may well depend on the quantity available, so if your office churns out large quantities of computer paper, check to see whether this can be collected separately.

Although about 760,000 tonnes of waste paper was used in Australia in 1987–88, the amount of any one grade is very small indeed. In a country with a low population density like Australia there are two restrictions on the development of a wider range of papers: one is the small local market and the other is the limited supply of good quality waste available within a reasonable distance of the producing mill. Perhaps better tactics would be to encourage the use of recycled fibre in a wider range of products rather than to try for too many products made from 100 per cent recycled material. After all, it doesn't really matter where new fibre is replaced by old, as long as it is replaced as much as possible.

Distributors in Australia of recycled paper include the following companies: Boomerang Trading Pty Ltd (Melbourne); Bowater Paper (Melbourne); BRG Paper (Sydney); Commonwealth Paper Company (Sydney, Melbourne, Brisbane, Adelaide, Perth); Consolidated Paper Industries (Sydney, Melbourne, Brisbane, Adelaide, Perth); Dalton Fine Paper (Melbourne); Ecopaper (Sydney); Edwards Dunlop & B.J. Ball (Sydney, Melbourne, Brisbane, Adelaide, Perth); The Paper House (Melbourne); Raleigh Paper Co. Pty Ltd (Sydney, Melbourne, Brisbane); Riegel Paper Pty Ltd (Melbourne); Spicers Paper (Melbourne); Tomasetti Paper (Sydney, Melbourne, Brisbane, Adelaide, Perth); and VRG Paper (Sydney, Melbourne).

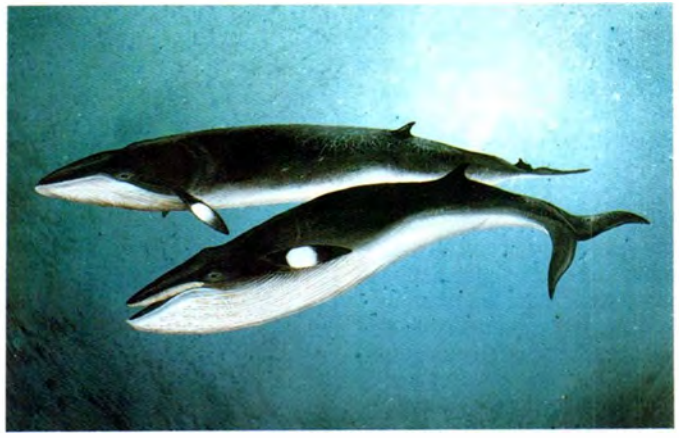
—F.D.

Why Whales?

Q: Why do the Japanese kill almost 900 Minke Whales each year for research?

—K. Rockwell
Northbridge, NSW

A: The Japanese have stated that they would like to kill almost 900 Minke Whales for research in order, they say, to determine whether whale populations are rising or falling. In the past year, however, the whaling fleet only managed to take 241 out of a target of 300 Minke Whales. They claim that this does not represent a reduced population of whales but instead is the result of bad weather and interference from "Greenpeace terrorists".



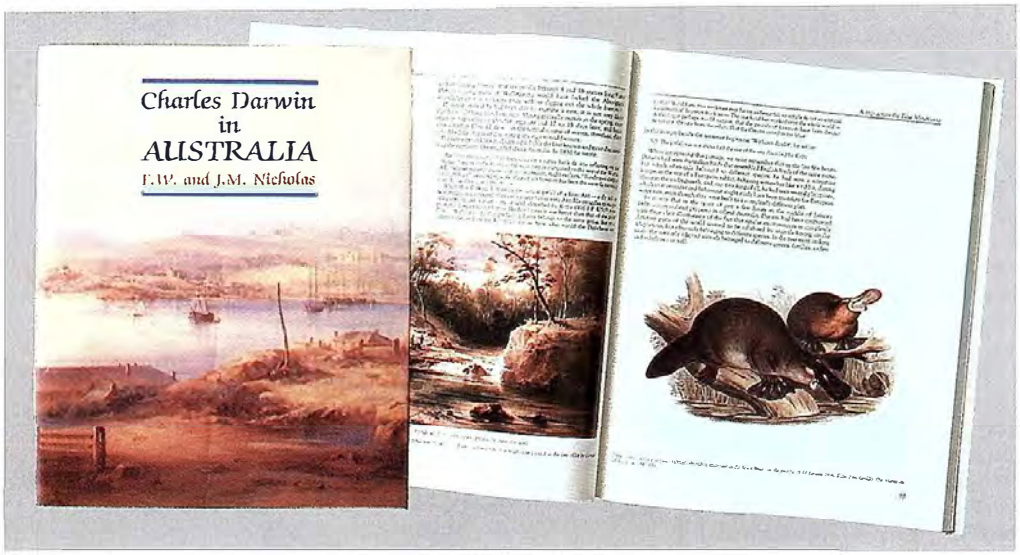
KATHRYN FOLEY

Minke Whales.

