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Australian Natural History
AUTUMN 1990 VOLUME 23 NUMBER 4

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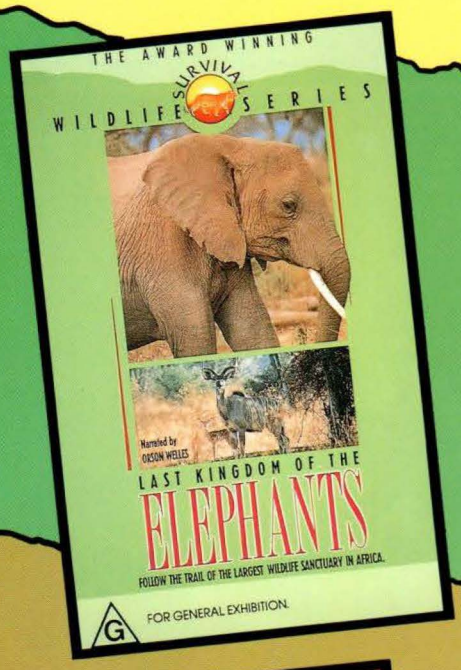

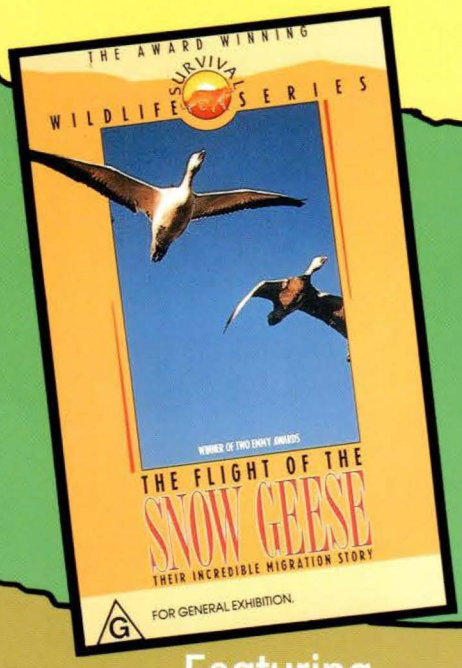

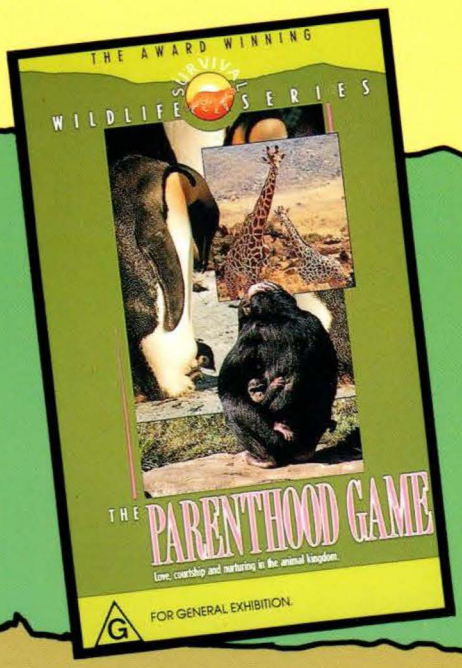

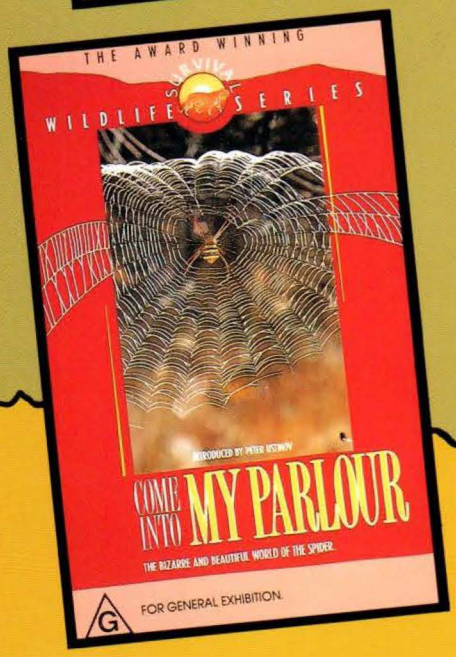

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Front Cover

Few people are aware of Bauer, the Austrian artist who accompanied Flinders on his circumnavigation of Australia. Illustrated is the delicate Twining Fingerlily (*Thysanotus patersonii*). Photo: British Museum (Natural History).

EDITORIAL

THE GREENING OF ECONOMICS

BY FIONA DOIG
EDITOR

THE DIFFICULTIES FACED IN MANAGING environmental stress are largely a product of an inadequate economic framework. Economic growth is the catchcry; growth means increased consumption, income, employment, greater tax revenue and better social services, all of which supposedly lead to improvements in the quality of life. Yet economic models ignore the fact that we live in a finite system (planet Earth). Growth is only sustained at the expense of the Earth's environment, on which we are dependent for *future* economic growth. As the context in which economic growth occurs, the environment is virtually ignored when the sums are done.

We have been living on the Earth's 'capital': those elements that make continued production of renewable resources possible (e.g., soil, air, water, biological diversity). Entire nations' economies are suffering from failure to manage environmental capital. Thailand, for example, a country heavily reliant on timber exports, has banned logging due to the massive flooding and mudslides it has caused. The environment is claiming compensation.

Economists forget that many effects on the environment are irreversible, unlike market trends, which fluctuate widely. Why can't they see the biosphere as an asset that needs careful management like their precious balance of payments?

Economists see only current gains and losses, not future ones. The cost of banning CFCs *now*, for example, would be minimal compared with that of attempting to totally restructure agriculture to withstand increased UV radiation from ozone depletion.

It is not that economics can't solve environmental problems. Economic models just aren't equipped to do so because we're ignorant of the value of our environmental capital. Without sensible values on it, sensible economic adjustments cannot be made. We will soon be paying for our short-term, high-profit ignorance.

Just as ignorant is seeing conservation as an end in itself. The payoff is the future—economically and environmentally.

Economics and the environment are not conflicting issues that need to be balanced as many people imagine. They are inextricably intertwined. It is this false split that allows companies to sponsor environmental organisations while at the same time create noxious waste or ecological destruction—and then conveniently sweep it under the economic carpet. A combined force between economics and the environment is essential if we are to create long-term sustainability. Too many outrageously ignorant decisions have been made in this country (like banning fishing in Port Kembla because of industrial pollution but allowing industry to continue to pollute the ocean).

So what can be done? How can economists and environmentalists work together in harmony to create the quality of life we seek? Together, they need to invent an appropriate, workable value system. Economics can then provide useful tools for supporting it. Taxes and tariffs, for example, can discourage consumption of environmentally hazardous products or energy sources and be used to replace environmentally unsound technology as quickly as possible. But most importantly, financial incentives for people and companies to take responsibility for the future of their environment are sorely lacking.

An awareness of the environmental element in economics *is* emerging and some sound management practices are occurring. In California, for example, a power company found it cheaper to give away energy-efficient fluorescent tubes than build a new power plant. The Denver Water Authority gave a 'dam' about water conservation—quite literally—its plans to build a new dam were scrapped when it was found to be more economic and environmentally sound to supply households with water conservation appliances. At home, the National Farmers Federation and the Australian Conservation Foundation have joined forces to combat land degradation with a tree-planting and educational campaign. All of this points out that environmentally economical decisions can be very cost-effective in both the short and long term. Unfortunately, poor decisions that are neither economic nor environmentally sound are too frequently made. Elcom could have spent the $900 million that the Mt Piper coal-fired power station has so far cost far more effectively on solar hot-water systems for every home in Sydney.

What's essential is not just economic or environmental management. It is the creation of an ecological framework to guide the overall economy. One that correctly identifies and values *all* our resources in order to provide a context for sustainable development, rather than uncontrolled growth. It won't be cheap. It won't be easy. It will require changing the way we live. But it must happen: the economic cost will be much greater if it doesn't. ■

IN THIS ISSUE

BY GEORGINA HICKEY
SCIENTIFIC EDITOR

LAST WORD FIRST: IN THE PREVIOUS ISSUE OF ANH, LYN Goldsworthy made clear her support for Bob Hawke's decision not to sign the Antarctic Minerals Convention. In this issue, to show the other side of the coin, Phillip Law has The Last Word. He puts forth a strong argument against the Government's campaign to declare Antarctica a "World Wilderness Park".

Also followed up from the last issue is the full story behind the quip "Monotremes Still Have Some Shocks in Store". Uwe Proske (pictured) recounts the exciting story of the discovery of electroreception in the bill of the Platypus. He explains his role in elucidating the actual nature of the sensors involved and describes an experiment designed to test for electrosensitivity in echidnas.

COURTESY UWE PROSKE

This issue is also a 'coming out' for Ferdinand Lucas Bauer. Featured in the article on page 296 and the poster are some of the superb colour illustrations of this long-forgotten Austrian naturalist in Australia. Marlene Norst pays tribute to him.

Other articles deal with the role of termites in the Top End; the important research being carried out at the Australian Museum's Lizard Island Research Station; and the discovery last year of Banded Stilts breeding in South Australia—the first time for nearly 60 years. Mike Archer discusses the issue of biological hoaxes and describes how it feels to be the bunny; Tim Low wraps his teeth around witchetty grubs and lets us in on their gastronomic and nutritional secrets; Robyn Williams homes in on Professor S.A. Barnett—an animal behaviouralist who pulls no punches; and Molnar and Ingram invite you to an uncertain marriage of evolution and entropy.

Also included are Frazier's flights of fancy, Whale Sharks, archival glass negatives, evolution of pregnancy sickness, and lots more.

Articles

LORE FROM THE LIZARD: LIZARD ISLAND RESEARCH STATION

Set up by the Australian Museum in 1973 on a relatively remote and pristine island off Cooktown, Lizard Island Research Station supports a wide range of research projects and has attracted worldwide recognition.

BY JENNY GATES & PETER HOYLE

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A TALE OF THREE SPECIES: THE STILT, THE SHRIMP AND THE SCIENTIST. . .

The Banded Stilts had disappeared from all their usual non-breeding coastal haunts in a mysterious response to rains hundreds or thousands of kilometres away. This provided scientists the first opportunity for nearly 60 years to study the breeding behaviour of these resident waders in South Australia and their close relationship with the tiny crustaceans on which their survival depends.

BY HUGO PHILLIPPS

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Regular Features

FROM THE ARCHIVES

MONEY IN GLASS PLATES

Recently 14 glass plate negatives depicting girls from Collingwood Bay, PNG, at the turn of the century were resurrected from the bowels of the Australian Museum's Photography Section. The photographer was Percy J. Money and his negatives are of great ethno-historical significance.

BY RIC BOLZAN & ELIZABETH BONSHEK

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RARE & ENDANGERED

THE WHALE SHARK

Whale Sharks have recently been reported in large numbers on the Ningaloo Reef in Western Australia. Does this mean that the species should not be considered rare?

BY GEOFF TAYLOR

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WILD FOODS

WITCHETTY GRUBS

Even as Aborigines turn more and more to a Western diet, witchetty grubs remain a popular food item for them.

BY TIM LOW

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PROFILE

HOMO PUGNAX: ANTHONY BARNETT

Barnett's aggressive and unrelenting criticism and his insistence on hard evidence are among the reasons for his success as a behavioural biologist.

BY ROBYN WILLIAMS

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PHOTOART

FLIGHTS OF FANTASY

Butterfly form and colour are deliberately modified to reflect the photographer's personal feelings about these beautiful insects.

BY JIM FRAZIER

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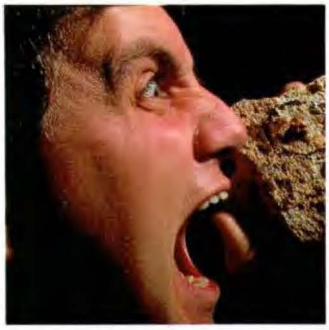

VIEWS FROM THE FOURTH DIMENSION

THE MUDDLED MOLAR MYSTERY OF RIVERSLEIGH

Hoaxes have long been the less serious side of biological science. Although no-one likes to bear the brunt of a hoax, its inevitable unravelling will ensure continued healthy suspicion in science.

BY MICHAEL ARCHER

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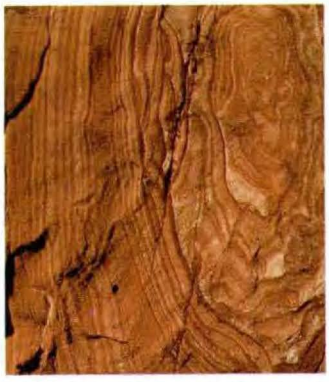

STILL EVOLVING

THE ORGANISATION OF LIFE: FROM ENTROPY TO EVOLUTION

In general, changes in non-living things are explained in terms of thermodynamics (entropy, heat flow etc.) and lead to disintegration; changes in living things are explained in terms of biological evolution and lead to greater complexity. Although thermodynamic and evolutionary change seem diametrically opposed, some people have attempted to explain biological processes in terms of entropy.

BY RALPH MOLNAR & GLEN INGRAM

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THE LAST WORD

ANTARCTIC WILDERNESS: A WILD IDEA

To declare the whole of Antarctica a "World Wilderness Park" is, in this author's view, not only unnecessary but absolutely impracticable.

BY PHILLIP LAW

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LETTERS

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

Selfish Genes

The article by Michael Archer (ANH vol. 22, no. 12, 1989) provides an interesting view of what it means to be human. However, his evidence concerning the behaviour of Kamala and Amala, the 'wolf-children', could more easily be used to dispute his contention that humans, and any potential rivals in outer space, will inevitably fall into a struggle for superiority and domination.

The difference between humans who have developed within 'normal' societies, and the wolf-children and the wolves they imitated, is seen in a move away from the purely selfish-gene-driven animal he regards us to be, and towards a type of being that is capable of actions not consistent with the desire to survive and procreate at all costs.

The idea of the 'selfish gene' is an attractive one that explains well the actions and evolution of most of the living world. However, it is hard to see the acts of some humans, such as the students who recently died in Beijing, as being totally "committed in self-interest and every thought reducible to the notion of the need to survive at *whatever* expense to the rest of the world." It is hard to believe that this was the only driving force of the thousands who have accepted death throughout human history, rather then deny a simple belief or perform a simple act. It doesn't make sense that our genes alone would lead us to enshrine our competitiveness in beliefs and values to help us achieve domination, if we then refuse to modify these beliefs when it is apparent they are leading to our destruction.

While the undoubted greed and selfishness of humans may lead us to destroy any competing aliens, the resultant protests that will ensue will have their roots in a source other than pure genetic 'imperialism'. Kamala and Amala fed and defended themselves when attacked in a way they learnt from their she-wolf tutor. This is evidence of their drive to survival but does not exclude the presence of other drives that, at least at times in some people, appear to be greater.

—David Bell
Brunswick, Vic.

Pi in the Sky

Georgina Hickey's article on pyramid construction (QQC, ANH vol. 22, no. 12, 1989) reminded me of the several occasions when the Eric Von Daniken set declared the fact that the ratio of the height of the pyramid to half the base is pi ($\pi = 3.141$) and thus indicative of the involvement of another civilisation (extraterrestrial beings?) with a working understanding of pi.

Certainly the relationship between the heights of the three major pyramids and half of their bases is close to pi. The three major pyramids at Giza built about 2600BC have the following dimensions:

Pyramid	Height	½ Base	Ratio
Khufu	775.5'	240.2'	3.222
Khafre	707.5'	235.5'	3.005
Meukra	356.5'	109'	3.270
Average Ratio			3.167

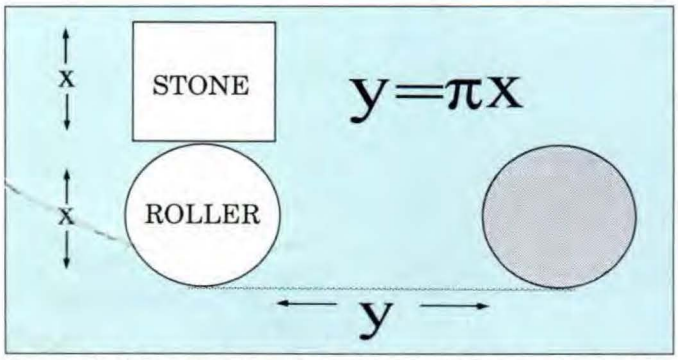
Yet the Egyptians have made no written record of understanding the factor pi, nor do they seem to have used it in any other particular way. They were an agricultural nation and no translations from the Rosetta stone seem to indicate an understanding of the subtleties of this form of geometry. It thus seems unlikely that they would have spent many years constructing permanent records to its omnipotence. The Mesopotamians had an understanding of pi in 4000BC, approximating it to 3⅛. The Chinese used 3 as pi in 3000BC but it was Ptolemy who refined pi for the Greeks to 3.141 at about the time of Christ, some 2,000–3,000 years after the Egyptians built their pyramids.

But the fact that the Egyptians didn't know pi does not necessarily mean that other civilisations, from who knows where, were involved. In fact I think it leads us to a better understanding of their method of construction. Consider the accompanying diagram.

If a stone is moved into place by a roller that has the same diameter as the height of the stone, then, because of the engineering principles involved, one full circle of the roller will move the stone horizontally by a distance that relates to the height of the stone by the factor pi. That is, if Y is the horizontal distance moved and X is the diameter of the roller and height of stone, then $Y = \pi X$. One could imagine a series of stone-moving sites, each incorporating a roller that is allowed to go one full turn and each carrying a block into place so that, at the end of construction of that particular site, the complete base would maintain a relationship to the height of the stones by the factor pi.

There are several variations on how this could be done but I feel that the incorporation of pi into the pyramids by this method was accidental. Pi was merely 'built in' and the pyramids stand more as a demonstration of ubiquity, rather than evidence of an extraterrestrial architect.

