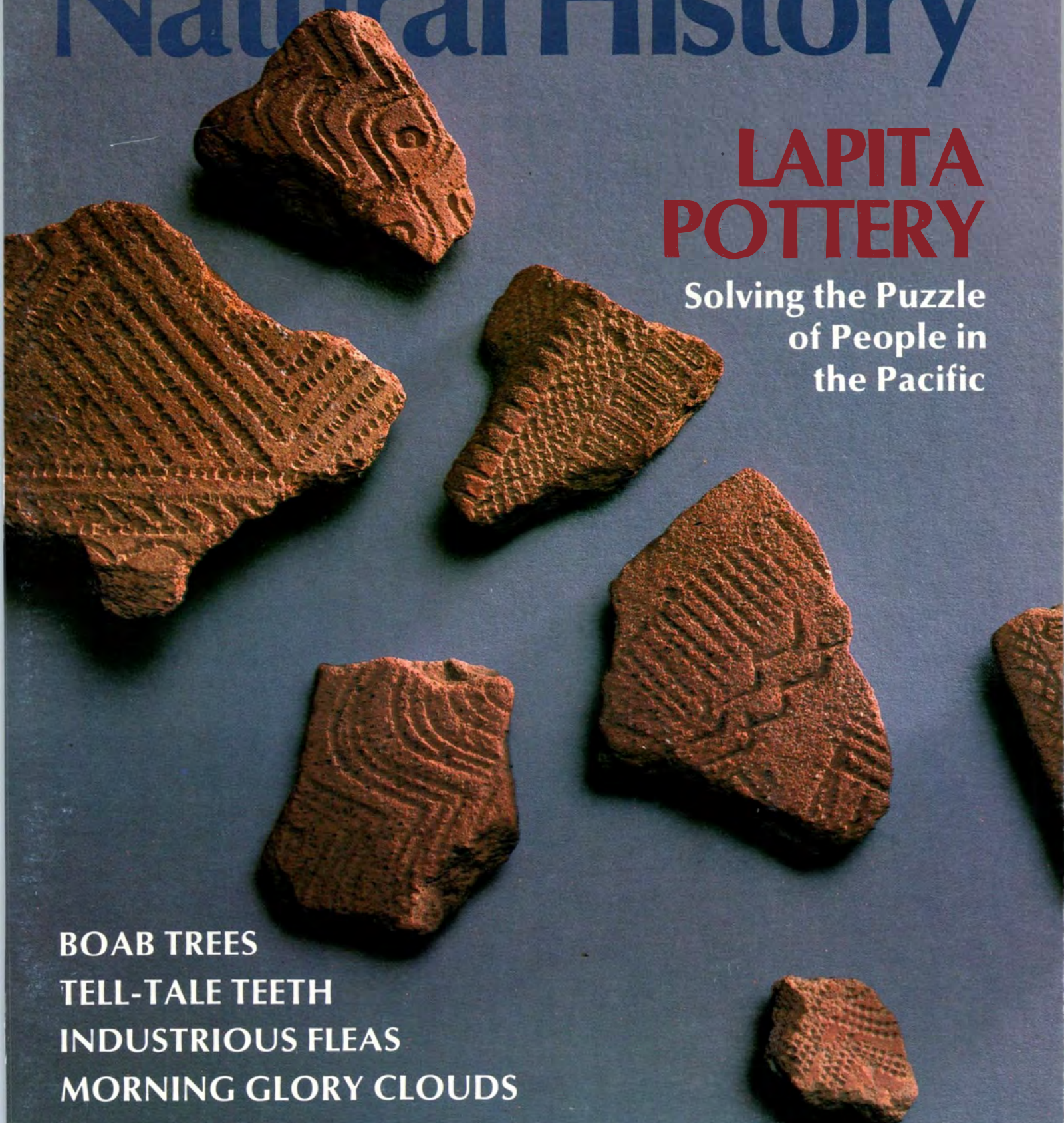


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LAPITA POTTERY

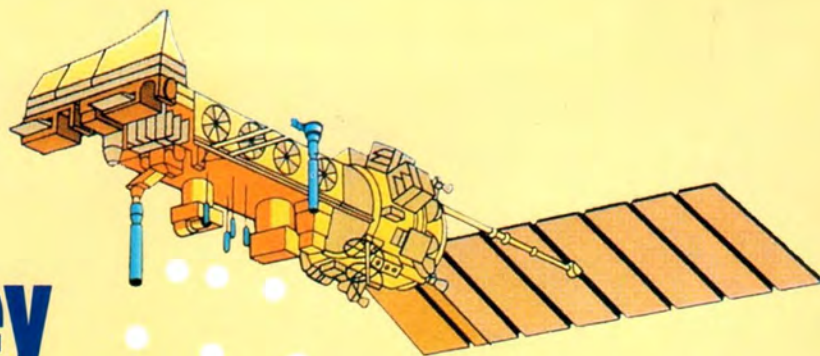
Solving the Puzzle
of People in
the Pacific



BOAB TREES
TELL-TALE TEETH
INDUSTRIOUS FLEAS
MORNING GLORY CLOUDS

WINTER 1988 VOL. 22 NO. 9 THE AUSTRALIAN MUSEUM

Where are they today?



Argos knows.

Not only did it know the whereabouts of Dr Gordon Grigg's camels, Argos also had information regarding the location, movement, air temperature and barometric pressure of 553 drifting and moored buoys, 11 ships, 3 balloons, 392 fixed stations and another 72 animals including caribou, turtles, whales and dugongs.

An informative article will appear in the next issue of this magazine.



Dromedary Camel

Australia is host to the world's only known population of feral camels. Introduced as pack animals after 1840, the advent of the car in the 1920's made them an outmoded form of transport. About 35,000 of them roam the harsh terrain of Western Australia, South Australia, Queensland and Northern Territory causing expensive damage to fences. Little was known about their biology in the wild so the Argos location system was used to gather more information about them. (See ANH Winter 1987)



Data Collection of Stromatolites

The understanding of the environment in which these ancient life-forms grow has been greatly enhanced by the use of the Argos satellite-based data collection system.



Drifting Buoy

The discovery and emerging understanding of the El Nino and "Southern Oscillation" phenomena owe much to drifting buoys tracked by the Argos system. These and similar phenomena are not only of immense importance to Australia and the weather we experience, but are among the most fundamental discoveries in recent times in oceanography, meteorology and climatology.



Dugong

The dugong, the only herbivorous mammal that is strictly marine, is considered vulnerable to extinction. The movements of dugongs have been monitored by Argos as part of a programme which aims to establish a sound biological basis for the management of dugongs in the Great Barrier Reef Marine Park.



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Front Cover

Fragments of Lapita pottery like these have been found in many archaeological sites in the western Pacific. Distribution of this pottery is an important indicator as to how these islands were settled. Photo by Anthony Farr.

EDITORIAL Important Puzzles

What can old pieces of pottery tell us about cultural origins? The highly decorated pottery pieces on the cover are known as 'Lapita'. Its occurrence in Pacific Island archaeological sites provides a vital clue to understanding how these islands were settled. Read about the findings of the Lapita Homeland Project in the article on page 410.

The lack of a centralised, up-to-date information base has long been a problem for biologists. In Australia, we have so many unique species and so few scientists studying them that researching them is a daunting task. Locating the latest information can be a nightmare: findings tend to be scattered throughout various research institutions or in obscure journals, and sourcing can be a tedi-

ous job. One organisation, the ABRS, is quietly dedicated to maintaining an enormous database that provides access to Australian biological research. And it's a world first. Find out more in Forum on page 430.

Much of the information for this database is being derived from museums. These are important research institutions—not just houses for collections and galleries, as many people tend to think. Robyn Williams discusses this museum myth on page 409.

Aside from studying nature, can we still identify with it? Are we heading for a biological blitzkrieg? These questions are raised by Michael Archer, our new regular columnist. His vital, questioning style is a valuable contribution to ANH.

—Fiona Doig, Editor



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A Cautionary Tale

Robyn Williams' article on snorkeling in the Spring 1987 issue of ANH (vol. 22, no. 6) was (as always) very interesting; the accompanying illustration, however, reminded me of a near-fatal experiment that I carried out, aged about 12.

I lived on the upper reaches of the Swan River (Western Australia) and frequently went canoeing. Being very interested in fish, I decided to watch them under water at close range.

To do this I devised a simple plan: I borrowed a garden hose, one end of which my friend was to hold in the canoe while I breathed through the other end on the river bottom.

I realised that, under water, I would not be able to remain motionless (to avoid frightening the fish) without something to weigh me down, so I tied an appropriately large stone around my waist and dropped over the side of the canoe with the end of the hose in my mouth— instant terror!

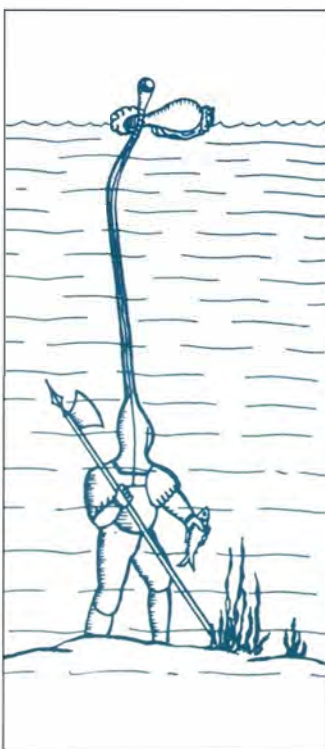
With a force that nearly ripped out the back of my palate, every vestige of air in my lungs departed up the hose, leaving me on the bottom with the stone around my waist!

I managed to free myself and, half dead and not understanding what had happened, reach the surface.

As an engineer I now realise that I would have had at least a tonne of pressure on my chest and that the only reason that I was not killed on the spot was probably that the hose was blown out of my mouth by the initial outrush of air.

Now, back to "Snorkel Sense"; it is only the illus-

tration that alarms me. Effectively it parallels my own situation; the end of the breathing tube is kept above the surface by the float and the diver's body is subjected to the pressure.



I have recently been told by an experienced professional diver that I was enormously lucky to survive my experiment. Perhaps it would be worthwhile to highlight the danger of copies, or variations, of the device illustrated.

—Eric Watkinson
Northbridge, NSW

Does This Ring a Bell?

Of the numerous articles I've read on Australian native plant foods, I have not yet seen mention of two berry plants that, as children 65 years ago, we commonly ate in summer during bush rambles.

I lived at that time in Redhead, about 20 kilometres south of Newcastle. The berries were known to

us as 'Fivies' and 'Tennies'. The names derived from the fact that the approximately pea-sized berries were held, in the first case, by a five-pointed bract, and the other by ten overlapping bracts. The 'Fovie' was harder, drier and not sweet, and contained a hard seed. It grew on a bush about 1.2 metres high, with light green tea-tree-coloured leaves and small clumps of leaves about seven millimetres long and four millimetres wide. If I remember correctly, it had small white tea-tree-type flowers before fruiting in mid summer. It was widespread in the sandy scrubland extending from Dudley south to Jewel's Swamp, just north of Belmont.

The 'Tennie' grew as a small ground-cover plant, in clumps between 30 and 45 centimetres across and no higher than 15 centimetres. The leaves were dark green, very thick, about one centimetre long and fin-like. The berry was prolific and preferred, as it was softer and sweet to taste. It too had a hard seed. If memory serves, it had a crimson to purplish flower prior to fruiting, and was a mid-summer harvest. It grew on the same sandy soil and was scattered among the low scrub where the 'Fovie' was found.

Another curiosity of the area was the 'Pandorea'. It was known to us children as the 'Chocolate Bell' because of the rich chocolate smell of its flowers, as well as the colour of part of the bells. Although I have recently travelled within a radius of 250 kilometres of Newcastle, and seen pandorea widespread, not one of the flowers had the delightful chocolate smell of the southern Newcastle

species of long ago. I am aware that there are three kinds of pandorea, but none of the flora reference books I've consulted has mentioned the scent of the flower.

Please let me know what you think these plants may be.

— Vic Bird
Forster, NSW

'Fivies' would most likely be a *Styphelia* species in the southern heath family, *Epacridaceae*. *Styphelia triflora* is known commonly as *Five Corners*, and *Maiden* in *Useful Native Plants of Australia* (1868, p. 61) writes that "fruits have a sweetish pulp with a large stone. They form part of the food of the Aborigines and are much appreciated by schoolboys."

This plant is an erect to spreading shrub, one to



DENISE GREIG

Leucopogon parviflorus.

two metres high with leaves 10 to 25 millimetres long and three to six millimetres wide (longer than suggested by Mr Bird). The flowers are pink with yellow or sometimes greenish yellow.

The *Fivies* might also be *Leucopogon parviflorus* or *L. lanceolatus*. The former grows on sand dunes near the sea, and has a white fleshy fruit four to five millimetres high. The leaves are 11 to 29 millimetres long, two to seven millimetres

wide, and the flowers are small, white and bearded. *Leucopogon lanceolatus* is more common in bushland. It has a small orange to red fleshy fruit, two to three millimetres high; the leaves are 12 to 34 millimetres long, two to five millimetres wide and, again, it has small, white, bearded flowers.

The 'Tennie' is most probably *Astroloma humifusum*, another member of the *Epacridaceae*. It is known as the Native Cranberry. It has a red flower and a green fruit with sweet, viscid pulp surrounding the hard stone. The leaves are six to 18 millimetres long with serrulate margins (that is, "fin-like").

With regard to the 'Chocolate Bell' I am unable to help. The botanical literature I consulted, likewise, gave no reference to the scent.

— Jocelyn Powell
Royal Botanic Gardens
Sydney, NSW

Giant Earthworms

I was very interested in Georgina Hickey's Rare & Endangered article on the Giant Gippsland Earthworm, *Megascolides aus-*

tralis (ANH vol. 22, no. 7, p. 320). There is a giant earthworm in the red soils of the Mt Warning region near Tweed Heads. I have also personally seen one dug up on Queensland's Mt Tamborine (at the back of the Gold Coast hinterland) and it was about as big as the one shown by Frazor Hercus. They are said to be common on the Mt Tamborine plateau. Could it be possible that this is an isolated patch of the same earthworm species?

— Roger Burgess
Tweed Heads, NSW

There are actually two 'giant earthworms' in Australia. The other species is *Digaster longmani*. Its type locality is Mt Tamborine, Queensland and so would certainly be the species you sighted. It has also been recorded from Kyogle State Forest, Richmond Range State Forest Toonumbar State Forest and Stradbroke Island.

— G.H.

Good Science

It is unfortunate that a regular reader of *Australian Natural History* describes this publication as being excellent except for its failure to promote creation theory as a scientific equal of evolution (Mat Vanderkluft, ANH vol. 22, no. 7, p. 291).

Creationism has about as much value to scientists as the flat Earth theory has to geographers. To put forward Creationism as a competing theory is akin to putting a garden slug in the barrier for the Melbourne Cup. Only those confident of the intervention of some divine catapult would back the slug.

— Roger Bourne
Brisbane, Qld



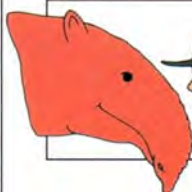
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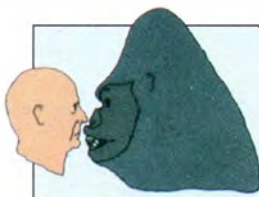
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Molluscan Dentistry

THE TALES THAT TEETH TELL

By **BILL RUDMAN** and **GEOFF AVERN**

MALACOLOGY SECTION, AUSTRALIAN MUSEUM

Many of the most delicate and beautiful objects in nature are unknown to the naturalist. This is simply because they are so small. Just as the light microscope of van Leuwenhoek opened the eyes of 18th-century scientists to the world of minute pond-life, and gave the adjective 'microscopic' to such small objects, the late 20th century has

given science the Scanning Electron Microscope (SEM), allowing even smaller objects to be examined.