In any study of any mammal population, basic data must be obtained from as many individuals as possible. Data includes information on sex, age, length, weight, condition, reproductive status etc. To gather this information from terrestrial mammals involves capture, restraint, examination and then release. The procedure becomes virtually impossible when dealing with animals the size of Minke Whales and in a marine environment. This is probably why the Japanese claim it is necessary to kill a certain number each year.

—Linda Gibson
Australian Museum

REVIEWS



Charles Darwin in Australia

By F.W. and J.M. Nicholas. Cambridge University Press, Cambridge, 1989, 179 pp. $45.00.

Is this the ultimate Darwin-in-Australia book? Probably not, but it will certainly do for a long time to come. Frank and Jan Nicholas have summarised all that is now known about the great man's visit to this continent, reconstructing his movements from day to day. Their detective work with meticulously detailed references, annotations and footnotes, and a thoughtful selection of contemporary illustrations and modern photographs, will bring this important episode in the history of biology to a wide audience.

Young Charles Darwin was not overly impressed by Australia. He arrived after four years of collecting, travelling and improvisation on land and aboard the cramped HMS *Beagle*. He was desperately homesick. The history of Darwinism might well have been different had the *Beagle* travelled in the opposite direction around the globe and arrived in Australia first!

Darwin was also a personality in transition. His early focus on geology had laid the foundations of doubt about the duration of Earth's creation. His mind was now turning more and more to the problem of the diversity and origin of species. On the evening of 19 January 1836, after a long day's ride down into the Wolgan Valley, he returned to Wallerawang Homestead where he was a guest. Typically he still found time for a walk: along Cox's River he spotted several Platypuses and, resting on the bank, watched a fly fall victim to an ant-lion. The authors argue, convincingly, that Darwin's account of this event in his *Diary* and the early edition of the *Journal of the Beagle* "... is one of the earliest glimpses we have, if not *the* earliest glimpse, of the theory that he was to use much later to explain the mechanism of evolution".

Alas, one would have to don one's wetsuit to find this hallowed spot, which was drowned in 1979 when Cox's River was dammed to supply the Wallerawang Power Station.

For my money, perhaps the most enjoyable and moving part of *Darwin in Australia* was the postscript, in which the subsequent lives of Darwin's closest shipmates are followed through to their ends, a process that adds wonderfully to our understanding of the social milieu in which the theory of natural selection emerged. Darwin's clerk, Syms Covington, emigrated to Australia, maintained a long correspondence with his former employer and died, a publican and postmaster, at Pambula in 1861. Philip Gidley King (Junior) stayed on here to become manager of Goonoo Goonoo Station and a pillar of the colonial establishment. He also continued to correspond and gave tentative support to *Origin of Species*. The depressive and intensely devout Captain Fitzroy, went on to become a Tory member of parliament, Governor of New Zealand, and the founder of our modern weather prediction services. Weighed down by his horror at the unwitting part he had played in fostering Darwin's heretical conclusions and, rather poignantly, "...increasing sensitivity to criticism of the inevitable accuracies in his weather forecasts", he suicided in April 1865.

Darwin in Australia manages to be both an invaluable reference work and a good read, and you can't do much better than that.

—Gavin Gatenby
NSW National Parks and Wildlife Service

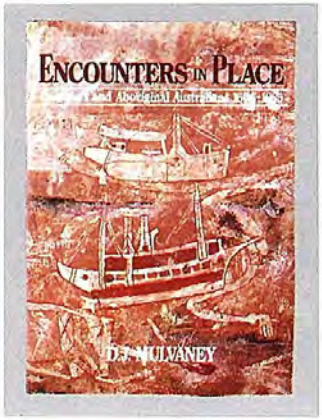
Encounters in Place: Outsiders and Aboriginal Australians 1606–1985

By D.J. Mulvaney, University of Queensland Press, St Lucia, Qld, 1989, 263 pp. $44.95.

The Register of the National Estate is kept in Canberra by the Australian Heritage Commission. Few Australians know of it, or what it is. Simply put, it is a list of places within Australia that are 'significant' for cultural, historic, social, scientific, environmental or other reasons. Like most such activities carried out by Commonwealth or States such a listing carries with it no legal protection—places on the register are 'protected' for only as long as the government of the day desires.

