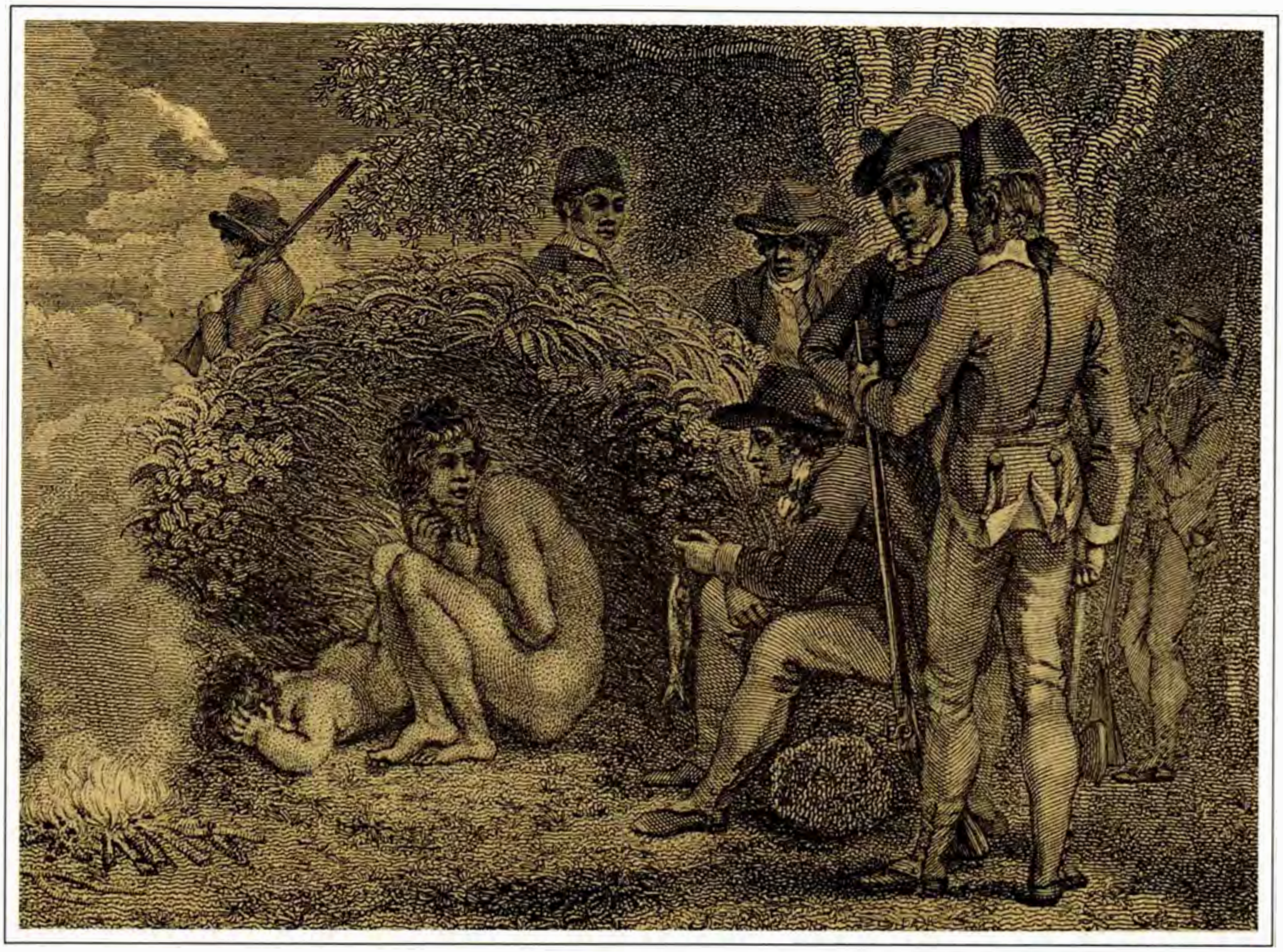
Australian Natural History

$4.50

FIRST FLEET FOODS

Surviving a Hostile New World



FIREBIRDS of the Top End ◆ CROWN OF THORNS STARFISH Unique Spawning Observations ◆ MUD,MUD, Glorious Mud ◆ AMMONITES Cretaceous Molluscs

SUMMER 1987–88 VOL.22 NO.7 THE AUSTRALIAN MUSEUM

Introducing the New Olympus AF-10.

With its elegant, technically ingenious design, the new AF-10 is remarkably appealing to the eye. And its price is music to your ears. Now you can get all the features you expect from a great compact camera at a fraction of the cost.

The autofocus mechanism lets you effortlessly shoot roll after roll of crisp, brilliant pictures. Both aperture and shutter speed are computer controlled for perfect exposures. The AF-10 also loads, winds and rewinds film and sets its own film speed automatically. The built-in flash reads the light, automatically fires in low-light situations, then recycles instantly.

With its sleek, pocket-sized shape, the new AF-10 is always in harmony with its surroundings, whether it's an evening at the symphony or a day at the beach. It's the world's most affordable masterpiece.

OLYMPUS®

For further information contact your nearest photographic retailer or write to the distributors,
R. GUNZ (Photographic) Pty. Ltd. PO Box 690, Darlinghurst, 2010

Australian Natural History

Published by
The Australian Museum Trust
6-8 College Street,
Sydney, N.S.W. 2000
Phone: (02) 339 8111
Trust President: Robyn Williams
Museum Director: Desmond Griffin

EDITOR
Fiona Doig
SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.
CIRCULATION
John McIntosh
ART DIRECTION
Steve Costello
TYPESETTING
Love Computer Typesetting Pty Ltd
FILM WORK
South Sea International Press Ltd
PRINTING
RodenPrint Pty Ltd
ADVERTISING
Jean Barnet
(02) 939 6263
(02) 339 8234

SUBSCRIPTIONS
Annual subscription (4 issues)
Within Australia $A16.00
Other Countries $A20.00
Two-year subscription (8 issues)
Within Australia $A30.00
Other Countries $A36.00

For renewal or new subscription please forward credit card authority or cheque made payable to:
The Australian Museum
P.O. Box A285 Sydney South
N.S.W. 2000, Australia

Subscribers from other countries please note that money must be paid in Australian currency.

Published 1987
ISSN-0004-9840

Australian Natural History is audited by the Audit Bureau of Circulations

Front Cover
From *Hunter's Voyage* (1793) held in the Mitchell Library. Discover how the First Fleeters struggled to survive in Old Sydney Town (p. 292).

EDITORIAL Save Our Soil

Flying over this country recently, what struck me most was the devastation of our land caused by the way we farm it. Tell-tale ripples in the soil and scarred hills indicate soil erosion is an urgent problem.

It made me wonder if there was something fundamentally wrong with our approach to agriculture—surely we shouldn't be destroying the land that makes production of food possible in the first place. Are our livestock and crops really suitable for Australian conditions—or are they simply a hang-over from our European heritage? Why are we so repulsed by the thought of farming (and eating) our native animals like kangaroos, lizards and crocodiles? The only barrier appears to be our own gastronomic attitudes. (I recently tasted crocodile meat. It is delicious.) Economically it makes sense, as we have the world market cornered. And farming—that is *producing*—these species makes ecological sense; it necessitates, economically, their ongoing survival. On page 312, Robyn Williams looks at farming failures.

Perhaps we simply started on the wrong footing. Our bicentennial article, *Foods of the First Fleet*, page 292, shows the kind of tunnel vision the British suffered on arrival. Many starved, for they sought foodplants comparable to English garden varieties, unaware of the plentiful delicacies enjoyed by the Aborigines. But has our approach changed? I think not. What chance do our native plants have if research scientists see some as unsightly weeds? (See Forum, page 306.) Perhaps now is the time to take a fresh look at where we are; to step outside what we already know and act according to what our land is telling us. Before it is too late.

—Fiona Doig, Editor

Contents

LETTERS Flipper, Skippy and the Sex Pistols

The Dolphin Dilemma

At last a sensible well-balanced, non-hysterical article about dolphins in captivity (ANH vol. 22, no. 3, p. 128).

I have spent many hours with captive dolphins and it is my belief that their lot is not as detrimental as the Georges Report claims.

High standards should be set regarding the land-based habitats for captive dolphins. Perhaps taking them from the wild should be banned, eventually causing all captive dolphins to be born in captivity. But to close down the dolphinariums and release the captive animals into the wild, where they would no doubt suffer and die, would be a cruel and extremely thoughtless act.

Better to worry about the thousands of dolphins and sea lions killed each year by careless fishermen. This would be far more beneficial to the animals' future survival than closing the dolphinariums.

Thankyou, Laura Mumaw, for a fine, well-researched article.

—Valerie Taylor
Sydney, NSW

Eat More ('roo) Meat!

May I commend Gordon Grigg on his excellent article (ANH vol. 22, no. 5, p. 204) advocating the exploitation of kangaroo meat. As a botanist frequently visiting areas grazed by cattle, I am all too aware of the devastation wrought by these hard-hoofed animals. Our natural grasslands are being irrevocably degraded largely because of a cultural prohibition against eating kangaroo meat. I for one am putting my house in order. Our local butcher sells containers of diced kangaroo meat as pet food. This meat is lean, and very cheap—about one quarter the cost of lean beef, its only drawback being the occasional piece of meat dyed blue to indicate its source. This dye is harmless, although I feed these pieces to the cat rather than eat them myself. Kangaroo meat tastes slightly stronger than beef, and is ideal for curries, stews and Chinese cooking. Last week I used it in Hungarian goulash with excellent results. I have spoken to a vet who assured me that, provided the meat is well cooked, there is no risk of bacterial or parasitic infection, even though kangaroo meatworks do not, at present, match abattoir standards.

Overgrazing and soil compaction by cattle is an environmental issue as important as rainforest preservation, and the conservation movement needs to act fast. I congratulate Dr Grigg for his timely focus on this critical issue.

—Tim Low
Brisbane, Qld

Snail Mail

I thought that Georgina Hickey's QQC article on the courtship behaviour of garden snails (ANH vol. 22, no. 6, p. 215) was absolutely amazing! Many times after the rain I've gone outside to masochistically count those seemingly passive, mindless munchers of my prized garden specimens. However, despite the fact that they are pests, I've always considered snails as being 'nice' animals—they just go along with their own business, quietly and slowly, negating any horticultural labours that have been spent the week before. Yet all along, there they were—those sexual deviants—shooting sex pistols at each other! How could I have missed such intriguing behaviour?

With my curiosity whetted, I went out to the garden after the next rain. The first two snails I came across were joined fast. With a small amount of pleasure, keeping in mind that perhaps there would be a few less snails in future to destroy my garden, I gently pulled them apart. Their penes were well entwined and the tip of each was swollen. There was a soft popping noise when they were finally separated. I thought if I looked very hard I *must* be able to find a dart. And sure enough I did. Embedded about two millimetres in one of the snails was a white spear, about a centimetre long—just as described and illustrated in the article. I was thrilled, but recalled blushing slightly when I realised what gave me the thrill. I had experienced the sense of discovery that I can only imagine a scientist would when discovering a new species. It just goes to show that there is truth in the adage "look and you shall find".

—Lisa Brooks
Mosman, NSW

Tribute to Wandjuk Marika, OBE

Wandjuk Marika, c. 1936–1987, was ritual leader of the Riradjingu people, and was from the Dua Moiety. He passed away suddenly in Darwin hospital, after a short illness in June 1987. He had been living with his family at Yelangbara, near Yirrkala, eastern Arnhem Land.

Mawalan Marika, shortly before his death in 1969, said to his son Wandjuk:

Take my stick
Take my word
Take my energy
Take my courage
One day the Balanda
they will come
And destroy our land
But I'm not going to see
What will happen
So you will have to
stand tall
To talk for our land
For our children
For your children's
children.

Wandjuk did indeed stand tall. He played a significant role in negotiations with the bauxite-mining company Nabalco, worked to obtain copyright protection for Aboriginal artists, and acted as Ambassador for his people throughout Australia and overseas. He was a highly skilled traditional musician and bark painter, who believed in sharing his knowledge with the wider community.

Wandjuk had a close association with the Australian Museum and for some years worked with the Anthropology staff, documenting over 100 eastern Arnhem Land bark paintings held at the Museum. He said of his work there:

"I am Wandjuk. I am telling these stories, from the artists, the men who are in charge of paintings and ceremonies. I am an artist too. I'm translating from my own language into English, so everyone can read and understand the stories . . . Some are special stories, very sacred and secret—I can't tell you everything. But I am telling you just a little bit, so you can know about our culture, the country and the dreaming of our tribes."

Wandjuk Marika was also

V. STEINWARD

One of Wandjuk's bark paintings depicts a whale,* mirinunu. *In accordance with Aboriginal custom, we are unable to publish a picture of Wandjuk.

a Founding Member of the Aboriginal Arts Board of the Australia Council, from 1973–1975, and was a distinguished Board Chairman from 1976–1979. Working for the Board was no easy task, as he had to act as a bridge between two cultures—that of the Balanda (white man) in the south with its constant travel and its endless bureaucracy, and that of his responsibility as ritual leader of the Riradjingu in the Yirrkala region of north-east Arnhem Land.

There is an instant range of memories of Mr Chairman Wandjuk Marika, playing yidaki (didjeridu) in a cold Moscow street with a fur hat pulled down to keep him warm; welcoming delegates to the UNESCO Conference on 'Preserving Indigenous Cultures: a New Role for Museums', held in Adelaide in 1978; or chairing an Aboriginal Arts Board meeting in Derby, Western Australia, where many men had travelled great distances to put their case for Board support before the members.

As Ambassador for his people, Wandjuk represented them at the South Pacific Festival of Arts, Rotorua, New Zealand and the American Bicentennial Celebrations in the USA. He had an infectious sense of humour and enjoyed life to its full. Wandjuk said:

"My own people, the Riradjingu, are descended from the great Djankawu who came from the island of Baralku far across the sea . . . I am the man descended from the Djankawu, the man himself, seven, eight generations ago."

The spirit of Wandjuk Marika has returned to Baralku.

As is customary, a length of cloth was sent by the Museum for one of his close family members to wear at the funeral ceremonies. Silk flowers were also sent to decorate the bark enclosure where his body will lie.

—Kate Kahn
Australian Museum

Not a Case for Confusion

In response to the article on Creationism by Michael Archer (ANH vol. 22, no. 4, p. 160), I hope that your magazine is sufficiently objective as to give the other side of the argument. Whilst not attempting to denigrate an otherwise excellent publication, I feel that some balance is needed, for it must be remembered that evolution is only a theory. No ultimate proof exists; indeed, there are very many faults in evolution. Therefore, any reasonably objective scientist would admit that it is only a theory, and cannot be proven.

The withdrawal of the teaching of Creationism in our schools would be a great mistake. Evolution is an integral part of the present curriculum; therefore, in order to give a well-rounded, balanced education, is it not essential to provide the other view of the Earth's origin? Surely that is the aim of education. Confusion should not arise if it is emphasised that the two views are quite incompatible. To give only one side of the argument would be, in many respects, similar to the type of society described in George Orwell's *1984*.

Although I would like to discuss in greater detail many points in the article, I shall be content with merely reiterating that a balance is needed. As a tertiary science student, and Creationist, I see this every day.

—Mat Vanderklift
Monbulk, Vic.

TIM LOW

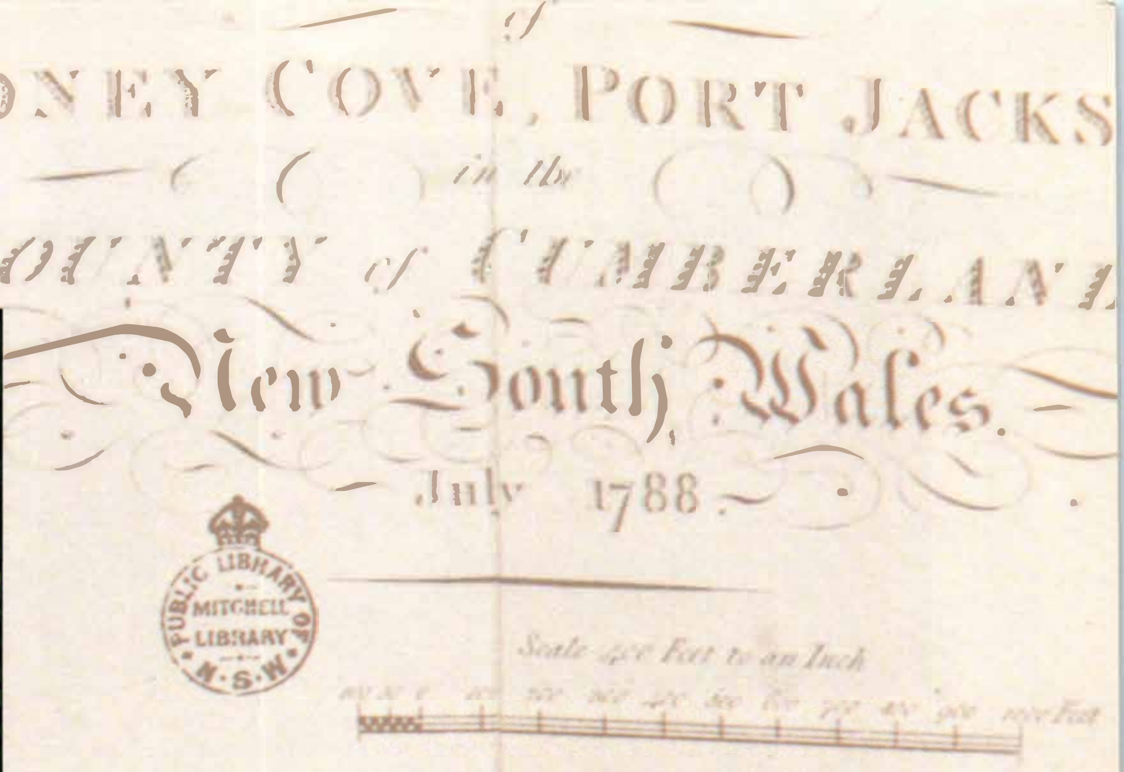
Grey Saltbush has very tasty leaves much appreciated by early colonists in New South Wales. This is almost certainly the "sage" listed by one of the First Fleet officers.