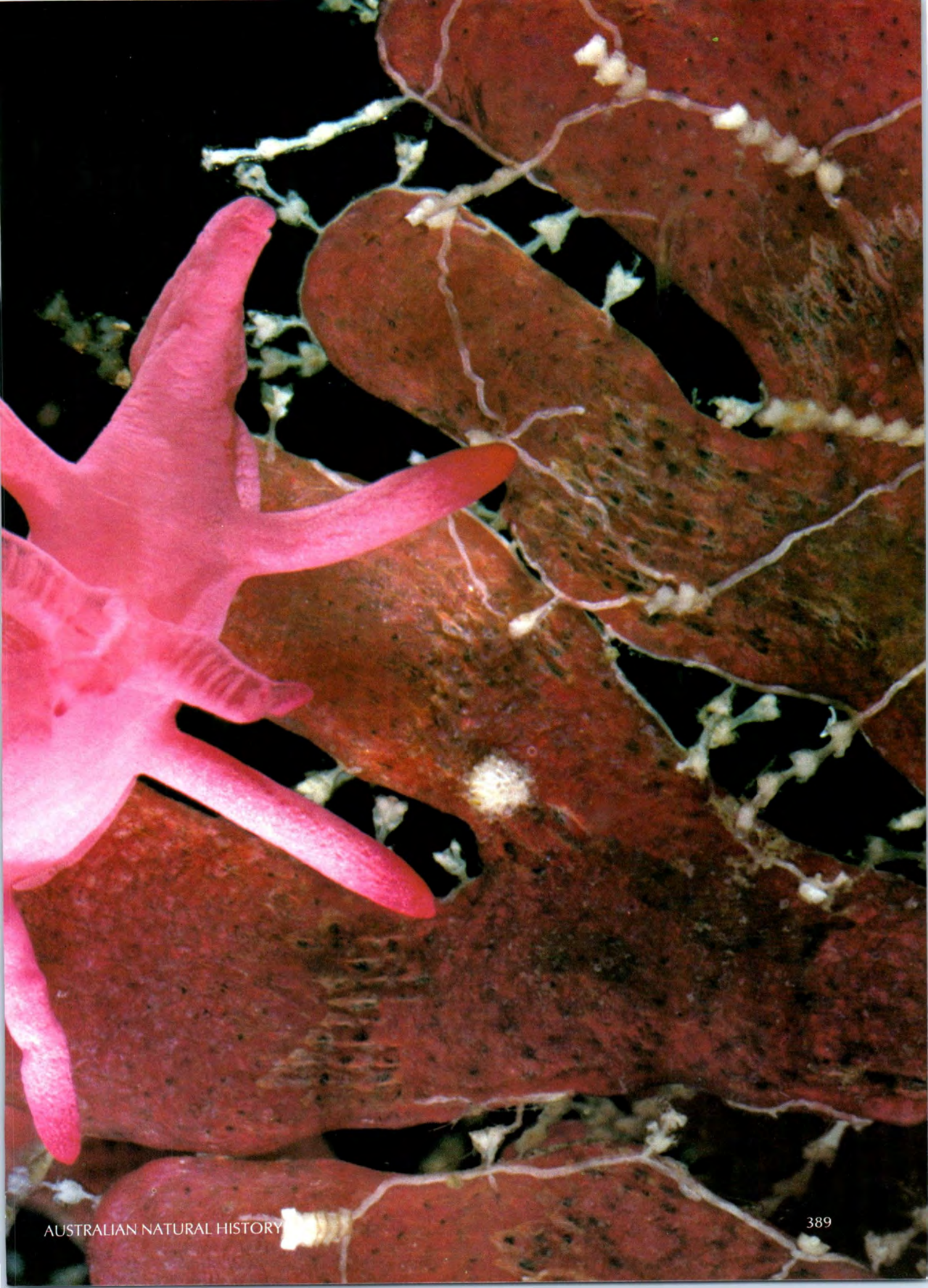
For the last seven years we have been using an electron microscope to study the intricacies of shape in the teeth of nudibranch sea-slugs—those beautiful shell-less snails described in a recent issue of ANH (Winter 1986). The teeth of snails are



COLOUR PHOTOS: BILL RUDMAN

SEM PHOTOS: GEOFF AVERN

Hopkinsia is another of the many nudibranchs that are seldom found far from their food. This species, which is known from many parts of northern New South Wales and the Great Barrier Reef, is always associated with the brown plant-like bryozoan colony it is photographed on. The strange teeth of this species are unique and it is not clear how they function.



very different from ours. They are made of chitin—the same substance that forms our fingernails and the external skeletons of insects—and, although seemingly delicate, are often very tough. Instead of being attached to jaws, they are attached in many transverse rows to a tongue-like, chitinous ribbon on the floor of the mouth. This ribbon is called a 'radula' and it is used to rasp or tear off pieces of food. As the oldest teeth wear out on the front of the radula, new ones are made at the back of the ribbon.

To study the radular teeth, they must first be removed by carefully dissecting out the mouth region of the animal. This tissue is then 'cooked' in a solution of concentrated caustic soda, which removes all surrounding muscle tissue, leaving a flexible radular ribbon with its rows of teeth. Finally, small pieces of food and detritus are removed from the teeth in a sonic cleaner—a machine that rapidly shakes the teeth by vibrating them with sound waves. Now clean, they are ready for SEM preparation.

The SEM works by 'bouncing' electrons off the specimen being studied. The electrons are collected and processed into a video image and recorded on photographic film. To ensure that electrons will readily bounce off the surface of the specimen, it is coated with a fine layer of gold. The whole preparation process is laborious and often time-consuming, but the information that can be obtained from a study of these teeth well-rewards the hours of snail dentistry.

We all know that mammal teeth are modified in different species for different functions: Bugs Bunny's two buck teeth are used for eating carrots, and the large canine teeth of dogs have evolved for piercing flesh. These functional differences are clear to even the most casual observer because the teeth involved are large and easy to see. In a snail or slug, however, it is difficult enough to find the ribbon of teeth, let alone see any differences in the shape of individual teeth. But the SEM has made this possible.

Two types of differences can be seen in mollusc teeth. The first results from the function to which the radula is put in different species—the radula of a grazing herbivore, for example, is going to be quite different to that of a specialised carnivore. A spectacular example of a tooth that

has evolved for a specific purpose is found in the tropical snails of the genus *Conus*. These 'killer cones' of shell-collecting lore have teeth modified to act as hypodermic needles or harpoons to sting, poison and capture their prey. The second set of differences comprises the normal variation one would expect to find between different species—closely related species often have similarly shaped teeth, while more distantly related species, even though feeding on similar foods, will often have quite differently shaped teeth.

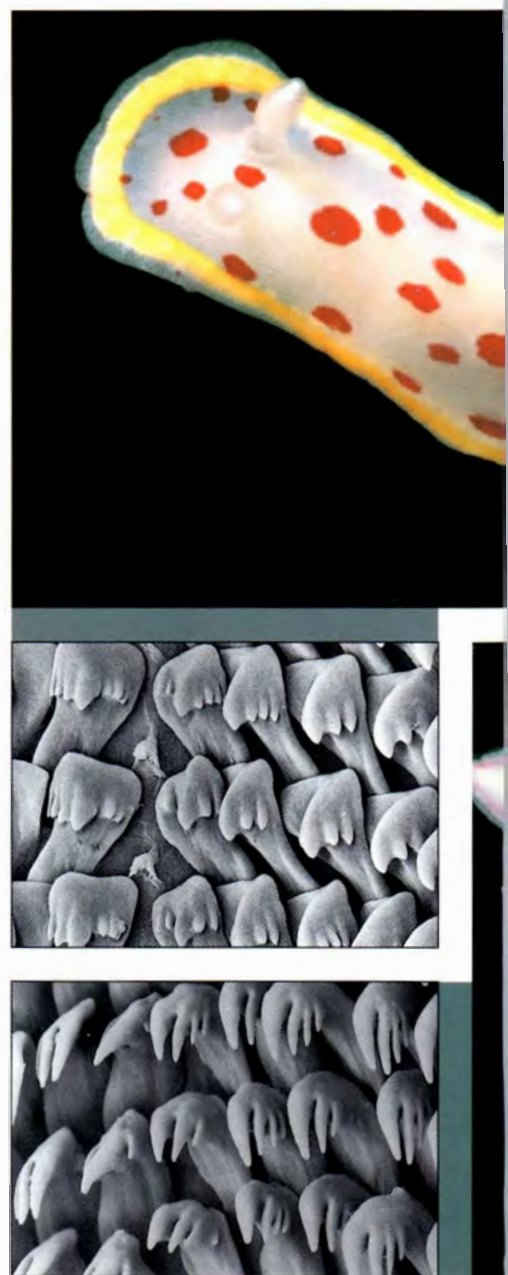
Knowing the shape of a species' teeth can thus provide information on both its feeding biology and its evolutionary relationship to other species that may look similar externally.

Marine sponges are the common food of many dorid nudibranchs, which graze by rasping off sections of the sponge with their radulae. Sponges, however, are often tough and have skeletal spicules of glass or calcium carbonate designed to prevent damage from grazing animals. To overcome this problem most dorid teeth are strong, simple, hook-like structures, their shape having been determined entirely by the need to rasp off tough bits of food. Because of this the teeth of most dorid nudibranchs feeding on spiculate sponges look the same. Their shape is almost entirely determined by their function. In these species, differences in colour, body shape and internal anatomy are needed to identify them.

The chromodorid nudibranchs, however, usually feed on a special group of sponges that, instead of skeletal spicules, have a network of fibres to maintain their shape. These fibrous sponges are apparently much easier to rasp, and the functional limitations on tooth shape are therefore less severe. Chromodorid nudibranchs feeding on fibrous sponges display an array of tooth shapes and denticulation that are clearly not of great functional importance. Three or four species with quite different teeth can be found feeding together on the same sponge. The sponges attempt to defend themselves by producing poisons, but the chromodorids take the poisons to protect themselves from being eaten by larger animals. In an elaborate game of hide and seek, these slugs have evolved to look as similar as possible in colour to the other slugs

feeding on the same sponge. In this way all the slugs share the load of teaching fish that they are unpalatable. While this is apparently effective for the slugs involved, it makes the job of the taxonomist, who is trying to differentiate species, very difficult. Fortunately it is in this family of nudibranchs that the teeth show so many interspecific differences.

The aeolids are another major type of nudibranch. They almost all feed on coelenterates, a group of marine invertebrates that includes the sea-anemones, corals, hydroids, blue-bottles and jellyfish. Within the aeolids each family group has specialised feeding habits (for example, some feed only on corals, some only on sea-anemones), and often each individual species will only eat one species of prey. Hence





- Chromodoris splendida
- Chromodoris hunteri
- Noumea haliclona
- Mexichromis mariei

These four chromodorid nudibranchs from New South Wales mimic each other in colour pattern. The differently shaped teeth show that each species is only distantly related to the others. Chromodorids feed on relatively soft sponges and this has allowed the development of the fine denticles on the teeth.



different shaped teeth have evolved for feeding on different types of coelenterates.

The aeolids have also evolved a radula quite different from that of dorid nudibranchs. In dorid nudibranchs, the radula, which is designed for rasping sponges, has many transverse rows of teeth and each row has many teeth; in aeolids, however, each row usually contains only one tooth. These teeth are designed to dig out individual coelenterate polyps or to tear out a

chunk of tissue.

Although the difference in tooth shape between closely related aeolid species is not great, the difference in shape between those that feed on different types of food is very clear. One can predict quite precisely whether an aeolid feeds on corals, soft-corals, hydroids or sea-anemones simply by looking at the shape of its teeth. Many small aeolids feed exclusively on hydroids, which are small colonial animals, each individual resembling a minute sea-

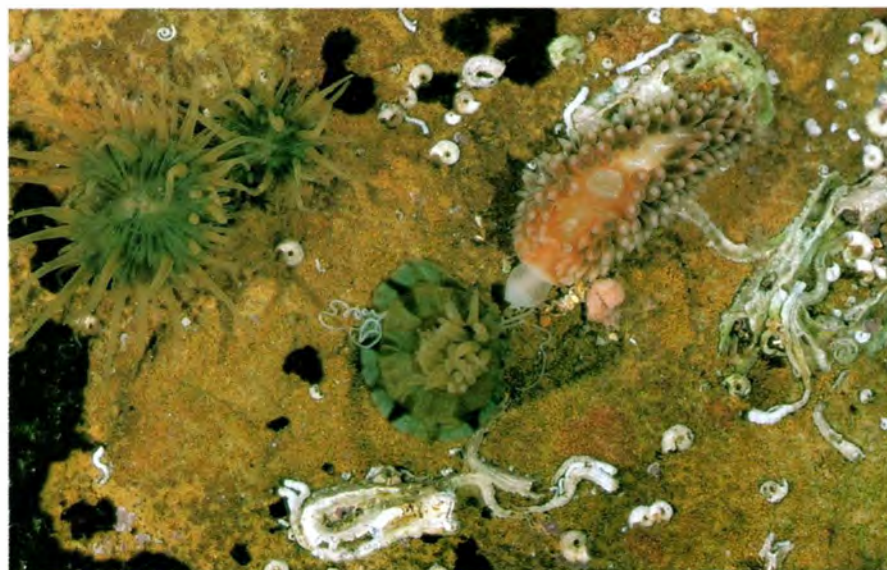
anemone. Each individual hydroid animal or polyp usually lives in a cup-like case and the aeolids that feed on these polyps have teeth designed to extract individual polyps from their cases. Each tooth has a large, pointed, triangular cusp with a series of small denticles on each side. In coral-eating aeolids, the teeth have evolved large comb-like denticles to reach down into the crevices of the hard coral skeleton to remove the animal tissue. Sea-anemones, on the other hand, are individual polyps without a skeleton. They are much bigger than the aeolids that feed on them so the aeolid, rather than eating them whole, can only take small bites. The teeth of anemone-eating aeolids have a shape specialised for this purpose, usually comb-like with a row of large, pointed denticles but without any prominent central cusp.

We still don't know what all nudibranch species eat and we still have much to learn about their biology. But by using the SEM to study the anatomy of species for which we do have some information, we are able to make predictions on the ecology and general biology of other species we know even less about. ■

The electronmicrographs in this article were taken by Geoff Avern on the SEM at Macquarie University's School of Biological Sciences. Geoff recently won the Best Micrograph category in the Australian Photomicrography Exhibition, sponsored by the Microscopical Society of Australia and Polaroid Australia Pty Ltd, and followed this up with a win in a similar category in the Polaroid-sponsored international competition held in the USA.

The Australian Museum is also delighted by the recent purchase of its own SEM, a Cambridge Stereoscan 120 from the UK, which, by the time of publication, will be photographing everything from the hairs on spider legs to mineral crystals to fibres in Melanesian fabrics.

Soft-corals and the related gorgonian *Junceola*, are the food of *Phyllodesmium*. The delicate white core of each of the tubular cerata contains part of the gut of this aeolid. The teeth are quite different from those of other aeolids and are designed for ripping out sections of soft-coral.



The common Sydney aeolid *Aeolidiella foulisi* feeds exclusively on sea-anemones. To prevent being stung by the anemone the aeolid must take a bite then quickly contract. The white threads from one anemone are defensive threads shot out to deter the aeolid.



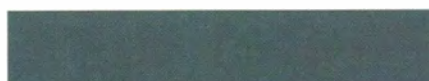
Some nudibranchs feed on arborescent or plant-like bryozoans such as Scupocellaria. These bryozoans often grow on the bottoms of ships, and the nudibranch *Polycera capensis* probably reached Sydney, where it is now common, by travelling, with its food, on the bottoms of ships.



The aeolid *Phestilla lugubris* feeds exclusively on the bommie-forming coral *Porites*. The long slender denticles on the teeth are used like tooth-picks to scrape the tissue out of the coral skeleton.



The bright red nudibranch *Madrella sanguinea* is almost impossible to see when on the similarly coloured bryozoan (*Mucropetraliella ellerii*) on which it feeds. The rake-like teeth tear sections from the tough skeleton of the bryozoan.



A Dying Need for Wild Places?

When I was an alien growing up in a farming community in New York State, the edge of our backyard was a vast swamp of soggy tussocks and willow trees, which for generations had been used as a graveyard for solid rubbish. Twisted edges of uninterpretable rusted things leered up out of pools of reddish water among squishy islands of swamp grass. Although my brothers preferred the backyard and my parents the front yard, to me that mixture of swamp, old bits of roofing iron and rusted refrigerators was a place of eternal mystery and discovery—because it was

the only place where I could see leopard frogs, water snakes and (best of all) Painted Turtles. At eight years of age, that ecological disaster area with its vestige of wildlife became my biological universe. Then I grew up, returned to Australia, mentally overdosed on Queensland's rainforests and fossils, and forgot America's rusted refrigerators; or so I thought.

Clearly, we are a complex mixture of chance imprinting and instinct. Twenty years after returning to Australia, while waiting for a suburban printer to produce page proofs, I strolled from his factory and down a back lane. It was something

to do. It led behind a row of houses to a narrow corridor of grassland that had been used for many years as a communal tip. And then *it* happened. As I stood absent-mindedly on bits of half-buried tin, I was suddenly overwhelmed by a feeling of nostalgia. With no comprehension of what was happening, I just wanted to stand there, to somehow make the good feeling last. Hours after upending memories for an explanation, I understood: a dormant bit of mental chemistry formed in childhood had just been given a kick-start—old suburban dumps were good places to be. Emotionally, I was hooked on rusted refrigerators—a dump junkie.

Although at first amused (I imagined spending the rest of my life sneaking around other people's backyards in search of rubbish), the wider implications began to bother me. If we're all made of the same stuff, and if we all identify most strongly with environments in which we were raised as children, people brought up in cities will be less able to emotionally identify with the need to conserve natural non-urban environments. And because we continue to suck the world to death as if it were an inexhaustible lollipop and to sanctify growth-spiral economies (which can whip the green off trees faster than you can shriek 'whazzat?'), the steadily diminishing areas of wilderness will imprint fewer and fewer childhood minds. As a consequence, future generations will simply care less and less about the Earth's wild things and eventually the emotional need to experience wilderness 'in the flesh' will probably die altogether. Which from my point of view is unthinkable; even a dump junkie needs a bit of grass with his rubbish.

Consider the facts. The world's tropical rainforests are being destroyed at the rate of 5.9 million hectares per year (about 11 hectares per minute). At this present rate of destruction, biologist Edward Wilson has determined that rainforests will vanish by the year 2135, taking with them into extinction somewhere between three and 15 million species (or maybe more), which is about half the world's total (*Nature* 323: 193, 1986). Because most humans also



MICHAEL ARCHER

A rusted-out wreck in the dump near the printers.



CLIFFORD FRITH

tend to churn out more than two 'rug-rats' per couple, world population size is predicted to double by the turn of the century and will almost certainly render AD 2135 an underestimate for D-day. This biological blitzkrieg has already well exceeded any previous disaster in the history of life.

If each succeeding, more demanding wave of humans that rushes over the world is less sensitive to the emotional need for wilderness, how do biologists who 'know in their

bones' that it is important to conserve biological diversity convince the growing numbers who don't?

First, all would-be Soldiers for Wilderness who feel the urge to do something should memorise the recent article by ecologist Daniel Janzen (*Ann. Rev. Ecol. Syst.* 17: 305–24, 1986). After totting up available figures, he predicted that: "For at least 90% of the 5–10 million species that live in the tropics. . .the ecological future (within the next 30 years) is extinction or restriction to wildland reserves. . .A seeming goal of humanity is to convert the world to a pasture designed to produce and sustain humans as draught animals." Although this paper is brutally depressing, it's also full of useful suggestions.

Second on the action agenda for biotic benefactors is a non-emotional prod guaranteed to mobilise even the most insensitive Philistine: good old-fashioned fear and greed.

What is there to fear or covet in the business of biological blitzkrieg? For something to fear, consider what will be lost as wilderness shrivels: 25 per cent of all life-enhancing drugs obtain their active ingredients from higher plants, and 50 per cent of all

Pelicans making use of our refuse.

species that produce these essential chemicals occur in the tropical forests now being destroyed. And for something to covet (something that will tickle even the most insensitive hip-pocket nerve), consider what is avariciously described as the 'biological wealth' of the world: the vast library of renewable genes and biochemicals. In fact, at least 50 per cent of the world's genetic resources occur in rainforest species, and over 80 per cent of the tropical species now being blitzkrieged have not even been named, let alone assessed for potential goodies.