The Register, nonetheless, is a useful document, for it has now identified nearly 10,000 places that have been accepted by the Commission as appropriate to preserve as 'our heritage'. Places that symbolise or exemplify interactions between Aborigines and other groups are clearly part of this, and Mulvaney's book is about 57 of them, most already on the Register, the rest, one assumes, soon to be.

Encounters in Place consists of 32 chapters, 3–13 pages



each, about a specific place or places. It starts in 1606 with the meetings between Cape York people and Willem Jansz, and Torres Strait Islanders and Luis Vaes Torres; it ends with "Uluru Returned"—the 1985 handing over of title deeds to what was formerly Ayers Rock to the traditional owners. Within these 380 years, Mulvaney ranges throughout Australia and a number of different kinds of 'contact' places. For each he gives a description of the location, some idea of what can be seen there now, and an

essay on the events that make it a significant contact place. Interestingly, it is not always these events that are the reason for its inclusion in the Register. Bernier and Dorre Islands, for instance, are fossil sand dunes off Shark Bay (WA), listed for their scientific and faunal value. From 1908 to 1918 they were also 'hospitals', one each for Aboriginal women and men, who were believed to be venereally diseased. Several hundred Aborigines were collected, often by police without any medical training, from all over Western Australia and sent there, many of them to die.

Most of the places Mulvaney records are the scenes of similar encounters of exclusion and extermination, although their nature changes somewhat with time. In the early years of our invasion of any area of Australia simple massacres were usual. Moorundie (SA), Cape Grim (Tas.), Cullinaringo (Qld) and Pinjarra (WA) are examples of these. Once most of the Aborigines had been 'dispersed' (a favoured 19th-century term: blacks killed by whites were 'dispersed', whites killed by blacks were 'massacred' or 'murdered'!), later encounters were more bureaucratic: murder by long-term dispersal. Some of these were medically motivated, like the leprosarium on Channel Island, near Darwin; others, like the Cootamundra Domestic Training Home for Aboriginal Girls (NSW), were set up to force Aboriginal children into respectable working class jobs. These children were forcibly removed from their families, nearly always for reasons that would never be used against a white family (until the 1980s, that is) and to put to work in the name of 'civilisation'. This legalised kidnapping went on until—wait for it—1957. Many of those children are still alive. This encounter is one of the saddest of all—and the house cannot tell it at all.

Not all encounters between Aborigines and non-Aborigines were so hostile or one-sided. When people did not attempt large-scale takeovers of land, as with Macassan (Indonesian) trepang fishers in the Northern Territory and the British settlements at Raffles Bay (NT), Port Essington (NT) and Albany (WA), Aboriginal people were happy enough to have new neighbours. There are also a few cases where, clearly for personal reasons, even a total invasion of their land did not turn Aborigines against particular invaders. It would be fascinating to know both sides of such cases. But in this book Aboriginal accounts of the contacts shine through clearly only in the superb colour plates of rock paintings.

The selection of places to write about reflects some of Mulvaney's own interests. The four chapters on central Australia are long, not so firmly anchored to particular places and revolve around the anthropologist Baldwin Spencer, whose biographer Mulvaney is. There is a good section on the graves of several Aboriginal cricketers who starred in matches in the late 19th century. Nonetheless, the coverage is wide-ranging and Mulvaney clearly enjoyed visiting nearly all the places he writes about.

Finally, next time the media tells you of an Aboriginal 'riot' in Redfern (NSW) or a brawl at Brindleton (any State), think of Mulvaney's book, for these are the 1980s "encounters in place" in the making.

—Peter White
University of Sydney

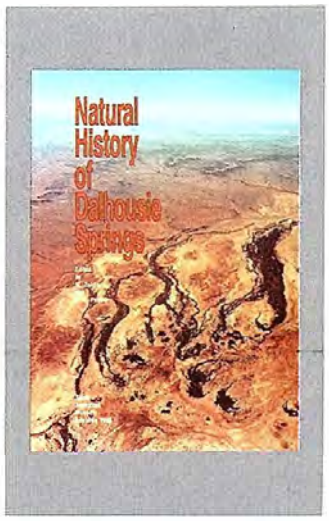
Natural History of Dalhousie Springs

W. Zeidler and W.F. Ponder. South Australian Museum, Adelaide, SA, 1989, 138 pp. $19.95.

Limnology is the science of inland waters and conventional limnological wisdom is largely based upon studies of permanent fresh waters in the northern temperate zone. This wisdom would have us believe that most water bodies in deserts are small, ephemeral, populated by a depauperate biota with good dispersal mechanisms and, as a result, comprise widespread if not cosmopolitan species with large gene pools. Increasingly, ideas of this sort are being shown not to conform closely with reality. It is true that *some* desert water bodies conform to the preconceptions of 'temperate' limnologists but it is equally true that many do not. Certainly the various water bodies at Dalhousie Springs do not, as this book clearly indicates.