Foods of the First Fleet

Convict Foodplants of Old Sydney Town

By TIM LOW

From Phillip's Voyage *(1790) held in the Mitchell Library.*



TIM LOW

Native Cherry was probably one of the edible "cherries" mentioned by Governor Phillip. This plant later became famous as one of the 'topsy turvy plants of Down Under'—the little cherry has its seed on the outside.

TIM LOW

New Zealand Spinach was almost certainly the spinach harvested by the first Sydney colonists. Joseph Banks introduced this plant to England, and may have informed Governor Phillip of its usefulness.

Two hundred years ago Captain Arthur Phillip landed at Port Jackson and founded the colony of New South Wales. His settlement devastated the local Aboriginal tribe, in spite of his kindly overtures. Phillip hoped to bestow upon the "natives" the gift of agriculture, noting earnestly in his diary that "to put into the hands of men, ready to perish for one half of the year with hunger, the means of procuring constant and abundant provisions, must be to confer upon them benefits of the highest value and importance".

But Phillip was wrong. The Aborigines were not hungry, his own men were. Agriculture, that "means of procuring constant and abundant provisions", failed dismally on Sydney's infertile soils. English supply ships came late, and ravenous convicts and soldiers were forced to forage like Aborigines, plucking at leaves and berries to supplement dwindling rations.

But the plants sought out by the colonists were not traditional Aboriginal foods. Due to a gulf in cultural outlook and techniques, the two cultures, although living side by side, were using quite different resources.

The aloof Englishmen could find almost nothing in the forest that looked edible and assumed that the natives lived on starvation's edge for much of the year. In fact, the forests around Sydney conceal dozens of edible plants and animals, and the Aborigines would have lived a comfortable existence. Starchy root-like stems of Bracken (*Pteridium*

TIM LOW

Currant Bush fruits saved the lives of scurvy-stricken convicts in Sydney in the 1780s. The fruits were later sold in markets in George Street, mainly for use in jams and jellies. Aborigines gathered the fruits in wooden bowls.

TIM LOW

Native Sarsaparilla was so intensively harvested as an antiscorbutic that it became scarce in the forests about Sydney. The vine is easily identified by its leathery leaves with three longitudinal veins. The black berries were not used; they are distasteful but appear to be edible.

esculentum) were probably a reliable winter staple when fish were scarce. But the colonists, too civilised to learn from savages, sought out plants in the image of English vegetables and dabbled hopefully with cures for scurvy.

Scurvy Cures

Eighteenth century officials knew that certain foods called antiscorbutics would cure scurvy, a disease we now attribute to vitamin C deficiency. There was no way then to detect an antiscorbutic, except by testing its effects through time, and the colony's surgeons made speculative judgments on what would work. Two plants were deemed efficacious, and these figured prominently in the life of the colony.

Currant Bush (*Leptomeria acida*) was no doubt chosen because its small green fruits taste much like limes, a recommended naval antiscorbutic. The fruits are gathered from a broom-like shrub common on the sandstone ridges about Sydney. The 'currants' (no relation) yield modest amounts of vitamin C—about 20 milligrams per 100 grams, compared with 50 milligrams per 100 grams in oranges. Four cupfuls of fruit *daily* would be needed to cure scurvy, an amount that would rarely have been available.

Nonetheless, Currant Bush probably saved a number of lives. The human cargo aboard the *Neptune*, a convict hulk that limped into Sydney in 1790, was lucky to arrive while the currants were still in season. Conditions aboard the *Neptune* had been appalling, and 164 convicts perished on board. The *Neptune* was privately contracted, and its owners had profiteered by setting rations at starvation levels. It was said that deaths among the convicts in irons were concealed so that others could share their rations—until the stench of the corpse alerted the officers. Once on land the pitiful survivors were restored with special bread rations and supplies of the "acid berry of the country", as Judge Advocate Collins described the currants.

The other scurvy cure of the colony was the Native Sarsaparilla vine (*Smilax glycophylla*), known then as 'Sweet Tea'. Soldiers and convicts trooped into the dark forests to gather its sweet-tasting leaves, from which a bitter-sweet tea was made.

So important was Native Sarsaparilla that the English risked death from hostile Aborigines to obtain it. But it was probably useless. Native Sarsaparilla leaves have not been tested for vitamins, but the green berries are known to contain a mere six milligrams of vitamin C per 100 grams. At this rate thousands upon thousands of leaves would be needed daily to allay just one person's scurvy. And Native Sarsaparilla is not a leafy or abundant vine.

We may wonder why the surgeons placed so much faith in an unknown and probably useless vine. I believe that the bitter-sweet taste provides the clue. In 1788 this odd combination of flavours would have seemed propitious. Bitterness was then considered medicinal by doctors using bitter Willow and Cinchona barks to treat fevers. (Willow bark later became the source of aspirin, and Cinchona of quinine.)

Wild Vegetables

The banishment of scurvy was one priority of the colony; a supply of vegetables another. The first vegetable farms using imported seeds proved failures, although fertile land was eventually found at Parramatta. In the meantime, parties of convicts were sent into the woods to scour for berries and leaves. The journals of several of the officers list wild vegetables of this time.

David Collins noted that "wild celery, spinach and parsley fortunately grew in abundance about the settlement: those who were in health, as well as the sick, were very glad to introduce them into their messes". Lieutenant William Bradley listed "wild spinage, samphire & parsley & small quantity of sorel & wild celery, all of which with the leaves of several kinds of bushes were used by us for want of better vegetables which were not yet supplied from the Gardens". Another officer (anonymous) wrote that "Parsley, balm, a sort of sage, and other European herbs, were found of natural growth". And the surgeon George B. Worgan listed "Balm, Parsley, Samphire, Sorrel, & a kind of Spinnage, but all indifferent of kind".

These lists make for fascinating reading, for it is possible to identify most of the plants involved, given a knowledge of the present Sydney flora. Two points become obvious. Most if not all of the plants come from seashores; and the plants were not traditional Aboriginal foods.

The "samphire" of Bradley and Worgan is the easiest plant to identify. It is *Sarcocornia quinqueflora*, Australian Samphire, a small saltmarsh herb very similar to European Samphire (*S. stricta*) which the English used at that time as a pickle.

The "parsley" and "celery" of Collins and Bradley are two varieties of Sea Celery (*Apium prostratum*)—one a wispy form that grows in shady swamp margins, the other a broad-leaved form of open dunes. This herb, common along coasts in temperate Australia, found its way into the cooking pots of a number of early voyagers. Captain Cook served it up to cure scurvy, presumably at Botany Bay, and the French botanist Labillardiere dined upon it in Tasmania in 1792. Sea Celery is closely related to culinary Celery (*A. graveolens*), and the two are difficult to distinguish when growing wild.

The "spinach" was almost certainly New Zealand Spinach (*Tetragonia tetragonioides*), a plant made famous by Joseph Banks, who drew its attention to the British House of

T.J. HAWKESWOOD, ANT

Australian Samphire was recognised by the English colonists for its similarity to the edible samphire of England. They used it successfully as a vegetable.

TIM LOW

Sea Celery has juicy leaves and stems tasting slightly of culinary Celery.

Commons in 1779 when the colonisation of Australia came under consideration. New Zealand Spinach grows on the shores of Australia, New Zealand, China and South America, but was first eaten by Cook and Banks in New Zealand, hence its name. Banks considered the leaves to "eat as well as spinage", and he introduced the plant to Europe where it was grown as a summer spinach last century.

The "sort of sage" can only be Grey Saltbush (*Atriplex cinerea*), a seashore shrub with edible leaves of the same colour, size and shape as English Sage (*Salvia officinalis*), although it is unrelated. Grey Saltbush grows in the same places as Australian Samphire, Sea Celery and New Zealand Spinach, and all of these were no doubt collected by the convicts on the same outings.

The "balm" and "sorel" I cannot identify with certainty, although the latter is probably a native woodsorrel (*Oxalis* species), a small herb of forests and beaches with small sour-tasting leaves.

Captain Phillip's colony had over a thousand hungry mouths to feed and, not surprisingly, stocks of these wild vegetables became scarce. Foraging parties roamed as far as Botany Bay, where they risked violence from the Aborigines. Yet the wild greens, although important, do not seem to have been popular among the officers, judging by the comments in their journals. The convicts were no doubt less fussy, and perhaps overindulgent, as suggested by a comment in Collins' journal: "One poor [convict] woman about this time killed herself by over-loading her stomach with flour and greens which she had made into a mess."

But to the Aborigines, these plants were probably not foods at all. They do not appear on recent or historical Aboriginal food lists from eastern and southern Australia. Indeed, the historian Daniel Mann, in 1811, wrote that Botany Bay greens (Grey Saltbush) "are esteemed a very good dish by the Europeans, but despised by the natives".

I think I know why. The wild greens eaten by the English (except perhaps the "sorel") were halophytes—plants that store salt in their tissues. This salt leaches out during boiling, producing a tender and succulent vegetable. But traditional Aborigines had no cooking pots and no way to boil foods. They would have scorned the halophytes, which

The Sandpaper Fig grew in the centre of Sydney in the 18th century where its fruits were probably used as food by the officers and convicts (and certainly by the Aborigines).

are too salty to eat raw.

Halophytes thrive on saline soils where they absorb enough salt to render them distasteful to most plant-eaters. Plants of other habitats use other means to deter planteaters—they produce hard leaves containing distasteful tannins, essential oils, or poisonous alkaloids. Substances like these are not removed by boiling and the leaves of forest-growing plants are rarely edible. This explains why the plants of seashores were so important to the foundling colony.

First Fleet Fruits

Wild leaves (and the fruits of Currant Bush) are the foods most mentioned in the early journals, but there are passing references to other bush foods, mainly fruits. Unlike the sweet tea and the seashore leaves, these fruits would have been Aboriginal foods.

Unfortunately they are difficult to identify. Governor Phillip mentions a "small wild fig, and several cherries", and surgeon Worgan records a fig and berries (plus the inner shoot of the Cabbage Palm, *Livistona australis*). The fig is probably Port Jackson Fig (*Ficus rubiginosa*), or possibly Sandpaper Fig (*F. coronata*), and the "cherries" of Phillip are probably Native Cherry (*Exocarpos cupressiformis*) first mentioned specifically in *The History of New South Wales* in 1801, and the Magenta Lillypilly (*Syzygium paniculatum*), discovered by Joseph Banks at Botany Bay. Worgan also mentions "a Shrub bearing a fruit like a Sloe"—probably the Native Plum (*Podocarpus spinulosus*).

Common Appleberry or Dumpling (*Billardiera scandens*) was certainly among the first of the berries to be used, for it is mentioned as edible in an English plant book (*A Specimen of the Botany of New Holland*) written by James E. Smith in 1793, only five years after the colony's founding.

Poisonings

Sampling wild plants is not as risky as most people think, and mishaps among the Europeans were few. One convict was poisoned by cycad seeds (*Macrozamia* species), which were eaten by Aborigines only

TIM LOW

Common Appleberry was eaten during the first years of convict settlement at Sydney. The small green berries have a sweet apple flavour.

TIM LOW

Governor Phillip was poisoned by the seeds of the Beach Bean, which he boiled up as a vegetable. The well-boiled seeds are, however, safe to eat, and are cooked as porridge in Indonesia, where this beach creeper also grows.

after careful preparation. And Governor Phillip and Surgeon General John White were poisoned by the Beach Bean (*Canavalia rosea*), as White's 1790 journal recalls:

"As we proceeded along a sandy beach, we gathered some beans, which grew on a small creeping substance not unlike a vine. They were well tasted, and very similar to the English long-pod bean. At the place where we halted, we had them boiled and we all eat very heartily of them. Half an hour later, the governor and I were seized with a violent vomiting."

Phillip and White probably nibbled on these beans prior to boiling them, for the cooked beans are known to be edible—Captain Cook ate them at Endeavour River and I have tried them a number of times without mishap.

Two hundred years have passed since the founding of Sydney and botanically much has changed. Gone are the beaches and forests of the inner suburbs; the coasts have become infested with weeds; and Botany Bay is now an industrial wasteland.

But hardy forests still linger in the outer suburbs, where the foodplants of the convicts can still be found. Native Sarsaparilla vines still twine along shaded gullies; Currant Bushes bear fruit on the ridges in autumn; and New Zealand Spinach thrives on coastal cliffs beneath runoff from houses and drains. These plants are our history, no less than Cadman's Cottage or Fort Denison. In their cycles of growth and fruiting a part of our convict past lives on. ■

References

Anonymous, 1789. *An Authentic Journal of the Expedition under Commodore Phillip to Botany Bay.* Forster: London. p. 20.

Bradley, W., 1969. *A Voyage to New South Wales: The Journal of Lieutenant William Bradley RN of HMS Sirius.* Ure Smith: Sydney.

Collins, D., 1798. *An Account of the English Colony in New South Wales.* Cadell & Davies: London. p. 90.

Low, T., 1988. *Wild Food Plants of Australia.* Angus & Robertson: Sydney.

Mann, D.D., 1811. *The Present Picture of New South Wales.* Booth: London. p. 51.

Phillip, A., 1789. *The Voyage of Governor Phillip to Botany Bay.* Stockdale: London.

White, J., 1790. *Journal of a Voyage to New South Wales.* Debrett: London. p. 200.

Worgan, G.B., 1978. *Journal of a First Fleet Surgeon.* Library Council of New South Wales: Sydney. pp. 11–12.

Black Kites hunt so close to the flame that younger, inexperienced birds are often singed.

JEAN-PAUL FERRERO, AUSCAPE

FIRE-BIRDS OF THE TOP END

By RICHARD BRAITHWAITE and JOHN ESTBERGS
CSIRO, DIVISION OF WILDLIFE AND RANGELANDS RESEARCH, DARWIN

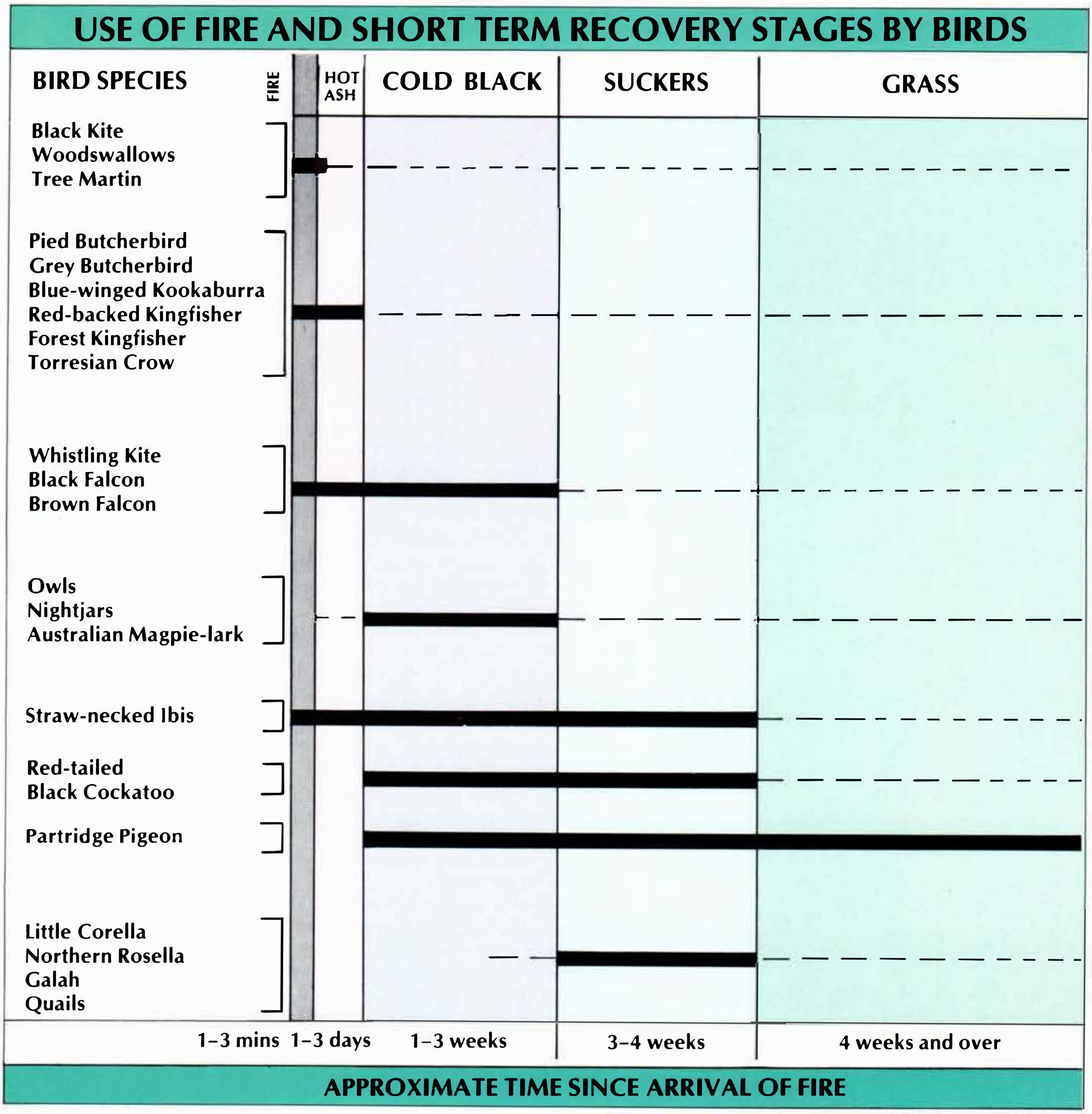
Each year a myriad of grassfires follows the profuse growth of the wet season. The high frequency of fires in the Top End has been implicated in the decline of various animal species. However, the long fire season from April to December provides a range of burning conditions that creates a wide variety of habitats favoured by different species, particularly sedentary animals like small skinks.