Personally, although I now realise I'm a dump junkie, I'm nevertheless in love with biological diversity for its own sake, which is why I became a palaeontologist—you get to wallow in the ledger book of all Life's comings and goings. Unfortunately, having seen the rate at which beasts seem to be checking out of this book, I don't share anyone's optimism about the future of Earth's biological diversity. In fact, sometimes our perverse indifference to the well-being of Life so amazes me that I'm tempted to skip to the back of the book to see how we end. ■



"Don't be afraid dear — it's a tree!"

The Industrious Flea

By ARTHUR WOODS

UNIVERSITY OF NEW SOUTH WALES

"Sir," thundered Dr Samuel Johnson in 1783, "there is no settling the point of precedence between a louse and a flea." It is true that the old bully was really discussing the comparative merits of a couple of contemporary poets, but his analogy was false, for while nobody loves a louse, fleas are almost agreeable. The Reverend William Kirby and the Reverend William Spence, the 19th-century fathers of popular British entomology, had a friend—a young woman—who was confined to bed with a broken limb and complained of the attentions of fleas. "Dear Miss, don't you like fleas?" asked her visitor, an elderly lady. "Well, I think they are the prettiest little merry things in the world. I never saw a dull flea in my life!"

It's an odd distinction—this one between 'bad' louse and 'nice' flea. After all, a visit by head lice is not a sign of neglect, and they attack only people and spread no diseases. Fleas, on the other hand, are often more catholic in their tastes and

some can carry the bubonic plague bacillus from rodents to human victims, and the typhus rickettsia. But tastes change of course. The louse used to be considered a good omen. When Thomas Beckett was murdered in Canterbury Cathedral in 1170 his fellow monks were overcome with both grief and joy: grief for the loss of the Saint, and joy at the sight of lice—a sign of his piety—swarming from his cooling corpse.

Fleas (there are 1,500 or more described species in the world, and more than 70 in Australia) are beautifully adapted to their ectoparasitic life on animals with hair or feathers. The head is wedge-shaped with the antennae tucked away in grooves, and the body behind is smoothly contoured, with no sharp neck or waist, so that the insect can slip through the hairs or feathers without hindrance. The body is, however, adorned with spines, often arranged in combs, that point backwards. Thus the animal has no difficulty in dashing forwards but cannot easily scurry backwards. On the other hand, the

spines give excellent anchorage: it is notoriously difficult to drag a dog or cat flea from the fur without bringing some of the host's hairs with it. They are, of course, quite wingless, although wingbuds can be seen on some pupae. Wings, however, are not needed, for fleas are notoriously excellent jumpers.

One authority convinced himself that fleas jump backwards. No other biologist has repeated this claim, although it is known that, owing to the distribution of the weight in their bodies, fleas flip over and over in 'flight' and often land facing the other way. While airborne, one pair of legs pokes over the back so that whichever way it lands on the host it can use some leg spines as grappling hooks. In short, the legs on each side resemble those of the three legs in the coat of arms of the Isle of Man; and the flea could well share that island's motto, which translates as 'However you throw me, I stand'!

The leaping abilities of fleas have been exaggerated. While it seems that the flea hunted on the sheet can jump the length of a king-sized bed, the most olympian of human fleas, the widespread *Pulex irritans*, can achieve no more than 300 millimetres in the high jump and 900 millimetres in the long jump. Some even claim these figures to be gross exaggerations. Naive calculators sometimes scale this up and conclude that a man-sized flea would achieve 100 metres and 300 metres in these events. Similarly Charles Rothschild, Walter Lord Rothschild's brother, whose lifelong passion for fleas was initiated by an Australian helmet flea in a slide collection, concluded after watching the performers in a flea circus that their efforts were equal to a man dragging two dead elephants round a cricket field. These computations ignore the relatively rapid increase in the ratio of weight to muscle-cross-section area as an animal increases in size without change



An electron micrograph of *Ctenocephaloides* sp. This genus of flea contains both the cat and dog flea, which were introduced into Australia with their respective hosts.

SUE DOYLE

KATHIE ATKINSON



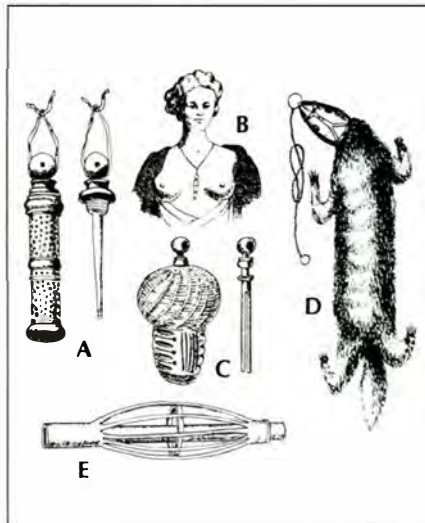
Dog flea, Ctenocephaloides canis.

Clean-up after the 1900 bubonic plague in Sydney. The Oriental Rat Flea transmitted the plague from rodents to humans.



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Before the advent of pesticides, ingenious flea traps were used. A and B illustrate an 18th-century ivory cylinder punctured with holes. A peg smeared with blood was inserted (presumably to attract the fleas) and the whole structure was hung around a person's neck. A similar trap (C) was also used in the 18th century. In this case a piece of wool doused with syrup to attract fleas was held in place by a split peg. Another trap (D)—perhaps as old as the 16th century—consisted of the skin of a small animal attached to an artificial head and worn around the neck. A Chinese flea trap (E) consisted of a tube of bamboo coated with bird lime, enclosed in a wider, slotted tube. Carried inside the folds of sleeves, the fleas supposedly adhered to the lime.

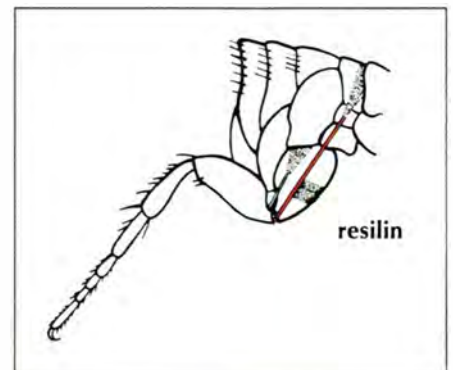


in shape. If the length increases 100 times, the cross-section (which is proportional to muscle strength) increases only 10,000 times, but the weight increases a million times. Realising that a man-sized flea would simply crumble, Charles Rothschild settled for two dead sheep.

A flea's jump should not, however, be taken lightly. Kim Parker, using high-speed cinematography, found that in the first two-thousandths of a second the acceleration of a jumping flea is about 1.4 kilometres per second per second (140 times the acceleration due to gravity), which is about 20 times that of an Apollo moon rocket. Fortunately for the flea, and sadly for us, its surface-area to weight ratio is high so air resistance soon brings it back to Earth. The speed with which the limbs move is far too great for muscle

contraction to be an explanation, and the flea owes its agility to a special, superelastic protein called resilin in its hindlimbs.

The life-cycles of fleas are fairly uniform. The adults of both sexes are parasitic blood-suckers on mammals or birds, and are equipped with crowns of spikes inside the anterior gut to pierce red blood cells and release their contents. The larvae, on the other hand, are long, thin, hairy, maggot-like creatures that feed on the rubbish in the lair or nest of the host. The adult females of most mammalian fleas drop eggs 'overboard' or lay them in the fur from where they soon fall. Most fleas that are restricted to birds live more or less permanently in the nest, feeding only when the owners are in residence, and consequently lay their eggs directly into the rubbish. The



A superelastic protein called resilin in the flea's hind leg releases energy when stretched and enables the flea to jump extraordinary distances.

grubs of at least some flea species need to eat blood (for the iron it contains), but obtain it not directly from the host but from the faeces or drops of undigested blood that the adult fleas release. When fully grown the larvae form pupae inside silken cocoons that are soon disguised with dust and debris. In time the adult fleas emerge from the pupae but remain within the cocoon until some stimulus—often the footfalls of an animal—urges them to break free and look for a host. Consequently people who enter a room or house that has been undisturbed for weeks, or even months, are often attacked by swarms of hungry fleas.

QUIPS, QUOTES & CURIOS

The Harvestman's Taxonomic Tool

Imagine an animal that looks like a beer barrel walking on eight legs. Although an arachnid, it is not a spider, which has two parts to its body separated by a narrow waist. It is a harvestman, and it differs from its spider relatives in several ways. Harvestmen don't have venom or fangs but simply crush and tear their prey (small invertebrates) apart with their crab-like nippers. Harvestmen don't have silk; they have two eyes instead of eight; and the second legs, which are the longest, are used as 'feelers'. Harvestmen have stink glands on either side of their bodies that shoot out a foul defensive liquid; and they have something else that spiders don't have—a penis.

Spiders mate literally at arms-length using a special swelling at the end of the male's pedipalp, a leg-like appendage at the front of the body. This swelling works a bit like an eyedropper bulb—it sucks up

sperm, which comes from the sex opening on the underside of the male, and expels it inside the female's sex opening. In many spiders this follows a long courtship during which, by careful stroking, the male 'persuades' his mate not to bite and eat him.

Unlike spiders, scorpions and other arachnids, harvestmen mate using a penis, which is extended from an opening, usually between the male's hind legs, into a similar opening beneath the female. There is only a short courtship during which the pair gets into the correct mating position.

They remain linked for several minutes, or even hours. The female can store the sperm in special sacs for months, until it is released to fertilise the eggs immediately before they are laid. She uses a telescopic egg-laying organ that stretches from her sex opening to probe for suitable egg-laying sites in rotting wood and other moist places. Spring is the main egg-laying season for most Australian harvestmen, although some species lay at other times of the year when conditions are favourable.

Harvestmen's penises are equipped with all sorts of plates, spines, knobs, bristles and curly bits—the envy of any Parisienne maritalaidsboutique. Their function, however, is purely practical. They ensure that the penis has the correct orientation for mating and they prevent closely related species from interbreeding.

My work at the Australian Museum has included a study of harvestman penis structure, and it is clear that the penis is one of the best



GLENN HUNT

Holonuncia sp. uses its large, spiny pedipalps to crush prey.

tools for use in separating and describing different harvestman species.

From an evolutionary point of view the harvestman's penis is an advanced adaptation for internal fertilisation. The ancestors of the arachnids lived in the sea where sperm could swim through the water and fertilise the eggs outside the female's body. Most land arachnids, such as scorpions, spiders and their kin, evolved complicated methods of internal fertilisation using indirect methods of sperm transfer. Harvestmen evolved direct sperm transfer using a penis. For this and other reasons, harvestmen are considered to be only distantly related to spiders and scorpions. Their closest relatives are the mites, some of which have also evolved a penis.

Australia is home to many native species of

harvestmen. They commonly live amongst vegetation near the ground or under rotting logs and other debris in moister regions of the continent. Some species live in arid areas of Australia including the Olgas and the caves beneath the Nullarbor Plain. Another has been introduced from Europe and now thrives in many backyards and gardens. It has become thoroughly 'domesticated' and I have even seen one cleaning up milk and other scraps of food left by my cat.

—Glenn Hunt
Australian Museum

When is an Animal a Plant?

All flesh is grass—that is to say, all animals are dependent, directly or indirectly, on plants. Without green plants the human race would die out in a mat-



GLENN HUNT

An SEM photograph of a harvestman's penis (Equitius altus).



ter of weeks: this is the ultimate disaster that would face us in a 'nuclear winter', when dark clouds would obscure the life-giving rays of the sun. Without adequate daylight, green plants can't live: they need it as a source of energy to fix atmospheric carbon dioxide by photosynthesis. But, even though we have sunshine, it does seem a pity that we cannot live at least partly as plants do, perhaps replacing bread and potatoes by a few hours of sunbathing. We can't, of course; but some animals can do almost as much, with the help of plants—chiefly algae.

There are several ways in which this trick can be accomplished. Some can be designated as a kind of symbiosis, while others might originate by cell-cell fusion or 'somatic hybridisation' (as it is called by genetic engineers), or by 'organelle adoption' (the capture of specific cell

components, in this case chloroplasts). We could describe such phenomena in a sequence, starting perhaps with the growth of algae on the grooved hairs of sloths, which may thereby benefit by a little verdant camouflage. (Polar bears in zoos sometimes have green fur, attributable to algal cells growing inside hollow hair-shafts, but no-one suggests that this could be of use to the animals under any circumstances.)

Various species of algae grow on the external skin or shell surface of many kinds of aquatic animals, and in some cases they may be mutually beneficial because of the production of oxygen during the hours of daylight. Some occur in special cavities, while others occur actually inside the cells of the animal. Here the metabolic activities of plant and animal cells must be very carefully integrated so that neither organism outgrows the other. In a few algal symbiotic associations (such as with the green flatworm *Convoluta* sp.) the partners work so well together that no other food is needed; in the adult stages, at least, the animals have reached a state of Nirvana, living by the energy of sunlight and

eschewing all gross solid food. In some cases (some giant clams and the green flatworm), the animals must catch new algae every generation; yet others, such as the green *Hydra* and some seasquirts, carry parental algae from one generation to the next, thereby paving the way for co-evolution in the two symbionts (that is, both host and alga).

Intracellular algae have to be closely integrated with their hosts—spatially and metabolically. One could say that their presence is tolerated by the host cells only because, by paying metabolic rent (the products of photosynthesis), they offer compensation for the inconvenience of having to house them. Ultimately associations of this sort may lead to such a close interdependence that host and guest cannot live without one another. Like Philemon and Baucis of Greek mythology, their lives become so closely entwined that the two different organisms grow into one, and the intracellular algal symbionts may be indistinguishable from cell organelles, specifically chloroplasts.

A whole subclass of

algae, the Glaucophyceae, seems to have evolved in this way, and no-one is sure whether the blue-green objects in their cells are blue-green algae (alga-like bacteria) or chloroplasts. The choice is almost a matter of personal philosophy or dogma, since now we have quite a body of evidence indicating that chloroplasts may have evolved originally from bacteria-like algae.

Recent studies by American marine biologists on certain protozoans that ingest algae throw additional light on such evolutionary processes. In a recent publication on this subject, D.K. Stoecker and others (*Nature* 326: 790, 1987) have shown that, while much of the cellular substance of the algae is digested in the ciliates' food vacuoles (their 'stomachs'), many of the chloroplasts remain intact and continue to function for a short period of time, carrying out photosynthesis and thereby contributing to the organic nutrition of the ciliate cells. This probably also happens when other transparent animals ingest algae: as long as the chloroplasts in their food remain undigested, and providing light and carbon dioxide can get into their guts, some photosynthesis can take place. The longer these animals can keep their ingested chloroplasts working, the less need they have for external food. So, starting from beginnings such as these, natural selection would inevitably favour those ciliates that can retain more chloroplasts intact and for longer periods of time—thus leading to more and better symbioses.

—Ralph A. Lewin
University of California



This seasquirt (*Diplosoma virens*) has a symbiotic relationship with algae. Here it is releasing bubbles of oxygen after a hard day's photosynthesis.

RALPH LEWIN

Morning Glories of the Gulf

By DOUG CHRISTIE

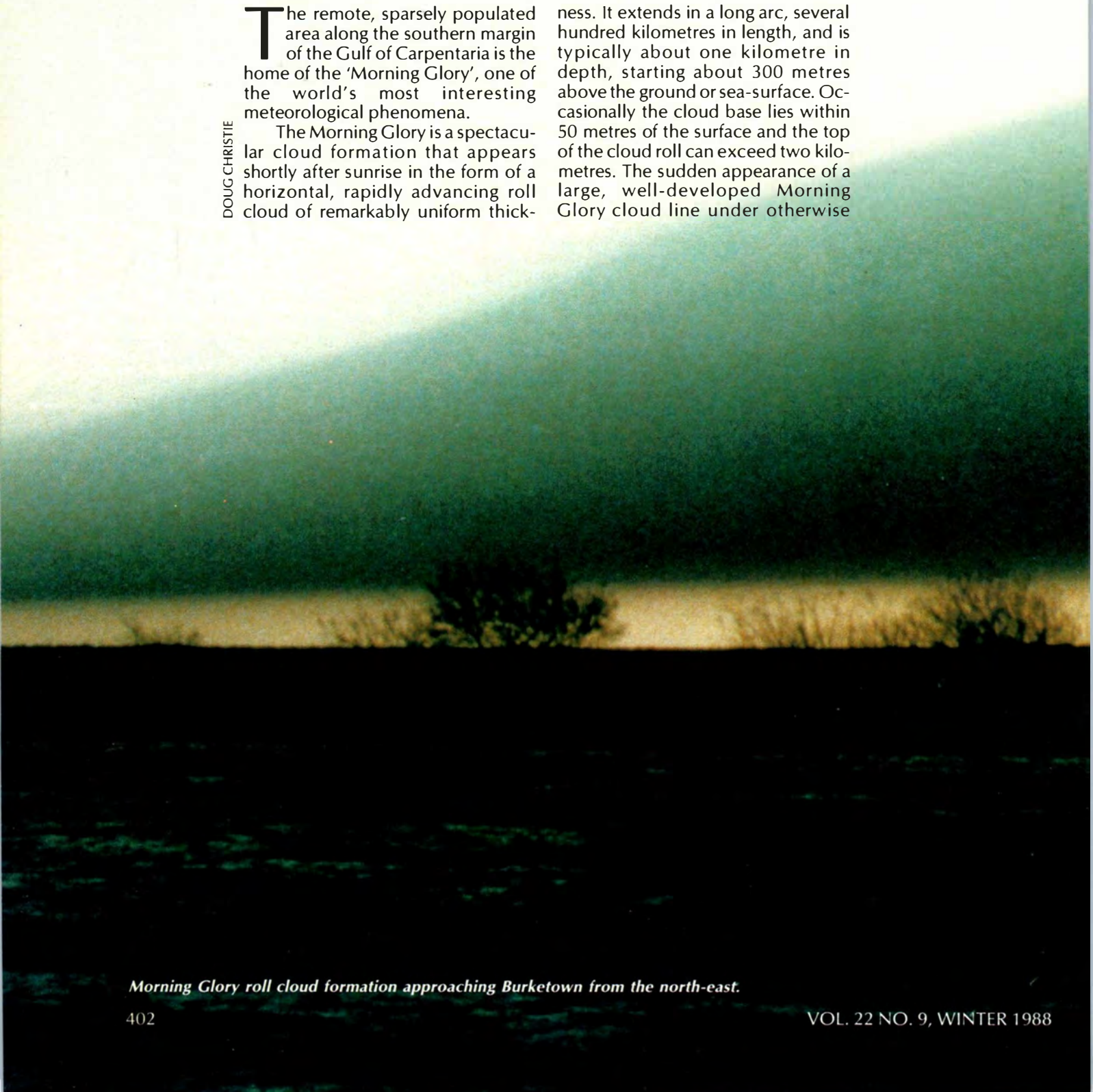
AUSTRALIAN NATIONAL UNIVERSITY

The remote, sparsely populated area along the southern margin of the Gulf of Carpentaria is the home of the 'Morning Glory', one of the world's most interesting meteorological phenomena.