The difficulty of studying desert waters needs no elaboration, the dearth of publications about them, no explanation. This useful compendium about Dalhousie Springs is therefore a most welcome addition to the literature in this area, and the authors and editors deserve thanks and praise for their efforts. My concerns are that their book may not be as easily accessible to limnologists (wherever domiciled) as it ought, nor receive the publicity it deserves. This review might help alleviate the second concern; with regard to the first, note that the book may be bought directly from the South Australian Museum or, of course, ordered through your favourite bookseller.

Dalhousie Springs is an impressive set of water bodies impounded behind calcareous mounds and fed by large volumes of water that issue from the Great Australian Artesian Basin. Located at the western edge of the Simpson Desert, they occur in some of the most arid landscapes found in Australia: temperatures are extreme with summer values often over 40°C, rainfall arrives episodically (the mean annual rainfall is only about 13 centimetres) and evaporation is intense (annual value exceeds three metres). There are some



60 springs in the complex in a zone of some 70 square kilometres. The springs are perhaps some one to two million years of age.

Not surprisingly, the springs are the focus of much archaeological, historical, geological and biological interest. This book attempts to highlight and document major features of such interest. In it, there are chapters on archaeology and Aboriginal and European history, on geology, hydrology and hydrogeology, and on a number of the more important groups of the biota (algae, macrophytes, molluscs, crustaceans, fish and mammals). All chapters are written by acknowledged experts, many located outside South Australia, so that the book is a serious attempt to be both comprehensive and authoritative.

The book is not, of course, as the editors acknowledge, the last word on the springs. It forms, however, a most commendable starting point for future studies. There is no doubt that Dalhousie Springs are of major scientific importance, and the South Australian Government is to be commended on its wisdom in acquiring the area for public ownership. All that remains is for the Government to accept the scientific recommendations put forward by the editors for the protection of the springs and their scientific exploration.

I thoroughly recommend this book for purchase by librarians of all institutions in Australia concerned with studies of the Australian environment. This book is *not* another superficial, glossy piece of 'outback' Australiana, but several cuts above that literary genre; it is a serious addition to the literature on an important group of desert water. I hope it will catalyse further studies of both waters at Dalhousie Springs and elsewhere in the Australian desert. Australian students and scientists should have easy access to it. I am glad to see it on my bookshelf.

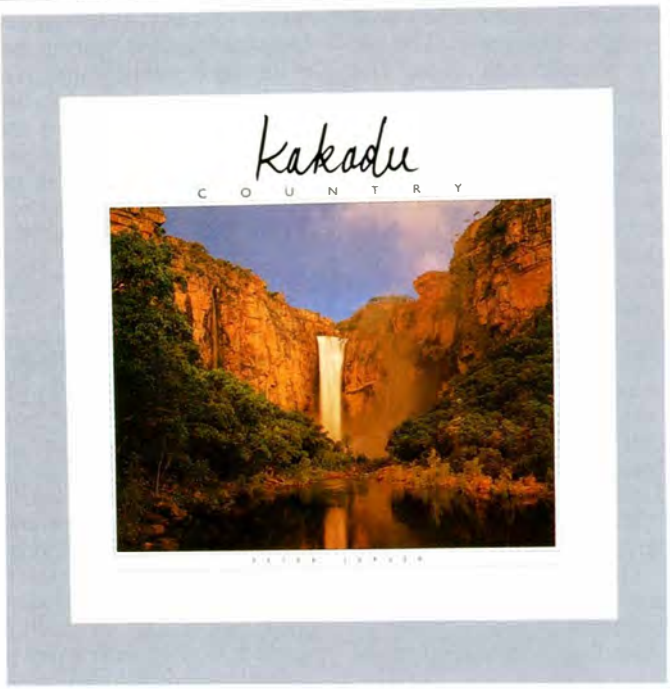
—W.D. Williams
University of Adelaide

Kakadu Country

By Peter Jarver. Thunderhead Photographics Pty Ltd, Darwin, NT, 1988, 119 pp. $34.95.

I first stumbled across Peter Jarver's photographs in a gallery in East Sydney a few years ago. The experience had an immediate and lasting effect on me. So I was very glad to be able to review his latest book *Kakadu Country*.