Eighty-five per cent of woodland in Kakadu National Park is burnt annually while the open forest is most commonly burnt in two out of three years (48 per cent). These habitats together occupy 60 per cent of the park. Other less flammable habitats like wet forest, monsoon forest, riparian woodland, wetland and rocky escarpment experience a substantially lower frequency of fires, a situation more similar to that of southern Australia. It is the high-frequency fire regimes of the open forest and woodland that provide many special but very temporary habitats for mobile species of birds. The fires are so common for so much of the year that the creation of new habitat is occurring almost continuously.

Most ephemeral of these habitats is the fire itself. Brown and Black Falcons (*Falco berigora* and *F. subniger*) perch in trees immediately in front of the fire and hunt the grasshoppers, lizards and small mammals that try to escape it. Whistling Kites (*Haliastur sphenurus*), and particularly Black Kites (*Milvus migrans*), spectacularly hawk around the curtain of flame preying on grasshoppers, cockroaches and other small fleeing animals. They hunt so close to the flame that younger, inexperienced individuals are sometimes singed as they pursue prey. The dark smoke of a fast-moving fire is visible on the horizon, perhaps 20 kilometres away. As in other parts of the world's tropics, large numbers of Black Kites aggregate around fires, often travelling long distances. They roost in the trees amid the still-smouldering vegetation. The next morning, they may search for carrion if the fire has been severe, rejoin the fire if it still has a strongly burning front, or soar the thermals and search for a new fire.

Local Aboriginal people believe the Black Kite actually sets fires by carrying burning sticks from fires to new locations and dropping them into dry grass and setting it alight. While we have seen birds occasionally pick up small smouldering sticks, they usually quickly drop them. They are likely to have accidentally picked up sticks while stooping for small fleeing prey close to the fire.

Other raptors, including Black-shouldered Kites (*Elanus notatus*), Australian Kestrels (*Falco cenchroides*), Black-breasted Buzzards (*Hamirostra melanosternon*) and Spotted Harriers (*Circus assimilis*), attend fires but are much less common. Torresian Crows (*Corvus orru*) and Australian Magpie-larks (*Gral-*



lina cyanoleuca) can be seen foraging in the burnt area immediately behind the fire front. Tree Martins (*Hirundo nigricans*), Black-faced Woodswallows (*Artamus cinereus*) and Little Woodswallows (*A. minor*) are sometimes seen foraging at canopy height above the fire, while swifts forage much higher again. All these aerial-foraging species are presumably feeding on fleeing insects that have been caught in updrafts from the fire. This only happens with very hot fires, which occur on sites with dense annual *Sorghum* grass under dry and windy conditions, usually in the mid to late dry season.

The raptors often remain in the vicinity after the fire has passed, feeding on the bodies of animals killed or made vulnerable by the fire. Animals are mainly killed by very hot fires such as frequently occur during August to October. However, many prey species are temporarily narcotised by the enhanced carbon monoxide and carbon dioxide and low oxygen levels, and most species are disoriented by the changes to the habitat. The changed appearance and odour of habitat, plus new distribution of resources and dangers, greatly increase the vulnerability of prey species. Other predatory species exploit the two to three days of the 'hot ash' phase and the subsequent two weeks of the 'cold black' phase after the smouldering has stopped but before vegetative sprouting has begun.

Grey and Pied Butcherbirds (*Cracticus torquatus* and *C. nigrogularis*), Straw-necked Ibis (*Threskiornis spinicollis*), Black-faced Cuckoo-shrikes (*Coracina novaehollandiae*), Australian Magpie-larks, Torresian Crows, Black and Brown Falcons, owls and nightjars have been observed at times, utilising these stages by foraging on vulnerable invertebrates and small vertebrates.

Red-tailed Black Cockatoos (*Calyptorhynchus magnificus*) and Partridge Pigeons (*Petrophassa smithii*) are also observed in these early post-fire days. However, they are the first of the animals that feed on the vegetation of the changing habitat. They forage on seeds that are more easily detected or have fallen to the ground as a result of the fire.

Many of the birds associated with fires and the immediate post-fire recovery are black, pied, or have some red plumage. This has lead to fire-related myths in many indigenous cultures, including those of many parts of Australia. In such myths, individual species were often originally white and achieved black, pied or red colouration in the process of stealing fire from some deity or in fiery punishment for such actions. Whatever the origins, these colourations offer some camouflage for ground-foraging birds.

However, the black, white and red colours of the landscape disappear as the days pass. In the weeks after the fire, resprouting of the vegetation progressively occurs—first the palms and cycads, then the woody dicots such as eucalypts, and finally grasses and herbs. The speed and degree to which this occurs depend on the reserves of these perennial plants, the available soil moisture and immediate atmospheric moisture. Thus this vegetative regeneration will usually be slowest in August to October, the period after the annual drying out of the soil and vegetation, but before the early rains of the next wet season. However, some sites have moisture at any time because they receive water from deep springs and seeps. The 'green pick' that follows fires is highly nutritious, sometimes with four times the protein content of other available vegetation at that time of year. A number of bird species utilise this phase in a variety of ways.

While the main beneficiaries of the tender perennial grass shoots are mammals such as Antilopine Kangaroos (*Macropus antilopinus*) and

M.P. KAHL, AUSCAPE

Lizard-eaters, such as this Blue-winged Kookaburra, utilise burnt areas in preference to unburnt areas of their territories for catching prey.

WALTER BOLES

A road sign south of Darwin calls for protection of the Frill-necked Lizard against fires.

R.W. BRAITHWAITE

Cryptoblepharus plagiocephalus ***skinks killed during a fire are tasty morsels for a range of post-fire scavengers.***

JEAN-PAUL FERRERO, AUSCAPE

Agile wallabies utilise the highly nutritious 'green pick' that grows after a fire.

The Cave of Fire: An Aboriginal Myth

The eagle, Wildu, furious with his nephews, soon made plans for revenge. From the summit of a high mountain, Wildu could see the birds and animals dancing to celebrate his death. The crow and the magpie stood out from the grey-coated animals, because, in those early days, both of those birds had glossy-white plumage.

Now Wildu, knowing of a cave in a group of boulders not far from the corroboree ground, estimated that a sudden squall of rain would drive all the performers into the cave for shelter. So the eagle asked his wives, the kestrels, to go into the air again and flap their wings, this time to draw up a heavy storm of rain from the south.

Everything happened as Wildu had planned. When the rain started to pour down, the performers rushed to the cave. The animals went in first, then the magpie, and finally the crow, their bodies almost blocking the entrance. This suited the purpose of the eagle very well. Quickly, he and his wives covered the opening with a huge pile of grass and dead branches, and set them on fire.

When the fire died away, it was found that the wallabies, bandicoots and other creatures had escaped unmarked. But the crow and the magpie were not so fortunate; the glossy plumage of the crow, who was nearest to the fire, was scorched completely black, while that of the magpie, being further from the fire, was scorched only in parts.

And, the aborigines explain, that is the reason why all the crows are black, and the magpies black and white.

From The Dawn of Time *by Ainslie Roberts and Charles P. Mountford, Rigby, Adelaide, 1969, p.28.*

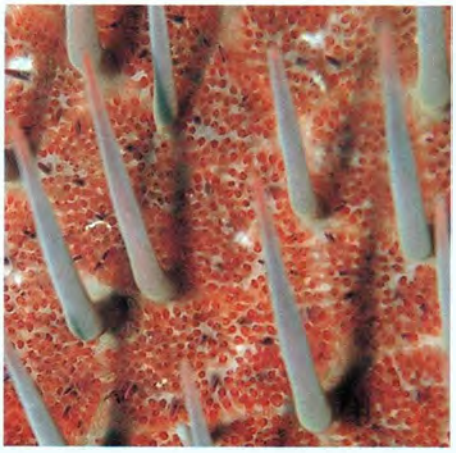
GRAEME CHAPMAN, AUSCAPE

Little Woodswallows often forage at canopy height above a fire. Here they are engaged in an early morning preening session.

Agile Wallabies (*M. agilis*), birds also benefit. Straw-necked Ibis come in again and feed on invertebrates that have responded to the vegetative changes. The granivorous species—Little Corellas (*Cacatua sanguinea*), Northern Rosellas (*Platycercus venustus*), Galahs (*C. roseicapilla*) and quails—can be seen feeding on the ground during this regenerative phase. Lizard-eating species like the Blue-winged Kookaburra (*Dacelo leachii*), Red-backed Kingfisher (*Halcyon pyrrhopygia*), Forest Kingfisher (*H. macleayii*) and Torresian Crow are generally sedentary with established territories. However, they too utilise burnt areas in preference to unburnt parts of their territories because of the greater accessibility of their lizard prey.

Throughout the couple of months after a fire, the accessibility and quality of the food resources for a range of bird species are enhanced. Part of the attraction of these recently burnt areas is undoubtedly the security from mammalian and reptilian predators for these ground birds feeding in the open burnt ground layer. It is clear that a series of fires throughout the fire season is utilised by these bird species. During the wet season, a number of the species (Black Kites, Black and Brown Falcons, Australian Magpie-larks, Red-backed Kingfishers and a few Whistling Kites) migrate deep into the arid lands to the south where fires continue to occur. However, fires are much less frequent in the arid lands and most foraging by these migrants is not associated with fires but with the more open ground vegetation and scavenging opportunities around waterholes. During the wet season, the ground vegetation for some species is too dense in the Top End.

In the wet-dry tropics, the provision of fires by national park management throughout the fire season from April to December would enhance the abundance of the species that utilise the fires and the phases in the short-term regeneration of the vegetation as the surviving individual plants resprout. The utilisation of these brief phases of minutes, days and weeks contrasts with that of the long-term successional changes of years following a fire in temperate or arid Australia. In the non-tropical areas, it is usual for a series of animal species to sequentially occupy the habitats serially created by the slowly regenerating vegetation over many years. In contrast, it is only possible for highly mobile species in a high-frequency fire regime, as is commonly found in the wet-dry tropics, to specialise on the ephemeral set of phases we describe. ■



WILLIAM GLADSTONE

WILLIAM GLADSTONE

A SPINE-BENDING STORY

By **WILLIAM GLADSTONE**
UNIVERSITY OF SYDNEY

Crown of Thorns Starfish (*Acanthaster planci*) have plagued parts of the Great Barrier Reef for many years. For this reason, these multi-armed and spiny starfish, previously known only by echinoderm taxonomists, have become part of public and scientific consciousness in Australia. Yet, in spite of the publicity and some recent research, much of their natural history is still unknown. I would like to share a unique observation of the spawning behaviour of the Crown of Thorns in the hope of solving one more mystery about this curious animal.

Coral reefs are threatening environments. Predators are abundant, ranging from passive waiting corals, to worms with mucous nets, to the most active piscivores (fish-eaters). The reef's inhabitants spend much of their time avoiding and deterring predators through behavioural and structural adaptations. They invest even more energy in improving their offsprings' chances of survival, as a way of safeguarding their own genetic record in evolutionary history. Many species lay eggs in carefully prepared nests and stand guard until the young hatch (this form of parental care is most elaborate among fishes that incubate the eggs in their mouth or inside a pouch on the male's belly). Others disperse huge numbers of eggs into currents, which carry them away from the reefs to the open sea where there are relatively fewer predators; here they grow, returning sometime later to spend their adult life on the reef.

Crown of Thorns have also adapted to the threat of predation and the need to ensure the survival of the greatest number of offspring. A Crown of Thorns needs four to six hours to evert its stomach over a coral and digest the living polyps; it is

Photo at left shows a close-up of Crown of Thorn's primary aboral spines at the moment of initial sperm release. As soon as sperm is released (right), the primary aboral spines bend. The white streaks are sperm.

WILLIAM GLADSTONE

The orange areas at the tips of the primary aboral spines are the sites for manufacture of a potent toxin.

BEN CROPP

A Crown of Thorns feeding on the polyps of a live coral.

immobile and exposed for all of this time. An impressive armour of poisonous spines, together with nocturnal activity, reduce the chances of predation. The entire body of a Crown of Thorns is covered by up to 8,000 spines. The spines on the upper surface of the body are known as primary aboral spines and are the most impressive: they grow to almost 30 millimetres and taper to a triangular spear-like tip. The skin covering them produces a potent toxin. The primary aboral spines are jointed. Each primary aboral spine is mounted on top of a skeletal plate with a columnar platform called a pedicel. In the region of the joint, the spine and the pedicel are enclosed by connective tissue that is permeated with muscle fibres. The connective tissue is normally stiff and keeps the spines erect. When the spine is stimulated, for example by physical contact, the connective tissue becomes 'soft' and the spines passively bend at their joints. Once the stimulus has passed, the muscle fibres contract and the spine straightens. It has been suggested that bending of the spines allows the starfish to crawl into narrow crevices. In this article I will describe active spine-bending during spawning. This is the first time such observations have been published and I suggest that its function is to facilitate successful reproduction.

Crown of Thorns become sexually mature at about two years of age. They are prolific breeders: over the spawning season a large female produces 60 million eggs, although very few survive. On the Great Barrier Reef spawning occurs during the summer months when water temperatures are high, seas are calm, and there is more food (in the form of phytoplankton) for the larval starfish. Spawning has only been observed on several occasions in the wild and I was fortunate to see a spawning event at Lizard Island.

On a summer morning in 1983 I watched the Crown of Thorns prepare to spawn as the tide was falling. Normally sluggish and inconspicuous, about 20 or 30 individuals had climbed to the tops of coral heads. In aquarium experiments a pheromone has been isolated from the gonads of males and females that attracts others and could function as a stimulant to synchronous spawning in an aggregation, thus increasing the likelihood of fertilisation. However on this occasion, the Crown of Thorns that I saw were well spaced—about three or four metres apart. At the top of the coral head each starfish stood on the tips of its arms, so raising its body even higher. For 20 to 30 minutes all individuals exuded clouds of sperm from gonopores opening on the upper surfaces of their bodies; there were no females in the group as I saw no eggs being expelled (eggs are distinctly visible when released by spawning starfish and look like translucent spherical sand grains). The sperm were quickly carried away in the currents of the falling tide.

As soon as sperm were released the normally erect spines began to bend. I swam among all of the spawning individuals in the area: all

RON & VALERIE TAYLOR, ANT

The triton* Choronia tritonis *is one of the few natural predators of the Crown of Thorns. Others include the trigger and pufferfish.

of the primary aboral spines were bent, and on each starfish they were bent in the same direction. As the last thin clouds of sperm were released, the spines slowly straightened, the starfish lowered their bodies, and crawled down from the coral heads.

Two features of spawning, in common with the event described here, have been previously described in the scientific literature: summer spawning, and the use of vantage points above the reef floor. I have witnessed the latter behaviour on many occasions by other spawning echinoderms including other starfish, crinoids and holothurians. It probably serves to elevate eggs and sperm above the reef-associated filter feeders and to place the gametes above the reef where the water flows more quickly than it does closer to the reef floor. Similarly, spawning on a falling tide will ensure the fertilised eggs are quickly taken away from the vicinity of the reef; this is a common strategy among the fishes and invertebrates of coral reefs. However, as far as I am aware, this is the first report, and the only photographs, of spine-bending during spawning in Crown of Thorns.

Crown of Thorns spawning has been observed on the Great Barrier Reef before this report, but not the associated spine-bending that I witnessed at Lizard Island. My explanation for this is that spine-bending might occur when local conditions are not entirely favourable for successful reproduction. However, spawning has been observed so rarely that I am uncertain whether spine-bending is exceptional, or whether it is part of the usual spawning event.

I wonder if female Crown of Thorns also bend their spines when releasing eggs? If so, I believe that spine-bending could enhance an individual's reproductive success. Reproductive success in an open-water spawner, like the Crown of Thorns, relies on sperm meeting eggs, which, in turn, is probably influenced by many factors such as the relative number of males and females and their proximity to one another, the direction of the prevailing currents at the time of spawning, and the presence of predators. For a spawning Crown of Thorns Starfish, water flow across bent spines would be unimpeded compared with the turbulence that could develop around erect spines. A smooth water flow would promote an even dispersal of eggs or sperm away from the spawning starfish. The chances of eggs and sperm meeting might then be increased.

Observations of spawning Crown of Thorns are rare. For this reason, this unique observation of spine-bending during spawning is even more significant. My explanation of spine-bending during spawning is speculative so I would be interested to know of other accounts of the phenomenon, or alternative explanations. ■

THE NURSERYMAN'S ROLE IN GREENING AUSTRALIA

By PETER BINDON
WESTERN AUSTRALIAN MUSEUM

"Today approximately 28 million hectares of woodland communities in eastern Australia are shrub infested to varying degrees. The shrub species are endemic and occur within their natural range."