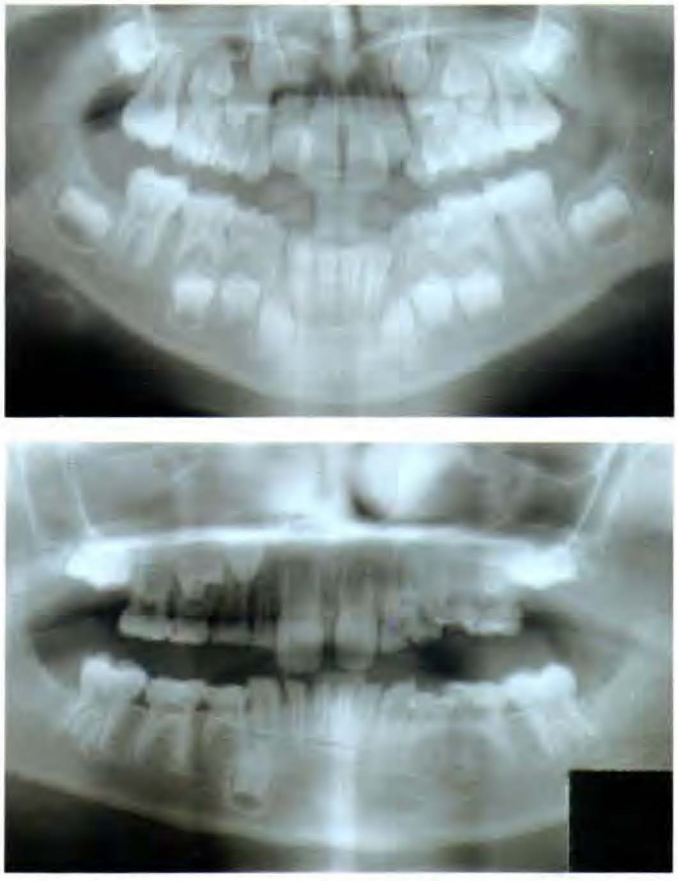
—Daryl Stephens
Ballarat, Vic.



The height of Egyptian pyramids is related to the base by the factor pi. Because Egyptians had no apparent working understanding of pi, some extremists have used this as evidence for the involvement of extraterrestrial beings. Yet simple engineering principles can account for the implicit relationship of pi. If a stone is moved by a roller whose diameter is equal to the height of the stone, one complete roll will move the stone by a factor pi, such that the horizontal distance moved (Y) equals pi times the height of the stone (= diameter of the roller).

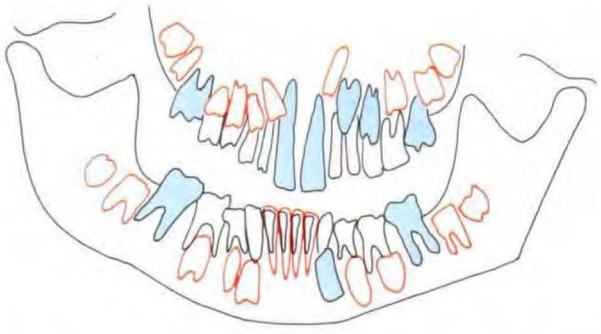
More Evolutionary Wisdom

In response to T.V. Blomfield's query about why she has only three wisdom teeth, while her predecessors have four, Ronald Strahan considered that evolution was not really active and that T.V. Blomfield was probably just lucky (Q & A, ANH vol. 23, no. 1, 1989). As a dental specialist who treats patients with missing teeth, I disagree with Mr Strahan. First, there has been a shortening of the human jaw, on average. We no longer have the robust jaws of Stone Age persons. This was mentioned in the reply. Second, Stone Age persons wore their teeth down during their life. As the teeth wore down they got narrower and the back teeth drifted forward to keep the teeth in contact. This forward drift of the molars made space for the wisdom teeth to erupt. And third, with evolution, unnecessary items are discarded. For example, we lost our body hair at some stage, Orang-utans lost th ir tails, and Dingoes lost their· ark. If we don't need something, people who are born without it (mutations etc.) will survive to carry their genes further. Less teeth is getting very common; I would see a couple of new patients each week with one or more teeth missing. I have three patients with only six to ten teeth each. If these three were born in a Stone Age or nuclear holocaust



COURTESY PETER VAUGHAN

Radiographs of two ten-year-old children. In the normal radiograph (top) the roots of the deciduous ('baby') teeth are being resorbed by the permanent ('adult') teeth. Within a few years the deciduous teeth will loosen and fall out, and the permanent teeth will erupt through the gum. In the lower radiograph, only nine permanent teeth are present. The deciduous teeth, which are smaller in both root and crown size and are less dense (that is, not as mineralised and hence not as visible on the radiograph), will wear down considerably and not function adequately. This patient will probably have to consider implants or dentures.



ANNA GREGG

A tracing of a child with only nine permanent teeth (blue). The missing teeth (that is, those that would be expected in a normal child of the same age) are outlined in red.

environment, their inability to chew would probably stop them living to reproduce. Fortunately they can live normal healthy lives in our community.

Therefore I feel we are evolving to have less teeth. Nature has given us smaller jaws but hasn't 'learnt' how to make the teeth smaller. Consequently people come to see people like me, the orthodontist, and unfortunately we occasionally have to extract teeth because you can only fit so many teeth in a jaw bone. If it's not us who extract the teeth, the oral surgeon will take the wisdom teeth because they certainly won't fit in. If only nature was a bit faster in the less-teeth business (and better organised too—it's not as good as it seems).

—Peter Vaughan
Newcastle, NSW

Paradise in Cape York: A Moot Point

Rod Julian's article "Paradise Parrot" (ANH, vol. 23, no. 1, 1989) does little to allay my concerns (a) over the lack of good evidence that the Paradise Parrot (*Psephotus pulcherrimus*) ever existed on Cape York Peninsula and (b) that searches there would only divert precious money and manpower from where they should primarily be directed: south-eastern Queensland and north-eastern New South Wales. Let us examine the evidence he adduced.

First, Gilbert wrote that he was surprised to see the birds, that he found them in several places, and that he saw them once in great numbers. What matters is that he neither collected specimens, nor described the birds, nor told us how well he saw them. It is indeed odd that Gilbert didn't collect a specimen. We thus have no palpable evidence. Mr Julian's vague claim that "two similar birds with similar nesting habits" can coexist not only opens an ecological can of worms but finds no support in his cited example. The two rosellas in his example actually hybridise and thus shed no light on whether the Paradise Parrot could coexist with the congeneric Golden-shouldered Parrot (*Psephotus chrysopterygius*; undescribed in 1845 and unknown to Gilbert).

Second, the report in about 1918 from a Coen police constable that the Paradise Parrot was "moderately plentiful" and that the Golden-shouldered Parrot was "similar in habits to the Scarlet-shoulder, but not so plentiful" is itself inadmissible as evidence. The phrase "similar in habits" is vague and useless and we know little of the constable's abilities as a field ornithologist. Mr Julian omitted the constable's report of the scarlet-shouldered birds nesting in termite mounds. This, even to me, is the single piece of evidence that might suggest the constable did not misidentify the remarkably similarly patterned, albeit larger, Red-winged Parrot (*Aprosmictus erythropterus*), a mistake that has been documented before. The 187 words that Mr Julian tells us Gilbert wrote to "describe the *colouring* [emphasis mine] of the Paradise Parrot" were not written in connection with his Cape York sightings and cannot properly be used as evidence in this case.

Third, the Australian Museum holds a Paradise Parrot specimen from Cairns dated 1894. It is well known that registration of old specimens was often incomplete and birds that died in captivity were often registered as having come from their place of captivity. Not having been prepared under field conditions, these skins often are of high quality that should raise doubts about their data reliability. More importantly, the specimen was from the Grant Collection, which was bequeathed to the Australian Museum and which is so notorious for inaccurate label data that specimens from it are customarily ignored. Mr Julian even noted that the specimen data are not absolutely reliable.

In conclusion, Gilbert was a fine collector who in this instance provided no specimen and left us only with inadequate field notes. I at least have no doubt that he would be the first to agree that, when reasonable doubt exists over a distribution record and there is no specimen, then the record must be dropped. I commend Mr Julian and ANH for encouraging the search for the Paradise Parrot but criticise both for fostering a belief that in this case evidence exists where it never has (except, perhaps, for the tantalising report of parrots with scarlet-shoulders nesting in termite mounds). Although I may seem overly pedantic, I feel that this is the only satisfactory approach when deciding where to search for a bird that is probably (but we hope not) extinct.

—Leo Joseph
University of Queensland

I feel compelled to respond to the views expressed by Leo Joseph. The purpose of the article on the Paradise Parrot was to show that it is just possible the species may survive in a remote area of Cape York Peninsula; that there is some evidence to support this view. Indeed, if there were irrefutable proof one way or the other, there would be no controversy, and very little interest in the subject.

There is merit in several points raised by Mr Joseph. Apart from the disputed Gilbert sightings, I agree there is no scientifically acceptable proof that the Paradise Parrot ever

*existed on the Cape. However, the reliability and accuracy of Gilbert as a field ornithologist has never been doubted. Indeed, there is much acclaim for his eye for minute detail. If we reject his record sightings, then doubts must be raised over his competence. This is inconceivable. Given Gilbert's impeccable credentials, if he did not see Paradise Parrots, then what did he see? Those who reject Gilbert's sightings are still to give a plausible and totally acceptable explanation. It is most unlikely he mistook the Golden-shouldered Parrot (*Psephotus chrysopterygius*) for his "*Platycercus *of the [Darling] Downs", considering the completely different wing covert colouring, and the fact his first priority was to discover new birds for his employer, John Gould.*

Apart from Gilbert, the constant rumours from the Cape over many years must be worthy of some investigation. The Atlas of Australian Birds, *compiled very thoroughly by the respected RAOU, notes: "If the Paradise Parrot still exists it is as small remnant populations in remote*

ANTHONY FARR

AUSTRALIAN MUSEUM

Paradise Parrot (Psephotus pulcherrimus).

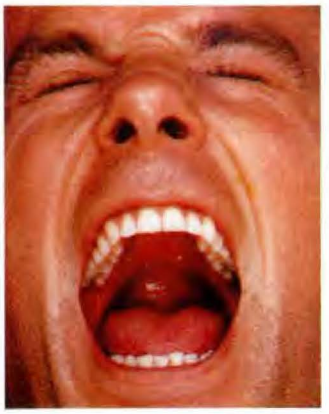
*country, perhaps in northern Queensland where many rumours are centred." In fact, the idea of Paradise Parrots existing on the Cape is not new. Donald P. Vernon, of the Queensland Museum, suggested it nearly 20 years ago (*The Sunbird *2:17–23; 1971).*

I am very sorry Mr Joseph seems so offended by the article. However, to suggest there is no evidence at all to support this concept seems a trifle extreme. Perhaps this is because things have changed so much since Gilbert travelled down the Mitchell River. In the 19th century, Gilbert's word was sufficient in itself. Today, our standards are much higher: we expect, and we demand, much more.

—Rod Julian
Warrimoo, NSW

Uncontrollable Yawning

I have just finished reading (at last) the quip "Guaranteed to Make You Yawn" by G. Hickey (ANH vol. 23, no. 1, 1989). It was the most amazing thing I have read in my life. Not long after receiving my copy of ANH



It really is catching!

I started to read this article: amazing instant yawn after the first paragraph; the yawning was uncontrollable. It took a total of nine readings before I eventually managed to read the complete article without yawning.

Thanks for what was a very interesting article, even though my wife seemed to think I was bored to tears because of all the yawning.

—Michael Ayre
Fullerton Cove, NSW

Human Slough

I noted the recent discussion on snake slough in your Q & A column (ANH vol. 23, no. 1, 1989).

Your readers may be interested in the fact that some humans have a similar process. Some unfortunate people develop a skin disease called Pemphigus. In this disease, a blood antibody arises against the intercellular cements of the skin. As a result, the cells of the outer layer don't stick together and skin sloughs off.

Russian workers have recently shown that this same human antibody will specifically bind to shedding snake skin, but only at the early stages of shedding. Prior to, or after shedding, the human antibody would not bind to the snake skin (*Med. Sci. Res.* 16: 165–166, 1988; *Dermatol.* 178: 8–11, 1989).

These workers have hypothesised that the 'shedding' gene is repressed in higher vertebrates but is potentially responsible for the appearance of the disease in humans. Further study of this mechanism of shedding in snakes may help in understanding Pemphigus.

—Chris Commens
Pennant Hills, NSW

Creation Scientists?

Browsing through a doctor's waiting room reading material yesterday, I read an article in vol. 22, no. 11 of ANH. It was a book review by Alex Ritchie of an offering by Arthur Strahler: *Science and Earth History.*

If your reaction already is what I have come to expect from those who claim the sole right to the title of 'scientist', I do not expect you to read any further, and certainly would be flabbergasted if you bothered to check up on the claims I am about to make.

Almost every article I read written by evolutionists, commenting upon the case presented by creationists, accuse the latter of falsely claiming to be scientists. Ritchie, and I assume Strahler does the same in his book, refers to the creationists as "pseudo scientists."

This is a blatant untruth, as a simple glance at the name and title of the various authors on Creation can easily establish their claim to be as academically qualified to the title as those who hold to the discounted theory of Darwinism.

Membership of the USA Creation Science Foundation originally required a science degree, and there were over 600 on the roll at the beginning of the '80s. Most of them had at least a Master of Science degree.

On 4 June 1988 the ABC broadcast a statement that corrected and apologised for statements made by a university professor last February concerning the standing of the Creation Science Foundation.

We have come to expect this untruthful conduct on the part of evolutionists who either do not take the trouble to check their facts (some scientists!) or who knowingly use these tactics to protect their discredited theories.

—Owen Wainwright
Bass Hill, NSW

Anti-creationist Responses to L. Johnston

L. Johnston (Letters, ANH vol. 23, no. 1, 1989) views the "appearance of a forum for sniping between atheists and creationists" in a magazine for natural science with alarm. He or she sees such argument as immature and irrelevant. However, with situations such as we saw in Queensland in 1984, when Mr Lin Powell, the Minister for Education, moved to have creation 'science' put on the biology syllabus, surely we *should* be subjecting the issue to public debate. The pseudo-scientific 'style over substance' approach of creation 'science' often seems to be quite persuasive, particularly to those with no background in science. In America, the pressure of the creationist lobby on publishers has been so great that it has led to several biology textbooks being printed with no mention of evolution—an idea as fundamental to modern biology as Boyle's Law is to chemistry or

S. KOSSARD

Not only do snakes slough their skin but humans with the skin disease Pemphigus do too.

Quantum Theory is to physics. Let's prevent such a situation occurring here by making this a scientific debate, rather than seeing it simply in terms of religion.

—Michael E. Harvey
Dee Why, NSW

I would think Mike Archer sufficiently confident of his standing not to need backing in his reasoned campaign against superstition and stupidity. However, I expect he'll get some, and in case you'd publish a bright one, here goes:

L. Johnston of Coal Point can list me as an extremist on the 'atheistic' side, although that's not an epithet I use myself, since I can't see how you can be slammed for being 'without' something that likely does not exist. His letter (ANH vol. 23, no. 1) is short—a virtue I seem never to attain—but having had 50 years' experience confronting fundamentalists, I pride myself on being able to identify a few of their tricks, and there's the odd clue in his that leads me to class him, provisionally at least, as an extremist of the other variety. "Natural Science(s)" is a bit of a giveaway—what other sort is (or are) there? But in particular I recognise the old trick of stifling criticism and discussion of the spiritual stance by hinting it's not 'nice', wicked even, to dare talk about such subjects. Is that because they subconsciously realise themselves their position is too intellectually weak to be sustained on the grounds of logic and reason alone? For 50 years since I was ten I have suffered aspersions on my breeding and 'couthness' for questioning the logicality of, and evidence for, any religious proposition. It embarrasses me now to have to admit I reached that age before beginning to perceive a certain hiatus between the theory and application of the Christian religion, and that's likely the one in point here. In particular, about then Dart and Broom had been digging up the various *Australopithecus*es [*sic*] with photos being shown in newspapers, and the religious people in my little part of the world just wouldn't (and couldn't) talk about them. Not much changed in 50 years apparently.

A few ideas now, original perhaps, on the relevance of discussing theology in a scientific context. Let's begin like Socrates and define terms. I would not count as a fair dinkum scientist one who professes the title but does not consider as his main aim, 'at this point in time' (to coin a phrase they've not yet picked up in Canberra), the preservation of all forms of life on this endangered planet. I'd be generous enough myself to include in my concern, along with the Bilby and Noisy Scrub Bird, the lower forms too, not even excluding Christians and AIDS viruses, or at least temporarily until we see how the bickies crumble. I have been told by enough self-styled Christians (and again what other sort is there?) 'not to worry about extinction of life on the planet as we'll all be happy in heaven by then', to apprehend that the two driving motivations—religion and survival—are mutually exclusive, and if we really are worried about the latter, it's probably already past the time we kicked the former. (Please don't write in telling me I'm wrong on this point, or I'll likely write a book setting out the 1,001 incontrovertible evidences that support the thesis.) In fact, if I could only score a job as one of those immature editors Johnston denigrates, I reckon I'd be mature enough to hit on one logical guideline to use when deciding whether or not to publish any letter supporting the fundamentalist–spiritual, or whatever, cause. If it were not written, or at least countersigned, by one of the three singular divinities, I'd consign it to the WPB. Lions used to be recognised by claws. Surely that at least hasn't changed.

—Des Petersen
Bunya Mts, Qld

Frogs in Debt

I must thank the editors of ANH for the very fine selection of photographs, the layout and overall general appearance of the article I wrote on frogs (vol. 23, no. 1, 1989).

I would like to point out that the illustration of the life cycle of the frog was based on a line drawing by Bob Hamilton-Bruce, which was redrawn and coloured by David Kirshner. As I provided the line drawing myself, I feel that appropriate credit needs to be made to the original artist.

—Michael Mahony
SA Museum

QUIPS, QUOTES & CURIOS

COMPILED BY GEORGINA HICKEY
SCIENTIFIC EDITOR

Morning Sickness: Hard but Fair

Women who have experienced that wretched feeling of nausea during early pregnancy should appreciate this one. The fact that it is often considered to be a mere side effect of pregnancy with no benefits *per se* makes the condition even more vile. But research has shown that it may, after all, have some purpose. Margie Profet, now at Harvard University's Peabody Museum, has suggested that 'morning sickness' (a misnomer as it is not necessarily restricted to the morning) during the first trimester (three months) of pregnancy may have evolved as protection to the embryo against an array of toxic foods available to the mother (*Evol. Theory* 8: 177–190; 1988). The biochemical mechanisms triggering pregnancy sickness are not well understood, although some people have attributed it to hormone levels.