It's no picnic lugging photographic gear through rainforests—a friend of mine got a hernia doing just that. But you'd think Peter Jarver had spent half his life camped in the wilderness with his camera gear at



the ready. There is no weather condition or time of the day that is not keenly observed and translated into outstanding images by him.

There is an obvious technical excellence in his photography and the observer is immediately aware of his deep understanding of his environment. Undoubtedly the main feature of these photographs is the drama and surreal quality that the lighting conditions around this area produce. Whereas an artist has total control over his medium, a photographer needs a fair amount of endurance and luck to achieve his interpretation of a scene. Yet these photographs are not just lucky snaps: they are carefully planned endeavours.

The photographs are concentrated around the Kakadu National Park, Katherine Gorge and Gurnig National Park. Peter explains in the text that the areas he had photographed are under threat from the mining industry. There are so few places left in Australia and the world that have not been ravaged by some industry or other. Stronger control is needed, National Parks must be protected at all costs, and areas outside the protection need a sensible conservation strategy.

Peter Jarver's photography is in one sense a lasting record of this region, but a closer look reveals what could be lost if we don't take an active interest in conserving this fragile and magnificent environment.

—Kate Lowe
Australian Museum

Fiji's Natural Heritage

By Paddy Ryan. Southwestern Publishing Co. Ltd, Auckland, 1988, 184 pp. $30.00.

While this is a book that will appeal to a wide audience, there are two groups of people who will especially benefit from its unique combination of skilled writing and superb photography: those who have already spent time in Fiji and those who hope to do so. However no-one who dips into this book will fail to join the second group, even if already a member of the first!

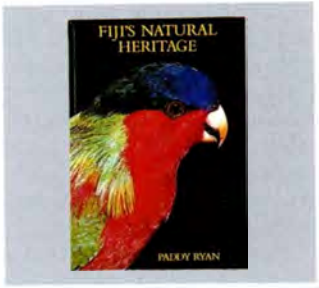
The soft cover of *Fiji's Natural Heritage* and its lavish coloured illustrations may create an initial impression that it is just another mass-market tourist pot-boiler. True, the tourist or casual browser will find the book entertaining and visually delightful. But within its glossy pages lies a wealth of hard information about Fiji's ecosystems and biotas, with many gems for the biologist, ecologist and biogeographer.

The book is divided into a series of short 'chapters', mostly concerned with groups of organisms of varying taxonomic grades: from corals, worms, molluscs etc. to birds, mammals and plants. The treatment is rounded off with a brief introduction, an 'overview' (which briefly but succinctly addresses the issues of conservation and pollution), a section on 'places to visit', a too-short glossary, and finally a useful bibliography and index. I could find no significant errors about which, as a reviewer, I could legitimately carp.

It will be obvious to the reader that I am a great admirer of Paddy Ryan. Until recently a professional biologist and teacher on the staff of the University of the South Pacific in Suva, he is also a 'naturalist' in the most honourable and traditional sense of this oft-maligned and much-denigrated word. Combine this with a lucid and entertaining writing style (caption: "*Pteropus samoensis*, the Samoan fruit bat, surveys the world from upside down, a posture that changes rapidly when it needs to defaecate!") and we have a book that is a delight to read. None of the ponderous prose of the scientist here.

It will be equally obvious to the readers of this book that Paddy Ryan loves Fiji. The current political problems facing that country are judged by him mostly in terms of the impact of corporate greed, personal ambition, racial disharmony and community complacency on the fragile terrestrial and aquatic ecosystems of this most beautiful of countries.

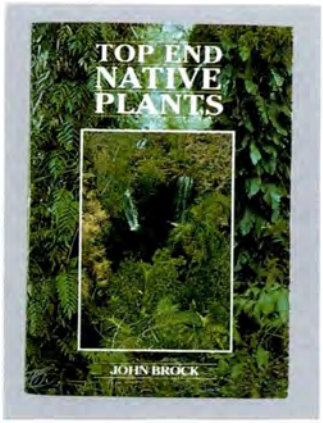
It behoves a reviewer to



make some criticisms, and those that follow are from the sections on reptiles and frogs, groups with which I am most familiar. For example, a few typographic errors have crept in (e.g. *Engyrus* instead of *Enygrus*, page 111). I was occasionally irked by the use of the word "discovered" when the author means 'named' or 'described', and by the creation of the misleading name Pacific Boa Constrictors (implying a closer affinity than intended with the true Boa Constrictor of tropical America) for the phylogenetically-distant Pacific boas (*Candoia* spp.) of the western Pacific. The sea krait on page 114 is not identified to species (it is the Pale-lipped Sea Krait, *Laticauda colubrina*). No mention is made of the introduction of the Australian Green Tree Frog (*Litoria caerulea*) of which I saw a wild-caught specimen from the vicinity of Suva in 1983. Has it become established?