In a continent not noted for brilliant greenery but more for its browns, yellows, olive greens and a formidable red heart, and where every tree, every shrub and each blade of grass is precious, what could have prompted this statement from a CSIRO scientist?[1] How is it that, at a time when we are being encouraged to green Australia with massive tree plantings, endemic shrubs occurring within their natural range can, somewhat emotively, be considered an infestation, as if they were unwanted weeds? Ironically, a recent and unusually rapid change has occurred in the floral composition of some grassy woodlands, causing them to revert to shrublands. As an archaeologist, I find these ecological changes of great interest, because each change to the environment generally has a corresponding human response, and the study of these human reactions excites my attention.

In recent Earth history we find that humans, far from being innocent bystanders during environmental turmoil, have often been the initiators of change. In eastern Australia, both the so-called original grassy woodlands and the shrublands now developing, are products of human enterprise. Archaeological evidence reveals that by about 50,000 years ago Aborigines were burning shrublands to encourage the growth of grasses. With the arrival of white pastoralists in the same areas, the burning was discontinued. Aboriginal land management ceased and the non-burn policies designed to protect the introduced stock encouraged the re-establishment of unwanted shrubs to the detriment of the desired grasses. Meanwhile, overstocking and poor management resulted in widespread erosion of the denuded pastures. This example of mismanagement and lack of understanding is one among many that has led to the degeneration of much of Australia's landscape. We now need a concerted effort by both individuals and governments to redress some of the imbalance that has accumulated through years of abuse and neglect.

In this quest to right past wrongs, we must beware of over-reaction. It is, for example, unrealistic to suggest that all grazing should be stopped on our rangelands. What we must do is to balance our demands for rangeland products with our desire to restore ecosystems. Presumably, Aborigines managed these same rangelands in a manner that supplied both the resources they required and a landscape that supported their chosen way of life. We can do the same. Individuals must take up this challenge, discarding apathy and complacency. We cannot leave the important task of greening Australia to a handful of enthusiastic organisations, or to the government.

Just as humans can cause massive detrimental environmental change, so too can they be responsible for beneficial alterations in the natural world. Urban dwellers can make radical changes to their immediate environment, just as readily as those who enjoy spacious country living. Home gardeners collectively plant hundreds of thousands of plants each year. Some individuals have even achieved this acting alone: in a few decades of hard work, Elzeard Bouffier, living in a barren part of south-eastern France, managed single-handedly to re-establish forests in a valley previously devastated by charcoal burners.

But what to plant, and where? Plant richly, using a wide range of plants that suit your location, and if you wish, a blend of natives and exotics. Read something about the plants you choose, to avoid producing a chaotic landscape of many water-hungry, exotic plants in inappropriate locations. With regard to native plants, it is important to identify the origin of each specific clone; we now realise that higher survival rates occur with seedlings raised from seed collected in the area being replanted. This is most important for ecosystem renewal in metropolitan areas where food cycles of insects, reptiles, birds and mammals have been interrupted by a complete lack of proper foodplant species.

Public awareness of appropriate uses for specific plants is still at a low level. I suspect that most gardeners obtain information about plants solely from the printed labels attached to them in the nursery. With a few exceptions, there is little more information available in nurseries about plants you buy and, proudly and expectantly, take to your little patch. There must be thousands of disillusioned gardeners around whose plants have suffered continued failure through too little knowledge. At the Perth Garden Week in March 1987, public response to various talks indicated that there is a genuine thirst for knowledge about planting and maintaining Australian native flora in suburban gardens. There are many sources of free literature that nurserymen could obtain and distribute, enhancing their own images and, at the same time, disseminating worthwhile and relevant information. Some local shires and State government departments have suitable material on suburban gardening, conserving water in the garden and the like, as do Commonwealth agencies and non-government organisations such as Greening Australia.

Lists of suitable species, cultivation notes and suggestions for planning small domestic landscapes will all assist the home gardener's efforts to green Australia and will ultimately filter through to our terminally-ignorant local government bodies, which persist in planting forest giants beneath power lines, in unsightly pruning for the sake of pruning, and in removing nutrient-rich leaf litter.

We can make use of those scarce lands that, having sufficient natural rainfall, are capable of growing trees. But how can we achieve this?

Only recently have we begun to plant trees and shrubs along highway edges, freeway median strips, railway easements, parks and other strips of public land. But what we see is just an unimaginative application of plants. Disregarding the major difference between re-building an ecosystem and simplistic tree-planting, someone has unloaded a heap of gum trees and a few shrubs, planted them in a regimented pattern, and installed trickle irrigation. In many countries this so-called wasteland is too precious to treat in such a manner. Food crops would take the place of these native plantings. Fortunately, our economy is not yet in such dire straits, and we can afford the luxury of having decorative species in place of those with economic use. However, it is time that we made these areas living corridors for the movement of birds and insects by planting a rich mixture of native plants of all types and sizes, which will look attractive, provide food for native species and screen zones of development. Sadly, after 200 years of living with our native flora, there is still little understanding by Australians, particularly by public agencies, of the potential of our floral resources. All too often it is just their suitability as landscaping subjects or their use as land-stabilising and reclamation agents that is recognised. There is almost no recognition of the food resources, nor the medicinal potential, locked within our native flora.

"terminally-ignorant local government bodies. . .persist in planting forest giants beneath power lines, in unsightly pruning for the sake of pruning, and in removing nutrient-rich leaf litter."

While discussing the decorative and practical aspects of planting a shelter-belt to surround a northern town in Western Australia, horrified opposition was encountered when it was suggested that acacias be used in the initial plantings. Now, acacias have a short but vigorous life. They fix nitrogen in the soil, provide quick-growing shelter, they are decorative and are relatively easy to remove. In fact they are an ideal group to use while other slower-growing genera establish beneath their cover. The local spokesman who refused to consider their use on the grounds that they would all die in ten years, had completely misunderstood the role that these plants can play in re-establishing ecosystems. The very reason for using them had eluded those who should have been providing examples of efficient yet aesthetic plant-use for the rest of the community.

Wouldn't it be nice to have a lot of understanding, some environmental conscience, and a little imagination blended with the principles of good landscaping, and the results applied to our public areas? We need to consider the re-establishment of whole plant systems rather than the plant-sprinkle concept so often seen in such places. Rather than just considering this, let's act on it. ■

[1] *Hodgkinson, K.C., 1982. Fire Ecology of Shrub-infested Arid Lands. In* Land Resources Management, *Divisional Report from the CSIRO. Division of Land Management: Wembly, WA.*

photoart

COLOURFUL CRUSTACEANS

Most people are familiar with crabs, prawns and lobsters: they are large, conspicuous and great to eat! But the majority of nearly 40,000 crustacean species are small, inconspicuous animals rarely seen by humans. Yet these animals play a major role in the overall ecology of the seas.

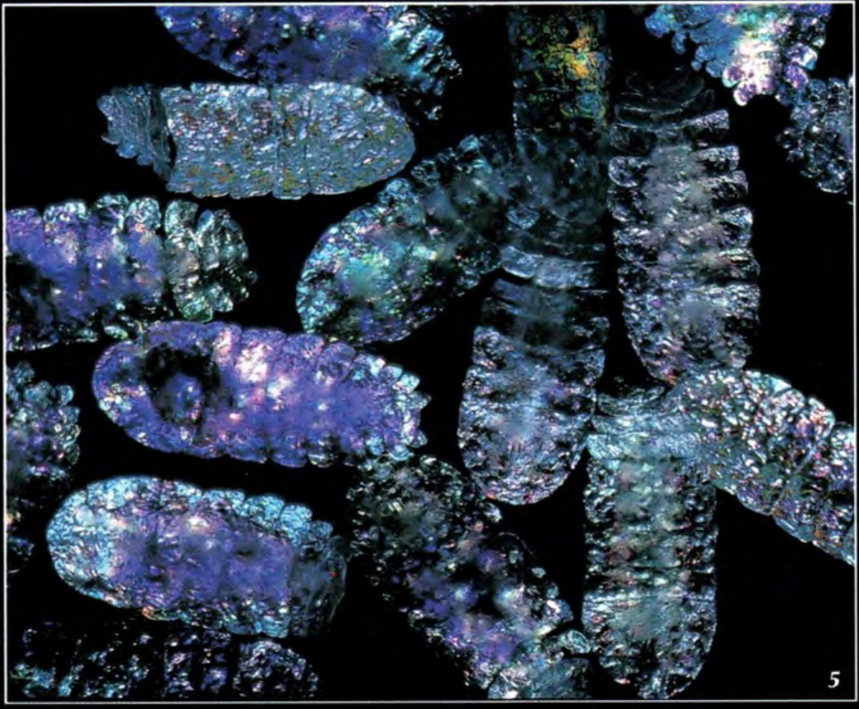
The crustacean section of the Australian Museum is a major centre for the study of crustaceans known as decapods, amphipods and isopods.

Photographing these animals is difficult and time-consuming. Large numbers of live animals are hand-collected by scuba diving and then sorted in the laboratory. Specimens for photography are cooled to slow

RUDIE KUITER

1

ROGER SPRINGTHORPE



5

F.G. MYERS


3

ROGER SPRINGTHORPE

1. This nebaliacean is a bottom-dweller living in mud or sand and, although there are probably quite a number of species in Australia, they have yet to be studied.

2. **Amaryllis** *sp. is an amphipod famous before it has a name. This animal is featured on the two-cent stamp. It lives as a commensal on bryozoans along the coast of south-eastern Australia.*


2

ROGER SPRINGTHORPE


4


6

ROGER SPRINGTHORPE

3. **Galathea balssi** *is an elegant anomuran found on sponges up to depths of 30 metres along Australia's east coast.*

4. **Pagurus lacertosus** *is a small, exceedingly abundant hermit from the intertidal zone. The female's soft abdomen is covered with eggs and is usually protected by a mollusc shell.*

5. **Sapphirina** *is a small copepod commonly occurring in the plankton. The iridescence is caused by guanine crystals under the cuticle.*

6. **Cymodoce aspera** *is an isopod that has cryptic colouration, offering excellent camouflage in its algal habitat.*

them down and photographed using special lenses.

Over the years we have built up a large photographic index of crustaceans of eastern Australia. This index is a useful aid for identifying living specimens, much as a bird watcher uses a guide to identify birds. Preserved specimens in museum collections lose their colour and can only be identified using morphological characters. But these pictures are not merely functional; they illustrate a little-known and very beautiful part of our Australian fauna. ■

—**Jim Lowry**
Australian Museum

ROGER SPRINGTHORPE

ROGER SPRINGTHORPE

ROGER SPRINGTHORPE

ROGER SPRINGTHORPE

1. **Anilocra nemipteri** *is an isopod parasite of the fish* **Pentopodus setosus** *from the Great Barrier Reef. The parasite clings to the skin of the host just above and slightly behind the eye.*

2. **Aega sp.** *is a deepwater isopod dredged from depths of 1,000 metres off Port Jackson, Sydney.*

3. **Cyproidea ornata** *was one of the first amphipods studied in Australia. It is minute and one of the most common inhabitants of subtidal seaweed in south-eastern Australia.*

4. **Paratanais linearus** *is a common tanaidacean living among intertidal algae along the shoreline of Port Jackson, Sydney.*

ROBYN WILLIAMS

Our Greatest Mistake?

Jared M. Diamond, writing in *Discover* magazine (May 1987) put it most starkly: "The worst mistake in the history of the human race", he railed, "in many ways a catastrophe from which we have never recovered."

And what was this historic blunder? Why, agriculture! "With agriculture came the gross social and sexual inequality, the disease and despotism, that curse our existence."

Jared Diamond is professor of physiology at the University of California Medical School, Los Angeles. And he's not the only scientist to see agriculture as a blight.

Without agriculture, humans had lives that were by no means as 'nasty, brutish and short' as legend would have it. There was, in many places, a rich variety of foods. By taking what was available, or even using 'slash and burn techniques', the natural environment was little affected and could recover quickly from people's exploitation. There was less dependence on fixed territories and therefore less inclination to defend definite borders. Warfare, accordingly, was minimal. As people moved about in small bands, the tasks had to be shared: there was less rigid division of labour between men and women. But when monocultures such as wheat and potatoes were favoured, there was social stratification, populations increased, ground was cleared more and more for fields, and life became precarious. If the single crop failed, the people were in terrible trouble. Pests, which were once low in numbers in wild circumstances, became superabundant as their potential victims (our crops) became almost unlimited in supply.

People also became less healthy. Professor Diamond cites a report by Dr George Armelagos of the University of Massachusetts, who compared human skeletal remains from the United States before and after the advent of intensive maize farming at around AD1150. He concluded that life expectancy decreased from 26 to 19 years, and that most of these people had died as a result of malnutrition and hard labour.

One can perhaps forgive our ancient ancestors for such alleged foolishness. Afterall, how were they to know? It was an experiment. They were trying to feed themselves more efficiently. Did they realise that the penalties could be so severe?

Our own misuse of agriculture, on the other hand, is not forgiveable. We are not attempting to provide for the world's starving people. There is, in fact, a vast oversupply of things to eat. The European Economic Community last year produced an excess of agricultural products worth $US10.8 billion! It was either stored or dumped. The cost of running the EEC's refrigerators alone, to store the oversupply of dairy produce before it is thrown down old mineshafts, comes to $US63,000 *per hour*!

Subsidies to the farmers of Europe, the United States and Japan are creating a monstrous imbalance in the food supply. Farmers in poor countries are unable to get a fair price for their wares and there is a need to grow cash crops, rather than food crops, to service foreign debts. The economies of those countries are in tatters. Meanwhile, where short-term profit can be gained, new fields are being created by smashing down forests. This land may last a few seasons before erosion, salination, leaching or breakdown of soil structure makes it useless.

In Australia we have wrecked vast regions by poor farming methods. No less a figure than Malcolm Fraser, once prime-minister of Australia and himself a grazier, told me that misuse of the land is the single most important threat to this nation's environment. Sir Mark Oliphant, one of our greatest scientists, has said the same. I have been to parts of Australia that once supported strong stands of vegetation and, within them, huge varieties of fauna. Now the land is as flat and hard as a city car park.

And still too many of our farmers won't learn. "Warwick reckons he's farmed here for 50 years" I was told in northern New South Wales. "But he hasn't. He's just farmed for one year, 50 times!" Even after three or four years of drought, Warwick will hang on, in case there's one good year. But these hard times can lead to greater pressure on the land in a vain attempt to make economic returns.

Now a combination of droughts and economic disaster have finally removed many families from the properties that can no longer pay. Perhaps we should take this historical accident, brought about by the crash in commodity prices, to think again about our own agricultural practice. Scientists such as Dr Dean Graetz of the CSIRO have pleaded for that. Over the past 200 years there has been a holocaust spreading across the Australian landscape.

Salt is poisoning areas where once the water was sweet. (In Western Australia the water from the Swan River could, last century, be used for boilers, so soft was it. Now it's so salty it practically comes out of the tap in lumps.) Salinity is increased by clearing trees, and also intensive irrigation. The water table rises as a consequence, bringing up salt deposited millions of years ago in sea floors now submerged.

Clearing combined with cultivation also removes plants that bind the soil. This can then be washed or blown away. Remember that awful cloud of dust that covered the whole of the Melbourne sky earlier this decade? That was once topsoil. And as a substantial proportion of Australia has a very thin layer of topsoil, we can't afford to lose it through poor farm management.

Thus in Australia we are particularly vulnerable. And so too are our neighbours in the tropics—in Africa and in the Amazon—where clearing continues apace. While we *know* the causes of various forms of land degradation and have a good understanding of the means of preventing them, the missing factor is the *will* to implement the appropriate management methods. If we are not to indulge in humanity's 'Second Greatest Mistake' the destruction must stop. Afterall, it is not for food. It is for something much more ephemeral and tawdry: money. ■

POSTER Lemuroid Ringtail Possum

The Lemuroid Ringtail Possum, *Hemibelideus lemuroides*, is one of three unique ringtails living in the rainforests of northern Queensland. The Lemuroid, meaning lemur-like, is the only member of its genus and was named because of its resemblance to one of the Malagasyan true lemurs. It lives in the high canopy where it leaps from tree to tree: from the end of one branch to the outermost leaves and twigs of the next. It is the crashing sound of their landing, limbs outspread, that signals the beginning of the night's activities. It has a rudimentary gliding membrane so it is no surprise that its closest relative is the Greater Glider, a relationship reinforced by the possums' brilliant yellow eyeshine in a spotlight. Diet of the lemuroids consists of about 90 per cent leaves, with the leaves of the laurels and the green fruit of the Native Sarsaparilla being favourite food items.

Lemuroids live in pairs. One young a year is born and it remains with the parents until the next young emerges from the pouch between October and April. When disturbed at night they often huddle together in a tight ball of brown fur with eyes, ears and tails positioned in the most unlikely place, like a Picasso painting of the treetops. The family nucleus shares a den and up to eight individuals may congregate in a favoured feeding tree. On the crests of the ranges it attains densities three or four times that of other ringtails, but is also the most sensitive to disturbance of its habitat. Its reliance on tree holes for dens, a diet that tends to favour trees of the mature forest, and its preference for the high canopy may make it more vulnerable to large-scale forest disturbance, and it disappears entirely from rainforest patches less than about 100 hectares in size.

Two discrete populations occur, the largest is restricted to elevations above 450 metres between Ingham and Cairns, and the smaller above 1,000 metres on the Carbine Tableland west of Mossman. They have been separated, probably for thousands of years, by a 50-kilometre low section of the coastal range. Fur colour is generally a greyish brown with a rusty white variety in both populations. On the Carbine Tableland, where the animal shown here was photographed, the proportion of whites is very high, possibly as a result of genetic drift through long isolation. It is symbolic of a group of animals and plants, which includes several frogs and a blue crayfish, that has had a long history of isolation on the summit of the Mt Carbine Tablelands. This unique collection of plants and animals is of inestimable value that could be threatened by the intrusive disturbance of logging. ■

—John Winter

BOOK REVIEWS Sea, Shore, Mangroves and More

Starfish Wars

Robert Raymond. MacMillan, Melbourne, 1986, xii + 218pp. $24.95.