The symptoms of pregnancy sickness are nausea, vomiting and aversions to foods with bitter tastes and pungent odours. Pregnancy sickness usually begins within two to four weeks after conception, peaks near eight weeks and disappears by 14 weeks, the beginning of the second trimester.

Experiments have shown that particularly pungent or bitter foods signal the presence of toxins, be they bacteria in meat or noxious chemicals produced by certain plants as a defensive mechanism against predators. Cooking often destroys these toxins but the process can also volatise them, such that the mere smell of cooking fumes can cause a pregnant woman to rush to the bathroom. The nausea brought on by such fumes deters the pregnant woman from subjecting herself, and thus her embryo, to the potentially noxious substance.

If this is indeed the case, why then do most pregnant women only suffer from nausea in the first three months of pregnancy? According to research carried out by Profet, pregnancy sickness coincides with the period of embryonic development when the embryo is most harmed by toxins absorbed from maternal blood through the placenta and when it is least harmed by loss of maternal appetite.

ANTHONY FARR

Pregnancy sickness may have evolved to protect the fetus from harmful substances in certain foods.

It takes 15 days from conception for the embryo to develop a placenta. During the first week the embryo travels down the Fallopian tube into the uterus and is nourished by uterine secretions; during the second week, while implanting itself in the uterus, it derives nourishment by digesting the cells of the mucous membrane lining the uterus. Experiments have shown that, before implantation, harmful substances ingested by the mother generally do not cause adverse effects on the embryo. During the third week, when the embryo begins to absorb nutrients from maternal blood and to differentiate rapidly, it is extremely vulnerable to damage by toxins consumed by the mother. This coincides with the onset of pregnancy sickness. And because the embryo at this stage weighs only a few grams and has scant nutritional requirements, the associated decrease in maternal appetite causes little effect.

At about eight weeks from conception, after the period of fundamental organ differentiation, the embryo becomes a fetus. It undergoes much less differentiation, gains significant weight and increases its nutritional demands on the mother. The fetus is, in general, much less susceptible to severe disturbances than the developing embryo and, by the onset of the second trimester, when the nutritional demands of the fetus require a substantial increase in maternal food intake, pregnancy sickness usually disappears.

Several studies have shown that pregnancy sickness in the first trimester is indeed advantageous. Women who experience pregnancy sickness have significantly higher pregnancy success rates (fewer miscarriages) than those who only experience mild bouts or none at all.

So, when did pregnancy sickness evolve? Profet argues, if pregnancy sickness evolved to protect the embryo against an ever-changing array of toxins, then it most likely evolved during the Pleistocene (two million to 10,000 years ago), the period during which ancestral humans were hunter-gatherers. Hunter-gatherer diets were probably quite high in toxicity, since wild foods generally contain greater concentrations of toxins than do their cultivated counterparts. Women who suffered from first-trimester pregnancy sickness would have been discouraged from eating the more toxic foods of their normal diets and from experimenting with novel toxic foods; at the relatively low cost of incurring short-term nutritional deficits they would have been able to sustain viable embryos. Those women who had no pregnancy sickness would have consumed the potentially toxic foods willy nilly, increasing the likelihood of abortion or abnormalities.

Today 75 per cent of pregnant women living in industrial societies suffer from first-trimester nausea, with 50 per cent feeling so sick that they vomit. Almost 90 per cent record having food aversions—particularly to coffee, tea and vegetables. Although comparable data for hunter-gatherer societies are lacking, the fact that pregnancy sickness appears to be so variable may indicate a decrease in selection pressures for pregnancy sickness.

—G.H.

Making a Beeline for Honey

The navigational skills of many different animals have long fascinated people, especially the ability of Honeybees to find such small food sources as nectar. While the famous Honeybee dance holds part of the explanation, researchers have for many years suspected that bees navigate by sensing the Earth's magnetic field. That suspicion was fuelled by the discovery that bees carry tiny crystals of magnetite, or lodestone, in their abdomens (magnetite has also been found in tuna, salmon and pigeons): about one million crystals are large enough to be permanently magnetic in each bee.

Michael Walker and M.E. Bitterman, of the University of Hawaii, have now found the strongest evidence yet that bees use the crystals for navigation (*J. Exp. Biol.* 141: 447–451; 1989). They glued tiny magnetised pieces of steel wire onto one group of bees, non-magnetic copper wire to a second group, and left a third group untouched as a control. The wires were stuck to the treated bees directly above the site of the magnetite in their bodies, where, in the case of the steel wire, it could disturb the bees' magnetic field.

WADE HUGHES/LOCHMAN TRANSPARENCIES

Do Honeybees navigate by sensing the Earth's magnetic field?

In a series of experiments the bees were offered two identical feeding bowls, one of which contained sugar solution while the other contained a salt solution. The sugary bowl was in a strong magnetic field and the bees received a small electric shock if they fed at the salty bowl. The bees carrying the copper wire or nothing soon learned to discriminate between the two bowls, but the bees carrying the steel wire did not. The results strongly imply that when subjected to strong distortions in their magnetic fields, bees lose their sense of direction. Or does it mean they lose their sense of taste?

—B.B.

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

LOUIS JACOBS

Unlike modern crocodiles, this early Cretaceous specimen from Malawi, central Africa, had complex cusped hind teeth and jaws that could be moved backwards and forwards. If the teeth had been isolated (rather than fixed in a crocodile skull), they might well have been mistaken as belonging to Mesozoic mammals.

Mammal-like Crocodiles from Malawi

The study of palaeontology is full of surprises. But usually not as surprising as a suggestion that some teeth usually regarded as from Mesozoic mammals may have fallen from the mouth of a crocodile instead. At the 1988 annual meeting of the Society of Vertebrate Palaeontology in the USA, it was revealed that vertebrate palaeontologists from Southern Methodist University in Texas had discovered what they called 'mammal-like crocodiles'. Recently described in *Science* (244: 1064–1066; 1989), these small crocodiles lived during Early Cretaceous times, 140–100 million years ago, in Malawi, central Africa. Mammal-like reptiles have long been known: they include the ancestors and relatives of the mammals, but not crocodiles, which are more closely related to birds.

As we all know, mammals have teeth of different form in

different parts of the jaw: incisors at the front, molars at the back, and canines and premolars in between. In modern reptiles, such as crocodiles, snakes and most lizards, this is not true. Their teeth may vary in size from one part of the jaw to another but they vary only slightly in form. Most reptilian teeth are simple cones, modified only by being taller or squatter, or by being somewhat flattened. It has been thought that all reptilian teeth were much more uniform and did not have the cusps that grace human and other mammalian teeth. However a small dinosaur from South Africa, *Heterodontosaurus*, proved that some dinosaurs did have differentiated dentitions, although their grinding teeth were quite different from the cusped molars of mammals. The Malawi crocodiles do have conical teeth at the front, in the premaxillary and the front of the maxillary bones. However their hind teeth are rather more complex. They have a tall, slightly flattened central cone bordered on the front, lateral side and back by a cingulum (girdle) bearing up to eight smaller cusps.

The teeth do not occlude (meet) with the precision found in mammalian dentitions, but they do indicate that these crocodiles did more with their food than just crushing and swallowing it as do modern crocodiles. In fact, the jaw joint of these little reptiles shows that the jaw could be moved forward and backward, so that their food could be broken up by their elaborate teeth. In modern crocodiles the jaw joint is a hinge, so forward or backward movement is impossible.

The Malawi crocodiles have a deep and short snout, unlike either the broad, flat snout of the Saltwater Crocodile or the long, slender snout of the Freshwater Crocodile. Together with the notosuchians, another group of short-snouted crocodilians from Argentina, they were related to the line of descent leading to modern crocodiles. Their food preferences are not known but, because they were small, only about half a metre long, they may have eaten insects. Another Early Cretaceous short-snouted crocodile, *Uruguaysuchus*, had teeth shaped like those of plant-eating lizards. During the Early Cretaceous crocodilians were evolving in directions that they have long since abandoned.

But what about the mammal teeth? If crocodilians had complex 'molars', could any of these have been mistaken for mammal teeth? Well no, they probably wouldn't fool a real expert. But realising that most palaeontologists are not experts on Mesozoic mammals, one can only wonder what errors may have been avoided by the chance discovery of these crocodile skulls. Just think, had only the isolated teeth been found, not even an expert would have realised that they had come from a crocodile.

—Ralph Molnar
Queensland Museum

How Many Trees?

The Federal Government's plan to promote the growth of a billion more trees in Australia by the year 2000 has prompted a lot of debate. One of the key questions remaining to be answered is whether a billion trees will be enough to make good the over-zealous clearing efforts of this country's pioneers.

It is common knowledge that vast numbers of native trees have been removed or killed since European settlers arrived but until now there has been no reasonably scientific way to estimate how many trees have gone, nor how many are left. Thanks to an immense effort by a team of botanists and geographers in Canberra, however, we can for the first time gauge the approximate dimensions of the problem. Dr John Carnahan, a visiting fellow and former senior lecturer in botany at the Australian National University, has spent ten years compiling the first national vegetation maps showing Australia's current distribution of major plant communities. The project follows his earlier map of vegetation types present at the time of European settlement.

Staff at the Australian Surveying and Land Information Group (AUSLIG) have produced detailed maps from which it is possible to compare the changes that have taken place over the past 200 years. Team leader Mr Frank Bullen, also head of the Environmental Information and Mapping Unit (EIMU) within AUSLIG, has made broad estimates of the actual numbers of trees involved in the changes, based on average tree densities for each species group.

FRANK BULLEN

Two hundred years of change in Australia's forests and woodlands: green represents remaining forests and woodlands; yellow, the reduction in tree cover (mainly forests thinned to woodland); and red, almost total tree loss (forests and woodlands changed to pasture and cropland).

While Bullen concedes that the resulting figures are little more than indicative of the true picture, they are the best yet available, and quite sobering. He calculates that in 1788, Australia had a stock of about 60 billion mature trees. Since then, clearing for agriculture has been the main cause of tree loss: about 20 billion trees have gone, leaving about 40 billion today.

Although one billion trees will help Australia's land degradation problems, it still only represents five per cent of the number cleared, if Bullen's figures are reliable. That does not include, of course, the number of trees cleared from mallee country, since mallee is classed as a tall shrub, not a tree.

CSIRO researchers also point out that it may be necessary to replant more trees than were removed in some cases, to combat the biological and physical changes triggered by the initial clearing. John Ive, Doug Cocks and Chris Parvey, of the CSIRO's Division of Wildlife and Ecology, have tried another informal calculation to estimate how many trees would be needed to limit land degradation problems in the Murray–Darling Basin (*CSIRO Occas. Pap.* No. 3, 1989). They caution that their figures are at best educated guesses (but the best possible at this stage). Using a computer model to predict dryland salinity in the basin, they estimate that, to keep salinity to a level of moderate or better, about 15 per cent of the basin or 15 million hectares will have to be reforested. That would require about 12 billion trees. This can be compared with Bullen's loss of about ten billion trees (half the national loss) from about 30 per cent of the Murray–Darling basin.

—B.B.

Giving Way to the Left

"Do right-handers live longer?" (or 'do left-handers die earlier'?) was the question asked by psychologists Diane Halpern and Stanley Coren from California State University and the University of British Columbia respectively (*Nature* 333: 213; 1988). Acting on an earlier report that left-handers were virtually absent from the oldest age groups (80 plus) and thus seemingly indicative of sinistrality (left-handedness) being associated with reduced longevity, they decided to investigate the relationship of handedness and death.

Analysis of raw data gleaned from J.L. Reichler's *The Baseball Encyclopedia* (Macmillan, 1979) showed that the mean age at death for the 1,472 right-handed baseball players (laterality being determined when both throwing and batting hand were the same) was 64.64 years and for the 236 left-handers 63.97. This greater longevity for right-handers was found to be statistically significant, thus confirming the earlier suggestion that left-handedness is associated with reduced longevity. They believe that the absence of left-handers from the oldest age groups reflects a higher biological and environmental risk.

Several factors have been suggested by other workers to explain why the condition of sinistrality remains in a population of predominantly dextral (right-handed) people. The most prominent theory is that a combination of birth stress factors may result in brain damage that can lead to a switch in hand preference from the right side to the left; or that birth stress leads to a defect in development of normal asymmetry of the brain. Halpern and Coren suggest that the factors leading to the condition of sinistrality may also reduce the individuals' ability to survive. Alternatively, left-handers may simply have more accidents in an environment designed for a right-handed majority.

Any left-handed person reading Halpern and Coren's article may well have been concerned. Two people (one of whom, Richard J. Perry, was a self-confessed "incurable sinistral") wrote into *Nature* (333: 603; 1988) with the suggestion that the reason for there being fewer (or no) left-handed people in the older age bracket is *not* because of their higher biological or environmental risk, but because there was considerably greater pressure in the past for children to use their right hands. Children that used their left hand to write, play baseball (or whatever) were, more often than not, met with a swift rap of the offending knuckles and, as Friedrich Katscher writes, "the 'higher environmental risk' [the authors] assume existed was only the strong hand of father and mother who did not want their child to be 'abnormal'."

Halpern and Coren discount, for several reasons, societal pressures as an explanation for the life span trend toward reduced sinistrality (personal communication). Firstly, it is extremely difficult to convert hand use; secondly, the percentage of left-handers worldwide has remained relatively constant for over 50 centuries; and thirdly, studies in North America have revealed no historical increase (that is, over the last 100 years) in the number of sinistrals in the adult population.

The authors *do*, however, admit their baseball study has limitations (personal communication). The sample is biased in that it is all male (and therefore it is impossible to generalise the findings to females) and made up of atypically athletic (and presumably healthy) young adults. Halpern and Coren have since repeated the essential study of age at death as a function of handedness, using an unselected random sample of deceased individuals—the first study to do so. Questionnaires were sent to the next of kin listed on public death certificate records in two inland counties of southern California. Of the 2,875 letters sent out, they obtained 987 usable responses, 495 of which represented deceased males, 492 females. The as yet unpublished results show that the mean age at death for right-handers was 75.00 years, and 66.03 for left-handers; and 7.89 per cent of the left-handers (1.49 per cent right-handers) died in accidents, 5.26 per cent (1.37 per cent for right-handers) having died while driving a motor vehicle.

These latest results confirm those obtained from their archival study of deceased baseball players and support the hypothesis that left-handers *are* more susceptible to accident-related injuries. In no way are the authors implying that sinistrality *per se* causes reduced longevity. Rather, it is the accidents incurred in an environment designed for a right-handed majority, together with the correlates of sinistrality (such as covert neuropathy and reduced immune system efficiency, which may also result from pre- or perinatal birth complications and for which sinistrality can be considered a 'soft sign'), that lead to reduced longevity in left-handed people.

—G.H.

ANTHONY FARR

Left-handed people are apparently more susceptible to accident-related injuries in an environment designed for a right-handed majority.

The Sacrificial Sibling

While studying the ecology and distribution of seabird populations at Raine Island, my attention was drawn to an unusual breeding strategy called brood reduction (or, less politely, sibling murder) for two species of booby. The Brown Booby (*Sula leucogaster*) and Masked Booby (*S. dactylatra*) both produce a clutch of two eggs from which only one chick survives. Sometimes one egg is laid and very occasionally, for Brown Boobies, three; the norm, however, is two.

The eggs are laid between three and five days apart. The first egg is usually more than ten per cent larger than the second egg, is the first to hatch and produces a larger chick. This chick, which is then fed and brooded by the parents, grows for several days before the second egg hatches. Thus it is substantially larger and stronger than its new sibling.

The first chick does not accept the presence of its nest mate and attacks it more or less continually. Unable to retaliate, the newly hatched chick passively accepts the punishment offered. The two chicks also compete for food from the parents and, because the older chick is stronger and begs more vigorously than the younger, it is more successful. It also actively interferes with the smaller chick's attempts to beg and receive food.

The result is inevitable. The first chick continues to grow in size and strength, is alert and active in the nest, and maintains its attack on the younger sibling. The second chick, if it doesn't meet its death after being pushed out of the nest, loses weight from the day of hatching and becomes weak and emaciated. My own observations show that within three to five days of hatching, at most a week, the second chick is dead. Very rarely is a nest found that has two surviving chicks more than a fortnight old. In seven years of study at Raine Island, I saw only three such cases. Unfortunately I do not know whether any of these twin broods survived to independence.

The chick's survival depends on the ability of its parents to provide enough food for it. In tropical oceanic waters, which are generally low in productivity, a single egg and chick is usually the rule. Yet here we have two oceanic boobies that use a different strategy—laying and incubating *two* eggs to hatching but with only one chick eventually surviving.

Why then do the birds go to such trouble to waste half of their yearly reproductive output? What is the value of producing two eggs that produce only one surviving offspring? We must assume that this apparently wasteful system is adaptive. If it did not assist the survival of the species, it could not have persisted.

Samples of one-egg and two-egg clutches were examined in Masked and Brown Boobies by C.B. Kepler (*Publ. Nuttall Ornith. Club* 8; 1969) and J.B. Nelson (*The Sulidae*, Oxford University Press, 1978) respectively. They compared the proportions of each type of clutch that produced surviving offspring. No two-egg clutch was found to produce two fledglings; and, compared with one-egg clutches, two-egg clutches in both species had a significantly greater chance of producing one independent offspring.

How then might this benefit the parents' reproductive effort? Some advantage may come from the second egg or chick acting as insurance for the first. During the long incubation period (40 days) and for the first few days after hatching, two eggs (or chicks) in the nest means that, should one be lost through accident, predation or starvation, the other will be there to replace it. An attack by a single predator often results in the loss of one egg or chick, so the chances of the complete clutch being taken are less.

Is it wasteful to the parents? Apparently not, if we consider the weight of the eggs as a proportion of the weight of the adult female. The total weight of eggs produced by various species of booby with different clutch sizes is always around five per cent of the body weight of the female. Therefore, the two-egg clutch of Masked and Brown Boobies is no more taxing than, for example, the one-egg clutch of the Red-footed Booby.