DOUG CHRISTIE

The Morning Glory is a spectacular cloud formation that appears shortly after sunrise in the form of a horizontal, rapidly advancing roll cloud of remarkably uniform thick-

ness. It extends in a long arc, several hundred kilometres in length, and is typically about one kilometre in depth, starting about 300 metres above the ground or sea-surface. Occasionally the cloud base lies within 50 metres of the surface and the top of the cloud roll can exceed two kilometres. The sudden appearance of a large, well-developed Morning Glory cloud line under otherwise



Morning Glory roll cloud formation approaching Burketown from the north-east.



clear conditions can present an exceptionally vivid picture in the still of dawn.

Despite their rather formidable appearance, Morning Glories seldom produce rain. They are, however, invariably accompanied by a short-lived—but often intense—wind squall. The motion of cloud elements in the strong up-draughts along the leading edge, and down-draughts along the trailing edge, gives the impression that the cloud is rolling backwards as it advances. Morning Glories may occur as single, isolated, propagating roll cloud formations, or as a long series of up to ten individual roll clouds separated by about ten kilometres and ten to 15 minute intervals.

On average, Glories travel at 40 kilometres per hour, but occasionally they travel at over 60 kilometres per hour. They are most frequently seen between the months of August and November.

The area along the southern margin of the Gulf of Carpentaria—particularly in the neighbourhood of Burketown—is unique in that it is the only known location where Morning Glory cloud formations can be seen with any regularity. A few isolated observations of similar roll cloud formations over other maritime regions of Australia, the Gulf of Papua, the Straits of Malacca, northern Germany and the mid-western United States have, however, been reported.

Until recently, the Morning Glory was regarded as a meteorological mystery of unknown origin. It is now known that Morning Glory roll clouds are visible manifestations of

Measuring the wind structure ahead of a Morning Glory Cloud.

large-amplitude 'solitary waves'. Unlike the more familiar, continuously oscillating type of wave, solitary waves are localised waves with only one isolated crest. These individual waves arise quite naturally from a wide variety of atmospheric disturbances such as intense thunderstorms and sea-breeze frontal systems. If conditions are suitable, these waves produce what appears to be a propagating roll cloud, as moist air from near the surface is lifted along the front of the wave to the condensation level. The cloud that is formed by this process later evaporates as air descends in the down-draught along the trailing edge of the wave.

Solitary waves do not generate Morning Glory roll clouds when the lower atmosphere is dry. In this case, the disturbance is marked at the surface by a sudden, short-lived wind squall and by a change in pressure, typically of about one millibar. Atmospheric disturbances usually generate more than one solitary wave. Occasionally these disturbances appear as a long sequence of waves, with the leading solitary wave having the largest amplitude and usually producing the most spectacular Morning Glory cloud line. As a rule, however, most disturbances along the southern coast of the Gulf of Carpentaria are accompanied by only a few solitary waves and last for only a relatively short period of time.

Most Morning Glories in the Burketown area appear over the Gulf from the north-east. These usually break up and dissipate within the first 100 kilometres of their inland journey into drier air. The solitary wave



ROGER SMITH

disturbance, with its strong wind squall and turbulence, is not, however, destroyed by the disappearance of the cloud line. Instead it remains coherent and continues to travel inland, often over substantial distances, as a clear-air disturbance.

Our recent investigations have shown that Morning Glory waves extend over a much wider area than has previously been realised. North-easterly Morning Glories originate during the evening of the previous day over the highlands of the Cape York Peninsula. Aided by prevailing winds and topography, the disturbance moves south-west, arriving near dawn on the following morning over the Burketown area. In their earlier stages, these disturbances may extend as far north as Weipa and at least as far south as Cloncurry. The disturbance continues to propagate during the daylight hours inland over northern Queensland and along the southern side of the Gulf of

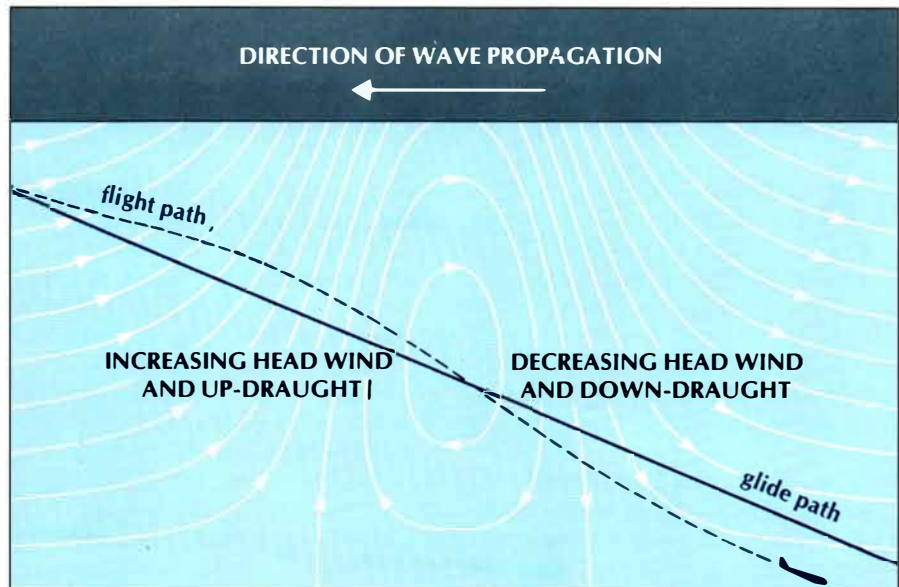
Morning Glory from the air.



ROGER SMITH



Morning Glory occurrence in northern Australia



Influence of wind shear on the behaviour of an aircraft during a head-on encounter with a solitary wave on final approach to the runway.



BRUCE FUHRER

Morning Glory over Burketown.

Carpentaria. Observations using sensitive microbarometers have been made of Morning Glory waves at Camooweal near the Queensland-Northern Territory border and at Boroloola along the south-western side of the Gulf. Remnants of these disturbances have also been recorded on numerous occasions during the evening of the same day at the Australian National University's Warramunga Research Station near Tennant Creek, some 1,000 kilometres from their origin over the Cape York Peninsula.

Spectacular Morning Glories are also observed during the early daylight hours from the south and south-east. The origins of these southerly disturbances, however, are not fully understood.

An extensive investigation of the properties of Morning Glory waves has been carried out over the last few years, and it is now recognised that solitary waves and related nonlinear wave disturbances occur commonly over much of the Australian region and elsewhere. The waves that are found in inland areas appear to be similar in all respects to Morning Glory waves except that they occur without cloud. It is now realised that, even in the area along the south-eastern margin of the Gulf of Carpentaria, solitary wave disturbances occur more frequently than not as clear-air disturbances.

The results of these investigations are of considerable value since they provide insight into the fundamental dynamical behaviour of the lower atmosphere. Since solitary waves have very large amplitudes, they constitute an important triggering mechanism for the formation of

thunderstorm squall lines. Studies of Morning Glory waves can therefore be expected to lead eventually to improved weather forecasts for the Gulf of Carpentaria region. These investigations also have an important bearing on our understanding of the transport of noxious insects by local winds, the redistribution and dispersal of atmospheric pollutants, and the prediction of wind-shift lines, which have a strong influence on bushfire control.

One particularly important aspect of the Morning Glory solitary wave research program is the recognition that waves of this type may produce intense horizontal and vertical windshears near the ground that are a potentially serious hazard to aircraft, especially during the landing or take-off stage. The leading up-draught and trailing down-draught in these disturbances may exceed 16 knots, and the horizontal wind component near the surface may vary by more than 30 knots during the passage of the wave. The most hazardous situation occurs when an aircraft encounters a clear-air solitary

wave from the front during final approach to the runway. In this case the aircraft rises above the intended flight path under the influence of the leading up-draught and increasing headwinds. The normal reaction of a pilot at this point is to decrease thrust and increase drag in an attempt to return to the normal glide path. This action, however, when combined with the sudden loss of lift due to decreasing headwinds and the down-draught at the back of the wave, could leave the aircraft perilously close to the ground, well short of the runway threshold. Jet-powered aircraft, with their relatively slow response, are particularly susceptible to sudden transient windshear disturbances of this type, but all types of aircraft may be affected.

Low-altitude windshear has been recognised for some time as a serious, but often poorly understood, worldwide hazard to aviation. The Morning Glory solitary wave studies have highlighted a new source of windshear and turbulence that may help to account for some previously unexplained aircraft accidents.

It seems unlikely that there is any other place where conditions are as favourable as those along the south-eastern corner of the Gulf of Carpentaria for the production of spectacular Morning Glory roll cloud formations. A visit to Burketown during the spring months to observe and photograph this unique and often awesome natural phenomenon can be a very memorable and rewarding experience. ■

RARE & ENDANGERED Rufous Hare-wallaby

When explorer Ernest Giles was returning across the Gibson Desert in 1876, he commented on the abundance of small wallabies living in the spinifex. He noted that they were exceedingly good eating and were similar to rabbits in size and taste. These were Rufous Hare-wallabies, *Lagorchestes hirsutus*.

Almost 60 years later in 1930–31, O.H. Lippert travelled through the Great Sandy Desert repairing wells along the Canning Stock Route. He also found Rufous Hare-wallabies to be plentiful and collected several specimens for the Western Australian Museum. In 1933 H.H. Finlayson recorded a unique and fascinating account of Aborigines hunting Rufous Hare-wallabies with fire near the Musgrave Ranges in northern South Australia. Again several museum specimens were obtained.

The situation then changed rapidly for these wallabies, known as Mala by Aborigines of the deserts along the Western Australian border. Information provided by these people show that the wallabies vanished from their vast desert tribal lands sometime in the 30 years following the work of Finlayson and Lippert. Just when this happened is not clear, and it seems to vary from place to place.

A tiny and extremely vulnerable population of perhaps 50 animals occupying about 50 square kilometres in the Tanami Desert is about all that remains. Additional security is provided by populations on Bernier and Dorre Islands off the Western Australian coast, but island populations

are well known for their susceptibility to catastrophic events.

As noted by Giles, Mala are approximately rabbit-sized, reaching 1.5 to 1.8 kilograms when fully grown. They are covered with thick woolly fur that was once plucked and spun by Aborigines into string. Aborigines recall the meat as a great delicacy and regard the blood remaining in the body cavity after cooking as good medicine for old people.

Mala once lived among the highly flammable hummock-forming spinifex communities on sand dunes and sand plains. Permanent surface water is normally absent from these areas and the Mala must derive their moisture from food. Small, crudely prepared squats are made under spinifex and low shrubs in winter, but in summer they often dig short burrows to escape the heat. Mala tend to sit tight in their squats but, when disturbed, explode from the cover and bolt with remarkable speed between the spinifex hummocks. Unlike many other macropods they do not thump their hind feet in alarm but emit a sharp squeak. This led to them being called 'whistlers' by the early colonists of Western Australia.

The Mala is one of four described species of hare-wallabies, two of which are already extinct. The reason for the rapid and catastrophic decline

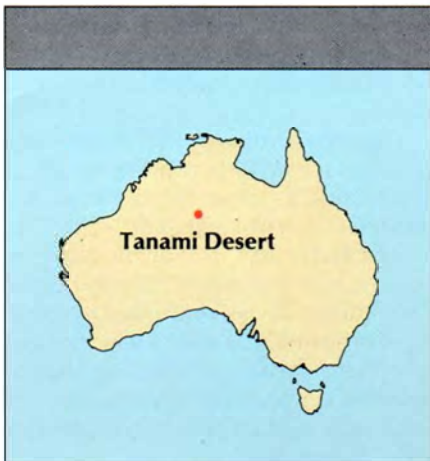
Aboriginal burning patterns are being used to re-create the Mala's former habitat.



A.G. WELLS, NPIAW

A Mala or Rufous Hare-wallaby. Only a small, vulnerable population remains in mainland Australia.

of Mala in the central deserts is uncertain but, because this area was not used for pastoralism until recently, it is clear that grazing is not implicated. Feral cats were present for at least 50 years before the Mala abruptly crashed, so it seems unlikely that they were a singular cause. Rabbits invaded the central desert at the turn of the century and foxes followed in



KEN JOHNSON



KEN JOHNSON



Typical Mala habitat, showing runways in foreground.

the 1930s. They most probably had a considerable effect in the south. In the northern deserts, however, their impact was probably slight as foxes never reached these areas until recently and rabbits appear never to have been in high numbers.

A common feature of the decline in all areas is its close correlation with the time that Aborigines left their country for the missions, stations and settlements. Their universal land management tool was fire, and it is the changing fire regime that undoubtedly affected the Mala. Burning by the Aborigines throughout the seasons produced a mosaic of vegetation in different stages of recovery that ameliorated the effects of large summer wildfires, produced a shifting diversity of habitats, and ensured a continuity of shelter and feeding areas for the Mala. Fires of 30,000 square kilometres (half the size of Tasmania) have occurred in recent years.

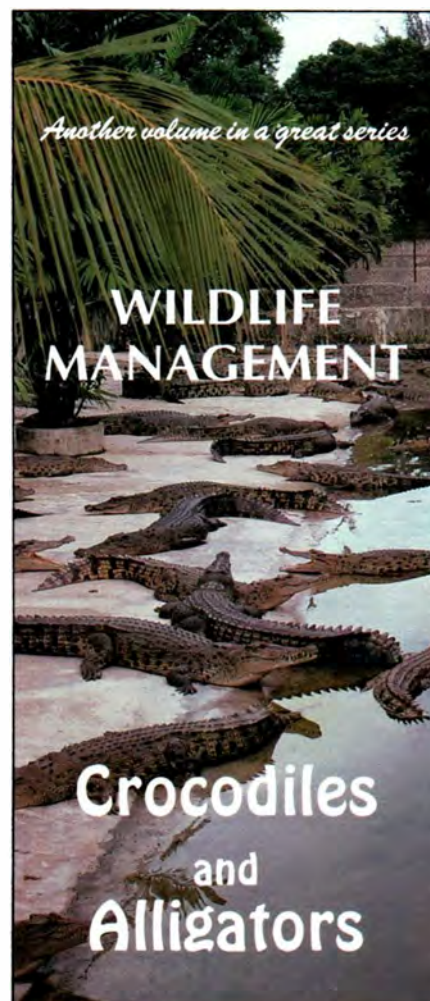
An effort is now under way that employs fire in the remaining Tanami Desert Mala colony to create habitat diversity similar to that produced by traditional Aboriginal burning patterns. The situation is critical given the extremely low number of animals. It is anticipated that this management will prevent a catast-

rophically destructive wildfire and create sufficient diversity to maintain the colony.

A captive breeding colony in Alice Springs is producing Mala for re-introduction into a part of their former range on Aboriginal land. The traditional owners are very keen for this to happen and have provided enormous assistance and advice in the project. This includes the selection of suitable areas for re-introduction, the explanation of how Mala once used these areas, and advice on the use of fire to create suitably patchy habitat.

The status of the Mala on mainland Australia is at best precarious, and on Bernier and Dorre Islands it is certainly vulnerable. There is no assurance that re-introduction will succeed or that the existing Tanami population will sustain itself through the certainty of periodic drought, predation and perhaps other unknown factors. Habitat management and re-introductions are the first steps by the Conservation Commission of the Northern Territory in a positive effort to prevent the third hare-wallaby of mainland Australia from becoming extinct. ■

—Ken Johnson
Conservation Commission
of the Northern Territory



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M. SEYFORTH, NPIAW

Of the five 'red-breasted' robins in Australia, the most widespread is the Red-capped Robin, *Petroica goodenovii*. It is common throughout most of its range and occurs through most of the southern half of the continent and much of the northern, with isolated populations on Rottnest Island off the Western Australian coast, on Greenly and Pearson Islands off the Eyre Peninsula in South Australia, and on Flinders Island in Bass Strait. It is absent from Tasmania and Kangaroo Island.

The Red-capped Robin is the dry-country member of the red-breasted robins, ranging through most habitats except wet, dense forests and treeless plains and deserts. Most of its suitable habitat is on the western side of the Great Dividing Range, but in a few places its distribution reaches the east coast. It breeds between August and December throughout the southern part of its range and, as in many other species, the birds disperse after breeding. In the northern parts of its distribution, it is only a winter visitor.

Except in odd instances, the division of labour in breeding is the same as for most robins, with the female performing the bulk of the work. She constructs the nest and incubates the eggs. The male feeds her as she sits and, on about the fourth day after hatching, begins to feed the chicks as well. This species is one of many that unwittingly plays host to the eggs of cuckoos, especially Horsfield's Bronze Cuckoo. Waiting for an unguarded moment, the female cuckoo sneaks into the nest, where it deposits an egg to be hatched by the unsuspecting robins. The chick in the photo is a bronze cuckoo, although not identifiable to species level.

Sexual dimorphism in the Red-capped Robin is pronounced. Immature males look like females but may have some reddish breast feathers. Older females gain a reddish tinge to the crown and many have a pronounced pink tinge on the breast. Young, hen-plumaged males may mate and rear young, although they do so with a lesser degree of success than older birds.