"The Crown of Thorns is not destroying the reef", announced the Premier of Queensland, Joh Bjelke Petersen, to a crowded press conference in September 1969. The Premier was commenting on Dr Robert Endean's Crown of Thorns Starfish report, which had been prepared for the Queensland Government and which failed to be released for almost 18 months (the report took two years to prepare and concluded that the starfish was a serious threat to the Great Barrier Reef). In trying to make this distancing stance seem credible, the Premier referred to additional expert advice he had received. His source was a bizarre, back-room briefing just one hour before the press conference where, along with some of his ministers, he had been reassured by underwater filmmaker Ben Cropp that "the starfish is probably helping rather than hindering the growth of corals . . . the Crown of Thorns prunes the staghorn to give it a firmer foundation".

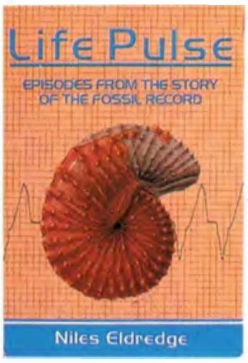
Robert Raymond's *Starfish Wars* chronicles this incident and many others in what is, for two thirds of its length, a fascinating account of the history of the Crown of Thorns' controversy. In three acts Raymond outlines the recent history of Crown of Thorns' outbreaks worldwide, and the responses of governments and scientists. In particular, Raymond compares the fortunes of two early protagonists on both sides of the Pacific: Dr Robert Endean (Australia) and Dr Richard Chesher (USA). Both predicted the ultimate destruction of coral reefs if the starfish were not contained. The governments of both countries responded differently to their pleas but both scientists, particularly Endean, were widely criticised on their alarmist stances by the marine science community. Endean's role is followed throughout the book.

Acts One to Three are a very readable and generally objective synthesis of a mass of historical and biological data. Act Four of *Starfish Wars* is largely a transcript of the supporting television documentary and is Raymond's account of the current situation. Raymond reports it like a courtroom drama with 'prosecution' (Endean and some tourist operators) and 'defence' (many of Australia's tropical marine scientists and administrators).

Raymond, however, is less than an unbiased arbiter. His questions to the prosecution are undemanding and often rhetorical, for example "What do you think can be done now, if anything? . . . Where is this going to leave Australia in the eyes of the rest of the world?" Raymond demands more than opinions from the defence, for example ". . . what are the figures for the number of reefs that have been damaged by the starfish? . . . What about the effects of predators on the larvae?" Unwilling to make unqualified predictions, and with few research results to draw upon, most of the defence sound unconcerned and unconvincing. Raymond might have intended this to draw attention to the lack of research results but his own stance would appear less biased if equal pressure had been applied on both sides of the courtroom. In particular, the Great Barrier Reef Marine Park Authority is severely dealt with.

Raymond supports Endean's prediction that the Crown of Thorns is a serious threat to the reef and should be stopped; he is undecided about the causes of the outbreaks. His concern sounds more political than sincere in the face of his final words that only reefs of "particular value or interest" should be protected, and ". . . the fate of the Great Barrier Reef is too important to be left to the scientists". *Starfish Wars* is a very interesting book. Recommended.

—William Gladstone



Life Pulse. Episodes from the Story of the Fossil Record

Niles Eldredge. Facts on File Publications, 1987, 246 pp. $US19.95 (approx. $A35.00).

The title *Life Pulse* must at first have the reader puzzled but, after a short excursion into the book, one will come to realise the significance and appropriateness of this brief title. Niles Eldredge, co-author of the theory of punctuated equilibria, puts forward in this book a synthesis of his and others' ideas on the evolution of life from 3.5 billion years ago to the present.

It is refreshing to see a work of this type written by an invertebrate palaeontologist, since such a large proportion of life's history involves invertebrates, which today still make up by far the biggest slice of that cake called life. Even so he does not exclude vertebrates, since without them the story would be far from complete, and he tackles them more than adequately.

Eldredge, not unexpectedly, emphasises the episodic nature of evolution and the overwhelming importance of extinction in producing the opportunities for the rapid bursts of expansion and re-adaptation that are the essence of evolution. He justifiably claims that it is only through extinction that the world has reached where it is today.

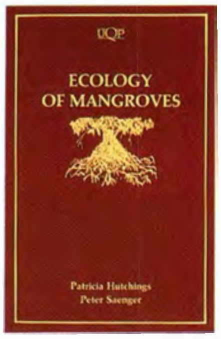
On the whole the book is an easy-to-read, lucid account of Earth's history. Eldredge gets his point across smoothly but appears in some instances to assume the reader has some prior knowledge of the subject.

The book is well presented in hard cover, with a glossary and index. It is simply illustrated in black and white with photographs and line drawings. The most obvious and glaring mistake occurs with the transposed captions for figures 6 and 7, as well as the accompanying photos being incorrectly oriented. Although not a mistake that would be noticed by the layman, it is an embarrassing one for the author, an invertebrate palaeontologist.

Apart from numerous typographical errors, little fault can be found with the text. It is written for a worldwide audience but, understandably, has a slight North American bias. Being an Australian geologist there is just one point in the text about which I must take the author to task. Eldredge, in his chapter "Life in Palaeozoic Seas", claims that hardly a trace of limestone is found in the Upper Silurian and Lower Devonian rocks of Gondwana. He claims this is because the Gondwanan continent, during these times, was not within the tropical zone. Yet there *are* significant Upper Silurian–Lower Devonian deposits of limestone, packed with corals and other reef-forming invertebrates, in eastern Australia. The most recent palaeogeographic reconstructions show that a large part of the present Australian continent was in the tropical zone at that time. Even the map at the beginning of the chapter shows eastern Australia well within the tropics. However, this point should not detract from the overall reliability of the book.

Finally, this book is indeed a welcome addition to the ever-increasing collection of literature on fossils and the evolution of life. I believe the reader will not be disappointed with this book and, having read it, will have a far greater understanding of evolution and palaeontology. At $35.00 it is moderately priced.

—Robert Jones



Ecology of Mangroves

Patricia Hutchings and Peter Saenger. University of Queensland Press, St Lucia, 1987, 388 pp. $34.95.

Mangroves are among the world's most productive but least understood and appreciated ecosystems. Mangroves, and the salt marshes and sea grass beds that are often associated with them, provide a major part of the energy used by other estuarine and near-shore organisms for growth and reproduction. This is energy that humans ultimately harvest as fish, oysters, crabs and prawns. The relationships between plant and animal, mangrove and human are well established and provide a sound base on which to manage and conserve estuarine ecosystems. Yet human societies persist in ignoring or even rejecting these links. The problem is that mangrove forests occupy some very valuable or potentially valuable real estate. Worldwide they are under threat to provide quick profits or simply living space for a rapidly growing and voracious human population.

Mangroves are tidal forests. They grow in estuaries or on sheltered coasts where they are flooded daily by tides and protected from strong currents, wind and waves. These are the very places that people value as places to live and play, to practise mariculture or to dispose of trash, garbage and industrial wastes.

Australia is rich in mangroves. Thirty species of trees and shrubs, including a palm, grow as mangroves along the Australian coast. The greatest number of species occur in the tropics but one species, the Grey Mangrove (*Avicennia marina*), occurs around the entire coastline. With nearly 1.2 million hectares of mangroves, Australia is third only to Brazil and Indonesia in the extent of its mangrove forests. Australia's wealth of mangroves is explained by its warm climate, extensive northern estuaries, and by its historical position as part of the centre of world mangrove evolution.

Of all countries with extensive mangrove forests, Australia is the least populated. As is the case with Australia's rainforests, this places a special responsibility on Australians. Australia is a wealthy country. With its well-educated population and technical expertise and scientific knowledge, Australia is one place where it should be possible to protect, conserve and manage mangroves for the long-term benefit of society. Yet there is little evidence that we are prepared to do this. Few mangroves are included in national parks or marine reserves and large areas, particularly in southern Australia, have already been cleared or otherwise vandalised by an uncaring bureaucracy. Other large areas are under threat in the interest of jobs and profits.

To understand the importance of mangrove ecosystems and to know why we cannot afford to sacrifice their long-term benefits for short-term gains, you must read this book. It is the most comprehensive account of the ecology and biology of mangroves available. Although the authors use information from other continents where necessary, emphasis has been placed on Australian studies. The book is also well written and easy to read in leisurely moments. My copy has already been pirated for use in at least one college essay and I imagine this book will be used by students throughout Australia for years to come.

The Ecology of Mangroves is not of restricted interest. As a review of mangrove ecology and biology, it will be useful for students and mangrove biologists throughout the world. As a source of information, vital to the battle to protect and manage mangrove and estuarine ecosystems, it will be a source book for conservationists, fisheries biologists and concerned town planners wherever governments or developers forget their responsibilities to the future and base their decisions on short-term gain. Pat Hutchings and Peter Saenger are to be congratulated for a superb effort.

I wish I could be so complimentary to the University of Queensland Press. For a book of this importance, it has been cheaply produced yet highly priced. I have no quarrel with the use of inexpensive paper and bindings, if the objective is to place a book within reach of students and others traditionally short of the 'hard and readies', but there is no excuse for poor quality *and* high prices. Australian publishers need to understand that their responsibility goes beyond printing and profits. They have a responsibility to make information available at a cost that people can afford. My only hope is that people will look beyond the presentation of *The Ecology of Mangroves* and read its word and adopt its message. These *are* worth the cost.

—Harry Recher

Shorebirds in Australia

Text by Brett A. Lane, illustrations by Jeff N. Davies. Nelson Publishers, Melbourne, 1987, 187 pp. $49.95.

This book is based on results from a national survey organised by the Royal Australasian Ornithologists Union between 1981 and 1985. The purpose of this study was to determine the distribution, abundance and migration routes of shorebirds in Australia. 'Shorebirds' refers to the wading birds which include the thick-knees (Burhinidae), painted snipe (Rostratulidae), oystercatchers (Haematopodidae), lapwings and plovers (Charadriidae), stilts and avocets (Recurvirostridae), sandpipers, phalaropes, snipes, godwits, curlews and allies (Scolopacidae) and pratincoles (Glarididae). Oddly the family Jacanidae is omitted save for a passing mention on page 16.

This impressive array of waders adds up to no less than 71 species for Australia, which is almost exactly one third of all recognised species of waders on a world listing.

Following a brief introduction, the first important chapter discusses the distribution of shorebirds in Australia, giving emphasis to the three major regions in which waders regularly occur: the north-western coast between Broome and Port Hedland; the coast of north-eastern Arnhem Land and the Gulf of Carpentaria; and the south-eastern coast and lakes between Eyre Peninsula and Corner Inlet. It is suggested that about two million waders migrate to Australia from their arctic breeding grounds. This chapter also includes useful general descriptions of coastal and inland shorebird habitats and the influence on them of factors such as wave action, climate, tides, rainfall and the like. There follows an excellent short chapter on feeding behaviour contributed by Peter Dann. The next chapter concentrates on the analysis of migratory movements, tracing the origins of the migrants that visit Australia and describing briefly the various methods used to reveal their movement patterns. All of the first part of the book takes up a mere 35 pages.

Now follows, to my mind, the most unsatisfactory section: a species by species account occupying 114 pages. There is a rather superficial explanation of the way the RAOU study was organised and the methods used to analyse the counts. Regrettably, inland distribution is poorly covered and therefore most of the resident waders do not receive sufficient attention. The author concludes that it is not possible at present to estimate the population size in Australia of most of the migratory species and, by implication from the methods adopted, none of the indigenous ones. The consequence of this is that "it is not possible to apply the internationally accepted criterion of a wetland being of international significance if it holds more than one per cent of the population of a species in a migratory 'flyway' or biogeographical region".

The species accounts are embellished with 16 full-page colour plates, but the method used to caption them is, to say the least, irritating. In addition several species are inexplicably consigned to monochrome. This niggardly decision was presumably dictated by the publishers for there can be no good reason to ostracise in this manner the seven species concerned.

I question the value of much of the text in these species accounts and the usefulness of the accompanying plates. Far better and more reliable information on field identification can be found in the recent book by Hayman *et al. (Shorebirds—an Identification Guide to the Waders of the World*, Croom Helm, London, 1986), a book that is now widely acknowledged as the 'front-runner' on such matters. The plates in *Shorebirds in Australia* fall far short of the exacting standards of those in Hayman *et al.* There are, for example, no illustrations of birds in flight.

My other quibble is that more emphasis should have been put on the waders of the major areas studied during the survey. More comprehensive descriptions of these habitats and the ways they are used by shorebirds would surely have been possible and of lasting value. Unfortunately, this topic is given short shrift in a 13-page chapter, mostly consisting of tables. Finally, there is a chapter which reviews some of the problems concerning hunting, disturbance, habitat destruction, pollution and the future of shorebirds in Australia.

Shorebirds is generously illustrated with line drawings, maps, diagrams and several black and white photographs. The book includes an extensive bibliography and a modest index.

—Peter Fullagar

QUIPS, QUOTES & CURIOS

Industrial Melanism: Not a Black and White Case

Britain's Peppered Moth (*Biston betularia*) is probably one of the most often-quoted, textbook examples of evolution through natural selection. The story goes something like this: at first there were light-coloured moths that rested during the day on lichen-encrusted tree trunks, well camouflaged from predatory birds. With the rise in urbanisation and the industrial revolution in northern Europe, the tree trunks of industrial areas were blackened and mutant dark forms became better hidden. Birds picked off the lighter, typical forms and so natural selection favoured the dark, melanic forms. Melanic forms became more frequent in industrial areas and lighter forms in cleaner, rural areas. And now that the air is cleaner, following the enactment of anti-pollution and smoke-control legislation in the 1960s and '70s, melanic frequencies have declined in industrial areas.

The first melanic moth was discovered in 1848 near Manchester, but at the time its significance wasn't appreciated. The failure to follow the early rise in frequency of the dark-coloured form was probably one of the great lost opportunities in science. But the current reversal in morph frequencies has provided a second opportunity.

Using co-efficients of visual selection based on the relative fitnesses of the forms and on the assumption that the moths habitually rested on appropriately-coloured tree trunks, computer models have been developed to predict future frequencies of the melanic form. But the observed phenotypic data do not fit the predictions. In particular, there are more melanic moths in rural areas than the models allow. It seems then that other non-visual selective factors (that is, selection unrelated to visual predation by birds) are involved. Indeed, this would occur if the moths do not rest in a way that directly exposes them to predators.

Recently, Rory Howlett and Michael Majerus, from the University of Cambridge, have suggested that the moths don't in fact rest on the exposed surfaces of tree trunks as the story goes, but instead prefer to rest in more hidden areas, such as beneath a branch, or in the shaded area just beneath where a branch joins the trunk (*Biol. J. Linn. Soc.* 30: 31–44, 1987). Part of the problem stems from the fact that Peppered Moths are elusive in the wild and are rarely found at rest. However, of the 25 noted by Majerus since 1964, only four were found exposed on trunks. Of the other 21, 15 were found just below a branch–trunk join, four on the underside of branches and two unexposed (behind foliage on trunks). Although moths have been found exposed on tree trunks, this does not appear to be their primary resting site. When this is

These pictures demonstrate how light and dark-coloured moths are well camouflaged on trees in unpolluted and polluted woods, respectively.

J.L. MASON, ARDEA

J.L. MASON, ARDEA

taken into account, it may help explain the discrepancies between the model-predicted frequencies and those observed.

But this idea is not new. The late Bernard Kettlewell—the man who, in the 1950s, was responsible for much of the inspirational work on industrial melanism in the Peppered Moth—wrote in 1958 that the species' normal resting position is "beneath the larger bough of trees, less commonly on the trunks" (*The Entomologist* 91: 214–24). Yet he continued to conduct his experiments with the moths resting on tree trunks. It seems strange that he didn't take heed of his own observation.

According to Kettlewell, moths assess their optimal resting site by visually comparing their own colour to that of the substrate (*Nature, Lond.* 175: 943, 1955). In one of his classic experiments, in which typical and melanic moths were given the choice of resting on equal areas of black and white card, Kettlewell showed that typical forms preferred to settle on white, and melanic forms on black. But Howlett and Majerus point out that the wings of the light-coloured form are partially translucent so, in terms of the light reflected from them, they are more like black than white. They measured the reflectance of the wings of a typical and melanic form. Each measurement was made with the moth in contact with backgrounds of varying degrees of reflectance—100 per cent (white) through to five per cent (near black). The optimum resting site in terms of the background reflectance was 30 per cent for the light-coloured moth and seven per cent for the dark. Therefore, given a straight choice between black and white, both should choose black. Repeating Kettlewell's experiment, Howlett failed to obtain the same results. Instead, as he and Majerus had hypothesised, he found that both forms preferred to settle on black. The preference of the melanic form was slightly greater than that of the typical form, but the difference was not significant. Howlett and Majerus do not offer any explanation for the difference in results. They do, however, point out that there have, in fact, been no field observations that show moths pick appropriately-coloured backgrounds, and in the wild there may be additional components other than visual for choosing rest sites—tactile, for example. It appears that site selection is more complex than at first thought.

To investigate how different resting positions might affect differential bird predation, Howlett and Majerus conducted a pilot experiment in which they placed light and dark forms in polluted and unpolluted woods, either exposed on tree trunks or just below the junction of branch and trunk. Not unexpectedly, the birds selected more light forms in polluted woods and more dark forms in unpolluted woods. This bias applied to moths in both resting positions, although the number of moths taken from the trunks was significantly greater than from the hidden position. More significant, however, was the finding that, in both locations, the dark forms were better hidden at the branch joint than the light moths; and most significant was that this bias was greatest for melanic moths in unpolluted woods.