This method of reducing the number of chicks in the nest (that is, 'sibling murder') is unique, although a similar system of brood reduction operates for the eggs of some gulls. The Glaucous-winged Gull (*Larus glaucescens*) and Herring Gull (*L. argentatus*) both have a three-egg clutch in which the last egg laid is smaller than and conspicuously different in colour and pattern from the first two. Observations have shown that, if the clutch is predated, then the last egg laid is more likely to be taken.

When considering the strategies that animals adopt, we must remember that the evolutionary process may not always produce the *best* method of solving a particular problem of survival; rather it acts to produce one that *works*. If you consider what the process of specialisation means, once a species is locked into a particular line of evolution, it must then follow that path in succeeding generations, thereby excluding other options. In many cases also, it is our ability to understand the way in which a system operates that is at fault, and our interpretation of the situation may be incorrect.

Whatever the explanation, these two booby species have adopted a novel, if seemingly heartless, method of solving a basic problem of species survival.

—**Brian King**
Queensland Museum

An older Brown Booby chick pushes its smaller and weaker sibling from the nest.

C.J. LIMPUS

Under the Shade of the Rattlepod Tree

A few jolly swagmen may have camped beneath a Rattlepod tree, but very little attention has been paid otherwise to this surprising native plant. Indeed, although it is commonly used as a shade tree in Queensland towns and cities, the Rattlepods planted there are descended from stock imported from India, before it was realised that it also grew naturally in northern Australia's monsoon regions.

Known also as the Indian Siris, or East Indian Walnut tree (*Albizia lebbeck*), the Rattlepod is slowly being recognised as a highly valuable addition to grazing lands. Dr Brian Lowry, of the CSIRO's Division of Tropical Animal Production in Townsville, has been studying the tree for its potential role in pastoral management.

Not only does the Rattlepod tree provide high quality fodder for cattle, but its abundant shade helps to conserve soil moisture.

BRIAN LOWRY

Within rapid succession over the period August to November, the tree drops all its big leaves, produces a vast crop of yellow flowers, then another large crop of the big (earlier-formed) seed pods that give it one of its popular names.

Nutritional studies have shown that the falling material makes high-quality fodder for cattle (especially the flowers) at a time when native pastures in the north are at their poorest (*Trop. Grassl.* 23: 84–91; 1989). Better still, the tree requires no management once established and its abundant shade actually helps to conserve soil moisture, rather than deplete it as some other trees do. And to top all that off, it provides cabinet-quality timber. All this makes its seeds definitely worth putting into your tucker bag.

—B.B.

MYSTERY PHOTOGRAPH SOLUTION

A Funnel's Fungal Shroud

This rather strange looking object is a Sydney Funnel-web Spider (*Atrax robustus*) that has died as a result of fungal infection. Spiders live from less than one year to more than 20 years depending on the group, but many succumb before their time to other predators and climatic exigencies or by contracting a variety of ailments. Some of these are exotic enough to appeal to the most hardened gore-monger.

The fungus that killed this funnel-web belongs to the genus *Cordyceps*, one of several fungi that infect spiders and insects. Their tiny airborne spores probably erode their way mechanically and enzymatically through the soft cuticle of the spider's abdomen and into the body cavity. Once inside, the spores germinate and the fungus grows rapidly, consuming tissues and producing a toxin that debilitates and eventually kills its spider host.

A Sydney Funnel-web Spider that has succumbed to fungal (*Cordyceps* sp.) infection.

MIKE GRAY

Having thoroughly colonised the spider internally, the fungal hyphae spread through the integument and, appropriately, cover the corpse in a glistening white shroud. Finally, as if adding insult to injury, the fungus produces a large phallus-like fruiting body that, in this case, appears to be growing from the spider's head.

An even more grotesque fate awaits spiders that are parasitised by certain nematode worms in the family Mermethidae. The adult worms are free-living and moisture dependent so that spiders living in damp areas are especially vulnerable. Tiny larval worms enter the spider's body cavity either directly or when the spider eats prey already carrying the larvae. Rather than poisoning its host like the fungus, the worm (usually only one develops) simply eats the spider alive from the inside. It is, however, selective in regard to the tissues it eats, for it is essential that the spider remains alive and thus a food-rich, protected environment for the worm. Consequently, the worm may consume the spider's entire digestive system, its reproductive system and much of its musculature, leaving the spider very debilitated but still alive.

By the time it is ready to 'hatch', the worm may be up to 30 centimetres in length, its thin hair-like body tightly coiled inside the spider's abdomen and sometimes extending into the cephalothorax. The worm emerges simply by rupturing the abdomen and crawling out through the hole, just like the creature in the sci-fi film "Alien". The spider, now largely an empty husk, collapses and dies.

There is one further oddity to add to this parasitic horror story. Some mermethid worms are aquatic as adults and must complete their life cycle in a pond or swamp. A spider carrying such a parasite will actually leave its web or burrow and migrate, automaton-like, towards a water source where the worm duly emerges. So these parasites not only consume their hosts but also manage somehow to manipulate the spiders' behaviour to their advantage.

These are just a couple of the more bizarre afflictions with which spiders must contend. Individually, such conditions are not common in spider communities (between zero and eight per cent incidence for worm infections) but, in conjunction with parasitism by flies and wasps, are significant sources of spider mortality.

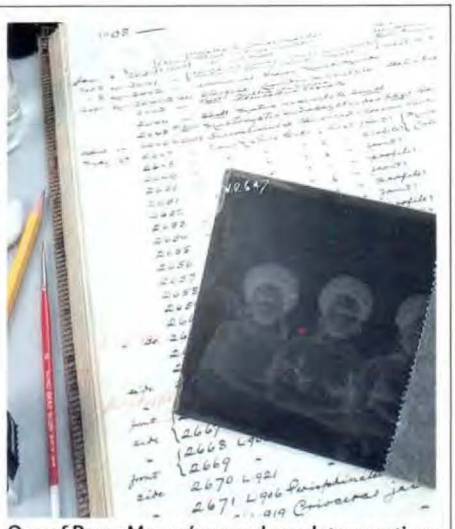
—Mike Gray
Australian Museum

"Without specific written documentation of historical photographs, interpretation of information presented within them is problematic."

MONEY IN GLASS PLATES

BY RIC BOLZAN & ELIZABETH BONSHEK

PHOTOGRAPHY SECTION, THE AUSTRALIAN MUSEUM
ANTHROPOLOGY SECTION, THE AUSTRALIAN MUSEUM



One of Percy Money's rare glass plate negatives of "native girls" from Collingwood Bay in Papua New Guinea, received by the Australian Museum in 1908.

WE'VE ALL HEARD STORIES ABOUT unknown treasure being found in museum basements or archives. Well, this happened recently in the Australian Museum's Photography Section, where 14 rare glass plate negatives of ethno-historical significance were discovered during a routine inquiry. They depict "native girls" from Collingwood Bay, Papua New Guinea, at the turn of the century and are part of a large number of photographs taken by Percy J. Money, an Anglican lay missionary.

There are several puzzling features of these glass plates. They were registered in the Photographic Register in 1908, but there was no record of this donation in the Anthropology Section's records. While it is not unusual that Photography should hold the negatives and record their accession in the Register, it is odd that there is no reference to these glass plate negatives in the archives of Anthropology.

By 1908 Percy Money had donated a considerable number of artefacts to the Australian Museum, complete with documentation. Because he had corresponded with the Museum for ten years while stationed at Wanigela in Collingwood Bay, the lack of information regarding the acquisition of these glass plates is notable.

Adding further to the mystery is the fact that there are variations in the conditions of the plates, indicating they had been separated at some stage, then reunited. The individual glass plates exhibit different types of physical deterioration yet they were all stored under the same conditions within the Museum. Seven have lifting and cracked emulsion, two have extensive mould growth, another two suffer from pinholed emulsion and the rest have various combinations of these problems.

On his return to Sydney, Money offered for sale a set of 100 prints (including some taken from the newly discovered plates) to every major museum in Australia for ten pounds. In a letter to the Australian Museum he noted they were "particularly valuable as they are the only ones of the kind in existence, and it will not be long before European influence will affect native habits". Some sets were sold as prints and others in albums with hand-written captions. The Australian Museum bought a set, as did the Queensland Museum, the Museum of Western Australia, the South Australian Museum and the Mitchell Library. The Natural History Museum of Carnegie, Pennsylvania, and the Bishop Museum, Hawaii, hold partial sets.

Four young girls in frontal view, showing facial tattoos and wearing body ornaments. On closer inspection the tattoos appear to be painted over with a dark substance. Without specific documentation we do not know whether this is standard practice or a device used by Money to ensure they would show up in the photograph.

In his correspondence with the Museum, Money stated that he wanted to present a documentation of the daily and ritual life of people living in the Collingwood Bay area, capturing customs that were already dying out. His photographs show scenes of food preparation, hunting, fishing, pottery making, bark cloth making and mourning ceremonies. These photographs are a valuable source of ethnographic information. Not only because there were no other photographs made or cultural material collected from that region at that time, but also because of their high quality.

Money carried out his task with notable respect for the people of the area. For example, he agreed to the decision of the elder men not to give him their sorcery objects, which were to be burnt on their conversion to Christianity. His Bishop was concerned that Money spent too much time collecting items and information for the Museum. He was directed to give the artefacts to the Church and to send only duplicates to the Museum. Money was con-

PHOTOS: RIC BOLZAN

Percy Money (centre) documenting Collingwood Bay customs with the help of a translator, Sem.

cerned about this directive because he wanted his collection to be housed properly and researched scientifically. In his view the only place these aims could be achieved was in a museum.

The glass negatives are especially valuable because all of Money's negatives were thought to have been destroyed. There are two theories regarding this loss. The first is that they were accidentally destroyed; the second that he destroyed the plates himself. It was a known, although not common, practice at that time to destroy original negatives after the production of limited-edition prints. However, due to his concern for the future of artefacts he collected, it seems unlikely that he would have destroyed the negatives intentionally. Only 13 other negatives by Money are known to still exist; these are held in the South Australian Museum.

Without specific written documentation of historical photographs, interpretation of information presented within them is problematic. How representative are they, in this case, of the lifestyle they claim to illustrate? Despite the intention of the photographer to be objective, no photograph can be truly unbiased. The creation of a photograph is the product of the interaction between the photographer and the subject.

In the newly discovered plate illustrated here, for example, four young girls are seen in frontal view showing facial tattoos and wearing body ornaments. The tattoos appear to be overpainted with a dark substance that makes them stand out. But is this overpainting normal, or a device used by Money to ensure that they would be recorded by the photographic emulsion? Considering the cost and effort of carrying heavy glass plates and associated equipment into remote areas, Money would surely have treated photographic sessions seriously. He would have taken as many precautions as necessary to achieve the result he wanted. The unusually formal composition indicates a considerable degree of cooperation, but what understanding did the girls have of the process or its complexity?

On another level, interpretation of these intriguing images is mediated by our own individual biases, experiences and knowledge. Just as Money's contemporaries focused on certain aspects, so do we. We may look at either the aesthetic, technical, ethnographic, botanic, erotic, photographic or political aspects. While individual cultural biases in interpretation do exist today, as they did in the past, these glimpses of a past lifestyle cannot be dismissed because of them. Rather we must recognise our own bias when we 'read' an image.

Material thought to be of marginal interest or value at one time takes on different values as the context in which it is viewed changes. The discovery of these glass plate negatives has added to the historical record, not only because of the images contained within them but also because they are now artefacts themselves. They form part of a historical record, not only of another culture but also of our own. The Australian Museum's responsibility as curators of this historic material will ensure accessibility and preservation for the future. ■

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Mr Ric Bolzan is Manager of Photographic Services and the Archival Photographic Collection of the Australian Museum. The collection contains some of the earliest natural history photographs in the world and excellent collections of ethnographic images. Miss Elizabeth Bonshek is currently working in the Anthropology Section of the Australian Museum, helping to sort and move the Pacific collection of artefacts. She is undertaking postgraduate studies at the University of Queensland on traditional designs of the Oro Province, Papua New Guinea.

"Some are born rare and some have rarity thrust upon them."

THE WHALE SHARK

BY GEOFF TAYLOR
UNDERWATER CINEMATOGRAPHER

THE WHALE SHARK (*RHINCODON TYPUS*) is the largest shark reaching lengths of 12 metres and, as such, is the largest fish in the oceans. Despite its sensational size, it has attracted little attention in the past and little is known about its migrations and breeding. This is largely because of its rarity and lack of commercial value. The Whale Shark is rarely eaten, although they have been taken by fishermen in the Caribbean Sea and Indian Ocean.

Some are born rare; what about the Whale Shark? The answer probably depends on whom you ask. Ask the fishermen of the Seychelles or Sri Lanka and some of them might say no. However, Jacques Cousteau, at the time of publishing his book on sharks in 1970, had only seen one pair of Whale Sharks after many years of cruising the oceans; and the late E.W. Gudger of the American Museum of Natural History, considered to be the world authority on Whale Sharks, took about 30 years to collect only 76 reports of encounters with them. The Whale Shark cause was later taken up by the late Fay Wolfson of the Hubb's Marine Research Institute in San Diego. She collected 320 accounts of Whale Shark sightings from records that went back to 1850.

Three hundred and twenty sightings in 140 years, documented by the scientific community: surely few large animals on Earth have such a meagre record? And what of the prevalence? The greatest number previously recorded was on the Kenyan coast, where 21 Whale Sharks were seen in two months along 550 kilometres of the coast.

All these facts reinforce the uniqueness of the relatively recent experience on the Ningaloo Reef in Western Australia. The North-West Cape sticks out into the Indian Ocean, taking the coastline closer to the edge of the continental shelf than anywhere else in Australia. The region has only been populated for the last 25 years. During the past seven years I have personally made over 150 Whale Shark sightings there. On one brief aerial survey, 28 Whale Sharks were sighted in 30 minutes along a 64-kilometre stretch of coast. Studies of the species over the past six years have shown that their annual appearance is predictable and correlates well with the annual mass spawning of coral.

So, *is* the Whale Shark rare? Well, the answer is 'yes and no' —it depends upon whom you ask and where you look. The Osprey is considered rare in the United Kingdom and is highly prized, yet they abound around our coastline. The Ningaloo phenomenon should not be taken for granted. For the first time we have the opportunity to study one of the world's most fascinating creatures, and it may be that the time for us to do so is running out.

Some have rarity thrust upon them; is the Whale Shark endangered? Almost certainly so. It is, in some respects, an enigma as to how such a large filter-feeder survives at all, living as it does in tropical seas, where the waters are notoriously devoid of nutrients. Although it comes as a surprise to many, it is well recognised by marine biologists that tropical waters are low in nitrogen and have low concentrations of phytoplankton, except in the immediate vicinity of coral reefs—hence the crystal clear waters of many tropical regions. Other filter-feeders such as the Humpback Whales migrate to the cold Antarctic and Arctic waters to find food and only visit the tropics to breed in the summer months. It seems the Whale Sharks must be dependent on the coral reef ecosystem to sustain them. The annual appearance of the Whale Sharks at Ningaloo would fit with this hypothesis.

Occasional sightings of Whale Sharks at Ningaloo are made throughout the year. However, it is in the autumn following the annual mass spawning of corals that their appearance has been found to be predictable. The release of coral eggs and sperm gives a massive boost to the food chain, and large slicks of spawn can be seen travelling out to sea on the out-going tide. Within a week the sharks appear. There are several theories for the Whale Sharks' appearance. Initially it was considered that they were migrating and it still appears that the majority of them sighted are travelling north. However, maybe they are swimming into the prevailing current. When such large numbers of a species aggregate, it is likely that they are breeding, but so far breeding behaviour has not been witnessed. The coral spawning is closely linked to the lunar cycle, one week after a full moon, and follows its annual precession. Likewise the appearance of the Whale Sharks has followed this pattern and the evidence is compelling that the spawning is the trigger for their appearance.

Yet the coral reefs themselves, both in Queensland and in Western Australia, have suffered severely in the last decade: in Queensland from the Crown of Thorns Starfish (*Acanthaster planci*) predation, and in Western Australia from a small snail (*Drupella cornus*). The effects of this must surely be passed on to all species that are dependent on the reef. Furthermore, Whale Sharks filter a huge biomass of small fish, jellyfish and plankton, and in doing so are vulnerable to concentration of toxic substances. Marlin caught on this coast are inedible because of the level of heavy metals in them, and this also applies to some shark species. We have no idea of the effects on the metabolism of such species of all the toxic products such as organochlorines that must inevitably find their way into the food chain. Historically, large species have not fared well on this planet. Whale Sharks will probably go the same way.

Is there any evidence to support this? Between 1983 and 1987 Whale Sharks were readily found each autumn along the northern reefs on the North-West Cape. During these same years the coral has been progressively destroyed by the snail *Drupella cornus*. There are now large tracts of the reef where destruction is almost total. This has obviously greatly reduced the amount of spawn released with each annual spawning. There is evidence that the Whale Shark behaviour is changing already and this year, despite a three-week search, only three Whale Sharks were sighted at the northern end of the reef, in areas where they had previously been in abundance.