There is little about the voice to attract attention. Although very distinctive, the song and calls are feeble and frequently insect-like.

The Red-capped Robin is a very restless bird. It sits for a few seconds nervously flicking its tail and wings, then darts to a new perch, sits briefly, and continues moving. The sudden flash of red of a moving male adds a pleasant spot of colour to some of the drier inland scrubs but it is surprising how inconspicuous he can remain until such movement.

This robin is one of the tamest members of a group noted for this characteristic. Unfortunately, even with its remarkable tolerance of humans, it has not stood up to the advances of habitation around larger urban centres. It could once be found in the vicinity of Sydney, Melbourne, Perth and the other large cities, but it is now greatly reduced in number or absent from these places. ■

Extracted from The Robins and Flycatchers of Australia by Walter E. Boles (National Photographic Index of Australian Wildlife, 1988). Available from the Australian Museum Shop, 6-8 College Street, Sydney, NSW, 2000.



ROBYN WILLIAMS

What are Museums for?

I ask this question not as a piece of abstract musing, nor in search of definitions. I ask it because all our institutions of learning and research are in a state of upheaval. Fundamental reassessments are being made: of basic and applied research, of the efficiency of the CSIRO, of the importance of publishing papers *versus* teaching students at our universities, of the role of tenure. No-one is safe. Everyone in science should be able to argue convincingly about why their work is necessary. Especially in natural history museums.

The role of a natural history museum is mixed and much of the research side is unknown to the public. Most people see a museum as a place to visit, where dead animals are kept, where displays of body parts try to show relationships between animal groups and how they evolved. How many people realise the extent of research going on in the museum's basement, or by museum scientists away on field trips—be it up mountains, under water or in swamps?

Some folk might wonder why taxes should be spent on specialists in worms or reptiles or butterflies, who spend their lifetimes collecting specimens and studying their anatomies and classification. Indeed, there are some harsh people (not many) who say that scientists have a jolly nice time pursuing their interests at our expense in the pleasant surroundings of the laboratory or in the wild. Off they go dressed in jeans or rather less, for a few weeks at the Great Barrier Reef or in Kakadu National Park or even a tropical rainforest. Once there, our intrepid boffins seem to the outsider to do little more than many of us do on our holidays. Can we afford such things in these times of apparent austerity?

I believe that we *must* afford such research, whatever Australia's economic circumstances, for several reasons.

The first reason is that we must know what flora and fauna are here before we can possibly assess the im-

pact of development. And make no mistake, we have only just begun to record properly the extent of our biological heritage and the complexities of its ecology. How can you make effective decisions about the exploitation of kangaroos, rainforests or fisheries unless you know what's there? Frankly, our ignorance is staggering.

The second is that a natural history museum is a unique focus for such work. Like a botanical garden records and keeps plant life, so does a museum gather animal and human data as a reference available to the whole world. No other institution, certainly not a university, carries such a specific burden.

Third, a museum responds not only to other scientists but to public interest, often that of amateur inquiry. The museum belongs to everybody and should be open equally to Nobel laureates and children.

And fourth, a museum is a home to specialist societies, from bird-watchers to Aboriginal groups, wanting to marshall the scientific information available to different ends.

All that without even mentioning the obvious functions of education and as a place for the occasional visit.

There are indeed forces abroad to limit the activity of our publicly funded institutions and, indeed, the Natural History Museum in London has been reported by *New Scientist* as possibly having to severely cut its research because of poor funding. So how should we who love museums respond to hard times and likely critics?

For a start we must insist that those who do the scientific work are able to speak out convincingly about the worth of what they do. Research people can be a sheltered lot, talking only to their mates and rarely even considering how they would explain their *raison d'être* to the person on the Toorak tram.

Then we must realise that research cannot be open-ended. One can't possibly countenance all

manner of investigation in search of serendipity and some far-distant, as-yet-unknown 'relevance'. Australia is too small a community to 'manage blank cheques', and priorities must always be determined, as indeed they are at places like the Australian Museum.


Finally, we must not underestimate the importance of education as duty for the scientist. Many scientists regard it as a necessary nuisance, something that's done 'on the run'. But if only a few dozen experts know of a discovery, how can the public be expected to appreciate the value (real or potential) of the work? Science is, or should be, part of everyone's culture, not the currency of secret societies.

I have no doubt that the future of museums can be as glorious as their past. But this will not be achieved while complacency lingers. It is time for scientists to stand up and be counted, wherever they work. ■

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PEOPLING THE PACIFIC

The Lapita Homeland Project

By PETER WHITE,
JIM ALLEN and JIM SPECHT

UNIVERSITY OF SYDNEY, LA TROBE UNIVERSITY
and THE AUSTRALIAN MUSEUM

There is power in a piece of pottery. Perhaps meaningless to the average person, a certain type of pottery—Lapita—can solve a 200-year-old question that has been plaguing academic minds: how were the Pacific Islands settled? Peter White, Jim Allen and Jim Specht are three of some 30 researchers involved in the Lapita Homeland Project, which was set up to answer this question. In this article they explain the results of the Project.

Half a tonne of broken pots, hundreds of kilograms of animal bones, more than a tonne of soil, assorted rocks, bits of wood, and other garbage; spades, sieves, theodolites (to measure angles), tapes, photos. . . The equipment for and results of archaeological excavations are always bulky, heavy, dirty and expensive to move around. When fieldwork is in the remote Pacific Islands, moving equipment and people becomes a major problem, which is why we sought funds from the National Geographic Society to charter a boat for six months in 1985. About a dozen archaeologists were to be left at various parts of the Bismarck Archipelago, and later collected along with their finds.

The excavations were directed towards a single question: how did the Pacific Islands, from the Solomons to Easter Island, come to be settled?

Ever since Sir Joseph Banks started speculating about this in 1770, the most common belief has

been that it was by canoe-loads of migrants from mainland or island South-East Asia. Bypassing Australia, which was already inhabited by Aborigines, they headed out to explore and settle all the tropical Pacific Islands.

On a grand scale, this picture is true: every island east of Asia was settled from that continent. But how direct was this process? Did the settlers of Polynesia migrate directly from South-East Asia, or did their ancestors live for long periods on islands not so far to the west, such as the Solomons and the Bismarcks? Were these areas the real homelands, in which people actually learned all the skills necessary for them to become Pacific Islanders?

It was to answer questions such as these that the Lapita Homeland Project was formed in 1983. The Project is the collective effort of many researchers, and is supported by the national and provincial governments of Papua New Guinea. The name Lapita comes from a type of pottery that is found in the oldest sites of

Lapita pottery sherd from Watom Island, found in 1972.



JIM SPECHT





Sam and Kougas from Madina Village, New Ireland, sieve archaeological dirt from Balof 2 cave through flywire, recovering very small bones, shells, stone chips and pottery fragments.



human settlement from Santa Cruz to Tonga and Samoa. Lapita pots are very distinctive, being decorated with bands of very small, fine geometric decoration, impressed with a comb-like toothed stamp and sometimes filled with a white lime paste. This pottery is also found throughout the Bismarck Archipelago, and a few pieces have been found on Manus Island and the north-west coast of the Papua New Guinea mainland. In none of these areas, however, does it mark the oldest sites.

Lapita sites all date to between about 3,400 and 2,000 years ago. They have been found so far only in coastal or small offshore island locations. Those in the Bismarcks and as far east as New Caledonia contain obsidian (a volcanic glass), transported up to 3,000 kilometres from sources on Lou Island, and Talasea and Mopir on New Britain. This implies continuing contact between the people who lived on Lapita sites, a suggestion supported by the close similarities in the pottery whatever its age and location.

The Project developed a two-pronged attack on the problem. First, we set out to show that Bismarck cultures older than those making Lapita were developing in directions favourable to the emergence of Lapita cultures, including, in particu-



Balof 2 cave, New Ireland, has been occupied by people for 15,000 years. The excavation is just visible by the reflector, lower right.

lar, a familiarity with and common use of the sea and its resources. Second, if the Bismarcks were the homeland, we could expect that Lapita sites there would be the oldest, common, and occurring over a considerable time period.

Four limestone caves and shelters along the length of New Ireland were excavated. The findings indicate that humans have occupied this large island for the last 30,000 years.

The oldest radiocarbon dates are on marine shells from the bottom level of Matenkupkum, a cave about 15 metres above sea-level. Four dates, all of them around 32,500 years ago, have been determined for this site. The shells, some of which were probably burned, are directly associated with flaked stone tools and with bones of land animals that had been eaten. The shellfish in these earliest bottom levels are very large and never attain a similar size in later, higher levels, suggesting that we have discovered the initial occupation of this locality.

Two of the other three sites—Balof 2 and Panakiwuk—are younger, with basal levels dating to 14,000–15,000 years ago. Buang Marabak is not yet dated. Despite individual differences, all four New Ireland cave sites exhibit interesting similarities. All contain in their upper



Lapita pottery sherds from Watom Island, found by Father Otto Meyer in 1908–9, and now in the Museum für Völkerkunde, Basel.

levels obsidian from New Britain and Lou sources. Dates from Balof 2 suggest New Britain obsidian was reaching New Ireland between 7,000 and 8,000 years ago, but was subsequently largely replaced by material from Lou. At Matenkupkum only New Britain obsidian is present, and this site also lacks the undistinguished pottery that appears in the upper levels of the other sites. Matenkupkum may thus have been abandoned earlier than the other caves, and preliminary radiocarbon dates also suggest this. Four species of mammals (a possum, two rats and a wallaby) come in at various points in the archaeological sequences, strongly implying human introductions and supporting further ideas of considerable interaction between the various islands of the Bismarcks and the New Guinea mainland.

Another interesting find at Balof 2 is of sharks' teeth in all levels back to about 7,000 years ago. The teeth

come from three species of sharks, all of which live in coastal waters and grow to maximum lengths of about three metres. These teeth suggest that catching sharks, which has been prestigious in northern New Ireland until very recently, has a long history. This find, more than any other, shows a familiarity with the sea and its denizens thousands of years before the settlement of more eastern islands.

A different aspect of Bismarck Archipelago societies before the development of Lapita is shown by the discovery of settlements on some more remote islands. Such settlement required ocean-going canoes. These pre-Lapita settlements have so far been found in the Admiralty Group and on Nissan Island, and in each case the occupation occurs about 1,000 years earlier than the earliest Lapita pottery. From Nissan, one can see the most northerly Solomon Islands, so that pre-Lapita occupation of that chain also now



Obsidian flow on Schaumann Island, Talasea.

seems very likely.

In the Admiralty Islands, pre-Lapita occupation, dated to more than 4,000 years ago, goes along with the almost total absence of Lapita from the entire island group. This is a most surprising discovery, for much of the obsidian in Lapita sites actually comes from Lou Island in this group. This suggests that the obsidian miners were already established when the Lapita potters arrived, and were not interested in acquiring or making similar pots. What they received for their obsidian remains to be determined, as do the questions of what it was used for at Lapita sites and why it was so important.

The Project also recorded some 17 new Lapita sites or findspots, more than doubling the number already known from the Bismarcks. The majority of these were on small, offshore islands such as Duke of York, Kandrian and Arawes, with some examples on the larger, more continental islands. The presence of all these sites, which contain obsidian from New Britain and Lou Island, dispels any idea of a line of sites that might mark a rapid migratory passage. It also dispels notions of little contact between Lapita potters and other inhabitants.

As well as finding new sites, Project teams also returned to re-excavate at two previously known sites, Watom and Eloaua. On Watom, the presence of several levels of occupation is allowing the identification of an evolutionary sequence of Lapita development, which appears to span the period 600BC–AD100. This site was clearly more than a transit camp.

Re-investigation of the large Eloaua site paid off when rich water-logged deposits were found at its edge. A lens of fresh water (like that found on most atolls) preserved house posts, food plants and other organic remains, together with broken pots, shell tools and ornaments.



RIC BOLZAN

Lapita pottery fragments from New Ireland.

Radiocarbon dates available for six of these sites range over a period of about 1,500 years, starting about 1500BC. There is now enough evidence from Lapita sites to suggest that they are no earlier here than further east in the Pacific; but it is also true that Lapita pottery went on being made in the Bismarcks for quite a long time, and that there is no way it can be seen as the result of a rapidly moving group of colonisers,

just passing through.

The Project did, however, discover one piece of evidence conclusively demonstrating that people of this time had links with islands to the west as well as the east. At a large village site on the south coast of Lou Island, amid extensive evidence of an obsidian tool factory, was a small bronze artefact. This tool, possibly a chisel blade, is the first prehistoric metal object ever found in island

A Bronze Find in PNG

Life on volcanic Lou Island has always been both bountiful and dangerous. Bountiful because the volcanic soils grow first-rate gardens; dangerous because volcanic eruptions may at any time bury the landscape metres deep in ash and pumice. One such catastrophe happened near the present village of Baun, 2,100 years ago.

Our first evidence for this, in 1983, was at the foot of a five-metre-high cliff of volcanic ash. A daily high tide, eating into the land, revealed a layer containing obsidian (volcanic glass) points and blades, pottery and bone.

Returning for a fortnight in 1985, we found that the sea had washed away several metres of cliff but, after careful excavation of the site, a small section of the old surface, as it was when the ash and pumice rained down, was uncovered. There were some flat slabs of stone providing a small pavement, hundreds of obsidian points in various stages of completion from raw flakes, two stone axes whose wooden parts had long since decayed away, part of a pig's jaw, turtle remains, many shellfish and some fish bones. Broken pottery fragments were scattered about, along with charcoal and hearth stones from cooking fires.

We also found a small green metal object. It was coated, as were all the finds, in fine volcanic ash. Our instant impression was that this small tabular object must be a copper relic from the last war. But this could not explain its presence beneath five

metres of undisturbed ash that had been deposited 2,100 years ago. The object was carefully stored and brought back to the laboratory for a thorough inspection as the first-dated prehistoric metal from Papua New Guinea.

In the laboratory using an X-ray microprobe on a small section of the metal, it was possible to analyse its chemical composition. This varied from a copper and silica-rich crust weathered onto the outer surface, to a metallic copper-tin bronze near the core. Its composition was around 87 per cent copper, 12 per cent tin, 0.2 per cent lead and trace amounts of iron, manganese, antimony, silver and gold. But knowing at last that it was a true bronze failed to explain its use. Under a low magnification, certain surface areas showed how it had been shaped by filing or abrasion, but there was no clear sharp edge that would indicate its purpose as a cutting implement. There was no obvious way of suspending it from a cord if it was an ornament. If it had a use, apart from being an amulet or a

rare collector's item, it was not obvious.

The nearest likely sources for bronze over 2,000 years ago would be the islands of the archipelagoes stretching from the southern Philippines to the western end of New Guinea. In carrying this small bauble back to Lou Island there is no need to invoke long-range sailing exploits out of island South-East Asia: the ubiquitous obsidian found thousands of kilometres away in the islands to the east of Manus was most likely carried by the same adventurous sailors from Manus in ocean-going sailing canoes. This small bronze item is evidence that the same ability was exercised in sailing to the fringe of island South-East Asia 1,500 kilometres to the west. This occurred 1,600 years before the first account of the same route was recorded, in the journals of the Spanish conquistador Alvaro de Saavedra while on his way to the Molucas, via Manus, in July 1528.

—Wal Ambrose
Australian National University

Excavation of Sasi site, Lou Island, where the bronze object was uncovered.



WAL AMBROSE

The bronze object measures only 2.7 centimetres.



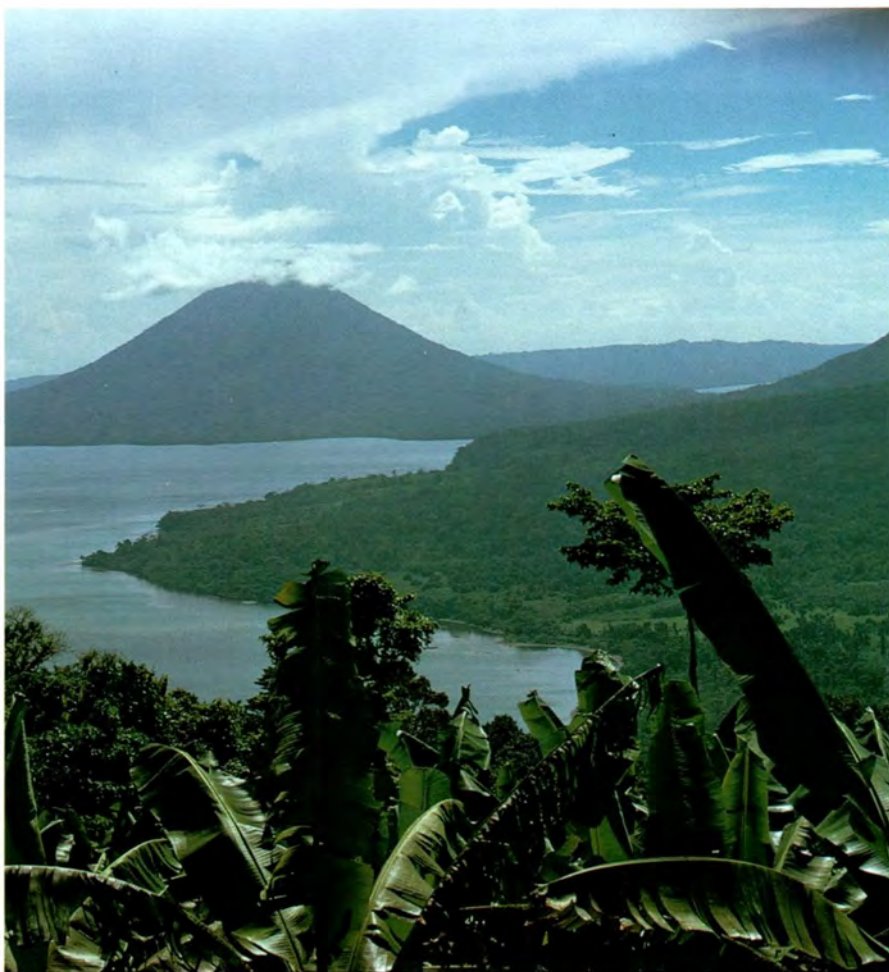
WAL AMBROSE

Archaeologist Peter White sorts washed finds of bones and shells at the field camp. This is work for the evening or 'day off'.