It seems then that the melanic form is even more advantaged than the typical light-coloured form in polluted areas, and at less of a disadvantage in unpolluted areas, than previously supposed. Revised co-efficients of selection, based on the moths' preferred hidden resting sites (as opposed to resting exposed on tree trunks), will have the effect of increasing the predicted frequencies of melanic moths in rural areas, thus resolving the discrepancies between model-predicted and observed morph frequencies.

Evolutionary biologists have generally regarded the story of industrial melanism in the Peppered Moth as one of elegant simplicity, thus making it one of the most often-cited cases for the illustration of evolution through natural selection. But it is now clear that a variety of factors other than differential crypsis and visual selection influence melanic frequencies. And it emphasises that, as is true with most biological systems, the real story is far more complicated than at first thought.

—*G.H.*

A Right Balls Up?

In 1857, Asa Fitch described a North American species of botfly (genus *Cuterebra*) that supposedly castrated its mammalian hosts. Apparently squirrels had been observed "seizing and biting out the testicles of their comrades" and, as the botfly larvae had sometimes been found in the scrotum, Fitch concluded that the squirrels were altruistically destroying their common enemy (*Trans. N.Y. State Agric. Soc.* 16: 315–490). He appropriately named the bot *C. emasculator*.

For the next 124 years it remained established dogma that botflies emasculated their male hosts through total consumption of the testes, yet no clear-cut evidence had ever been provided. 'Romantic' though this idea seems, two American scientists, Robert Timm and Richard Lee, have once and for all disproved the castration concept (*J. Med. Entomol.* 18: 333–36, 1981; *Evolution* 36: 416–17, 1982). They experimentally infected the groin area of Eastern Chipmunks (*Tamias striatus*) with *C. emasculator* and found no destruction of testicular tissue. The larvae were only found in the subcutaneous tissue and never in the underlying muscle.

Field observations of chipmunks showed little overlap in the time of reproduction (spring) and botfly infestations (mid to late summer). In the non-breeding season (that is, at the time of most infections), the male chipmunks' testes are normally reduced and ascended—tucked up 'out of the way' into the abdomen. The testes of some of these naturally infected chipmunks were examined; they appeared normal and undamaged. Again the larvae were only found under the skin and not in the underlying tissue of the scrotum.

Additional observations of a White-footed Mouse (*Peromyscus leucopus*) revealed an enlarged left testicle, such as is typical of mice in breeding condition, but the right one was not visible. A botfly larva was found on the right side of the scrotum. Superficial examination would thus suggest that the larva had consumed this testis. Closer examination, however, showed that the right testis *was* present but had been slightly displaced by the larva. Both testes were identically proportioned, of the same weight, and produced viable sperm. Whether or not undescended testes affect fertility, this condition is not, apparently, a major factor in botfly parasitism and this case is considered rare.


LINCOLN FOWLER, HORIZON

An Eastern Chipmunk.

Although botfly larvae have been known to physiologically affect their hosts, which may or may not affect fertility, the long-held tenet of the bots' emasculatory powers is unfounded. What still intrigues me, however, is just what *were* those squirrels up to in those North American woods, over a century ago?

—*G.H.*

RARE & ENDANGERED Giant Gippsland Earthwo

Gippslanders have something to boast about, for they share their land with the largest earthworm in the world. The Giant Gippsland Earthworm, *Megascolides australis*, which was first described by Frederick McCoy in 1878, has been recorded reaching lengths of up to three metres. Lengths of one to two metres, however, are more the norm, with diameters of between 23 and 35 millimetres.

The species is unique to the Gippsland region of southern Victoria, its restricted distribution forming a rough triangle between the hilly areas of the western Strzelecki Ranges in South Gippsland and the undulating country around Warragul to the north and Leongatha to the south-east. It is particularly prevalent on the Bass River flats stretching from Bass to Poowong. Damp, organic-rich soils are favoured in areas of well-drained, sloping country with high winter rainfalls.

The Giant Gippsland Earthworm is also one of the few species of earthworms to build permanent burrow systems. The average diameter of the burrows is about 25 millimetres. They swallow the soil in front of them and absorb the nutrients from it. Some reports suggest that they cast the undigested component of this soil at the surface of the ground (as opposed to other worms that let it block the burrow), although others claim that these casts are the result of yabbies.

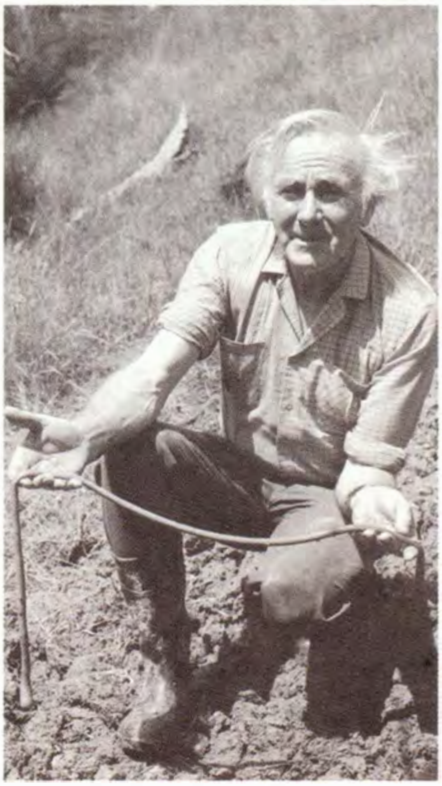
When held in the hand, the earthworm jets out a milky fluid from its dorsal pores. The purpose of this fluid is probably to moisten and lubricate the walls of the burrow so that passage through it is made easier. Some of the Aboriginal natives claimed that the fluid, when rubbed on the skin, was good for rheumatism.

DISTRIBUTION

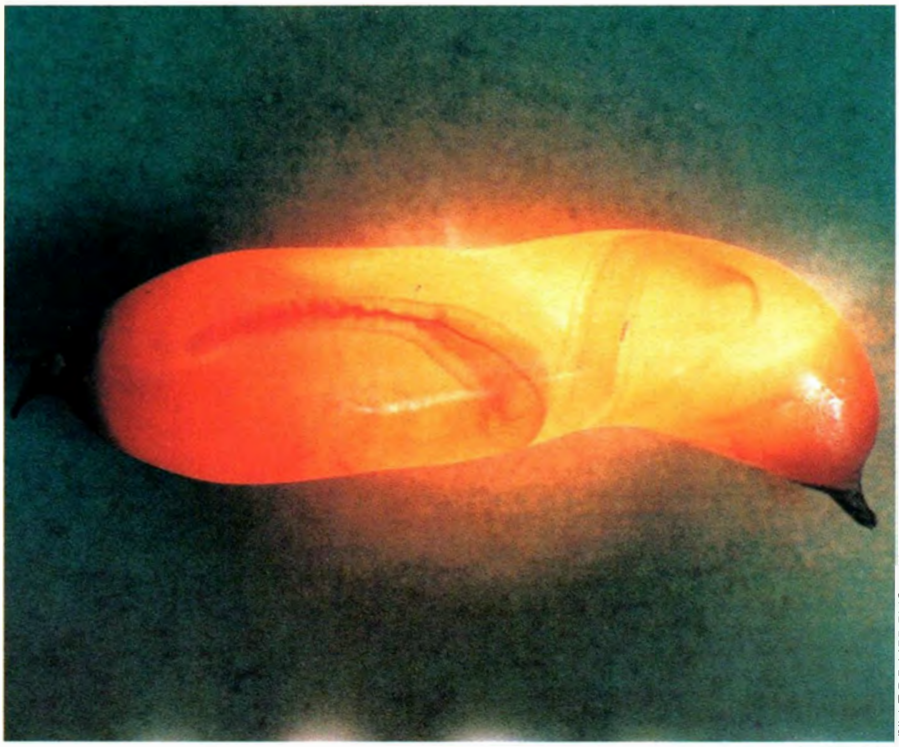
The most obvious way to detect these worms is the gurgling, sucking noise made (similar to when the plug is pulled in a bathtub) when one walks on top of their burrows, particularly when the soil is wet. The worms tend to stay close to the surface in winter, when the soil is wet, and retreat deeper into the soil in summer, sometimes up to two metres deep. Many people claim that disturbing the surface of the ground by digging or ploughing, and flooding or water-logging, induces the worms to come to the surface.

Because of their underground habit, the worms are difficult to study. A lot of the knowledge about the habits and natural history of the Giant Gippsland Earthworm thus derives from local or anecdotal information. No detailed reports on their reproduction have been published in the scientific literature, but they do lay greenish, translucent, sausage-like egg capsules that measure between 50 and 75 centimetres long. They have a stalk at each end and contain one embryo surrounded by a milky fluid. Freshly-laid capsules have been observed in early winter

Frazor Hercus, a lab technician from Monash University, encounters a Giant Gippsland Earthworm.



AUSTRALIAN INFORMATION SERVICE



FRAZOR HERCUS

The egg capsule of the Giant Gippsland Earthworm.

rm

TONY ZOANETTI

The unique worm museum at Bass is in the shape of a four-metre-high and 100-metre-long worm.

and, when mature and brown, they hatch in late winter and early spring when the ground is wet.

The worms emit a smell resembling creosote (coal-tar) and have been reported as being repulsive, live or dead, to domestic fowls. Perhaps it is the smell that offends them, although Kookaburras and magpies have been seen eating them. One rather stupefied Kookaburra was apparently 'rescued' when it appeared flightless with ten centimetres of worm hanging from its mouth. Thirty-six hours elapsed before the Kookaburra could fly again. Whether it had simply over-eaten or the worm contained some toxic substance is unknown.

The Giant Gippsland Earthworm was listed in 1984 by the IUCN as one of the world's ten most endangered species. Some people believe that ploughing and the application of superphosphate diminish populations, but most people are of the opinion that the worm is still locally very common.

The only area set aside for nature conservation in the Gippsland region is 164 hectares on the extreme western boundary of the Giant Gippsland Earthworm's range. If future land is to be nominated for nature conservation in the area, it should be closer to the centre of the worm's distribution.

To commemorate the Giant Gippsland Earthworm, two local businessmen have built an enormous worm museum at Bass, South Gippsland, in the shape of a four-metre-high and 100-metre-long worm. The first of its kind, this worm museum includes displays ranging from live worms of various species to a simulated walk through the intestines of a Giant Gippsland Earthworm complete with sound effects. A documentary film, showing where and how the Giant Gippsland Earthworms are found, can also be seen there.

The people of the Gippsland area are truly proud of their giant earthworm and will ensure that all measures to keep it there will be undertaken. ■

—Georgina Hickey
Australian Museum

WELDON TRANNIES

Boiling mud in a Maori village of Rotorua, New Zealand.

DAVID MAITLAND, AUSCAPE

*The mud-dwelling Red-fingered Mangrove Crab (*Sesarma erythrodactyla*) amongst the aerial roots (pneumatophores) of mangrove trees.*

In Praise of Mud

By ALLAN JONES
AUSTRALIAN MUSEUM

Has anything had a worse press than mud? The dictionary tells us that mud is worthless or polluting. Bad ideas, coffee or music are sometimes described as muddy. Mental confusion is a muddle. Staid people are stick-in-the-muds. Mud slows you down, stains your clothes and obscures your boundaries. In short, mud represents unrelieved bad news. With such received wisdom, why write in praise of mud?

ALAN JONES

An alpine lake in the South Island of New Zealand. Fine clay particles that remain in suspension impart a turquoise hue to the water by scattering light.

Firstly, its political importance is enormous. Politicians love to sling mud and the stickier species of mud can win or lose elections. More seriously, however, mud simply cannot be ignored; not just because it exists in vast amounts and is widely distributed, but also because mud has human uses ranging from food to architecture, supports highly productive ecosystems and has psychological significance. Even more basic, some scientists think that life began in clay (a component of mud) rather than the sea. Consequently, mud's appalling public image derives from a limited and biased view of its role in both human and natural environments.

What is Mud?

Mud is a varied and complex substance and has several definitions depending on context. In common parlance, it is wet, soft, earthy matter or mire. More formally, mud consists of silt and clay—fine sediment particles of diameters less than 62.5 microns (0.0625 millimetres). Larger particles are called sand, gravel or boulders. Measuring the particle size of muds is done by timing the rate of settling in water—the underlying principle (Stokes' Law) dictates that the smaller clay particles settle more slowly than the larger silt ones. Clay particles are so small that, when washed into still alpine lakes, they remain in suspension, and by scattering light, impart a turquoise hue to the water.

The chemical and mineralogical composition of sediments varies widely and is closely related to grain size. Mud, for example, is more complex than sand with more alumina, iron oxides and potash, and less silica. Silt differs from clay by having more quartz and less hydrous aluminium silicate, which carries an electrical charge. This charge causes clay particles to be oriented so that, when lubricated by water, the familiar plasticity of wet clay occurs. Another consequence of the small size of mud particles is that they have a large surface area in proportion to their volume, an attribute that promotes the biological productivity of muddy ecosystems.

Mud Ecosystems

The productivity of some mud-based ecosystems is higher than intensively-managed farmland. This is caused by several factors acting in concert. Tiny particles have a relatively large surface area and some are electrically charged. These attributes cause nutrients and bacteria to adsorb on the particles' surfaces. Together with an abundance of light and water, these nutrients enable plants such as reeds, seagrasses, mangroves and diatoms to grow quickly. The bacteria enhance productivity by decomposing organic matter thus making nutrients available for further plant growth.

As a place to live, mud presents some problems. In particular, very fluid mud has low density, is physically unstable and contains little dissolved oxygen, the last caused by biological and chemical decomposition of organic material. In these conditions, where an organism could easily be smothered or sink, connection with the aerated sediment surface is necessary for survival. Evolutionary adaptations of animals to such an environment include a reduction in density to promote flotation (for example, the delicate bivalve mollusc *Theora fragilis*), 'snowshoe' adaptations to increase the supporting surface area (the mudskippers), and an increased capacity for respiratory exchange via extensive gill systems or thin skin with surface blood capillaries (some polychaete and oligochaete worms, insect larvae and the mudskippers). Furthermore, the burrowing mud prawns (yabbies) in the genera *Callianassa* and *Upogebia* are behaviourally or physiologically adapted to the low oxygen tension of the water in their burrows. Some species, for example, simply ventilate their burrows more vigorously, while others reduce their metabolism or have a blood pigment (haemocyanin) with an extremely high affinity for oxygen.

Some mud-dwelling plants have also evolved special structures to enhance oxygen uptake. For example, Grey Mangroves (*Avicennia marina*) have spiky aerial pneumatophores that have many small openings called lenticels. Gaseous exchange occurs through these lenticels and oxygen is transferred to the roots for respiration.

Although muddy habitats support relatively few species, those present may exist in astronomical numbers. Microscopic organisms such as bacteria are astonishingly abundant (up to 1×10^{10} cells per gram of sediment), while larger organisms such as worms, crustaceans and molluscs may exist in tens of thousands per cubic metre. Many of these larger species live in protective burrows or tubes when adult. Some, such as the snapping shrimp *Alpheus euphrosyne* and the yabby *Callianassa australiensis*, rarely leave their burrows and their housecleaning activities send turbid clouds into the water column. In contrast, mangrove crabs (*Sesarma erythrodactyla* and *Heloecius cordiformis*) spend the low-tide period foraging for food or in courtship, and only retire to their burrows when high tide brings the threat of predatory fish. Some of these species filter their food from the water while most eat the muddy sediment directly, digesting either organic detritus or microbes attached to the particles.

Mobile animals such as prawns (*Penaeus plebejus* and *Metapenaeus macleayi*) depend on these productive mud ecosystems for food and shelter during their juvenile stages, although the adults are subsequently caught many kilometres away. The succulent mud crab *Scylla serrata* migrates to sea to spawn but spends most of its adult life in estuaries. Consequently, the muddy wetland areas are essential for these and other fisheries.

Human Uses

Food and shelter are basic requirements of humans. Surprisingly enough, mud contributes to both. Not only are muddy soils highly productive as farmland, and muddy peats good fertilisers, but some peoples actually eat mud, a practice called geophagy or pica (from the Latin for 'magpie'—a bird that col-

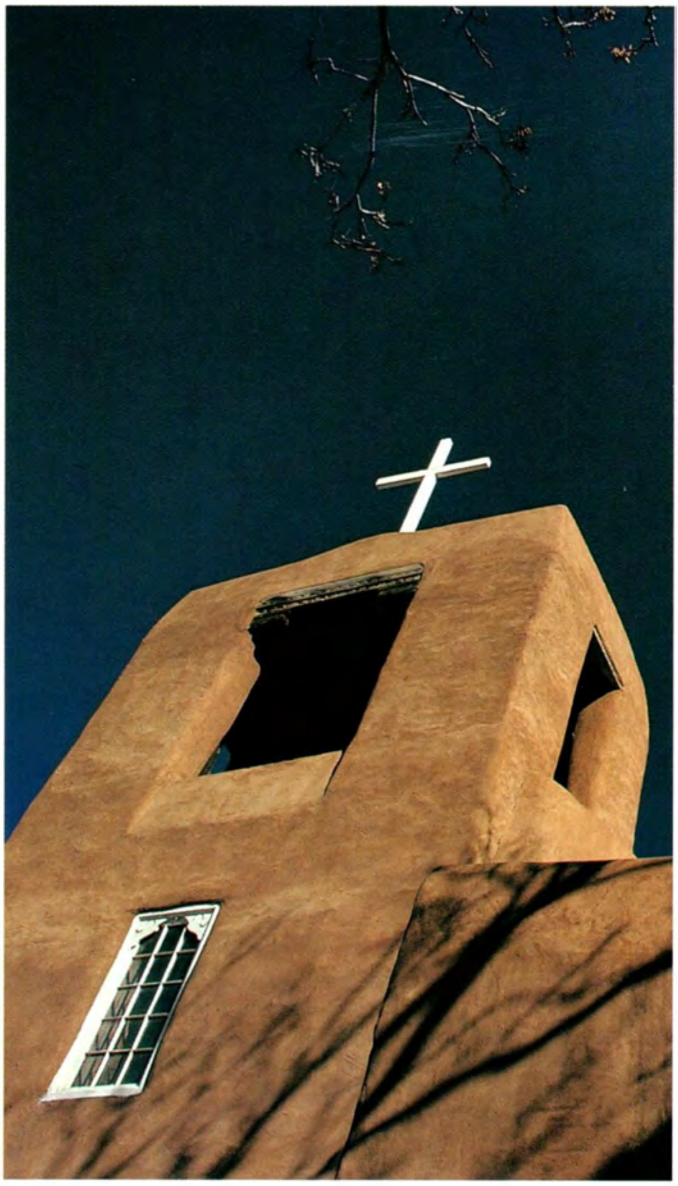
JEAN-PAUL FERRERO, AUSCAPE

Fighting mudskippers use their ventral fins to help them move over their muddy territory. Shown here are* Boleophthalmus *sp. from the Northern Territory.