But these are niggling criticisms of a splendid book whose special appeal finally lies in its quite superb photography. It is astonishing that one photographer (much less an author/photographer) could achieve such spectacular results and consistent high quality across such a diverse range of subjects and environments. This book may not be the definitive work on the natural history of the Fijian islands but, more than any other book published to date, it presents a scholarly and visually stimulating overview of the subject, which will be welcomed equally by scientist, resident and tourist.

—Hal Cogger
Australian Museum



Top End Native Plants
By John Brock. John Brock, Winnellie, NT, 1988, 350 pp. $45.00.

The Northern Territory is worlds removed from the publishing capitals of Sydney and Melbourne, and Top End writers often find it difficult to get their manuscripts published. In response, some nature writers have taken to publishing their own books. The results have been superb. In 1986 Kym Brennan brought out an excellent field guide, *Wildflowers of Kakadu*, and now John Brock has published *Top End Native Plants*.

Brock's book is set to become the standard reference on plants of the Top End. In 350 glossy pages he has described and illustrated in colour 450 of the more common, spectacular and unusual of the plants found around Darwin, Kakadu, Arnhemland and adjacent regions. The text is clear and concise, the format is intelligent, and the colour photos are sharp, aesthetic and diagnostic.

Brock's book is the closest anyone has come to a Flora of northern Australia. The absence of such a book is a major irritant to botanists and naturalists. There are complete Floras, identifying all the plant species, for South Australia, central Australia, south-western Australia, Victoria (somewhat out of date), Tasmania (ditto), the Australian Capital Territory, most of New South Wales and south-eastern Queensland (one volume yet to be released), but nothing at all for the vast tropical belt of Australia. Brock's book will help fill that gap. Many of the plants he depicts occur also in northern Queensland and the Kimberley, and plant lovers in those regions will find his book invaluable.

Especially helpful are the notes on Aboriginal uses of the plants. With the boom of interest in bush foods and medicines, this information, fully sourced, is most welcome. Many of the medicinal plants have never been photographed before.

My only gripe is with the book's format. Brock lists the plants in the alphabetic order of their scientific names. This arrangement has no biological basis and makes the book difficult to use as a field guide. The plants should have been grouped by growth form into herbs, vines, shrubs and trees, or perhaps into their respective families.

Brock works for the Northern Territory Conservation Commission and his book has been sponsored by the Northern Territory Government. All concerned should be congratulated for what is a splendid book.

—Tim Low

The Scarlet Gum (*Eucalyptus phoenicea*) is one of the most outstanding flowering eucalypts of the Top End.

All books reviewed in Australian Natural History are subject to fluctuations in price and overseas availability.

"It is hard to accept that the suspension of the Minerals Convention is likely to trigger an 'unregulated scramble'."

ANTARCTICA: WILDERNESS OR GOLDMINE?

BY LYN GOLDSWORTHY
GREENPEACE

THE FUTURE OF THE ANTARCTIC continent as a breathtakingly beautiful wilderness, scientific preserve and international zone of peace is currently up for grabs as a number of nations prepare to ratify a Convention that will permit mining activity in this last (relatively) untouched region. Australia has a crucial role in deciding that future; on 22 May 1989, the Prime Minister announced that Australia would not sign the Minerals Convention but would instead actively seek the urgent negotiation of a "comprehensive environmental protection convention". Three weeks later, the French Prime Minister publicly committed his government to support the Australian stance.

Several countries have already signed, including the USA, USSR and five other nations claiming territory in the Antarctic; signature, however, is only a voluntary statement of commitment to the Convention. The legally binding ratification process starts after 25 November 1989 but only when 16 of the 20 nations that participated in the final negotiating session have ratified. These 16 must include Australia, France, both super-powers and a total of five developing and 11 developed nations. Only then will the Convention enter into force. The Australian and French stance against the Minerals Convention therefore places the very existence of the new Convention in jeopardy.

Activity in the Antarctic currently focuses on collaborative international scientific research, as set forth under the Antarctic Treaty, which was negotiated following the tremendous success of the 12-nation International Geophysical Year scientific program in 1957–58. However, while dealing admirably with scientific and logistic coordination, and foreseeing the need for the development of regulatory measures for marine living resources, the Antarctic Treaty made no provision for mineral resource management presumably because, at the time of its negotiation in 1959, it was inconceivable that mining activity in the Antarctic would ever become a reality.