P. GORECKI

Melanesia and is indisputable evidence of contacts with Indonesia or the Philippines. It is, however, associated with pottery that is decorated with incised lines and applied bits of clay, and is not classic Lapita in any way. The village was occupied



JIM SPECHT

Volcanic landscapes at Talasea, one of the main sources of obsidian in the western Pacific.

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largely or wholly within the second half of the Lapita period, that is, probably around 200BC.

In terms of the questions asked at the beginning of the Project, it is now clear that the basic developments that lay behind the Lapita cultures occurred within the Bismarck Archipelago. In that area also we have found a continuity within Lapita culture and evidence of a developmental sequence in the pottery once it starts to be made there.

On the other hand, the Project found that Lapita, at its start, was a fully developed industry demonstrating a clear mastery of both technology and fine decoration. It is thus hard to avoid the view that pottery making, at least, was introduced into the area, presumably from the west. Pottery manufacture is found in island South-East Asia for at least 2,000 years before the earliest Lapita. The economic and cultural evidence, however, is against the notion of pottery being introduced via a large-scale migration of people. There is, indeed, no need to believe in migrations at all: pottery tech-

nology may just as well have been acquired by Bismarck inhabitants in the course of their voyaging in the western Pacific 4,000 years ago. What the Project has not managed to do, however, is show why Lapita pottery is so similar throughout the area of its distribution or how Lapita cultures are related to those succeeding them. What happened to the vast network of obsidian distribution, and what lifestyles people later had, also remain subjects for further research.

Thus the settlement of the Pacific Islands, from the Solomons to Easter Island, a subject that has exercised academic minds for two centuries, has been largely solved. To archaeologists it now appears to be a phenomenon for which explanations must be sought in the Bismarck Archipelago. ■

The Lapita Homeland Project encompasses a loosely defined group of more than 30 field and laboratory researchers in institutions in Australia, New Zealand and USA. The Project was co-ordinated by Professor Jim Allen and managed by Dr Chris Gosden, both of La Trobe University, Melbourne. They originally initiated the project at the Australian National University.

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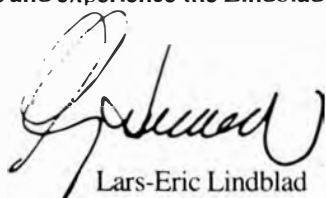
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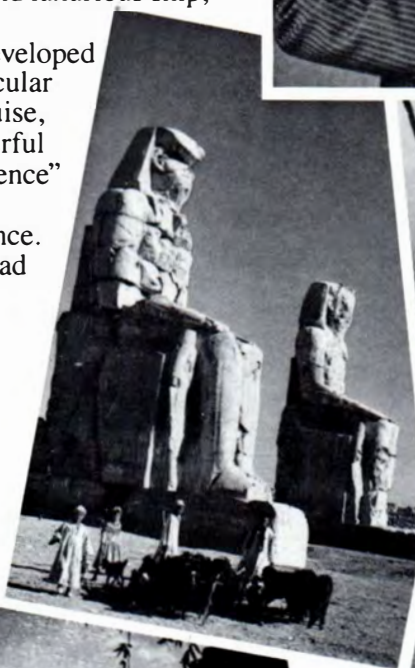
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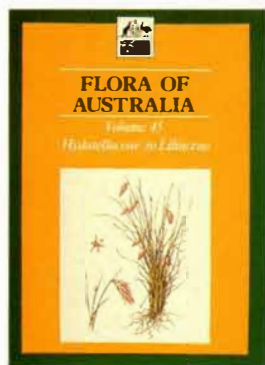
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**Flora of Australia.
Vol. 45.
Hydatellaceae to
Liliaceae**

Ed. by Alexander S. George. Australian Government Publishing Service, Canberra, 1987, xvi + 521 pp. \$54.95.

Volume 45 of the *Flora of Australia* is an intimidating tome. In 521 pages of highly technical prose it keys and describes some 404 species of Australian lily, ginger and related plants. In presentation and style its 36 contributors make no concessions to the general reader.

Nonetheless, this is an exciting and very important publication. The eighth so far to appear in the *Flora* series, it will eventually be joined by another 45 or so volumes to provide a complete record of Australian plant life.

Or such is the aim. In fact, Australia's plantlife is so incompletely known that this is no more than a token objective. The *Flora* volumes published so far leave obvious problems of plant classification unresolved, and Volume 45 is no exception.

Consider, for example, botanist Helen Hewson's comments about crinum lilies (*Crinum* species): "there are two large complexes (*C. flaccidum* and *C. angustifolium*) which re-

quire particular investigation. The two seem to merge into one species in Qld". A definitive revision of this genus was impossible, Hewson contends, because the crinum lilies are genetically unstable, and the specimens held by herbaria are poorly preserved.

Another contributor to the volume, Rod Henderson, notes that among the flax lilies (*Dianella*) the "tendency to hybridize is probably widespread in the genus and may account for some of the problems in placing some plants to species in the field and identifying particular specimens in the herbarium". Here is an admission that, despite a detailed revision of the genus—the product of more than a decade's research—Henderson is unable to identify with certainty some flax lily specimens.

Expressions of doubt like these appear throughout this volume, and highlight the problems faced by Australian plant taxonomists. Among these are the lack of a meaningful species definition (and the conflict between 'splitters' and 'lumpers'), the inadequacy of specimens, problems posed by hybridisation, and the failure of many botanists to complement herbarium work with experience in the field.

In the face of these shortcomings, the *Flora of Australia* series is probably about as good as we could hope for. Volume 45 is the largest and most significant so far, and includes the description of an unprecedented 48 new species, as well as many new varieties and subspecies and even a few new genera. Its impact will be felt in the natural history arena as

nature writers begin to use the new names and interpretations for well-known wildflowers.

The next *Flora* due is Volume 19, covering part of the eucalypt family (Myrtaceae); it too should prove a most interesting and significant publication.

—Tim Low



The Crown of Thorns Story

Video produced by the Education and Information Section, Great Barrier Reef Marine Park Authority, Townsville, 1987, 26min. \$35.00; plus booklet edited by Leon Zann and Elaine Eager, Great Barrier Reef Marine Park Authority, Townsville, 1987, 42 pp. \$3.00.

About 25 years ago in the early stages of the Crown of Thorns Starfish outbreak, many scientists were at a loss to explain or, worse still, had contradictory views on the phenomenon. The Great Barrier Reef is currently experiencing a second series of outbreaks, but at least scientists can now say something definitively about it. They certainly know a lot more about the starfish than they did 25 years ago. *The Crown of Thorns Story* (in booklet and video form) provides up-to-date accounts of the

Crown of Thorns phenomenon. Both were compiled and produced by the Great Barrier Reef Marine Park Authority (GBRMPA).

The booklet is a 42-page feature of *Australian Science Magazine* and was originally published as part of Issue 3, 1987. The contents are a comprehensive overview of the Crown of Thorns phenomenon written by some of Australia's respected marine scientists. A confident beginning is made with a discussion on the reasons for outbreaks, and an admission that there is still no answer. The need for continued research is stressed early and is a theme repeated throughout.

A second theme repeated often is the GBRMPA's unwillingness to control Crown of Thorns outbreaks on reefs other than those important for tourism or science. This is understandable for two reasons. Overseas attempts to clear reefs of the starfish were expensive, and failed. Also, partially successful clearings that left a residual starfish population could lead to sustained, endemic outbreaks that would cause prolonged damage to reefs. It is a commendable policy of the GBRMPA that, unless the outbreaks are proved to be human-induced, it will not interfere in a natural event.

Other sections of the booklet examine the biology of the Crown of Thorns Starfish, the history of outbreaks, and evidence for outbreaks being either human-induced or natural phenomena. Most interesting are the discussions on the variety of ways being investigated for controlling outbreaks (particularly biological controls), and new

geological evidence for past outbreaks.

Conspicuously lacking in the booklet is material by Professor Robert Endean, University of Queensland, one of the earliest participants in the Crown of Thorns debate. Most of the marine science establishment has disregarded Endean's controversial hypotheses on the Crown of Thorns phenomenon. Despite this, some of the Commonwealth's research money has funded Professor Endean's research into predators of the starfish. An update on his findings would have been a worthwhile contribution to this publication.

The video accompanying the booklet was produced by the GBRMPA's Education and Information Service. It contains the same material that is presented in the booklet. Scientists from the GBRMPA, James Cook University and the Australian Institute of Marine Science are interviewed in scenic laboratory settings about their research into the Crown of Thorns phenomenon. All speak well, although the Director could have used less technical jargon. Underwater footage of the starfish cuts in throughout the story, and there are some wonderful shots of larval Crown of Thorns.

The video is presented in an efficient, yet detached, monologue. It is a pity the GBRMPA did not cast an enthusiastic scientist as presenter. An eloquent scientist's excitement and curiosity about nature readily captures any audience's attention.

The booklet and video are valuable presentations on current knowledge of the Crown of Thorns Star-

fish. Together, they are an ideal resource for an ecological case study in the classroom. If you are unsure about which to buy, go for the booklet. It provides more information than the video and is a bargain at only \$3.00 (plus 30 cents postage, available from the GBRMPA). But both are recommended.

—William Gladstone

The Top End of Down Under

Peter Jarver. Thunderhead Photographics, Darwin, 1986, 2nd ed., 119pp. \$29.95.

During his eight years in Darwin, photographer-author Peter Jarver has managed to capture the beauty of the Top End when at its best: during the Wet. It's a time most of us would not ordinarily visit there, so this book is refreshing in its focus. It consists of three parts: Darwin, Kakadu National Park and 'Cloud Mountains of the Top End'. I found the latter the most fascinating, comprising a collection of Jarver's best storm and cloud photos. Very dramatic. But then we are looking at the Top End.

The emphasis is on images. There is just enough text to provide a background of information. Some may feel the book is too specific in the choice of areas covered; indeed this vague geographical area is generally considered broader than Jarver's coverage. Nevertheless, it gives us a taste of the tropics and that is an attractive lure. If it doesn't at least tempt you to visit, it is the perfect coffee table book for avid armchair travellers.

—Fiona Doig

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Edible red lerp is found on the twigs of Mulga. Tiny sap-sucking insects live beneath each red lump.

On the Liru Trail

I visited Ayers Rock for the first time last year and found the plantlife so enthralling that I never found time to climb the Rock. Almost 500 plant species grow in the national park, an extraordinary variety for a stretch of desert.

Near the Rock live Pitjantjatjara Aborigines, speaking their own tongue and maintaining many of their traditional ways. I hoped for some chance to make contact with these people, to learn first-hand about their desert foods.

My first opportunity came in the Olgas when an Aboriginal ranger strolled by. I asked him about the Sandalwood or Plumbush fruits (*Santalum lanceolatum*) I was photographing.

"Don't ask me!" he replied. "I'm a steak and vegies man. Apples and oranges are all I know about." It transpired that he was just down from

Darwin on work experience. The desert was as new to him as to me.

My second encounter was more enlightening. It came two days later, after contacting the ranger station, when four Pitjantjatjara women, national park rangers, led me along the famous Liru Trail, which runs to the base of Ayers Rock. I was awed by these desert women. They strolled into the 40° heat without footwear or water, while I lumbered along behind, embarrassed by my heavy waterbottle.

These women proved to be extremely shy. They knew almost no English, and I was shocked by the cultural chasm dividing us. I have travelled through many countries of the world, have stayed in remote Borneo villages, but have never felt so distanced from other human beings, and in my own country. I could not fathom the body language of

Mulga "apples", found on the foliage of Mulga trees, are one of the desert's more extraordinary foods. They taste like dried apples.



PHOTOS: TIM LOW

these people, much less the words they spoke.

To learn about their foodplants was difficult. For the most part they could only point and say “bush tucker”. They understood few of my questions and I could grasp little of what they said. Sometimes I could not decide if they were speaking Pitjantjatjara or English.

Once I pointed to a small leafy spurge (*Euphorbia* species) and asked if it was used as medicine. I knew that some desert tribes used spurge sap to remove warts. They seemed to confirm this usage, saying what sounded like “ointment, ointment”, until I realised with a jolt that their actual words were “Emu food, Emu food”—the spurge was merely a food of Emus.

Our outing was only brief—before long their feet became scorched and we had to return. On the way back they drank most of my water. But I was content for we had agreed to go out again the next morning.

On our second walk they showed me just how rich in wild foods a stand of Mulga (*Acacia aneura*) can be. Mulga is the common outback wattle that forms vast, bleak thickets in which few other plants can grow. A stand of Mulga looks an unlikely place for wild foods, yet it was here the women best flaunted their skills. They beckoned me to a Mulga stem covered in shiny red lumps—the sugary red shells of a tiny sap-sucking bug, Mulga Lerp (*Austrochardia acaciae*). In the foliage they pointed out Mulga “apples”—small green galls formed by wasp larvae. Most kinds of tree galls taste horribly astringent, but these were slightly sweet and reminiscent of dried apples. On the lower Mulga twigs the women found lumps of glistening gum, candy-hard outside, syrupy-sweet within. These precious sticky treats ooze from Mulga branches following insect attack.

The Mulga trees were not in seed, or no doubt I would have been shown another important food. The small but highly nutritious Mulga seeds were traditionally pounded to flour and baked as cakes. Dried Mulga seeds comprise 20 per cent protein and almost ten per cent fat.



The Mulga woodland at Ayers Rock looks bleak and inhospitable, but it is a rich source of wild foods.



Sweet sticky gum oozes from the stems of Mulga trees after insect damage.

At a different time of year I would also have seen the edible fruits of the Pale-leaf Mistletoe (*Amyema maidenii*), which hangs limply from Mulga boughs. In all, five different foods, four of them sweet, on one species of tree!

But this was not the end of the lesson. In open spaces between the stands of Mulga I was directed to clumps of Woollybutt Grass (*Eragrostis eriopoda*) and Pigweed

(*Portulaca oleracea*), two of the desert's most important foods. After rain these small plants produce copious tiny seeds that Aboriginal women also ground to flour and baked as loaves.

While photographing the Pigweed I was reminded of a comment written by colonial botanist Joseph Maiden in 1889: “One would suppose that so small a seed would scarcely repay the labour of collect-

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ing", although he conceded that the Aborigines "get in splendid condition on it".

Nutrition tests by Sydney University show why. Pigweed seeds outscore wheat and rice on almost every nutrient. They yield 18.5 per cent protein, compared with 11.5 per cent for wholemeal wheat and only 6.9 per cent for brown rice. Woollybutt seeds are just as impressive, scoring 17.4 per cent protein, and an iron content of 31 milligrams per 100 grams, compared with a mere 3.2 milligrams in wholemeal flour. By any reckoning, these are impressive foods.

Growing alongside the Pigweed were a number of tar vines (*Boerhavia* species), small herbs with dark-green triangular leaves. I know from Aboriginal food lists that the taproots of these were widely eaten, so I was surprised that the oldest woman shook her head dismissively when I pointed out one of these. But, after a brief disagreement with one of her colleagues, I was told that tar vines were in fact used as foods "in olden times". This was a salutary lesson, for it showed that, despite the obvious expertise of these women, some of their traditional knowledge has been lost.

The Liru Trail winds to a close at a bitumen road close to Ayers Rock. We made the short walk to the base of the Rock where stands of Sandal-

wood shrubs grew, their blue-grey drooping leaves shimmering in the heat. During summer these shrubs produce tasty purple fruits, relished by the Pitjantjatjara (and by white rangers), although Emus take much of the crop. Sandalwood shrubs seem to need the extra run-off from the Rock, for I never saw them growing in the surrounding countryside, although they were common in the Olgas along gully lines.

One other fruiting shrub grows at the base of Ayers Rock, or rather, on the Rock itself. This is the Small-leaved Rock Fig (*Ficus platypoda*), a scrawny shrub or sprawling tree that produces hundreds of sweet, gritty figs. Aborigines in some desert areas dried its small figs for future use, but during our walk we gladly ate all we could find.

My tour of the Liru Trail was privately arranged, but public walks are organised almost every week. Thousands of visitors from Australia and around the world have now been introduced to Pitjantjatjara foods. For me it was an exceptional experience, and I hope one day to return for an extended desert walk. I hope the women have forgiven me for my clumsy and, no doubt, offensive attempts at communication. Next time I shall make sure I have mastered some Pitjantjatjara words, and especially their rules of social etiquette. I owe them that much, at least. ■



Sandalwood fruits are purplish black with a ring at the base and a large round seed.

CRYSTAL ART

JIM FRAZIER
WILDLIFE PHOTOGRAPHER

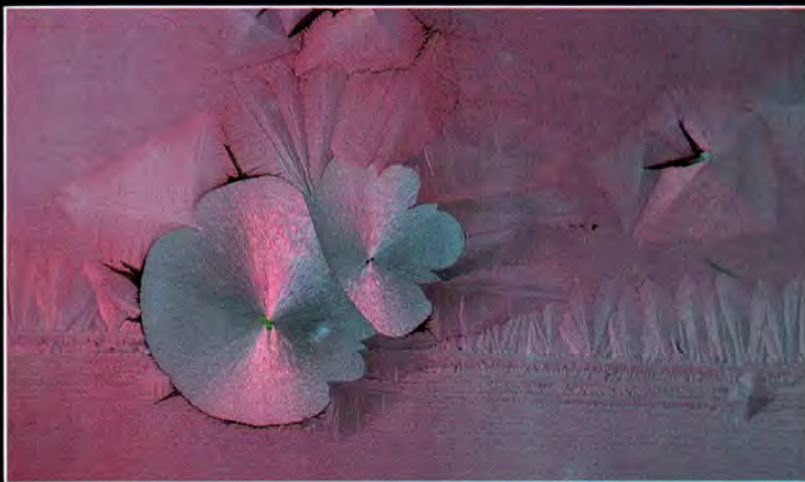
In his profession of wildlife cameraman, Jim Frazier has been involved in a number of notable productions, including David Attenborough's epic series *Life on Earth*.