GRAHAM ROBERTSON, AUSCAPE

MICHAEL JENSEN, AUSCAPE

Hippos are not the only animals that wallow in glorious mud. This Elephant Seal cow (*Mirounga leonina*) seems to be enjoying herself on Macquarie Island, as does this woman in the Adelaide River, Northern Territory.



MICHAEL FREEMAN, AUSCAPE

An example of mud architecture in New Mexico.

GRAHAM ROBERTSON, AUSCAPE

Mud houses birds as well as humans. These are White-winged Chough chicks (**Corcorax melanoramphos**).

MICHAEL JENSEN, AUSCAPE

The ancient art of pottery combines beauty with utility.

lects strange articles). Some examples include the following: in the 19th century, Persians considered clays a delicacy and could discriminate among various kinds. Geophagy was also widespread in Indonesia and Oceania where mud served as food or a food substitute, as medicine, as a source of enjoyment and as a part of 'oath-swearing' ceremonies. Edible clays came in many colours and were sometimes roasted or fried and sold in markets. Eating the clay was believed to cure diarrhoea, beriberi and syphilis, and to facilitate conception and childbirth. It was even reported to have been habit-forming. Arnhem Land Aborigines today still eat earth for both food and medicine. Red termite mounds contain protein, and white clay is a treatment for stomach upsets. Red earth is also applied to external sores and wounds. Finally, pregnant women sometimes experience cravings for a wide range of substances, which include not only exotic or sweet foods, but also coal, pencil shavings and clay! However, blood tests reveal no mineral deficiencies or other nutritional disorders in these women and, instead, psychiatrists offer various explanations for pregnancy cravings in general.

Mud contributes even more strongly to our need for shelter. That highly esteemed and zealously defended roof over our heads is often supported by bricks made predominantly of clay. More ancient and imaginative than the clay brick is the traditional desert mud architecture, which houses one quarter of the world's population in the desert belt from north-western India to Mexico. When properly treated, sun-dried mud becomes a versatile building material. Unlike concrete, mud insulates effectively against the substantial day–night desert temperature changes that occur in the absence of clouds and humidity. Some desert buildings exceed 400 years in age and their beauty and utility has warranted exhibitions at major museums. To some westerners, it is beyond belief that the monumental Great Mosque of Djenne in Mali (West Africa) could be built of mud.

For millenia, clay has been used by humans for sculpture and pottery. These arts are possible because clay becomes plastic when wet, rigid when dried, and vitrified when fired at high temperatures. The combination of utility and beauty has given rise to a booming ceramics industry. Because this industry is so ancient, pottery artefacts contribute to the reconstruction of past civilisations by archaeologists who also uncovered such wonders as the armies of terracotta soldiers guarding the tombs of Chinese emperors.

Another ancient use of mud-based products involves body painting, which has spiritual or mythological sigificance for many indigenous peoples. For example, the Australian Aborigines use yellow, brown and red ochres, which are a mixture of clay and hydrated iron oxide, to great effect. More frivolous perhaps is the modern cosmetics industry where fine, creamy mud is used for facial mud-packs, which are claimed to revitalise skin by regeneration of the epidermis. Sterilised reconstituted mud is now used because micro-organisms in natural mud can cause infections or allergies. How paradoxical it is that the much-reviled mud can produce a much-desired shining new countenance! And all it takes is a couple of hours and a wallet lightened by about $60.

Other industries that benefit from mud are tourism and entertainment. Rotorua in New Zealand is blessed with hot mud springs, which form dazzling sinuous patterns, and mud wrestling is enjoying quite a boom in the United States.

Origin of Life in Clay

Most scientists believe that life, as we know it, arose spontaneously on planet Earth—it was not created by supernatural forces or transported here from extraterrestrial sources. Another common belief is that there was a pre-vital chemical evolution of organic molecules such as amino acids, sugars and lipids, which comprised a primordial marine organic soup. These molecules then became organised into multi-molecular, self-replicating organisms subject to mutation and evolution by natural selection.

However, differences of opinion exist as to how these molecules became sufficiently concentrated and their chemical reactions catalysed to produce life. While some believe that these processes occurred unaided in the 'soup', others believe that the charged particles in clays enabled the molecules to become concentrated by adsorption. Furthermore, clay particles were abundant and may also have acted as catalysts in the earliest organisms before being replaced by complex polymerised organic enzymes in the form of proteins and nucleic acids.

A more extreme (and much-criticised) view of the role of clay is that clay minerals were the main materials comprising the earliest "low-tech" organisms and that the organic soup molecules played little part at the very beginning. The main proponent of this view, A.G. Cairns-Smith wrote in 1982: "Often the clay minerals that are produced from weathering solutions seem to organise themselves fortuitously, in a rough and ready way, into the kinds of things that might be needed in a primitive organism" (*Genetic Takeover and the Mineral Origins of Life*, Cambridge University Press, p. 4). Membranes, catalysts and primitive genes would all be made of clay. The inorganic components of these structures were then progressively replaced by organic molecules with "genetic takeover" a central concept. In other words, clay formed the "scaffolding" that permitted the construction of "proper organisms". Perhaps we really are common clay after all?

Psychology of Mud

Western society has emphasised the importance of the individual and our isolation from nature. This isolation is totally false, of course, but mud and dirt in general threaten this cherished separateness. Cleanliness has become a vital part of a myth that is necessary to the producers of personal images, soap, washing machines and dry-cleaning services. Furthermore, various psychological ambiguities or confusions also obscure our edges and we 'muddle' through. This is why, in the moral context, we think of certain jokes or minds as being dirty. Rigid rules are designed to eliminate such ambiguities but may well have the opposite effect.

We also demand that external entities be clearly differentiated and pigeonholed. We ignore the 'muddied' margins of so many phenomena in the natural world by erecting artificially-sharp classifications. In reality, it is even difficult to distinguish between living and non-living things. For example, how do we classify a crystallised virus? Is planet Earth itself a living being? Marketers are aware of this desire for cleanliness and distinctiveness and they hypersanitise appearances. Hence, the Western mud phobia is well and truly accommodated by our economic system.

However, alternative psychological approaches exist. They embrace the fact that we are not really separate entities at all. Rather, we are constantly exchanging energy and materials with our life-supporting environment. Various disciplines or therapies such as Buddhism or Jungian analysis seek to remove the boundary between the total organism and the environment. Such approaches would not only encourage us to treat our life-supporting ecosystem more sympathetically, but also to welcome a little mud as a connecting agent between perceived self and our surroundings.

In conclusion, it seems, we have much to praise mud for. It is an extremely valuable resource, it plays physicochemical and biological roles of sufficient importance for entire scientific symposia and numerous books to be devoted to it, and it can be perceived as a symbol of connection with our environment. Besides, how would kids make mud-pies if it wasn't for mud? ■

AUSTRALIAN WILD FOODS by Tim Low

Native Guava or Bolwarra is a common rainforest shrub found from Gippsland to northern Queensland. The fruits ripen in winter.

The Language of Fruits

The fruits of the forest speak to me. In their curves and colours, in their succulence and seediness, is the language of evolution writ large. Show me a wild fruit and I will tell you its story.

The key to understanding any fruit is its seed. Don't be fooled by seedless bananas and grapes—these are tricks of modern horticulture. The seed is every fruit's *raison d'etre*. The flesh is but a bait to lure some animal to swallow the seed, which is then dropped far away to begin life anew.

Some animals are good at spreading seeds, others are not. Birds, for example, usually swallow fruits whole and tend to scatter seeds miles away. But mammals such as rats like to chew the seeds and feed beneath the plant: they are poor dispersers.

Over millions of years, fruits have evolved close bonds with the animals best suited to disperse their seeds. It is this intimate relationship that can be read into the fruits of the forest.

Take Red-jacket or Hairy Birds' Eye, for example.

Red-jacket (*Alectryon tomentosus*) is a small tree of rainforest edges in eastern Australia. Its fruits leave no doubt when they are ready to be eaten—the furry capsules burst open to flaunt the scarlet pulp partly surrounding a shiny black seed. Birds like bright colours, and especially red with black. The bead of sweet pulp is

Red-jacket fruits are about a centimetre long. The tree is found in Queensland and New South Wales rainforests, south to the Hunter River.

PHOTOS: TIM LOW

bite-size for a silver-eye or small honeyeater, although it is also attractive to larger birds.

Taste a Red-jacket fruit and you will be struck by its astringency—the tannins in the pulp dry and pucker the mouth and tongue. This probably deters birds from eating too many at once; instead the crop is shared and the seeds spread more evenly.

Some botanists postulate that this kind of arillate fruit structure—a layer of red enclosing a black seed—is typical of the primeval fruit. There are certainly many primitive trees around the world with similar fruits, especially in the family Sapindaceae to which the Red-jacket belongs.

But I suspect the design of the Native Guava or Bolwarra (*Eupomatia laurina*) fruit is older. Native Guava is among the most primitive of all flowering plants—it is one of those 'ancient' rainforest species for which Australia has become world-famous. Its fruits ripen green and fall to the ground, where they advertise their presence by emitting a fragrant smell. What eats them? Certainly not birds, which depend on colour not smell to find their food. (Most birds lack the sense of smell.) The Native Guava seeds are distasteful to bite into—to encourage toothy animals to swallow them whole.

The Native Guava fruit tells me it is designed for a colour-blind, ground-dwelling rainforest animal with nose and teeth. This identikit fits pademelons and bandicoots, and almost fits rainforest dragons and large skinks. Given the Native Guava's great antiquity, is it possible we have here a reptile-dispersed fruit, designed originally to appeal to small rainforest dinosaurs?

Another plant that fascinates me is the Mountain Kangaroo Apple (*Solanum linearifolium*), a droopy shrub of cool forests in New South Wales and eastern Victoria. Its berries are designed for birds—note their sublime colours and elusive positioning on slender twigs beyond the reach of most mammals. What makes these berries interesting is their disconcerting habit of splitting open when ripe—like over-ripe, over-handled tomatoes. Berries of Southern Kangaroo Apples (*S. laciniatum*) do the same thing. These burst berries make it easier for small birds like silver-eyes to pick at pieces of their flesh. They can be spotted from afar and so birds waste little time perusing the whole crop.

But I feel vaguely dissatisfied by this arrangement. The fruits split unevenly, asymmetrically, and to human eyes look damaged. The bursting of the berries looks suspiciously like some evolutionary afterthought, as if a food originally designed for large birds (now extinct?) has been hastily modified for something smaller.

The fruits of Red-jacket, Native Guava and the kangaroo apples are edible and worth trying when next you're in the bush. Spare a thought for their form and function, and then consider all the other forest fruits. They too are beckoning the animals of their choice, calling out in a symphony of colours, shapes and scents that we are only beginning to understand. ■

Berries of the Mountain Kangaroo Apple are 1.5–2 centimetres long and taste sickly-sweet.

PHOTOS: VINCENT SERVENTY

A Karri tree being felled the old way. First a scarf was cut in one side with an axe in the direction in which the tree was planned to fall. Then, with a crosscut saw, a back cut was made until the weight of the trunk brought the giant crashing to the ground.

A Tall Story

I will never forget a bush camp in the undulating Karri country of south-western Western Australia some 30 years ago. The glow from the campfire lit up the boles of the Karri trees that soared into the darkness above. We could just glimpse the stars through the breaks in the canopy. Next morning, as I lay in my sleeping bag surrounded by a wall of trunks that reached towards the leafy roof, I had a feeling of both awe and excitement, the kind one has on the rare occasions when overwhelmed by beauty.

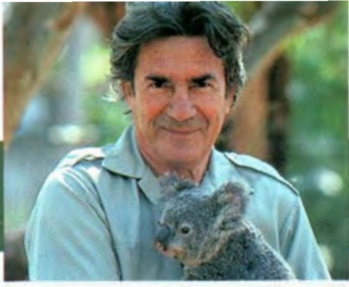
I have felt it among seabird colonies on the Abrolhos Islands, on sighting a group of grey kangaroos in the late afternoon light along a river bank, and at Coventry Cathedral in England. Yet there can be no finer cathedral than that of forests, such as the Karri and Moutain Ash or the Californian Redwood forests of North America.

Karri (*Eucalyptus diversicolor*) is one of our botanical giants, since it can reach a height of 85 metres. One, cut more than 60 years ago, took nine hours to fell. Four metres above the ground it had a diameter of nearly three metres. The total weight of the measured logs was more than 120 tonnes with another 50 or more tonnes being left behind as roots, base and branches.

The name *diversicolor* is a tribute to the fact that it sheds the outer bark-covering annually in thick plates. The new bark of bright yellowish orange contrasts with the white of the old bark, giving the tree a mottled appearance.

Water is the limiting factor for Karri growth. The trees are restricted to the south-western corner of Western Australia where, in addition to the wet winters, the mild summers also provide falls of 25 millimetres a month, making the annual total rainfall more than 1,000 millimetres.

On the other side of the continent, this time in the mountain country, the king of all hardwoods resides. This is the Mountain Ash (*Eucalyptus regnans*). The tree grows particularly well in valleys where it has deep soil and shelter, and on the mainland it is



found in the higher country of eastern Victoria, with an outlier in the Otways south-west of Melbourne. It is also found in Tasmania where it is usually called Swamp Gum and sometimes Stringy Bark, while the timber is marketed as Tasmanian or Australian Oak.

At present the tallest individuals known are in the Styx Valley in southern Tasmania. As a concession from Australian Newsprint Mills Limited, these trees have been set aside and, in a gentleman's agreement with the Tasmanian Government, protected from logging. A total of 25 hectares was set aside in 1957 and 1960. One individual measures 98.75 metres and nearby is a grove of 12 trees all more than 90 metres high. Although the world's tallest tree is a Californian Redwood (*Sequoia sempervirens*)—a conifer that measures 112.11 metres—we *can* claim to have the world's tallest hardwood or, alternatively, the world's tallest flowering plant.

Conservationists consider that the southern forests of Tasmania, which are now under threat from logging, may be hosts to taller trees, possibly even taller than the Californian Redwoods. Magnificent though the Styx Valley Mountain Ash are, they are almost unknown to the tourists who visit Tasmania. To see the world's tallest hardwoods, I had to first obtain a permit and then drive from Maydena, near Hobart, for half an hour over a treacherously-potholed dirt road. Any caring government would bring such groves of giants under national park or other safe reserve status. With suitable management plans, developed with the best botanical advice available, such groves would become the star attractions of a State that depends so much on its tourist trade.

The Forestry Commission of Tasmania has in fact reserved a small grove of Manna Gums (*Eucalyptus viminalis*) at Evercreech in north-eastern Tasmania. Here are four trees more than 70 metres high. One reaches 90.5 metres, making it the tallest Manna Gum in Australia.

When I walked through this grove I marvelled at the biological engineering that enables them to lift all the necessary minerals and water to the leaf factories above. I also wondered if any of our plant-eating marsupials make the long climb to the top to feed on the leaves.

It is sad to realise that, both in the west and the east, clear-felling is threatening many magnificent groves of tall trees. Such felling can be seen as analogous to dredging in the sea. The operator sifts through the material, picks out the items needed, and discards the rest. Sometimes the clear-felled areas are left to grow back naturally after a burn and sometimes seedlings are planted. However, usually only the commercially-important tree species are encouraged to re-grow, thus reducing tree diversity. Resources, such as hollows and certain foods vital for the existence of many animals, also disappear when mature trees are felled. Surely the emphasis should be on maintaining forests as closely as possible to their natural state. ■

This giant Mountain Ash is the tallest living tree so far found in Australia.

The tallest Manna Gum in Australia (90.5 metres) is one of four Manna Gums protected at Evercreech, Tasmania.

Some Karri forest still survives on private property. It is now under threat from the woodchippers.

Australian Ammonites

By KEN McNAMARA
WESTERN AUSTRALIAN MUSEUM

About 65 million years ago, at the close of the Cretaceous Period, one of the most cataclysmic events ever to occur on Earth wiped out many groups of animals, both land-dwelling and marine. The cause of this mass extinction is still not well understood. Recent discussion on its likely cause has focused on the theory that an enormous extra-terrestrial body, such as a comet or an asteroid, crashed into the Earth. But scores of other suggestions for the extinctions have also been made. The most favoured of these concern the effects of lowered sea levels, which severely restricted habitats, and relatively sudden changes in climate.