Interest in the potential mineral wealth of the Antarctic arose in the early '70s when, in the context of the first major oil price shock, the International Deep Sea Drilling Project found ethane, normally suggestive of hydrocarbon deposits, in Ross Sea sediments. The Treaty nations reasoned that a specifically designed agreement to cover mineral resource activity was needed, as the absence of such would lead to an "unregulated scramble" that would threaten the survival of the existing arrangement.

Negotiations, postponed for several years while the more urgent problem of unregulated fishing activity in the Southern Ocean was first dealt with, began in earnest in January 1982. Twelve long sessions later, the Convention on the Regulation of Antarctic Mineral Resource Activity (CRAMRA) was adopted in Wellington, New Zealand, on 2 June 1988 by the then 20 Antarctic Treaty 'Consultative Parties' (ATCPs), which on the basis of their ongoing and substantial scientific effort on the continent have granted themselves the right to make decisions on Antarctic activities.

The most contentious issues centred on who would reap the 'profits'. The Convention had to balance the rights of the seven nations, including Australia, that lay claim to sometimes overlapping sectors of the continent; developing world interests that have identified the Antarctic as the 'common heritage of mankind'; and mining nations wanting to ensure an automatic and smooth pathway toward economically feasible mining activity.

The Convention prohibits exploration or development activities unless the institutions established under the Convention give specific approval (prospecting activity can occur without authorisation as soon as the Convention enters into the force). The rules say that any Commission member may veto the opening of an area if they are not satisfied that the environment will be adequately protected. Protection of the environment is cited as "a basic consideration" in all decisions.

Critics of the Convention, however, lack confidence in the ability of the Commission members to translate CRAMRA's environmental good intentions into reality, particulary given the Treaty nations' unimpressive record to date.

For example, the French government is blasting an airstrip at their Pointe Geologie Antarctic base, killing penguins and thus violating a key provision of one of the Treaty agreements. Yet no ATCP has been willing to insist the issue be formally discussed. And while permit regulations for Specially Protected Areas (SPAs), designated ostensibly to protect a region completely from human encroachment, were being finalised at the 1975 Treaty meeting, the Soviet Union and Chile were calmly building bases in the middle of the Fildes Peninsula SPA. Instead of demanding a halt to the construction, the Treaty nations redrew the boundaries of the SPA to accommodate the new constructions.

Further, the Convention's apparently stringent 'Principles and Objectives' rely on undefined phrases such as "damage. . . judged. . .acceptable", and "significant adverse effects", and are thus fraught with interpretative difficulties.

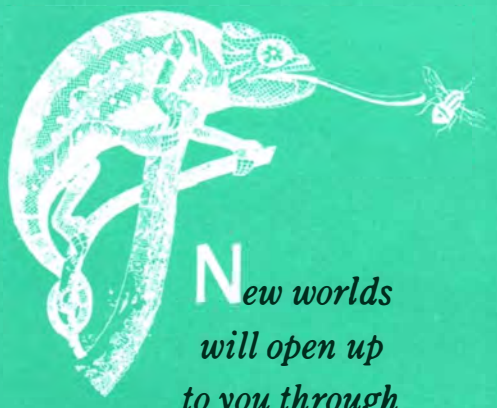
The Convention establishes a Scientific, Technical and Environmental Advisory Committee (STEAC), which is required to conduct technical and environmental assessments of proposed activities at most major decision-making points, and which may be invited to provide further advice on an *ad hoc* basis. However, the Regulatory Committee, the institution that will consider specific licences, can ignore even the unanimous advice of this Committee.

Irrespective of the effectiveness or otherwise of the Convention's environmental provisions, environmentalists are opposed to the Convention because they believe minerals activity in itself is incompatible with the survival of global values of Antarctica, as a wilderness, scientific preserve and pollution monitoring zone.

ATCPs have consistently insisted that extraction of Antarctic minerals will not take place for the forseeable future, not least because no exploitable mineral deposits have yet been identified in Antarctica. It is hard, therefore, to accept that the suspension of the Minerals Convention, pending the negotiation of a Protection Convention, is likely to trigger an "unregulated scramble", particulary in the absence of investment, security and property rights conferred by the Convention.

In the context of concern about global warming and climate change, it would also be short-sighted and morally wrong to open Antarctica to oil drilling. By the time it is economic to exploit the Antarctic's speculative reserve of fossil fuels, the world should have substantially reduced its dependence on them. ■

Ms Lyn Goldsworthy is Director of the International Environmental Coalition, Antarctic and Southern Ocean Coalition and Consultant to the Greenpeace Antarctic Campaign.