Jim's speciality lies in recording the intimate lives of the smallest animals, the ones we all tend to overlook until we see them literally 'larger than life' on our television screens. To enter this Lilliputian world, Jim had to adapt and improvise equipment and develop his own macro-filming techniques.

Some of this equipment turned out to have a secondary use, in the filming of 'special effects' sequences. It was while filming chemicals to simulate intergalactic events for a space saga that Jim first discovered the beauty of crystals forming under the microscope.

Intrigued, Jim spent hundreds of hours experimenting with an assort-

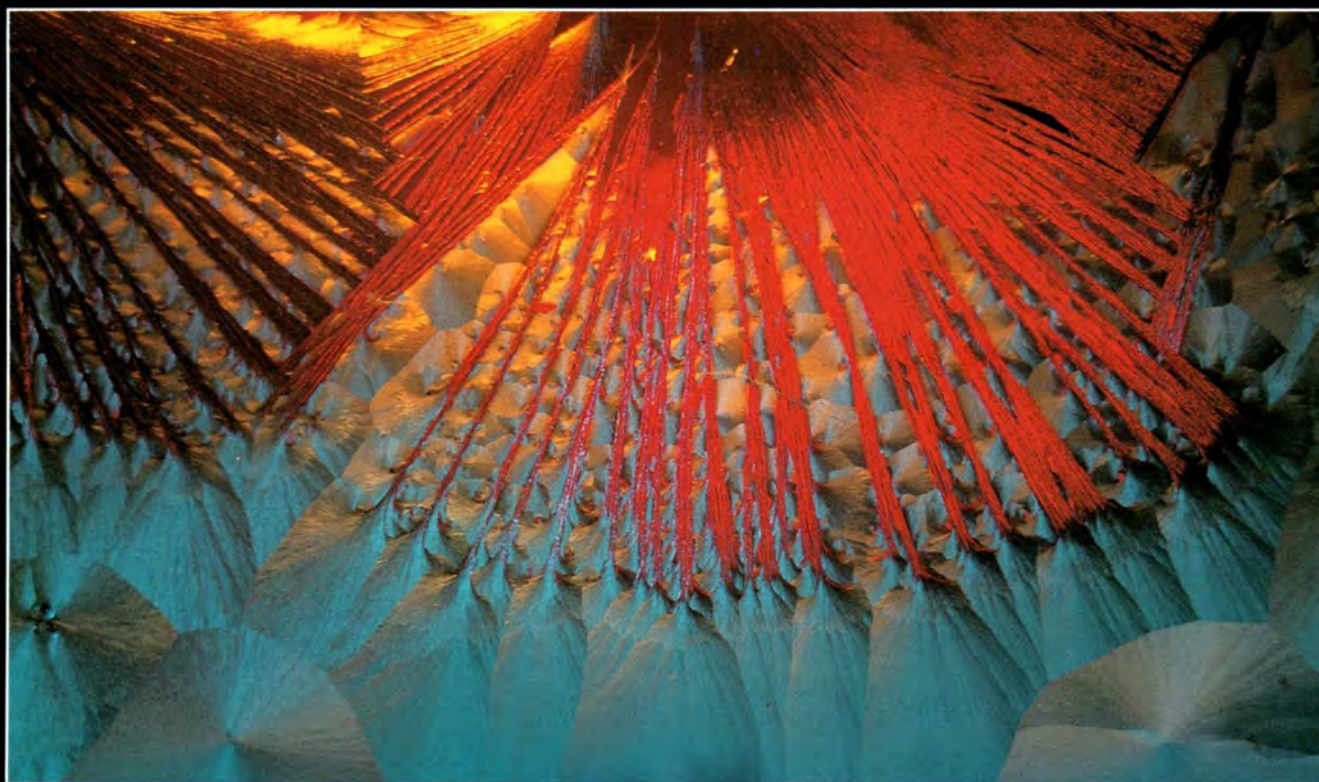
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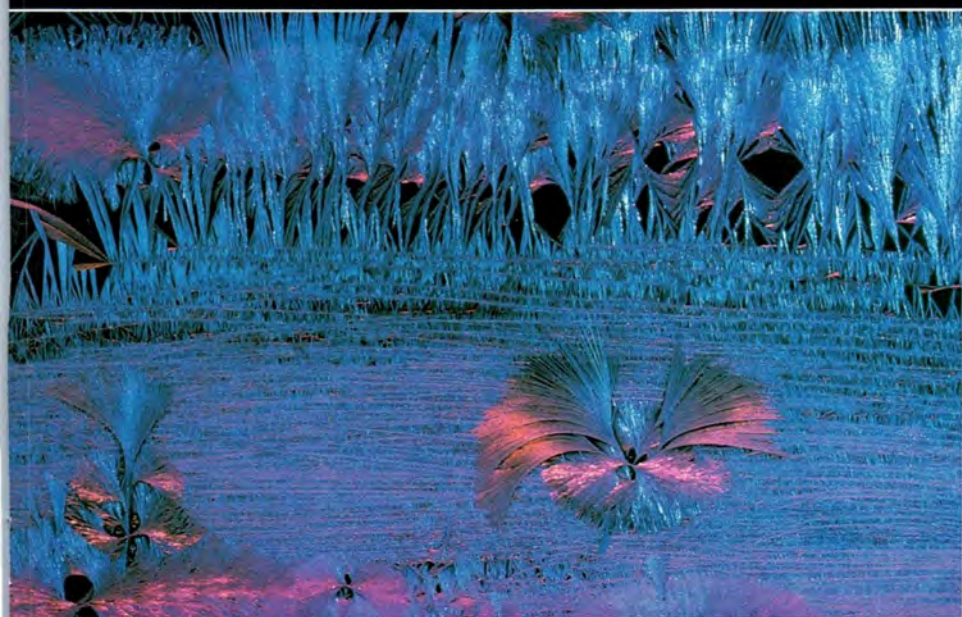
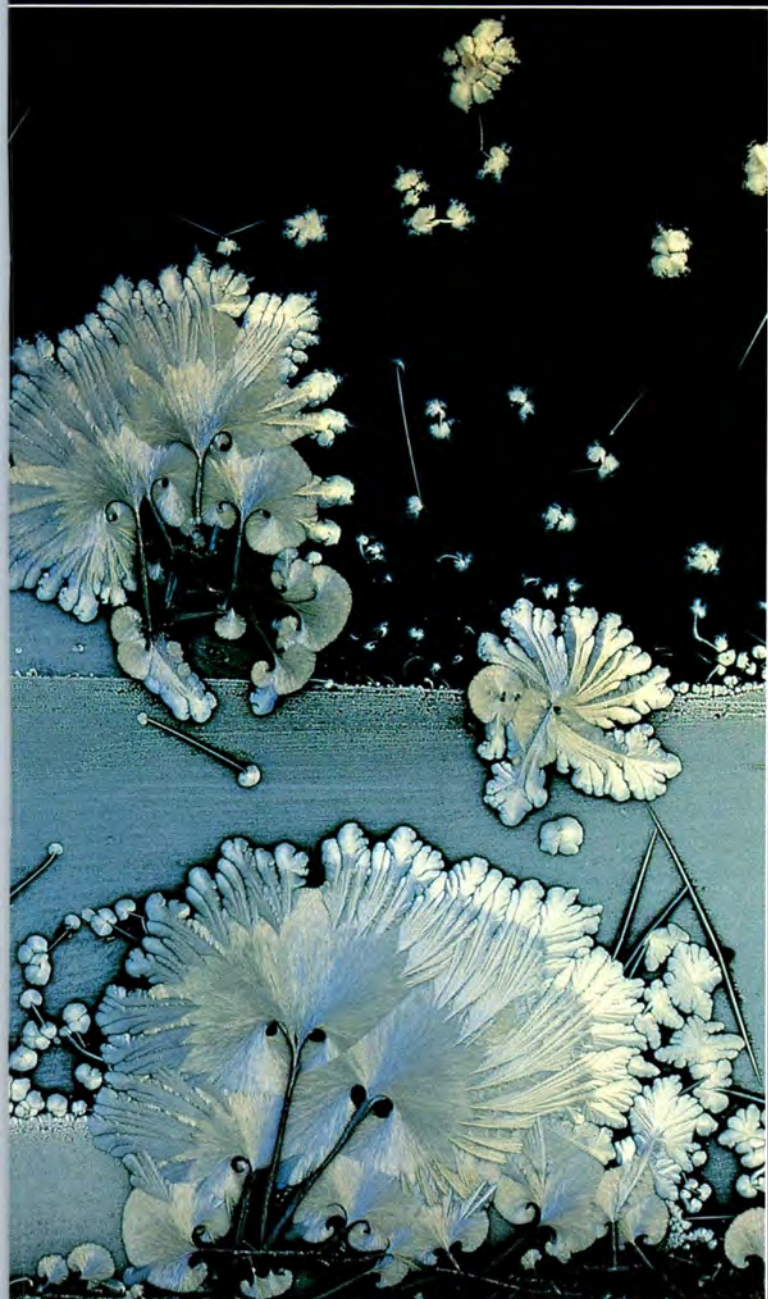
ment of common crystals. Once a suitable formation or pattern appeared he photographed it. But he didn't just accept nature's art—he learnt to manipulate the crystals as they grew, using fine instruments.

Traditionally, polarised light has been used to illuminate crystals, but this has its limitations. To avoid them, Jim developed a special 'light injection' system that could infuse any desired colour or colour combination into his pictures.

The result is a library of several thousand photographic images that the individual imagination may interpret as bizarre landscapes peopled with alien creatures—or simply as colourful and intriguing abstract designs. ■



photoart





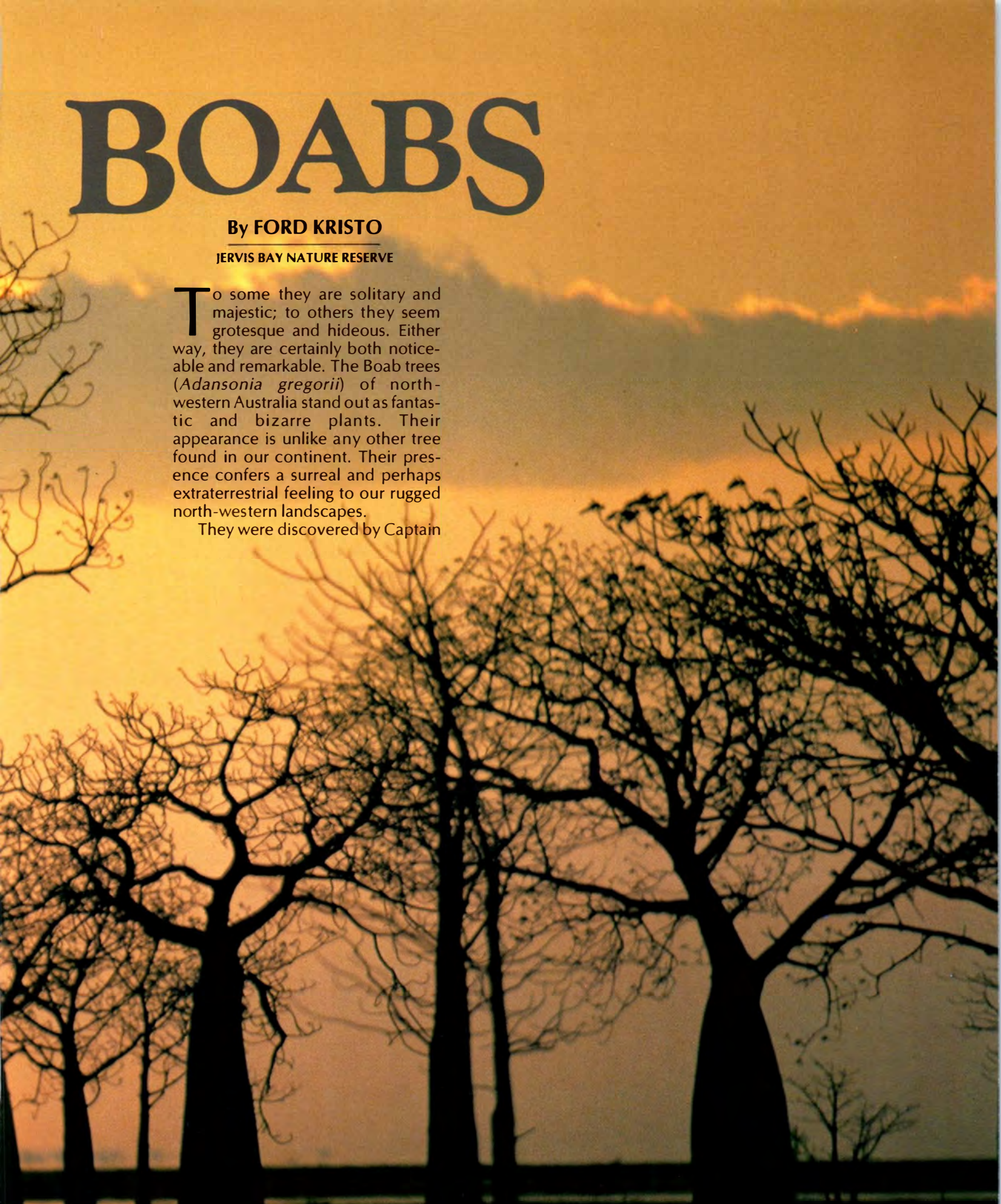
BOABS

By FORD KRISTO

JERVIS BAY NATURE RESERVE

To some they are solitary and majestic; to others they seem grotesque and hideous. Either way, they are certainly both noticeable and remarkable. The Boab trees (*Adansonia gregorii*) of north-western Australia stand out as fantastic and bizarre plants. Their appearance is unlike any other tree found in our continent. Their presence confers a surreal and perhaps extraterrestrial feeling to our rugged north-western landscapes.

They were discovered by Captain



Leafless Boab trees at sunset (Derby, Western Australia). According to Aboriginal legend, the Boab tree was rammed head-first into the ground for being arrogant. What we see above-ground today are its roots.

REG MORRISON, WELDON TRANNIES

(Sir George) Grey who initially believed them to be disease-affected examples of some other species.

Worldwide there are only three known species of *Adansonia*: *A. gregorii* is endemic to Australia, occurring in the hot humid to hot sub-humid climatic zones; *A. digitata* is found on the African continent; and the 'Monkey Bread Tree' (*A. madagascariensis*) is found in Madagascar. In Africa, the tree is known by the common name of 'Baobab', but in Australia the truncated name 'Boab' is more commonly used. The term 'Bottle Tree' is also used for obvious reasons; and for less obvious reasons, with the bush aesthete's enigmatic insight, the Boab is also called the 'Dead Rat Tree'.

The seasonally leafless boughs of the Boab are evidence of its adaptation to harsh, drought-like conditions typical of the northern Australian dry season. Being deciduous, the Boab avoids water stress that might otherwise occur in the dry season (winter) by transpiration through the leaf stomates. After shedding its leaves in the dry season it utilises stored nutrient reserves and available ground water until conditions are again favourable. In late spring to early summer, the monsoonal wet season provides the necessary conditions for leaf growth.

After fertilisation the large, cream-coloured Boab blossoms develop into gourd-like, woody fruits. The pith of these fruits is edible, the taste and texture being somewhat acidic like a tart, dried apple. The tree was a resource for the food economy of traditional Australian Aborigines in the north-west. The powdered pith



FORD KRISTO

was made into a bread or mixed with water as a drink or eaten dry. They also exploited water stored in hollows sometimes found at the bases of branches. Moisture was also taken from the tree by making holes in the trunk and chewing the roots. The wood is soft, fibrous, porous and spongy. The wood fibres were used to make cords and ropes. Today, souvenir Boab fruits etched with designs depicting wildlife and outback

Cream-coloured Boab blossom.

scenes are traded for the tourist dollar.

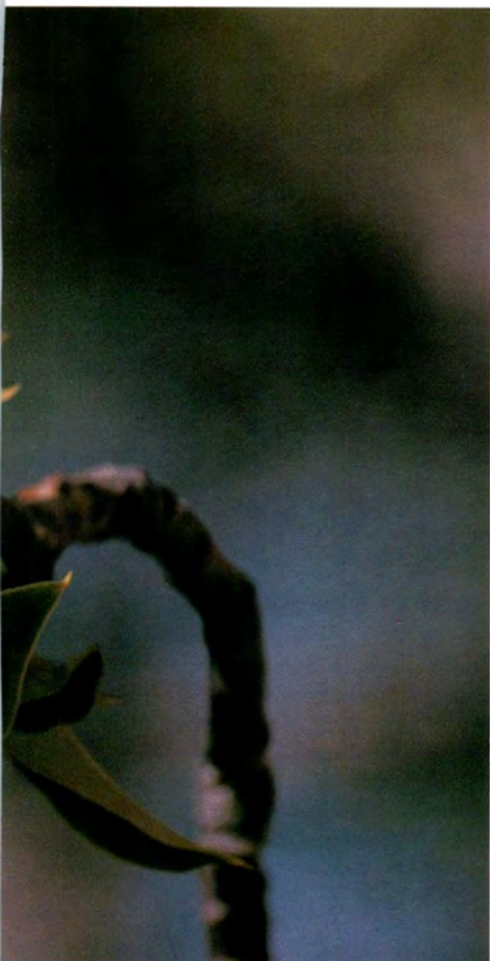
The Boab gourd isn't the only part of the tree to go under the knife. The bark has the quality of retaining inscriptions for long periods of time. Some inscriptions date back to the 1820s. Sir Augustus Gregory (in whose honour the Australian species was named), on his expedition in 1855-56, cut a message into a Boab for members of his party who had missed a rendezvous on the Victoria River. The inscription read "Letter in oven" (a camp oven was buried at the base of the tree). Once historical bulletin-boards for early explorers, their wide trunks now tempt peripatetic, insensitive, graffiti-carvers. Future generations will no doubt stand behind barriers to observe and marvel at the heavily-inscribed trunk of one of these trees and attempt to decipher the profound significance of the cryptic "R.J. L G.P. '78 True".