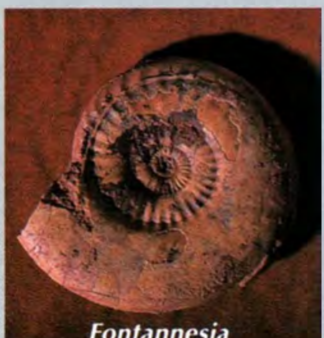
On land the most spectacular demise was that of the dinosaurs, remains of which in Australia have been found in Queensland, New South Wales, Victoria and South Australia. The dinosaurs' marine contemporaries—the dolphin-like ichthyosaurs, the long-necked plesiosaurs and the fearsome marine lizards, the mosasaurs—also became extinct. These creatures had all once roamed the seas around Australia. But perhaps the largest of the marine groups to be exterminated were the ammonites.

Although relatively little studied in Australia, fossilised shells of ammonites have been collected in all States except Victoria and Tasmania. Their closest living counterparts are the pearly nautiluses (*Nautilus* spp.). Four species exist in the Indo-Pacific, one of which occurs in waters off the Australian coast. The living nautiluses provide the modern analogue for interpreting the mode of life of the extinct ammonites. Nautilids themselves have an even longer history than the ammonites, and their fossils are found in most Australian deposits that contain ammonites.

Ammonites and nautilids both belong in the Cephalopoda, a group of molluscs that includes octopus, squids and cuttlefishes. Unlike these three groups, which have internal and often only remnant shells, ammonites, like *Nautilus*, possessed a chambered shell made of calcium carbonate. Although the soft parts of the ammonite animals have never been found, the close similarity of ammonite shells to those of *Nautilus* makes it likely that they were occupied by a similar, squid-like animal. It would have lived in the largest, outermost chamber of the shell (the body chamber), which opened to the outside. Connecting the many inner chambers of the rest of the shell (the phragmocone) was a narrow tube, called a siphuncle, which runs close to the surface of the shell. In *Nautilus* the siphuncle passes through the centre of each chamber wall and its function is to transfer liquid between chambers in order to adjust the buoyancy of the shell. In *Nautilus* the cross-walls or septa are simple, gently-curved structures but in ammonites they were often incredibly convoluted.

Despite these differences, the majority of ammonites had a shell similar in form to that of the nautiluses, being tightly coiled, with later whorls in contact with the earlier-formed inner whorls. However, unlike the nautiluses, which have smooth shells, many ammonites had strongly ornamented shells. Some had curving radial ribs that were often studded with tubercles or even spines.

Although ammonites lived from the beginning of the Triassic Period (215 million years ago), most Australian ammonites range in age from 65–110 million years and occur in the Great Artesian Basin. In Australia, Jurassic ammonites (205–135 million years old) are only found in abundance inland from Geraldton in Western Australia, and younger ammonites (about 65 million years old) are well represented in another area in Western Australia, discussed later.



KEN McNAMARA

KEN McNAMARA

Fontannesia ***was a tightly-coiled Jurassic (205–135 million years old) ammonite found near Geraldton, Western Australia. Unlike many of the heteromorph (loosely-coiled) ammonites, this animal was probably an active swimmer.*** **Myloceras** ***was a heteromorph ammonite, and may have led a somewhat sedentary life. This specimen was found in a 100-million-year-old deposit near Tambo, Queensland.***

Myloceras

In sediments 100–110 million years old, extending from the southern part of Cape York Peninsula, down through Hughenden, Longreach and Roma, across to the northern part of South Australia, large and quite unusual ammonites have been found. This region represents the near-shore environment of a great sea that once covered much of present-day western Queensland, northern South Australia and the southern part of the Northern Territory.

In these warm, shallow seas the marine life was prolific and often large. In Queensland and South Australia, remains of large ichthyosaurs and plesiosaurs, along with the fossilised remains of large fish, have been found. Some of the ammonites were also large, reaching almost one metre in diameter. These large ammonites, and some of the smaller ones, form a particular subgroup of the ammonites, known as 'heteromorph' ammonites. The shell was loosely rather than tightly coiled, with the inner and outer whorls often not in contact. Some smaller forms, such as *Myloceras* and *Labeceras*, began life as normally coiled ammonites, but as they approached maturity the shell progressively grew away from the inner whorls, before finally recurving in a strong hook. What this meant for the stability of the shell and mode of life of the ammonite is not clear. Tightly coiled ammonites were thought to have been active swimmers, darting through the water, like many modern cephalopods, by means of sudden expulsions of water through a siphon. Some of the loosely-coiled heteromorph ammonites, on the other hand, had shells that indicate the animals may have led a more sedentary life; for example, some formed spiral shells, mimicking snail shells. Other heteromorphs, however, had straight shells and may have been more active swimmers.

Large heteromorph ammonites such as *Tropaeum* and *Australiceras*, which lived about 110 million years ago, were wide ranging and have been found as far apart as Argentina, South Africa, Madagascar, Antarctica, India and Australia. The slightly smaller heteromorph ammonites *Myloceras* and *Labeceras*, which replaced the larger forms about 10 million years later, had a similarly wide distribution. But it must be remembered that at this time the continents were not in the positions they occupy today. The southern continents were all close to one another and the breakup of the great landmass of Gondwana had only just got underway. By the time the last ammonites were swimming in the southern oceans 65 million years ago, South America, Africa, Madagascar and India had split apart as separate units, and Australia remained attached to Antarctica along its southern coast. Even so, representatives of these last ammonites, found in north-western Australia, show remarkable similarities to ammonite faunas from all these southern continents, and even beyond.

In the dry country of north-western Australia, patches of sedimentary rock—testimony to periods of relatively high sea level—fringe the margins of the ancient Pilbara and


KEN McNAMARA

Cast of Australia's largest ammonite,* Tropaeum imperator*, from a 110-million-year- old deposit in South Australia.

Largest Australian Ammonite

The story behind the discovery of the largest Australian ammonite (recounted by Hans Mincham in his *Vanished Giants of Australia*, 1966) reveals some of the attributes necessary in making important scientific discoveries: serendipity and doggedness, in this case quite literally—in the form of an emaciated dog.

The finder of this one-metre-diameter monster shell was a policeman named Constable Jury who was based at Oodnadatta in South Australia. Jury set off one day in 1923 to search for a reported lost person. A lone, hungry dog had staggered into a nearby station, suggesting that its owner might be stranded out in dry country. While Constable Jury found no sign of any living soul, what he did find made his trek worthwhile.

When close to Lake Cadibarrawirracanna, and from the high vantage point of his camel, Constable Jury saw in a nearby dry creek bed what he thought was a car tyre. What an abandoned car tyre should be doing in such desolate country in the 1920s intrigued him. Walking over to satisfy his curiosity he realised that the 'tyre' was in fact made out of rock. He removed a small piece and took it back to Oodnadatta with him. After having been sent to the South Australian Museum, the piece of rock was recognised as being part of a very large ammonite. Professor Walter Howchin, who identified the specimen, wrote to Jury, encouraging him to return to the site to collect the entire specimen. He duly obeyed and, after a 150-kilometre camel ride, managed to relocate the ammonite. It was dug out in pieces and shipped off to the Museum in Adelaide. After having put the pieces back together, Howchin recognised the ammonite as a new species and named it *Tropaeum imperator*—truly an imperial ammonite.

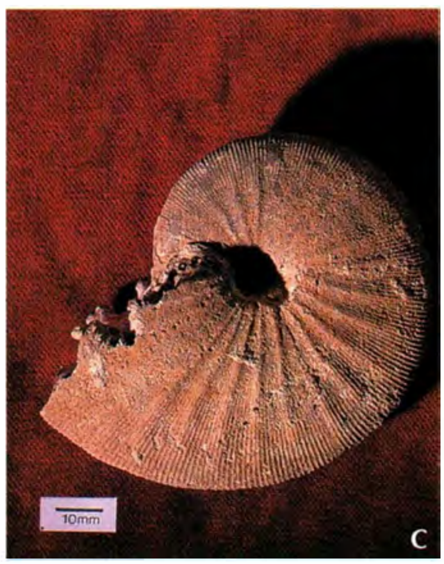
Yilgarn blocks. In one of these areas the transition from the Mesozoic to the Cainozoic Eras, which occurred 65 million years ago, can be seen. The change from one to the other is as sudden as it is startling, in terms of the change in fossils. The last metre or so of sediment deposited at the end of the Mesozoic (Age of Dinosaurs) is a veritable graveyard of fossils, particularly molluscs. Predominant amongst these are the ammonites. Although these ammonites are generally smaller than their older counterparts found in other parts of Australia, the deposit probably represents the world's richest assembly of the very last ammonites to exist, covering almost the entire range of possible shell shapes. Some shells are small, fat and smooth; others are narrow and sharply-ribbed, or large and coarsely-ribbed with big tubercles; some are tightly coiled, while others are more loosely coiled. Heteromorphs occur in great abundance. Their shells range from helically-spired to open triangular to trombone-shaped, while the common *Eubaculites* has a compressed, straight shell.

There is no sign here of a gradual demise in shell types before the big extinction. On the contrary, the range of shell shapes is about as great as that which occurred at any other time during the 150-million-year reign of the ammonites. The fossils occur in great profusion and many have extremely wide geographic ranges. Some species that occur in Western Australia have been found as far apart as Alaska, British Columbia, France, Zululand, India, Japan, Brazil and Antarctica!

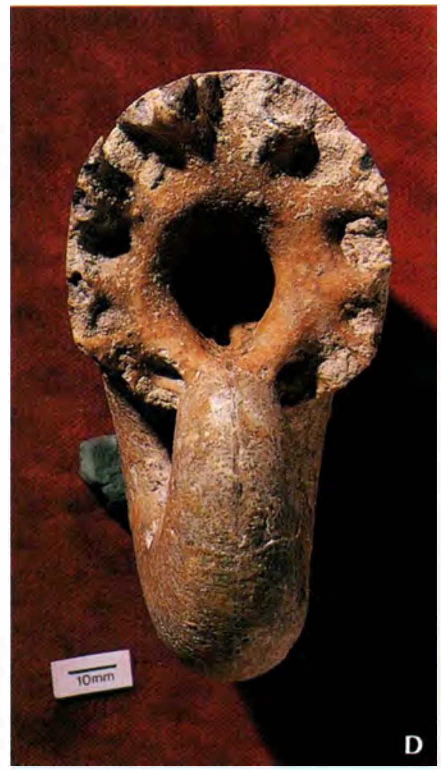
Not only do the different shells provide us with an insight into the richness of the fauna, but the fossilised remains of the ammonites themselves provide a fascinating insight into many other groups of organisms that lived in the seas around Australia 65 million years ago. The ammonites are preserved as internal moulds, representing the mud that, somehow or other, entered many of the inner chambers of the ammonite shell and then solidified. The sediment in which they were fossilised was rich in phosphate. Not only did this result in a relatively rapid hardening of the mud and quick fossilisation, but the thin veneer of phosphate that formed at the junction of the mud with the inner surface of the shell faithfully reproduced negative

KEN McNAMARA

KEN McNAMARA



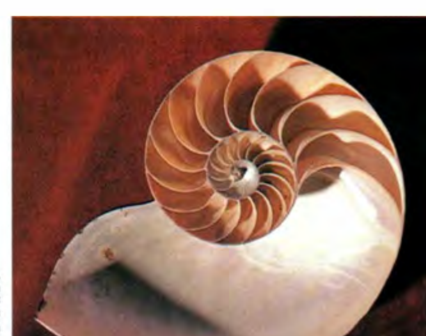
KEN McNAMARA



KEN McNAMARA

These four ammonites represent only a few of the huge range of shell types found in the youngest (65 million years old) ammonite deposit, near Exmouth, Western Australia. A: **Desmophyllites** ***was thin with a smooth shell; B:*** **Eubaculites** ***was straight with few coarse ribs; C:*** **Phylloceras** ***was thin with few coarse and many fine ribs; D:*** **Pseudophyllites** ***was fat with a smooth shell; this view also shows the crenulated chamber wall.***

KEN McNAMARA



KEN McNAMARA

Photo on the left shows the internal structure of an ammonite. Some chambers are filled with sediment, others are empty and lined with calcite crystals. A sectioned shell of the living pearly nautilus **Nautilus pompilius** ***(right) shows a smooth body chamber and cross-walls (septa) of the phragmocone.***

impressions of borings made into the surface of the shell. Scanning electron microscopy has revealed that the ammonite shells were hosts to a wide variety of living creatures.

Perforating the shells were minute channels made by the filaments of boring algae and fungi. Some are as narrow as one micron (a millionth of a metre) across. Groups of pits, like tiny bunches of grapes, were made into the shells by boring sponges. Many mollusc shells today are similarly honeycombed by sponges. Both polychaete and phoronid worms also bored into the ammonite shells. Bryozoans, corals, foraminiferans, worms and bivalves attached and grew on the empty shells of dead ammonites. Sometimes they also grew on the hardened internal moulds of shells that lay exposed on the sea floor for long periods. Sometimes the hardened mud inside the ammonite's body chamber is riddled with passages formed by burrowing crustaceans.

It is perhaps a little ironic to note that one of the more common elements of this Western Australian fauna is a nautilid (*Cimomia* sp.). Why did the ammonites disappear forever while the nautilids survive to the present day? And why should so many large groups of animals have become extinct at the end of the Cretaceous Period, while others seem to have passed through the crisis virtually unscathed? Maybe part of the answer lies with the reasons behind the persistence of the nautilids.

The shells of nautilids have changed little over hundreds of millions of years. Living nautiluses have a broad depth range, from near-surface down to 700 metres. They also have relatively unspecialised diets. The last of the ammonites, as we have seen, had more varied, specialised shell shapes, suggesting that they may have been highly specialised in their feeding habits. During great ecological crises it is these specialist forms that are most likely to become extinct.

Another possibility for the extinction of the ammonites—and not the nautilids—may lie with their differing modes of reproduction. During the mass extinction at the end of the Cretaceous, about 90 per cent of calcareous plankton in the oceans also became extinct. This may have occurred because of sudden changes to surface-water chemistry or temperature, or both. There is reasonably good evidence that embryonic ammonites hatched at only about one-tenth the size that nautilids do, and that they formed part of the surface-water plankton. The living nautiluses hatch at a more advanced stage in deep water, and appear to be able to swim and feed actively immediately after hatching. It is therefore possible that by living in deeper water, particularly during the early part of their life, nautilids escaped the impact of the extinction event that so dramatically affected the ocean's surface dwellers.

Whatever the reasons for the extinction of the ammonites, it was the conservative nautilids that survived. While we are still fortunate in being able to marvel at the beauty and elegance of the pearly nautiluses, the world is certainly a poorer place for the loss of the ammonites. But at least we do have their fossilised remains, weathering now on dry land from their ocean graves, to allow us to imagine what life in our oceans must have been like more than 65 million years ago. ■

KEN McNAMARA

A 19th century snakestone made by carving a head onto an early Jurassic ammonite (*Dactylioceras commune*) from Whitby, Yorkshire.

Snakestones

Ammonites take their name from their similarity to the ribbed spires of rams' horns, the insignia of the Egyptian god Ammun. The spiral form displayed by many ammonites has long fascinated mankind. It appears in graphic representation in Mesolithic art and the occurrence of ammonites in archaeological sites of this age indicates that interest in ammonites has a very long history.

While we now recognise them as being the fossilised shells of an extinct group of cephalopods, in the folklore of a number of countries ammonites were often referred to as 'snakestones' because of their coiled, snake-like appearance. To the ancient Greeks ammonites were thought to protect against serpents, and to be a cure for blindness, impotence and barrenness.

Ammonites from early Jurassic rocks of England, with heads carved into them, were used as charms in Elizabethan times. The fossils were supposed to have once been living serpents, until the doughty St Hilda turned a host of annoying snakes into stone, after first praying their heads off! During the 19th century a thriving business flourished at Whitby, in Yorkshire, carving heads onto the 'decapitated serpents'.

In India, where they are known as *salagrama*, ammonites from sources in the Himalayas were traded widely as charms and placed in Hindu temples as fetishes, being thought of as the embodiment of the god Vishnu. Drinking from water in which a sacred ammonite had been steeped is thought to wash away sin and secure well-being. This particular Vishnu cult can be traced back to the 5th century BC.

The North American Blackfeet Indians thought that ammonites resemble sleeping buffalo, hence their name *iniskim* or 'buffalo stone'. This led them to believe that the fossils possessed power over the great herds of buffalo. It was even thought that these ammonites, if properly wrapped in buffalo hair, would hatch baby buffalo stones. This legend may have arisen from the ease with which sections of the mud-filled chambers can often be detached when preserved as internal moulds. Upper Palaeolithic occupation sites in the north-western plains have yielded ammonites, suggesting that this practice of using ammonites to magically attract buffalo may have had a long history.

There is some evidence that ammonites were sometimes prized possessions of Australian Aborigines. A site at Condamine in Queensland that contained many artefacts also yielded two fossils, one being a piece of the ammonite *Myloceras*. The site is some 400 kilometres from the nearest known outcrop of rock that contains fossils of this type.

Saturated Color

Nikon FE, 20mm lens, 81B Filter.

Capture the true colors, the mood and the feel of the moment. Create a statement that brings the subtle variations of light and tone to life with Kodak Ektachrome 100 color slide film.

Remember color with Kodak

KODAK and EKTACHROME are registered trademarks. 336P5012 JWT.

Ektachrome
Film for Color Slides
100
DAYLIGHT
EN 135-36
36 EXP.
DX
35 mm