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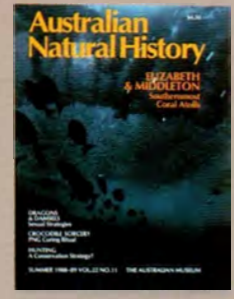

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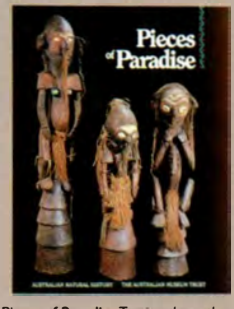

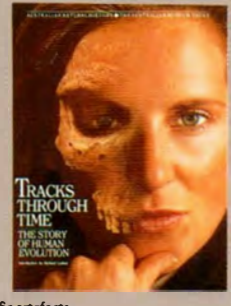

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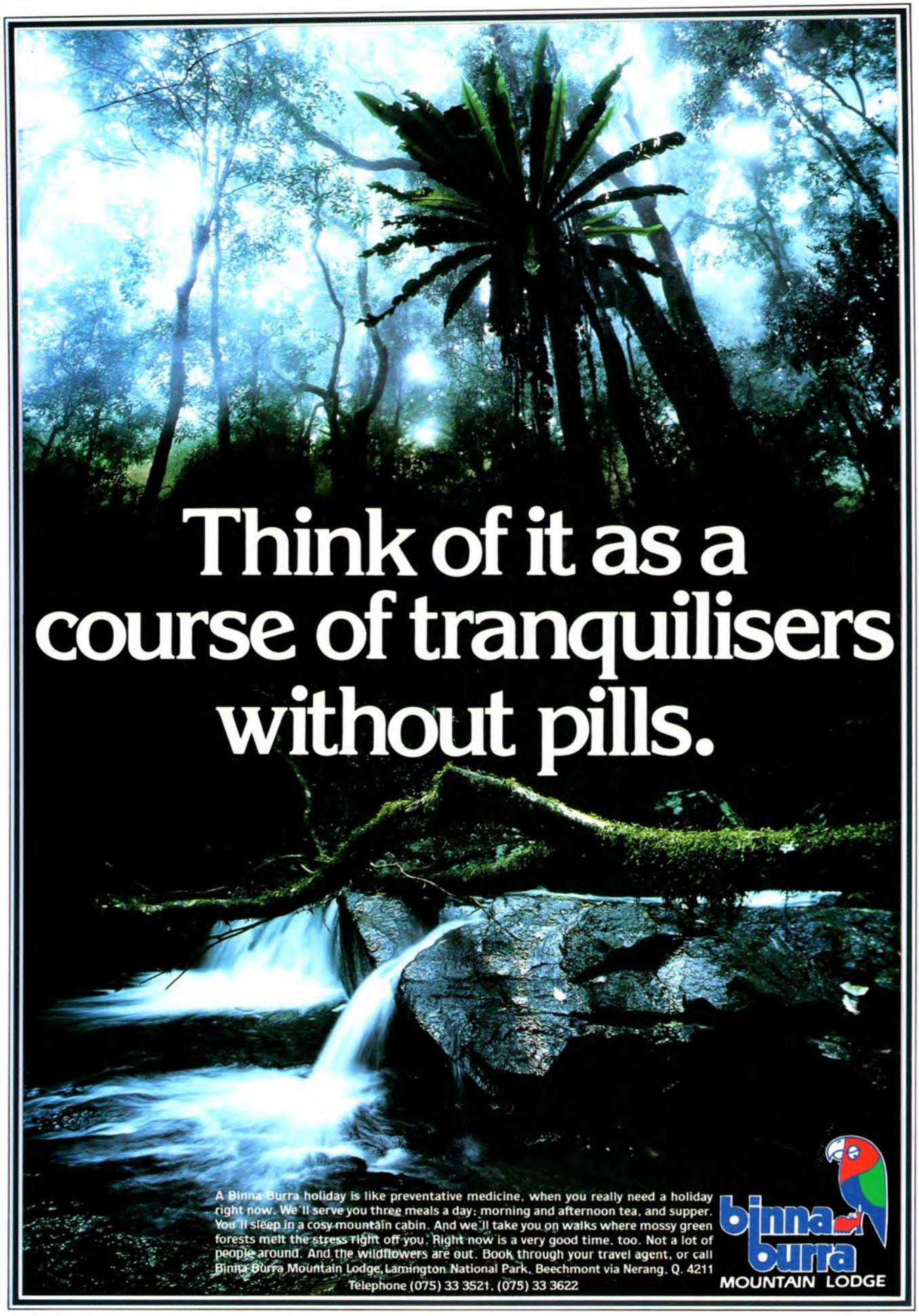
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