Both the age and the dimensions of these trees can reach incredible extremes. One African specimen has

Aborigines powdered the pith of the Boab fruit and made it into bread. Eaten raw it tastes like a tart, dried apple.



FORD KRISTO

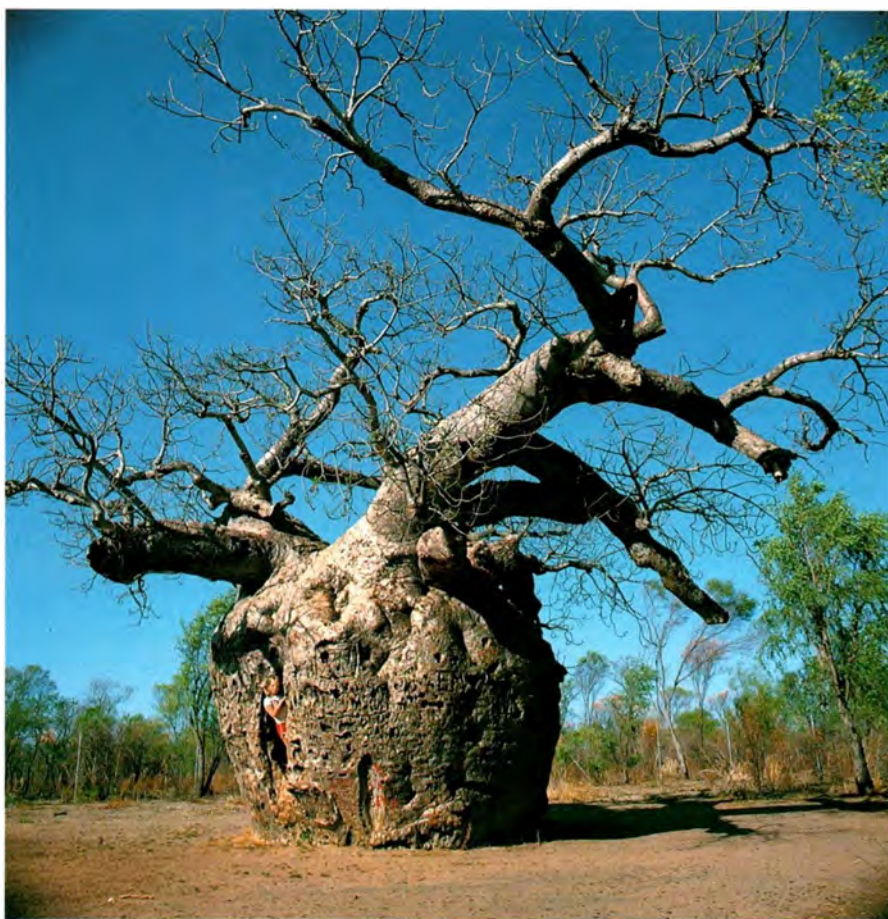


PATRICK BAKER

The message on this Boab tree, north of the Prince Regent River in the Kimberley region of Western Australia, reads "H.M.C. MERMAID 1820". It was carved by members of Philip Parker King's hydrographic survey of that date.

been dated at over 5,000 years old. African Baobabs can attain a height of 18 metres and a trunk diameter of nine metres. Australian specimens attain a height of nine to 12 metres and a trunk circumference of 15.7 metres; however larger trees are not uncommon. A huge cavity in the base of the trunk of a Boab near Wyndham, north-western Australia, was large enough to be used as a temporary lock-up by the local police until the 1890s. There is a similar 'prison tree' at Derby, Western Australia.

According to an Aboriginal legend recounted by the Wadaman people of the Northern Territory, Boabs were actually human beings in times past. The myth tells of how a young child pricked the ear of a Dingo, whose subsequent yelp unleashed an almighty cataclysm. As a result, all the lowland people of the area were changed into various types of plants and animals. People who had changed into Boabs and other plants stopped 'dead' in their tracks, instantly inanimate. (Which almost begs the question, is being lignified, dignified? Nowadays, only the fundamental, vegetarian reincarnationist might occasionally stray in this direc-



WELDON TRANNIES

tion.) Another Aboriginal legend maintains that the Boab was a very proud and arrogant tree. Apparently this must have been unacceptable behaviour, stepping way beyond the realms of Dreamtime decorum. The unfortunate offending Boab was rammed into the earth head-first by an unnamed, mythical being, and what we see of the tree above-

The prison tree at Derby, Western Australia.

ground today are supposedly its roots. Coincidentally, an Arabian legend runs along the same lines except, in this case, it was the devil who was largely responsible for the unfortunate tree's altered sense of perspective. ■

The ABRS — For What does it Stand?

Compared with many other countries, Australia has a large number of plant and animal species, many of which are unique. Yet the size of the scientific community researching our flora and fauna is rather small. The *Register of Taxonomists and Biogeographers* (Bureau of Flora and Fauna, 1987) for Australia lists 449 zoologists and 454 botanists. A recent survey conducted in the United States by the Association of Systematic Collections estimated 8–10,000 individuals (about 30 per cent of which were botanists) engaged in equivalent pursuits. Add to this the number of endangered species, many faced with the threat of extinction in the near future, and the task of documenting and researching our flora and fauna appears daunting. This task is clearly beyond the ability and resources of our scien-

tific institutions. With this realisation, the Commonwealth Government in 1973 created the Australian Biological Resources Study (ABRS).

A large number of professional biologists, as well as an increasing number of amateur ones, know about the ABRS. Well, at least they have heard of it, and some even know what the acronym ABRS stands for. But surprisingly few professional biologists, and fewer still amateurs, have any perception other than a hazy one of the ABRS. And that, in my view, is a pity, given its importance.

Its objectives, briefly, are: to provide a system of grant support for taxonomic (classification) and distributional studies; to commission and publish handbooks on the flora and fauna of Australia; and, by taking advantage of recent computer technology, to develop databases docu-

menting the identity and distribution of Australian plants and animals. In other words, the ABRS was planned as a focal point for the documentation of Australian biodiversity. It could not hope to do the primary hewing at the coal-face so painstakingly being undertaken by Australian biologists in museums, herbaria and elsewhere; rather, it hoped to support, sustain, expand, collate and (gently, as occasion demanded) provide for more direction in Australian taxonomic work.

To do all of this, a small group of biologists with appropriate technical support staff was set up in Canberra. The ABRS is co-ordinated by the Bureau of Flora and Fauna. Day to day events are under the control of the director, but the good ship as a whole is steered by an advisory committee, which reports to the Minister for the Arts, Sport, the Environment, Tourism and Territories. The advisory committee is itself advised about publications by the Fauna and the Flora editorial committees.

To avoid misunderstanding, it must be acknowledged that the ABRS has by no means done enough, as measured against original hopes and the tasks before it. Like all government departments, it has suffered from recent financial cut-backs, with predictable and inevitable consequences. Less money has meant fewer publications, smaller grants and a thinly spread staff attempting—sometimes without avail—to continue to implement policies begun in the first flush of ABRS life. Remarks of this sort, however, should not detract from some major accomplishments.

The ABRS has instituted a system of grants supporting research on the taxonomy of particular plant and animal groups that otherwise would not have been studied. These grants have led to the publication of more than 500 books and primary research articles. Vegetation maps at 1:1,000,000 scale have been prepared for over half the continent. Information on over a million mammal, reptile, amphibian and plant specimens has been included in the Biological Information System database distributed throughout museums and herbaria in Australia. As part of

the ABRS program, nine volumes of the *Flora of Australia* have been published and the series will continue as a publication that systematically catalogues the Australian flora.

The ABRS has also published a series of books derived from its database that scientifically documents groups of the Australian fauna (*Zoological Catalogue of Australia*) as well as a ten-volume zoological treatise of the whole Australian fauna (*Fauna of Australia*).

The described fauna of terrestrial, marine and inland aquatic environments of Australia numbers some 150,000 species in about 4,000 families. A similar number of species remains undescribed. Many described

(and undescribed) species play key roles in the functioning of ecosystems, yet the often scant literature on them is dispersed, in many languages, and often relatively inaccessible. The *Zoological Catalogue of Australia* was conceived as a concise, computer-based data bank containing current taxonomic and biological knowledge of the Australian fauna to serve as a nomenclatural and bibliographic directory for further work. A published database like the *Catalogue* is as useful to wildlife managers, environmental consultants and naturalists, as it is to taxonomists and ecologists.

Several volumes of the *Catalogue* covering more than 10,000 species

have now been published or are in progress. The first volume (1983) catalogued our amphibian and reptile fauna; subsequent volumes catalogued the ants and wasps, beetles (part 1), spiders (part 1) and pseudoscorpions. Volumes on mammals, dragonflies, stoneflies, caddisflies, springtails and mayflies are in press, and other volumes in preparation include those on sponges, fishes, non-marine molluscs, starfish, sea urchins, beetles (part 2), bees, true bugs and birds.

Data for inclusion in the *Catalogue* are assembled in four separate files. The standard *Catalogue* book format is generated by combining information from all four using a com-



COURTESY ALEX GEORGE

Senator Graham Richardson, Minister for the Arts, Sport, the Environment, Tourism and Territories, seen here launching Fauna of Australia with Margaret Cameron, Chairman of the ABRS Advisory Committee, and Tony Blunn (left), Secretary of the Department.

puter integration program. The book form of the *Catalogue* is 'written' by the computer. This system of preparation was developed to allow rapid updating of databases as information becomes available. As well as appearing in book form, the database can be accessed through the use of key standard search terms. These include terrestrial and marine geographical areas, political areas, life-history characteristics, feeding habits, community and habitat description plus vegetation types. As a consequence, a list of species names with particular taxonomic, geographical and ecological attributes may be extracted on request. Enquiries regarding use of the database should be directed to the Bureau of Flora and Fauna. This kind of database, combining nomenclatural, bibliographical, geographical and ecological information, is unique to Australia. No other country has such a program or information source. Properly funded and supported, the potential benefits of this database to

all Australians is enormous.

The incomplete state of our knowledge of the Australian fauna can be seen by examination of any of the invertebrate volumes of the *Catalogue*. For a large part of this fauna, the only relevant literature consists of the original description; the only known specimens are those in the original type series. Clearly, work on the biology of these species and descriptions of the remaining 150,000⁺ undescribed species are immense challenges for Australian biologists.

The *Fauna of Australia* has different objectives from those of the *Catalogue*. It is intended as a major reference source for scientists, fauna authorities, teachers, students and all naturalists. Volume 1A, dealing with general background topics, has just been published; subsequent volumes, dealing with major animal groups, will be published between now and 2001, although not in numerical sequence.

Obvious future plans are to con-

tinue to publish as fast as possible further volumes of the *Flora, Catalogue* and *Fauna*. The rate of publication, of course, will be determined by funding allocations, but the growing importance of these publications must provide solid testimony of the value of the ABRS to the Australian community and, thereby, attract continuous government funding. Because of present fiscal exigencies, there are also plans to concentrate ABRS grant-funding more on groups of fauna and flora of known ecological, environmental or economic importance than on taxonomically unknown groups of less determinate importance. And finally, the ABRS aspires to the greater support of Australian biologists.

The success of these plans and aspirations, of course, is dependent upon the continued support of the Commonwealth Government. Let us hope that our political leaders continue to be as wise as those visionary politicians who were responsible for the formation of the ABRS. ■

FAUNA of AUSTRALIA

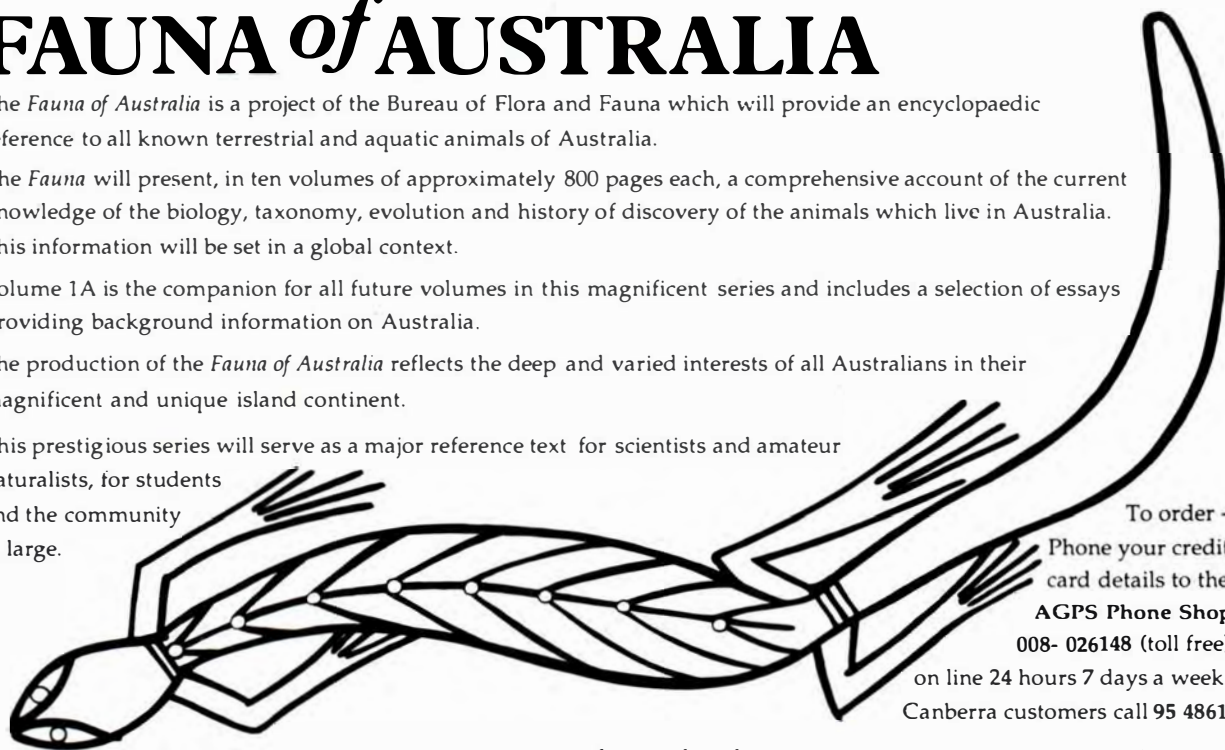
The *Fauna of Australia* is a project of the Bureau of Flora and Fauna which will provide an encyclopaedic reference to all known terrestrial and aquatic animals of Australia.

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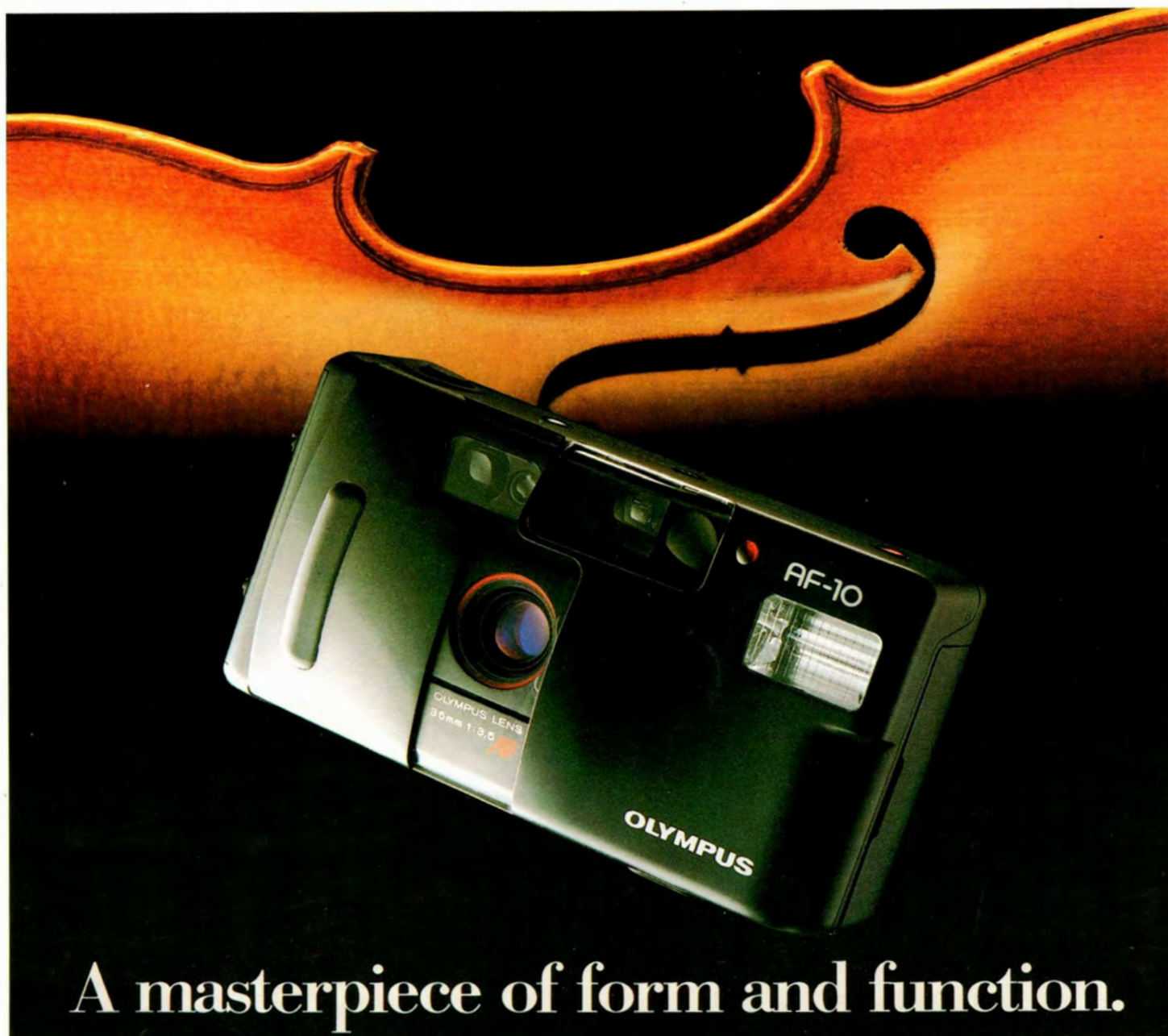
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