Yes, the Whale Shark is rare and, sadly, getting rarer. ■

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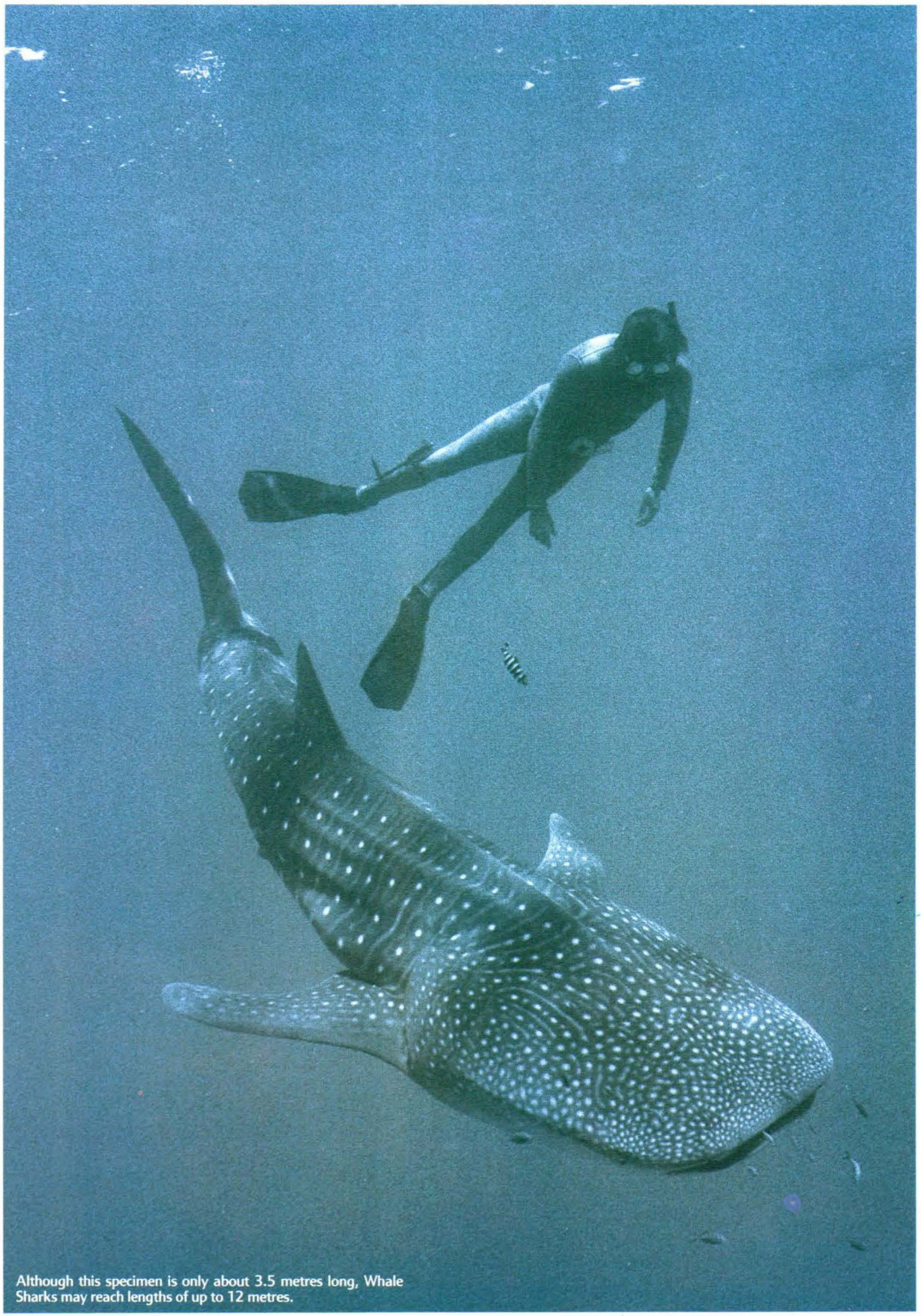
Dr Geoff Taylor is a medical practitioner in Exmouth, Western Australia, whose hobby is underwater cinematography. He has a special interest in Whale Sharks.



Although this specimen is only about 3.5 metres long, Whale Sharks may reach lengths of up to 12 metres.

PATRICK BAKER

"White Australians who express a disgust for grub eating betray their own cultural inhibitions."

WITCHETTY GRUBS

BY TIM LOW
NATURE WRITER

WITCHETTY GRUBS ARE PROBABLY the most famous of all bush foods and the most widely misunderstood. The fatty wood-boring grubs, larvae of the big grey cossid moths (*Xyleutes* species), are still regarded with disgust by most white Australians.

Bigoted colonists thought that Aborigines gobbled grubs from wretched necessity—to stave off ever-threatening starvation. We now know that Aborigines won a comfortable living from the bush, that starvation was never a problem except in the deserts during drought, and that witchetty grubs, along with a range of other insects, were, and still are, important and nutritious foods. They are high in iron and yield about 35 per cent fat.

But best of all, witchetty grubs taste wonderful. The nutty grubs, eaten raw or toasted at the edge of a fire, make a great treat for which there is no commercial substitute. Even as Aboriginal communities turn more and more to a Western diet, witchetty grubs remain popular. For example, at Cherbourg near Kingaroy, a community in Queensland where the language and traditions are all but forgotten, the people still gather a few fruits, the gums of two acacias (*Acacia bancroftii* and *A. pustula*), hunt "porcupines" (echidnas), and gather witchetty grubs. Lenny Duncan, an elderly member of the community, showed me eucalypt trees near the township bearing scars where grubs had been removed.

I have no doubt that future generations of Aborigines will continue to seek out witchetty grubs, and that a taste for these and other bush treats will help define Aboriginal identity in the future. Nowhere was this more obvious to me than on an outing last year with members of Theresa Ryder's extended family near Alice Springs.

We bought supplies at a supermarket then drove 50 kilometres north of town to picnic in a dry riverbed. On the journey out, the half dozen children were eagerly sucking iceblocks and munching potato chips. But, when we reached the picnic spot and Theresa pointed out the hole of a witchetty grub in a River Red Gum tree (*Eucalyptus camaldulensis*), the children gathered excitedly about.

Betraying the grub's presence was a swelling in the trunk, a tiny hole and a litter of sawdust below. Theresa chipped away the surface bark, inserted a grass hook, then to the squeals of the delighted children drew forth a large witchetty grub. Supermarket junk food had not dulled their enthusiasm for traditional tucker. Theresa made her hook from a stalk of curly windmill grass (*Enteropogon acicularis*). This is one of those special plants that allowed Aborgines to live a life of elegant simplicity. Always found growing beneath the kinds of trees that harbour grubs, it is perfectly designed for easy manufacture into a hook.

The witchetty grubs found in River Red Gum trees are considered good eating, but the best grubs of all are those found in the desert acacia called the Witchetty Bush (*Acacia kempeana*). Aboriginal women exposed the roots of these shrubs with digging sticks, collecting as many as 50 fatty grubs from one bush.

In eastern Australia an exceptionally

Janisa Ryder with witchetty grubs taken from a River Red Gum near Alice Springs. Witchetty grubs are still a very popular treat in central Australia.

PHOTOS: TIM LOW

Simple hooks for extracting witchetty grubs from tree trunks are easily prepared from the wiry stems of curly windmill grass, which grows beneath the trees.

large witchetty grub (*Xyleutes boisduvalii*) lives in the roots of eucalypts. After several years underground it emerges as a huge, sparrow-sized moth, believed to be the heaviest in the world, although as far as I can discover no-one has ever actually weighed one. So oily is this moth that specimens pinned out in insect cabinets invariably leak oil all over the drawer and, for this reason, they are usually gutted before mounting. Fatty moths of this size are very good eating and Aborigines harvested them as well.

Many people wrongly believe that any big white grub is a witchetty, including the curly grubs found in backyard compost heaps. These are larvae of scarab beetles and they do not taste as good, probably because of their musty diet. True witchetty grubs are moth larvae found only inside trunks or roots. Some writers extend the definition to include wood-boring longicorn beetle larvae (family *Cerambycidae*), as these look and taste similar, and Aborigines also ate them.

White Australians who express a disgust for grub eating betray their own cultural inhibitions. There is no basis for regarding oysters and fish eggs as gourmet foods and insect grubs as disgusting. They could learn from a story told by Constance Petrie in 1904 about her father Tom who, like many colonial lads, learned from Aborigines to eat grubs. After seeing Tom roast some grubs, "A man named Jack was awfully disgusted, and said he felt ill at the mere thought of eating such things! However, when the white boy took one, he followed suit after some persuasion, and liked the morsel so well that he ate more. In the end that man grew so fond of grubs that he would give the blackfellows tobacco to find him some." ■

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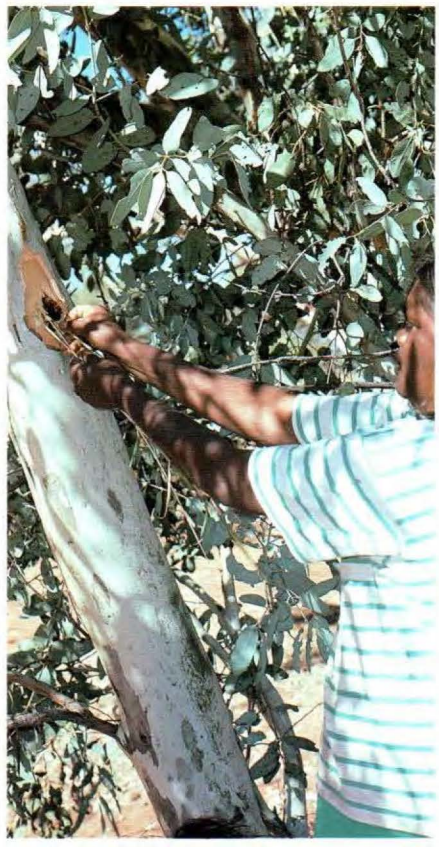
Tim Low B.Sc. is a full-time nature writer. He is the author of three wild food books, the latest being Bush Tucker, *which includes articles reprinted from his ANH column.*



Having felt the presence of a witchetty grub in its hole, Theresa Ryder twists her grass hook to embed its barb in the grub's fatty flesh.

Impaled on Theresa's grass hook, a witchetty grub is drawn from its hole, soon to be roasted and eaten at a Sunday picnic.

"What makes Tony unique in his unrelenting critique of behavioural theory? It has not made him popular in some circles."

HOMO PUGNAX: ANTHONY BARNETT

BY ROBYN WILLIAMS
ABC RADIO SCIENCE SHOW

I FIRST MET HIM IN 1972, ONE YEAR after he'd taken the chair of zoology at the Australian National University. Prof. S.A. Barnett sat opposite me in his ever so tidy office, his fingertips together as he spoke softly, very much like a friar muttering persuasively in the stillness about the perquisites of his monastery. There seemed to be a punctiliousness in his manner, as if he'd be very cross if one said something slipshod.

But then there were unmistakeable signs of impishness. His nameplate was in Hindi, sitting without explanation on the desk. Then came the little jokes, lots of them. Since that day we have done any number of broadcasts together and I'm quite surprised that Tony's manner is still perceived as severe, despite the exquisite drollness of his writing.

Tony Barnett is an ethologist, specialising in the behaviour of small mammals such as rats and mice. He's studied their reactions to stress: crowding, cold and sexual rivalry. The point of this research, apart from basic scientific interest, has been to fathom ways to minimise the depradations of rodent pests in the fields and forests of places like India. He has travelled to India many times and was indeed a founder of that nation's Ethological Society.

But what makes Tony unique is his unrelenting critique of behavioural theory. It has not made him popular in some circles. Fans of Konrad Lorenz and Robert Ardrey grind their teeth in incandescent fury over the devastating comment Tony has produced in response to some of their sweeping statements. The psychologist, Prof. B.F. Skinner and his more slavish disciples have fared no better. Anthony Barnett demands evidence. In the best traditions of scientific enquiry, he wants a clear statement of what you believe to be the case, a set of experiments designed to put that particular slice of nature on the spot, and then a rigorous assessment of what you've found: no more, no less. Too punctilious?

Not when you have the late Konrad Lorenz (he died in December 1988) making bizarre statements about the 'genetic decay' of the human race and our 'innate' tendencies to be aggressive and war-like. Not when you have writers such as Robert Ardrey giving the 'Territorial Imperative' a similar respectability in everyday conversation. This 'human nature' many people refer to, largely as a result of these popularisers, is accepted as flawed—at best the basis for our silly selfishness, at worst the cause of an inevitable World War Three; a kind of biological original sin.

COURTESY ANTHONY BARNETT

Profile of Anthony Barnett.

In 1975 Tony and I, with the ABC Science Unit's John Merson (writer and presenter of "Roads to Xanadu", on China) decided to produce a mammoth radio program on this subject, called simply "It's Only Human Nature". Prof. Peter van Somers, the psychologist from Macquarie University, joined us in the studio for the four-and-a-half-hour epic. Tim Bowden was the director. We spoke to Dr Desmond Morris, Prof. Steven Rose (author of *The Conscious Brain*), Sir Isaiah Berlin the philosopher, Margaret Mead the anthropologist, B.F. Skinner himself and many more. It was delightful to watch Tony, with sweet reasonableness and yet unrelenting precision, confront this daunting succession. At one stage late in the evening, I was so intent on watching him knock down arguments in that deceptively monkish manner, I didn't realise he'd actually stopped talking. Then I began to see two of him! It was the last time I drank wine during a 'live' broadcast. Listeners to the ABC Science Show, especially to the two series "Biological Images of Man" and "The Tree of Knowledge", will have already sampled the ideas it contains. But the wine merely made Tony more talkative.

In 1981 Tony Barnett's *Modern Ethology: The Science of Animal Behaviour* was published by Oxford University Press. It displays all the author's hallmarks: clarity, narrative, fun and a really compelling humanity. It's also beautifully written (Tony was a classical scholar at school but then changed to science, winning a scholarship to Oxford).

His latest work is *Biology and Freedom: An Essay on the Implications of Human Ethology*. It's just been published here by Cambridge University Press (1989). This is really Tony Barnett's summing up. There you have the grand sweep: scientific ideas on behaviour as they have grown this century from a small byway to a six-lane freeway of speculation and research; historical reference from ancient Greece to hippie culture; literary illustration in abundance from poetry to drama. It is an optimistic work to make sense of the intellectual turmoil created over the decades by nations of 'Naked Apes', 'Cave Men' and 'Noble Savages'. Let me give you a flavour of the range Tony Barnett allows himself. He writes: "We are not doomed to repeat, 'instinctively' or compulsively, the errors of our predecessors. All human communities can learn from their own or other's errors and successes, and can transmit what they have learned. When we try to do this, simple images of our species obscure understanding and obstruct action. Human beings and societies are infinitely diverse and changeable. We continually create novelty, and enjoy doing so. Freedom requires the recognition of complexity."

Biology and Freedom is highly recommended to everyone interested in the destiny of our species. ■

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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FRANK GROENEVELD

"If an entire sensory system has evolved de novo *in the Platypus, it must be considered a highly evolved animal and not just a primitive transition between reptiles and mammals."*

THE MONOTREME ELECTRIC

BY UWE PROSKE
DEPARTMENT OF PHYSIOLOGY
MONASH UNIVERSITY

"IF A PLATYPUS MUST ACTUALLY TOUCH before being aware of the presence of shrimps or other active prey that it so relishes and thrives upon in captivity, then, to my mind such wary creatures would be rarely taken alive when at large. On the other hand, if a *sixth* sense functions to assure direction, then it would be quite possible for a platypus to collect half of its own weight in live animal foodstuffs nightly, but not otherwise" (Harry Burrell, 1927).

Harry Burrell's prophetic words ring with a new note of significance following the recent discovery of electroreception in monotremes. German physiologist Henning Scheich and his Australian colleagues obtained behavioural evidence and made surface recordings from the brain of a Platypus (*Ornithorhynchus anatinus*) that indicated the animal was equipped with an electrosensory system. Their announcement in 1986 in the journal *Nature* was met with astonishment, almost disbelief. Yet neurobiologists familiar with electroreception had already speculated about the possible existence of such a sense in the Platypus.

A close-up of the surface of a Platypus bill showing the hundreds of pores. Notice that there are pores of different sizes and those of similar size tend to lie in strips running back from the front edge of the bill. The mucous sensory glands, which were shown to be the electroreceptors, are the largest pores.

What is electroreception? It is the ability of an animal to detect weak electric fields in its surroundings by means of specialised sensors located in the skin. The sensors detect voltage gradients from the minute electric currents generated across their receptive surfaces. These currents lead to the generation of action potentials—pulses of electricity that travel along nerve fibres and represent the nervous system's code for information transmission. When the action potentials reach the brain, brain cells analyse their number, frequency and where on the body surface they have come from, providing the animal with an awareness of the size of the electric field, its location in space and its strength. Incidentally, work by another Australian, Mark Rowe, suggests that the part of the brain concerned with electroreception is likely to lie right alongside the region where information about touch sensation is received. Maybe electroreception in the Platypus should be thought of as an unusual specialisation of its skin senses in much the same way as we consider the specialised sensory hairs, the vibrissae, in cats, rabbits and mice.

But why should the Platypus be equipped with an electrosensory system? Here it may be helpful to describe in more detail the behavioural experiments that led the Scheich group to make their claim. A Platypus, swimming freely in a large water tank, could be made to investigate a live battery placed on the floor of the tank. If it was replaced with a flat battery, the animal would ignore it. Similarly, the Platypus would overturn a brick behind which was hidden a live battery. Finally, the Platypus was able to detect and avoid a transparent plastic barrier placed in its way if the barrier had an electric field across it. So the Platypus appears to be attracted by sources of electricity as well as being able to use them to navigate around obstacles. To appreciate the significance of the Platypus' behaviour it is necessary to know that all animals, whenever they make movements, generate electricity in their contracting muscles. Thus each contraction is accompanied by a sizeable electric field in the animal's immediate vicinity. The Platypus' favourite food is freshwater shrimp. Scheich *et al.* calculated that the electric field generated by a single tail flick from a shrimp was large enough to be detected at a distance of ten centimetres by the Platypus.

So that was the reason for the Platypus' interest in live batteries! It thought they were sources of food. The Platypus feeds only in the water, commonly at night, and often the water is turbid. Sight would therefore not be much help in locating prey. In fact it has been known for a long time that, when a Platypus dives, it shuts its eyes, ears and nares. Thus under water the senses of sight and hearing are rendered useless and smell would be restricted to what the Platypus picked up from the water entering its mouth. So now it is believed that the Platypus is able to detect prey at a distance using electrolocation. During the final attack phase it probably also relies on information supplied by the many touch sensors that lie alongside the electroreceptors in the bill.

THE CONTRIBUTION THAT MY COLleagues and I have made to this story concerns the nature of the sensors. Scheich *et al.* knew that they lay in the bill but they did not know exactly what kinds of structures were involved. We were able to make the first direct recordings from the electroreceptors themselves. My colleague Ed Gregory and I had been working for a number of years on sensory receptors in skin and muscle of a variety of mammals. When we read the report by Scheich *et al.* we decided to try to identify the electroreceptors. For this work we were joined by two old friends, Archie McIntyre and Ainsley Iggo. I remember the occasion of the first successful experiment vividly. We had learned that Platypuses are very stress-prone animals, so the only reliable way to study them was to catch the animals ourselves and then transport them directly to the laboratory. On many a moonlit night we sat on the banks of a local stream, from time to time inspecting our nets and, during the many hours of waiting, solving the world's problems. To the surprise of most people Platypuses are not really rare; they are just shy so they are rarely sighted. Anyway, we soon had an animal in the net and before long we were recording from the nerve that supplies the skin of the bill, the trigeminal. Here again I remember vividly my astonishment. Skin nerves in most animals typically show little or no ongoing activity unless the skin is actually being stimulated. In the Platypus nerve there was a roar of activity from a steady barrage of action potentials in most of the nerve fibres. We soon found that, by applying weak voltage pulses to the moist surface of the skin with a bipolar electrode, this activity was modified. With the electrode in one orientation the activity would increase, with the reverse orientation it would cease altogether. The second important finding was that it was eventually possible to record from only a single nerve fibre and the activity in this fibre could be altered by applying a weak voltage pulse to a single discrete spot in the skin, less than one millimetre in diameter.

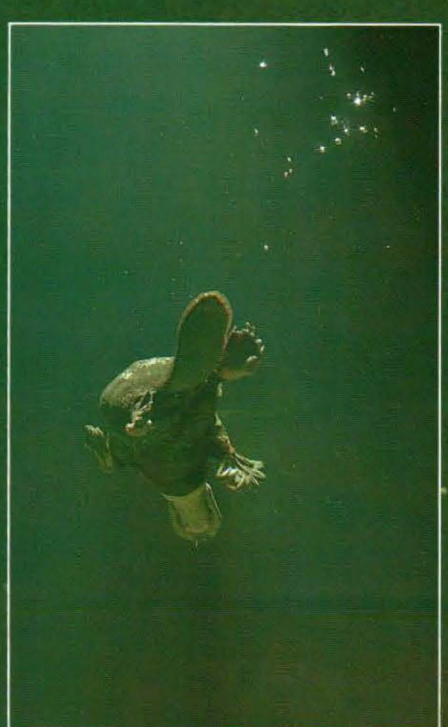
At this stage we were very much helped by a recent detailed account of the various kinds of nerve endings found in Platypus skin, reported by the German anatomists Karl Andres and Monika von Düring (1984). In particular, they described a mucous secreting gland that had numerous nerve fibres terminating in an expanded portion of the gland duct, about one millimetre below the skin. Andres and von During came to the important conclusion that this was some kind of sense organ and initially proposed that it might be a water flow detector. With our nerve fibre recordings we were able to track down single spots in the skin from which the electrically evoked activity was coming and, after marking a spot and examining it under the microscope, we were able to show that it was the site of one of these mucous sensory glands. What is remarkable about these structures is that they are completely different from the electroreceptors in the only other animal groups known to have such a sense, the fishes and amphibians.

In fish the receptor consists of a specialised hair cell that sits at the bottom of a canal and communicates with the skin surface. It is part of the acoustico-lateralis system, which is constructed rather similarly to our own inner ear. (Also it is supplied by the tenth cranial nerve and not the fifth as in the Platypus.) The receptor cell responds to a stimulating voltage by secreting a chemical, and that chemical in turn excites nerve fibres. In the Platypus the electric stimulus excites the nerve fibre directly and there is no chemical mediator. This is a fundamental difference, as is the fact that the nerve supply is different, and it

Recent research has shown that the Platypus detects prey under water by electrolocation.

means that the electrosensory system has evolved independently at least twice. It also teaches us that nature can construct something as basic as a sensory system, including the sensors, nerve fibres and receiving areas in the brain, in several quite different ways. The other interesting conclusion is that, if an entire sensory system has evolved *de novo* in the Platypus, it must be considered a highly evolved animal and not just a primitive transition between reptiles and mammals.

The electrosensory system in fish is used for 'passive' electrodetection as in sharks, which are able to pick up the presence of a flounder buried deep under the sand, or it may be 'active' where the animal generates its own electric field by means of an electric organ and the electroreceptors signal a disturbance of the field produced by approach-



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ing prey or predator. The Electric Eel generates an electric field strong enough to stun its prey. Other fish use bursts of electric pulses as a form of communication. We think the Platypus is a passive electrodetector like the shark. One interesting question is why aren't the electroreceptors in the Platypus stimulated by its own movements, its breathing or heart beat? We don't know the answer.

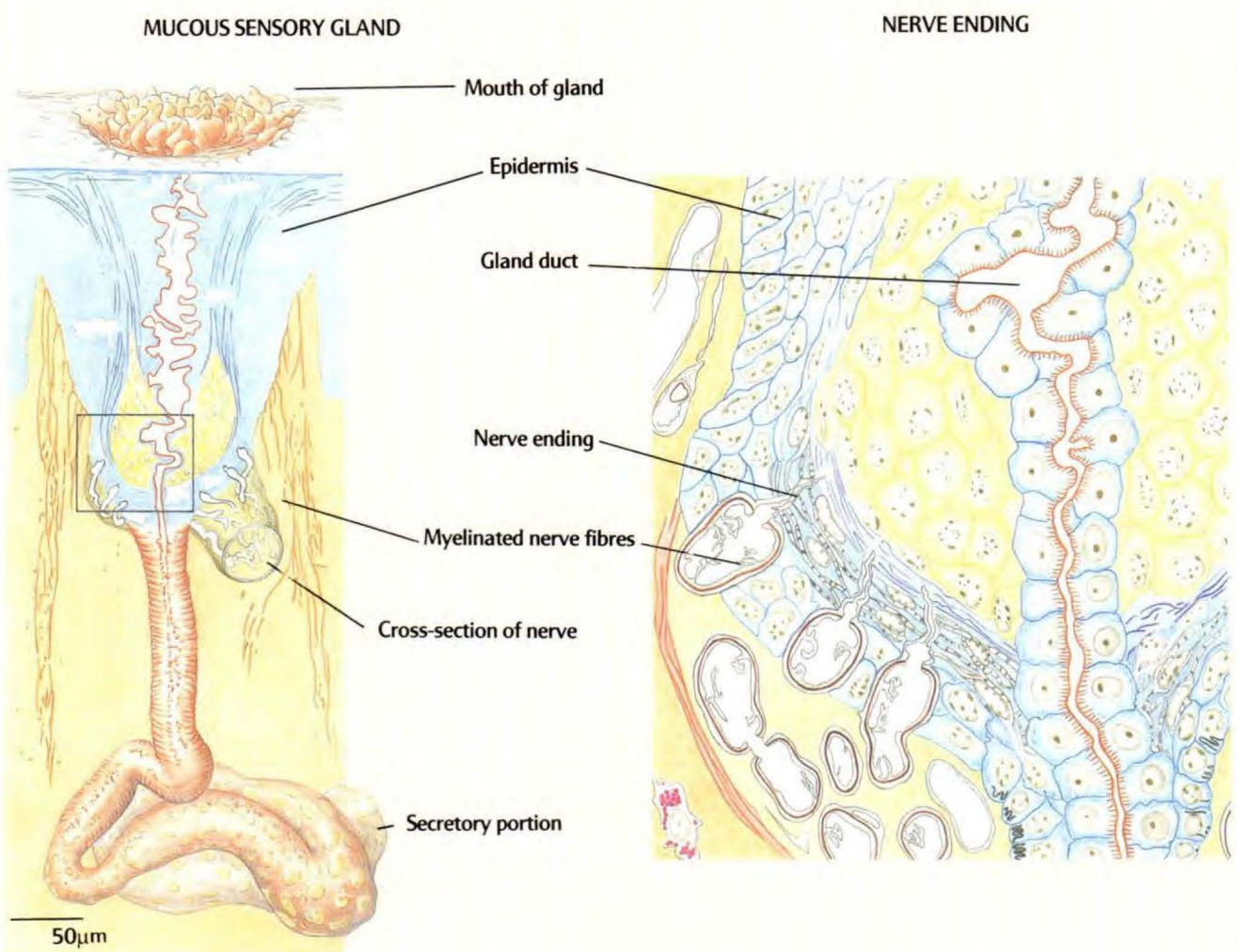
IN OUR STUDY OF THE RESPONSE properties of the electroreceptors we were particularly interested in the possible role they might play in the daily life of the Platypus. If the animal was going to be able to detect the tail flick of a shrimp, the receptors (= sensors) would need to be very sensitive, not just to steady electric fields, but to rapidly changing voltages as well. Furthermore, the receptors had to respond to such stimuli with the bill under water. We therefore made a series of measurements with the bill immersed in tap-water. The receptors did respond to alternating voltages applied through the water and they showed a maximum sensitivity to voltage pulses oscillating at 100 Hertz (that is, 100 pulses per second). Interestingly, Scheich *et al.* had calculated that the dominant frequency of the pulse generated by the shrimp's tail flick was 140 Hertz, close to the optimal reception range for the Platypus.

Thus the Platypus electroreceptors responded best to alternating voltages. If you ever watch a Platypus swimming freely in a tank or stream, you will notice that, while fossicking on the stream bottom, it continuously moves its bill rapidly from side to side. Is that to ensure that the electroreceptors remain in their optimal sensitivity range? The receptors are not distributed randomly across the bill but lie in lines that are visible to the naked eye. These lines extend over the shield—the flap of skin that extends beyond the base of the upper and lower jaws. The presence of such lines strongly suggests that the animal receives spatial information from the summed activity of its receptors. It therefore seems likely that the Platypus is not only alerted to the presence of a freshwater shrimp but is also able to tell how far away it is. The role of the shield has remained the subject of speculation for many years. Since it, too, has electroreceptors, perhaps it is important in helping to provide the Platypus with a three-dimensional view of its electric world!

IN THEIR ORIGINAL REPORT OF THE presence of sensory mucous glands in skin of the Platypus bill, Andres and von Düring mentioned in passing that they had also examined skin of the Short-beaked Echidna's (*Tachyglossus aculeatus*) snout and there, too, they had found these glands. Little is known about either of the two echidna species' sensory abilities (there is also a New Guinea species) and certainly, until now, no-one had suggested they might include an electric sense. Nevertheless, in view of the anatomical findings, we decided to try and search for electroreceptors in the Australian echidna's snout. The method was much the same as we had used with the Platypus.

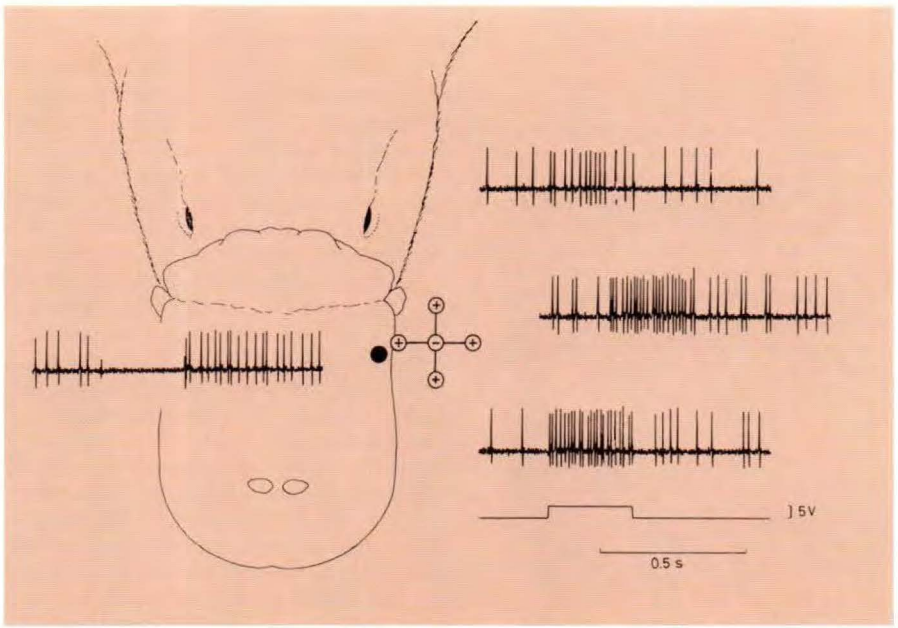
First impressions of activity in nerves supplying the snout was that they were much quieter than in the Platypus, with

Large mucous gland with sensory innervation, common in skin of the Platypus bill and now known to be the site of electroreceptor activity. The whole gland, including the secretory portion, is shown in longitudinal section (left) and the bulb-like swelling at the base of the epidermis where the nerve fibres terminate is shown in expanded view (right). Myelinated nerve fibres terminate at the epidermal border and send long filamentous processes into the inner core of cells through which the gland duct passes. These filamentous processes are probably the region of the nerve fibre that is selectively sensitive to electricity. (Redrawn from Andres and von Düring 1988).



LYNNE ALBERTSON

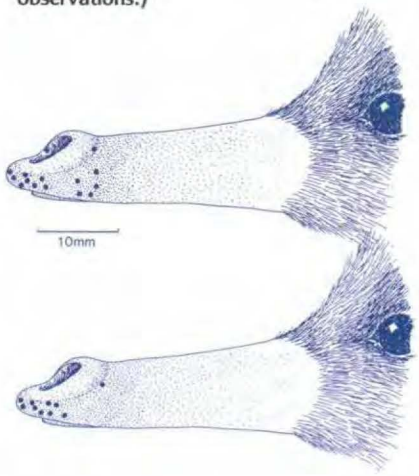
fewer nerve fibres showing ongoing activity. However, electrical stimulation of skin close to the snout tip soon revealed electrosensory spots from which patterns of activity, similar to those seen in the Platypus, could be generated. Yet there were several differences. Apart from the lack of ongoing activity, responses were weaker and covered a narrower frequency range than in the Platypus. There were also far fewer electroreceptors compared with the Platypus and these were all crowded into the snout tip. The rest of the snout was supplied only with mechanically sensitive and temperature sensitive receptors. Incidentally, during our searches for electroreceptors in both the Platypus and the Echidna, there was never any risk of confounding electroreceptors with the many mechanoreceptors located in the same region of skin and that presumably provide the animal with its sense of touch. Electroreceptors were insensitive to mechanical stimuli and, conversely, it required quite large voltages to stimulate mechanoreceptors with electric pulses. To give some idea of our own ability to sense electricity, we are readily able to detect the voltage in a 1.5-volt battery with the tip of our tongue. Both the Platypus and Echidna respond reliably to voltages 1,000 times smaller, far below our own detection threshold.



Recordings of activity in a nerve fibre supplying a single electroreceptor. The site of the receptor in the bill skin is shown on the diagram by a black dot. The bill is immersed in a bath filled with tapwater. The activity in the nerve was recorded in response to a voltage pulse applied in the water with a bipolar stimulating electrode placed close to the edge of the bill. Responses were recorded to four different electrode orientations. The negative terminal of the electrode (⊖) was always kept in the same position while the positive terminal (⊕) was rotated through 90° C. The nerve activity evoked by a voltage pulse with each electrode orientation is shown in the trace alongside. Notice that the receptor showed activity in the absence of stimulation and that, when the positive terminal was closest to the receptive spot, the ongoing activity was interrupted during the voltage pulse. For the three other orientations activity increased during the pulse.

FRANK GROENEVELD

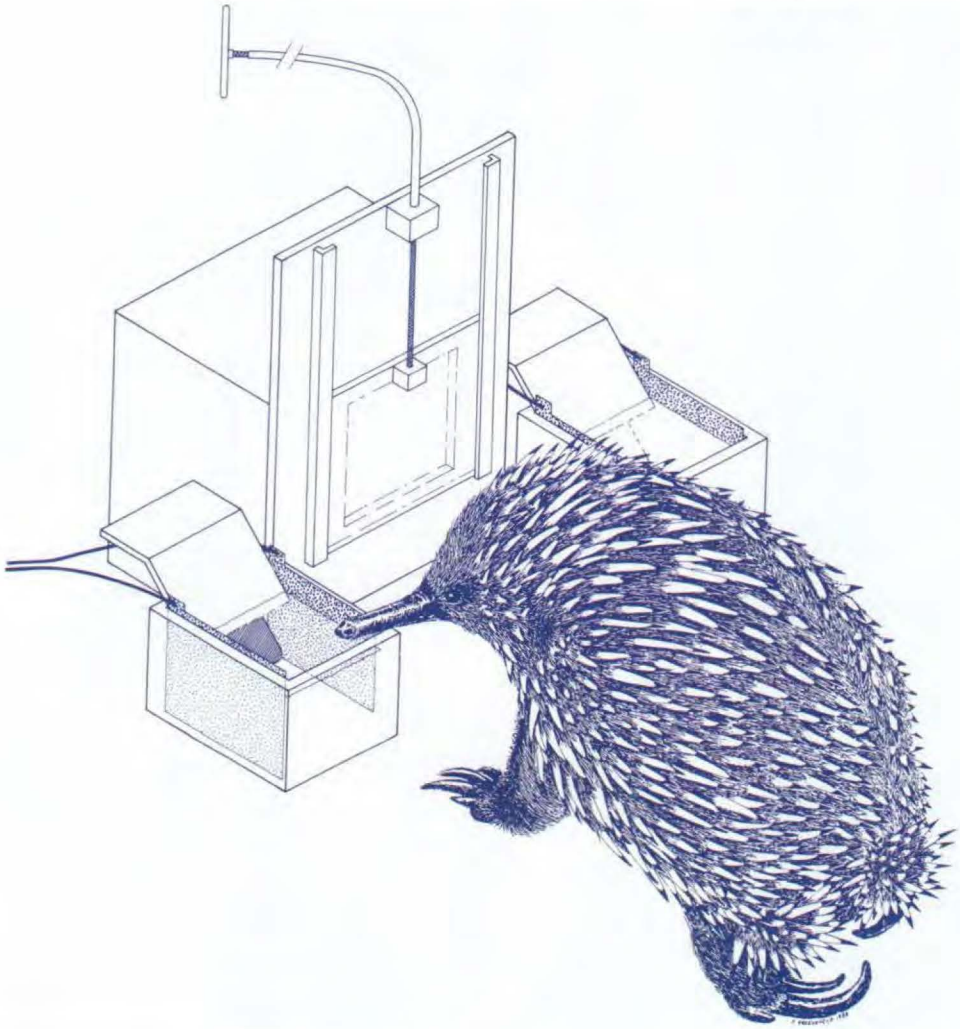
Distribution of electroreceptors in the snout of the Short-beaked Echidna. The lower view shows the location of ten electrosensitive spots determined by weak electrical stimulation of the skin surface. The upper view shows the location of mucous sensory glands determined by sectioning of the skin and examining it under the microscope. The fine stippling in both views shows the location of structures in the skin that are probably touch receptors. (Upper panel redrawn from unpublished work of Andres and von Düring; lower panel from the author's own unpublished observations.)



When we had established the presence of nerve endings selectively sensitive to electricity in the snout of the Echidna, we naturally wondered whether the Echidna actually makes use of this extra sense. Since the Echidna is closely related to the Platypus, it seemed possible that it had 'inherited' these receptors but that they were not functional (just like our own appendix). At Ed Gregory's suggestion we decided to design a behavioural experiment that would test for an electric sense in the Echidna. The apparatus consisted of two troughs filled with tap-water, in one of which was an electric field. We then trained an Echidna to choose between the two troughs and to pick the one with the field. To make its choice the animal had to press a lever submerged in the water. If it made the correct choice, a sliding door behind the trough would open and give the animal access to food. After a preliminary training period the animal quickly learned the task. In fact, we marvelled at its intelligence. It would first approach one trough, place the tip of its snout in it, then try the other, and finally commit itself to one side by pressing one of the levers. The animal was able to make significant numbers of correct choices, down to field strengths of 1.8 millivolts per centimetre, a value close to that obtained by direct measurement from single receptors.

To sum up, we have confirmed the existence of an electrosensory system in both the Platypus and the Echidna by making direct recordings from nerve endings in the skin. The behavioural experiments on the Echidna confirm that this sensory system is also fully functional and therefore cannot be dismissed as an evolutionary vestige. An important question that arises from this is, for what purpose does the Echidna use its electroreceptors? Preliminary attempts at recording from moving termites and ants, the Echidna's favourite food items, have revealed no sign of any electrical activity. Perhaps the Echidna relies on this sense for detecting other animals such as larvae and worms buried in moist soil. Here it is of interest that an Echidna always has a runny nose. Is this to maintain a pathway of low

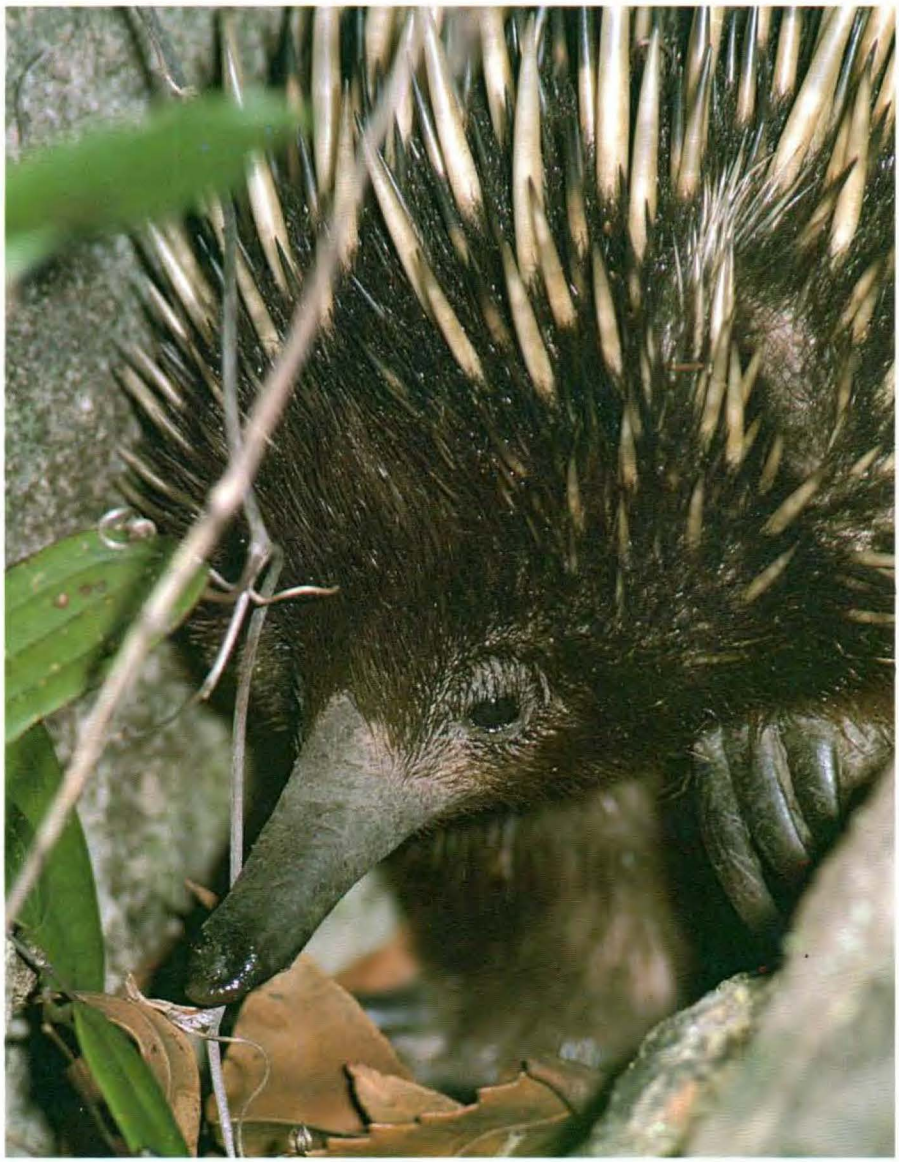
Apparatus used to test the Short-beaked Echidna's ability to detect electric fields. It consisted of a central food container, access to which was controlled by a remotely operated sliding door. At each side of the container was a tap-water-filled trough with a lever at the bottom. An electric field could be set up in the water by applying a potential between two aluminium plates placed along opposite walls in the trough. The field could be switched, at random, from one trough to the other. The animal had to correctly choose the trough with the field and press the lever to be given access to the food bin.



KATHIE ATKINSON

Preliminary attempts at recording moving termites, the Echidna's favourite foods, have revealed no sign of electrical activity.

electrical resistance between sources of electricity in the soil and the receptors? Another important question concerns the Long-beaked Echidna (*Zaglossus bruijni*) from New Guinea. Does it too rely on electroreception in its search for food in the leaf litter on the rainforest floor? ■



FORD KRISTO

The Echidna always has a runny nose. Perhaps this enables the maintenance of a pathway of low electrical resistance between the receptors in the snout and sources of electricity (larvae or worms?) in the soil.

Suggested Reading

Andres, K.H. & von Düring, M., 1984. The platypus bill. A structural and functional model of a pattern-like arrangement of different cutaneous sensory receptors. Pp. 81–89 in *Sensory receptor mechanisms*, ed. by W. Hamann and A. Iggo. World Scientific: Singapore.

Burrell, H., 1927. *The platypus*. Angus and Robertson: Sydney.

Gregory, J.E., Iggo, A., McIntyre, A.K. & Proske, U., 1987. Electroreceptors in the platypus. *Nature* 326: 386–387.

Scheich, H., Langner, G., Tidemann, C., Coles, R.B. & Guppy, A., 1986. Electroreception and electrolocation in platypus. *Nature* 319: 401–402.

Dr Uwe Proske is a reader in physiology at Monash University in Melbourne. He has been working for many years on the properties of sensory receptors, but the mainstream of his research is concerned with receptors found in our limb muscles and how these help to regulate posture and movement. His recent adventure with Platypus receptors remains a fascinating sideline.

"The unnatural separation of sketch and completed painting seemed, somehow, symbolic of the way his life was rent between two countries—Austria and England—and their two cultures."

RECOGNITION AND RENAISSANCE:

FERDINAND LUCAS BAUER
1760–1826

BY MARLENE NORST
PROFESSIONAL HISTORIANS ASSOCIATION, SYDNEY

FERDINAND BAUER WAS ONE OF THE SIX SCIENTISTS personally selected by Sir Joseph Banks to accompany Matthew Flinders on his circumnavigation of Terra Australis. Neither the fact that Bauer was Austrian and the only 'foreigner', nor the fact that he was almost twice as old as his travelling companions, seems to have worried Banks. He was simply interested in securing the services of the best available botanical artist. Ferdinand's salary was fixed at 300 guineas plus rations for himself and his servant Powel, and he was required to work under the direction of botanist Robert Brown.

Although the emphasis, due to Banks' strong predilection, was on the study of botany, Bauer was asked to pay some regard to zoological subjects. Even today, many naturalists are unaware that he also excelled in this field. He seems to have produced the first pictures that embody the unique quality of the Australian fauna. Unlike the French illustrations of that period, including those of Charles Lesueur that show great craftsmanship but so often give the animals thin, fierce features, Ferdinand's sketches show the gentleness of many of the creatures he depicts. Without falling into the trap of anthropomorphism, he endows each with the personality and energy peculiar to it. A fine example is the frog, which is poised ready to leap from the page.

Rainbow Lorikeets (*Trichoglossus haematodus*).

Ferdinand Lucas Bauer seems to have been destined to become an artist and naturalist. He was born in 1760 the youngest son of Lucas Bauer—court painter to the Prince of Liechtenstein and his wife Theresia—but was left fatherless in his first year of life. Together with two of his brothers, Joseph Anton and Franz Andreas, he was later placed in the custody of Pater Norbert Boccius, a physician and botanist who was Prior of the monastery in Bauer's birth place, Feldsberg. Here his scientific training really began and he learned to observe minute differences in structure and to distinguish nuances of colour tone. Ferdinand was still in his early teens when he began to contribute miniature botanical drawings to Pater Boccius' collection, which eventually extended to 16 volumes.

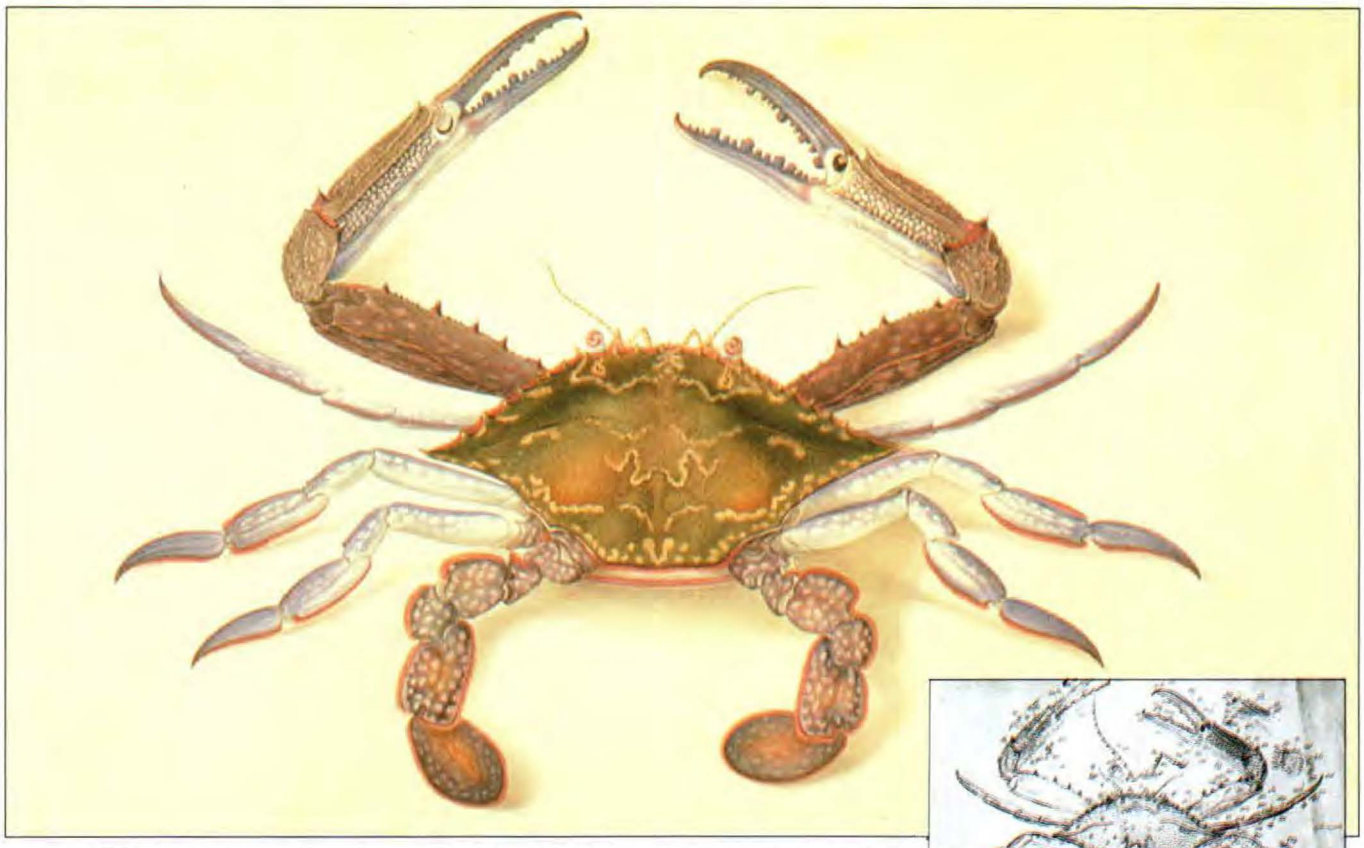
In 1780 Franz and Ferdinand were sent to Vienna to work under the direction of Nikolaus von Jacquin, foremost European botanist and Director of the Royal Botanical Garden at Schonbrunn Palace. Here they were introduced to the Linnean taxonomic system, with its emphasis on structure, and contributed to Jacquin's *Icones Plantarum Rariorum* (1781–86). Ferdinand also took lessons in landscape painting. It was during this time that he

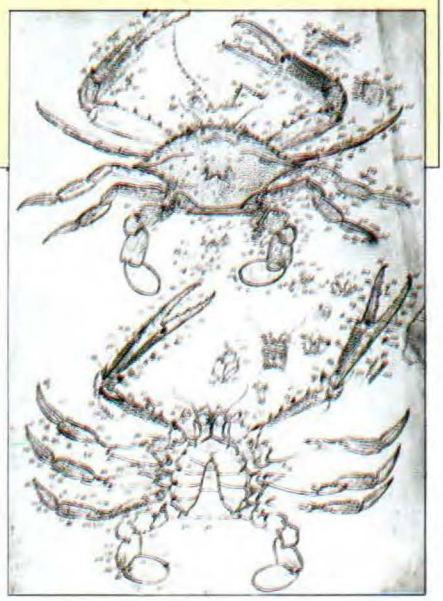
Bauer drew from life. This Golden Bell Frog (*Litoria aurea*) seems ready to leap from the page.

BRITISH MUSEUM (NATURAL HISTORY)

Bauer spent much effort detailing the reproductive system of each plant. Shown here is a *Petalostigma* species, originally identified as *Xylococcus sericeus*.

BRITISH MUSEUM (NATURAL HISTORY)





BRITISH MUSEUM (NATURAL HISTORY)

NATURHISTORISCHES MUSEUM VIENNA

Intent on capturing accuracy in tone and unable to carry with him the full range of colours, Bauer developed a code using numbers up to four figures that enabled him to finish the drawings at his leisure but with perfect accuracy. The Blue Swimming Crab (*Portunus pelagicus*) is the best example of colour-coded sketch and finished watercolour.

most probably met Mozart who was a regular visitor to the Jacquin family, composing Notturni for their musical evenings.

The next stage in Ferdinand Bauer's development as a naturalist painter came as the result of an invitation to accompany John Sibthorp, Sherardian Professor of Botany at Oxford, to Greece and Asia Minor. Jacquin had recommended him as the artist best able to assist Sibthorp in the delineation of medicinal plants. They completed their field work some 18 months later and returned to England in December 1787 with over 1,500 sketches including plants, animals, birds and landscapes. Ferdinand prepared the sketches for the engraver John Sowerby and the first of ten volumes appeared in 1806 after Sibthorp's death. Sir James Smith, who took over the editorship, wrote in the Latin introduction to the work: "Sibthorp took with him a painter of excellent reputation, Ferdinand Bauer, whose merits our illustrations demonstrate." Joseph Dalton Hooker was later to call the *Flora Graeca* with its 966 superbly hand-coloured illustrations "the greatest botanical work that has ever appeared" (*On the Flora of Australia*, London, 1859).

In 1788 Ferdinand's brother Franz was appointed by Sir Joseph Banks as chief botanical artist at Kew Gardens and the two brothers became accepted members of the scientific fraternity in London. Therefore it is not surprising that, when Banks organised the voyage of the *Investigator*, he thought of Ferdinand.

FERDINAND WAS A VERY ABLE, PRACTICAL botanist who collected his own samples, sketched them while they were still alive, coded them for colour and then dispatched the dried specimens to Austria. In a spirit of willing cooperation that seems to have marked their relationship, he also supplied Robert Brown with substitutes when the latter lost many of his best specimens on board the *Porpoise*, unhappily wrecked on the journey back to England. His industry and the standard of his work earned him the admiration of both Flinders and Brown. In his first letter to Banks from Port Jackson, dated 20 May 1802, Flinders praised them both: "[It] was fortunate for science that two such men as Mr Brown and Mr Bauer have been selected, their application is beyond what I have been accustomed to see." Brown, writing to Banks some ten days later, reported that Bauer had made 350 plant sketches and 100 of animals, and had "indeed been indefatigable and . . . bestowed infinite pains on the dissections of the parts of fructification of the plants."

Since he was intent on capturing accuracy of tone and shading, and found it impossible to carry with him the range of colours needed, his preliminary sketches are covered profusely with sets of numbers up to four figures. Banks was amazed by Bauer's precision. Writing to Marsden in January 1806 after Bauer's return to London, Banks says of the sketches that they "were prepared in such a manner by reference to a table of colours as to enable him to finish them at his leisure with perfect accuracy". He goes on to marvel: "[It] is beyond, what I confess, I thought possible to perform." The secret of the colour code has never been revealed but I feel confident that, using modern technology and referring to pictures like those of the Blue Swimming Crab, which we now have as a numbered sketch as well as in its final coloured form, it should be possible to break the code.

In Nuyts Archipelago Flinders named various points after members of the ship's company and the Austrian natural history artist had Cape Bauer near Streaky Bay in South Australia named in his honour. More than a century later, during World War I, when anything even remotely German in sound was rejected, Cape Bauer was renamed Cape Wondoma. Subsequently in 1925, Bauer got his Cape back, although on most maps the cartographers regrettably failed to restore his name.

When Flinders, in June 1803, resolved to

Unlike other illustrators of his time and without falling into the trap of anthropomorphism, Bauer manages to evoke the gentleness of the creatures he depicts.

return to England in order to obtain a replacement for the leaking *Investigator*, Bauer and Brown decided to remain in Australia to await his return. While Brown went to Van Diemen's Land, Bauer left for Norfolk Island where he spent about eight months. He also undertook excursions to Newcastle, the Blue Mountains and the south coast of New South Wales. When Brown and Bauer finally returned to England on the barely seaworthy *Investigator*, 11 cases of drawings by Bauer had been dispatched, containing 1,542 of Australian plants, 180 of Norfolk Island plants and over 300 of animals. In fact, although his brother Franz came to be renowned for his work with the microscope and his dissections for the eminent physiologist Sir Everard Home, Ferdinand was equally skilled, as his zoological dissections on the Australian voyage clearly show.

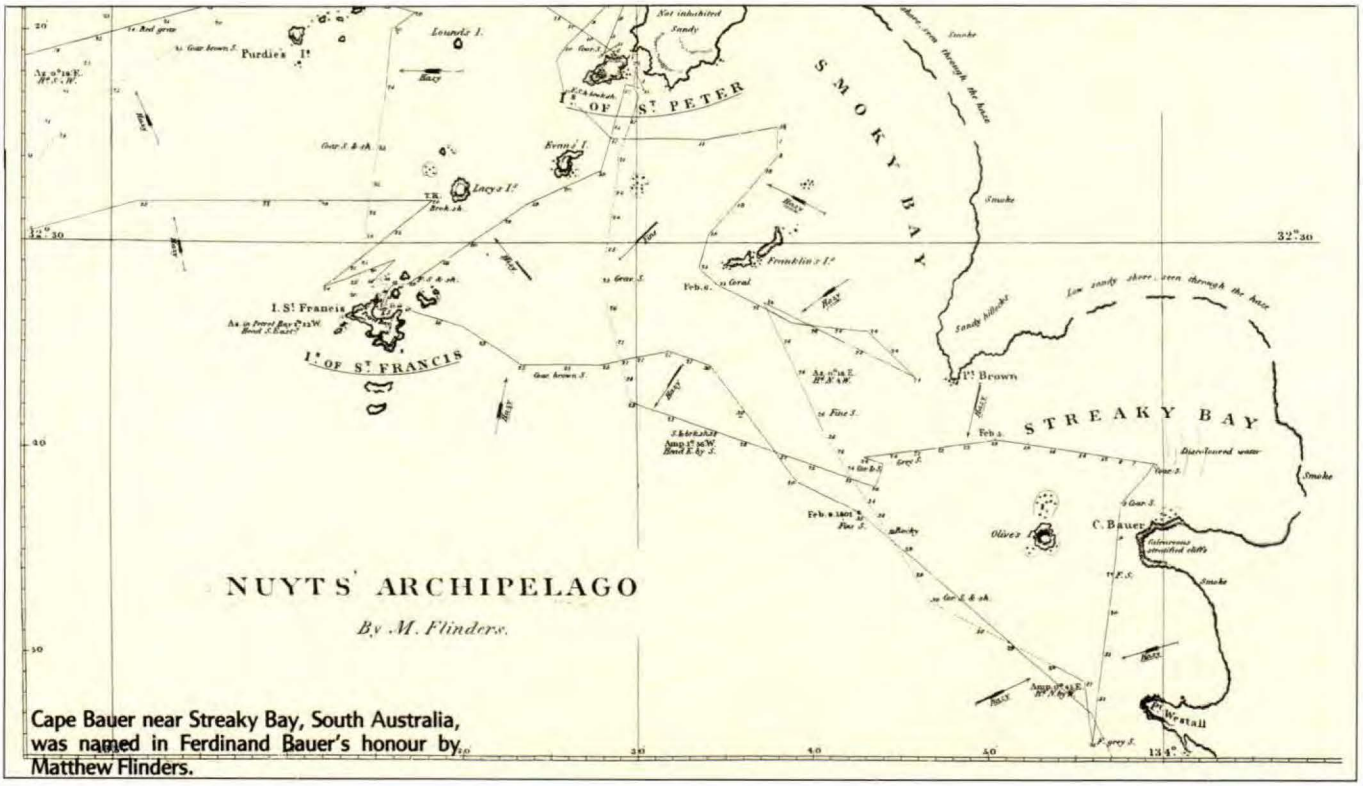
After their return to England on 13 October 1805, Banks persuaded the Admiralty to employ Bauer at his old rate of pay to allow him to publish "a succinct account of all the plants as he shall think worthy to be communicated to the public". For the next five years Bauer worked on the *Illustrationes Florae Novae Hollandiae*, intended as a companion volume for Brown's *Prodromus*, doing all the engraving himself. He also contributed ten plates to Flinders' *Voyage to Terra Australis*.

From 1806 to 1813 three parts of Bauer's *Illustrationes*, containing 15–16 plates, were published. Only 50 sets were printed, some of which were hand-coloured. Unfortunately the publishing venture was a failure and, bitterly disappointed, Bauer returned to Vienna in 1814. He acquired a small house in Hietzing near the Schonbrunn Botanical Garden and spent his time painting and making excursions into the Austrian Alps until shortly before his death from dropsy on 17 March 1826. The bulk of his finished paintings was acquired by the British Admiralty and, in 1843, transferred to the British Museum together with additional paintings that Robert Brown had bought from Franz Bauer. Most of the sketches of both flora and fauna, as well as the herbarium and a collection of skins, were acquired by the Austrian Imperial Museum and are now housed in the Natural History Museum (*Naturhistorisches Museum*) in Vienna.

In 1833, seven years after Bauer's death, the Austrian botanist Stefan Endlicher published his *Prodromus Florae Norfolkicae* using Bauer's pencil sketches and his herbarium collection. He gratefully acknowledged Bauer's contribution in both title and preface: "Whatever profit redounds to science from this small work, I believe is owed to the work of Bauer in gathering the plants, to his skill in drying them, and to his clearly God-given talent in painting them."

Endlicher had access to sketches of plants now extinct, such as *Streblorrhiza speciosa*, the Phillip Island Glory Pea. It is interesting to note that attempts have recently been made by Professor Riedl of the Vienna Natural History Museum to grow the plant from seeds collected by Bauer in 1804.

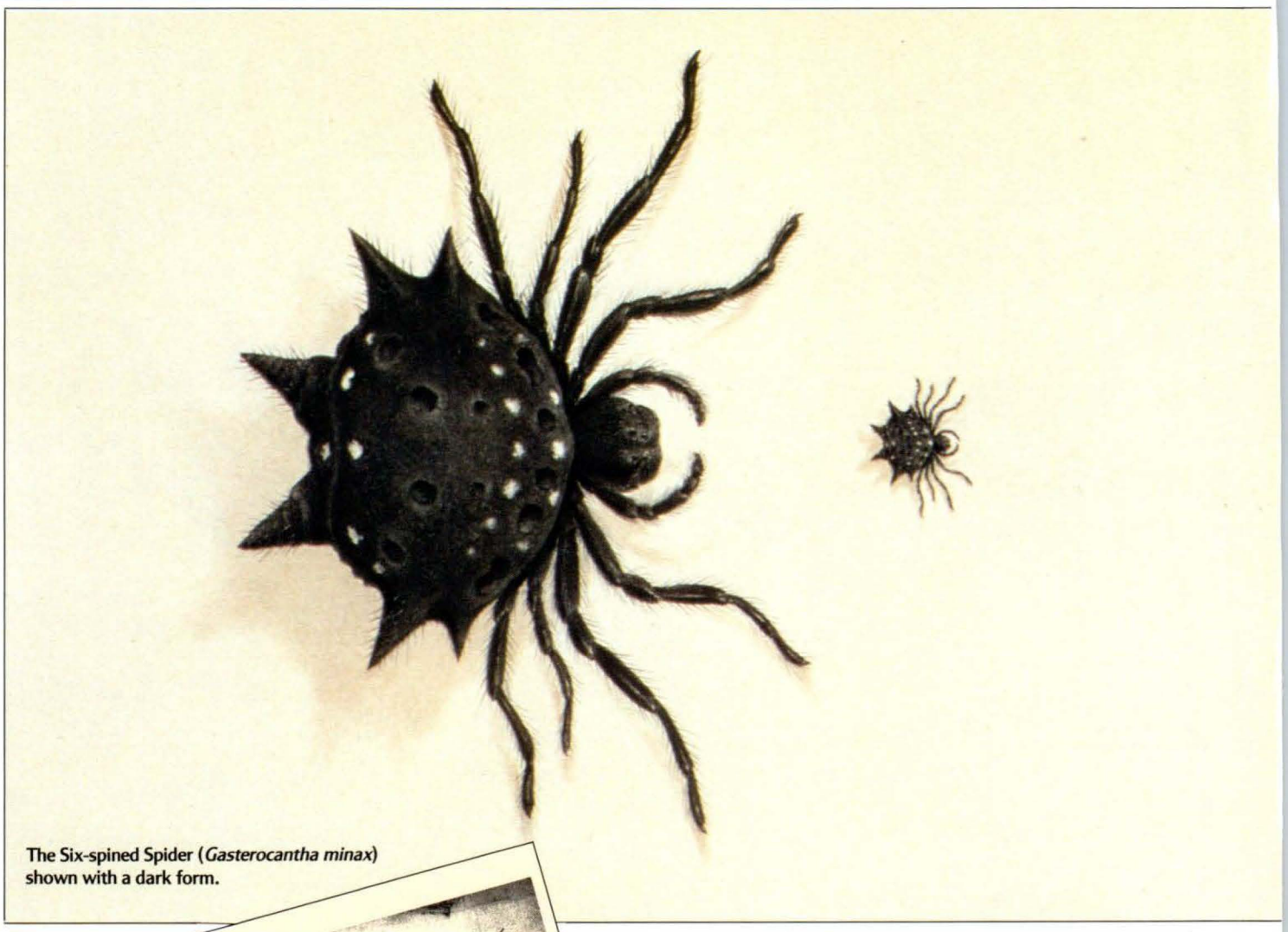
While Franz Bauer is remembered both by a portrait and a memorial in Kew, Ferdinand has no existing portrait nor any tablet to commemorate him. He merely rates a mention rather like a postscript in Franz's epitaph in St Anne's Chapel in Kew: "In the delineation of plants he [Franz] united the accuracy of a profound naturalist



Cape Bauer near Streaky Bay, South Australia, was named in Ferdinand Bauer's honour by Matthew Flinders.

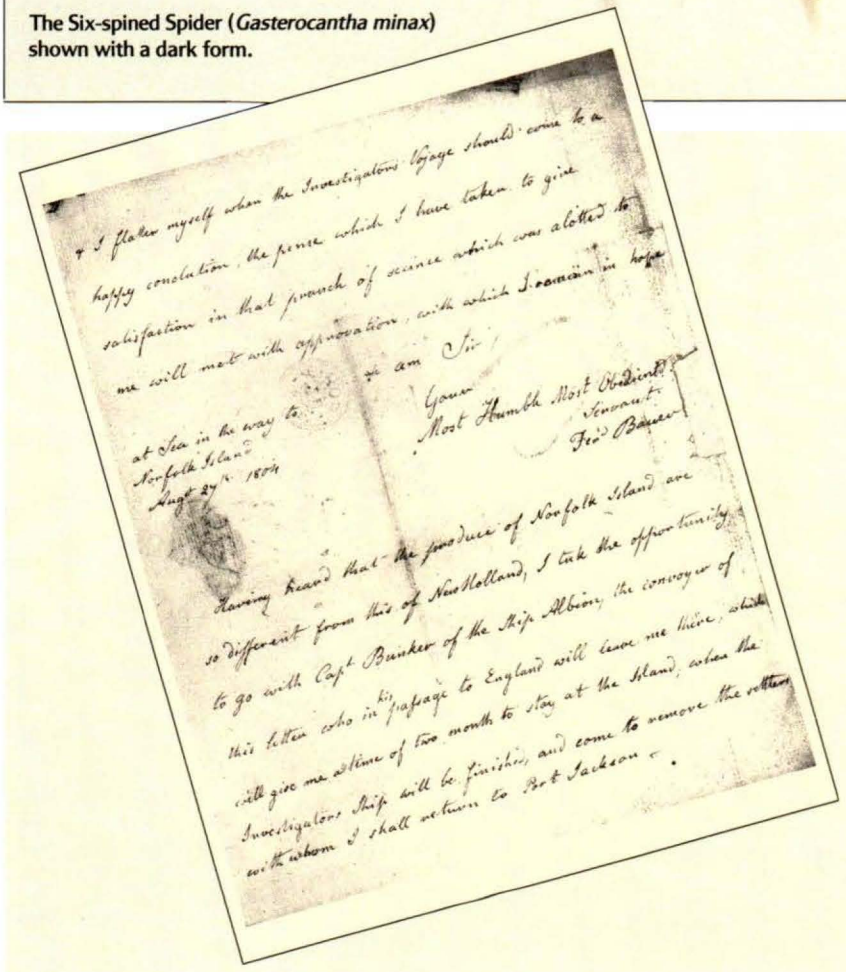
Bauer was also skilled at zoological dissections, as this drawing of the Koala shows.

BRITISH MUSEUM (NATURAL HISTORY)



BRITISH MUSEUM (NATURAL HISTORY)

The Six-spined Spider (*Gasterocantha minax*) shown with a dark form.



I flatter myself when the Investigators Voyage should come to a happy conclution, the pense which I have taken to give satisfaction in that pranch of science which was allotted to me will meet with approbation, with which I remain in hope

I am Sir

Your Most Humble Most Obedient Servant Fred Bauer

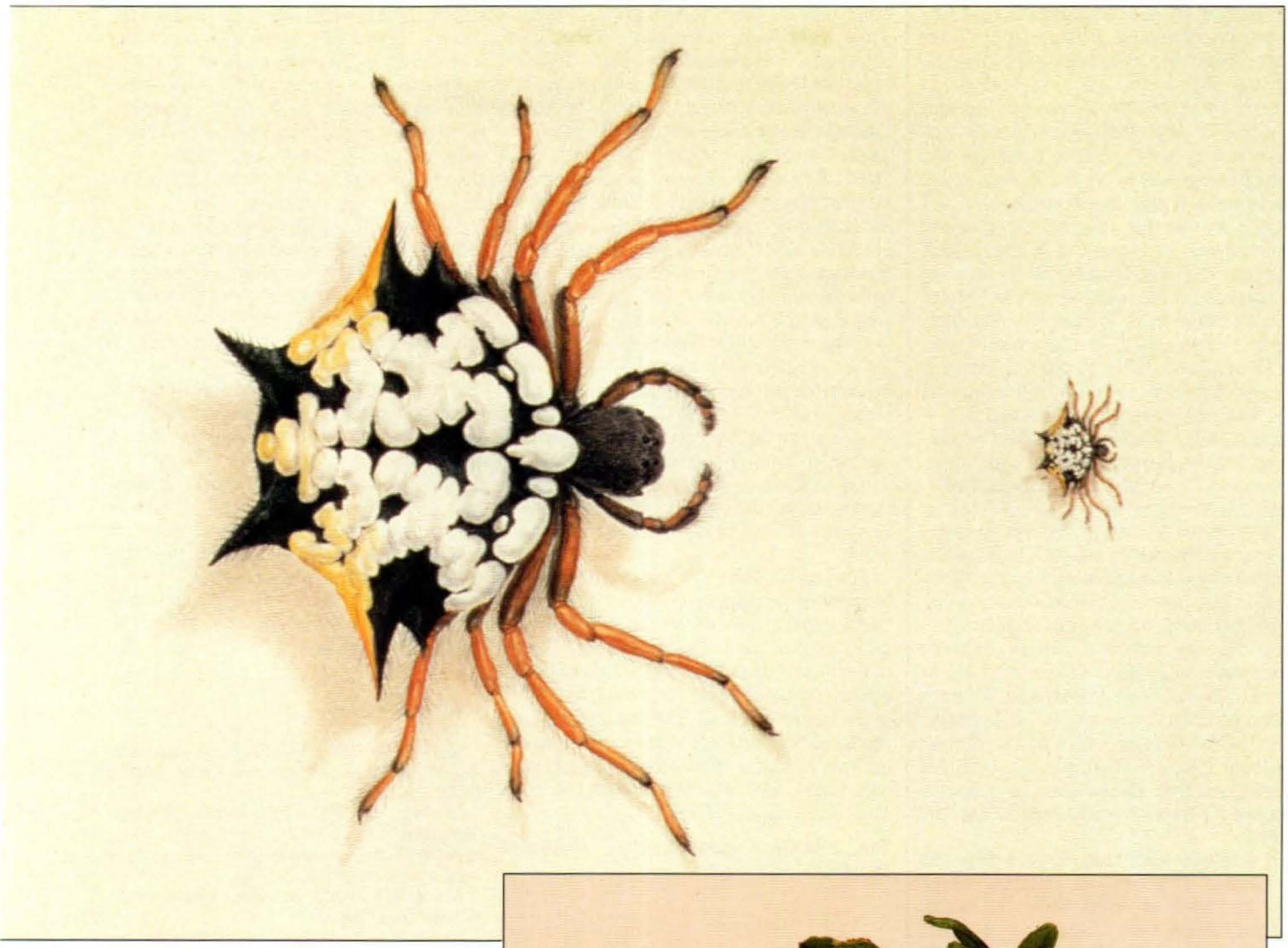
at Sea in the way to Norfolk Island Augt 27th 1804

Having heard that the produce of Norfolk Island are so different from this of New Holland, I take the opportunity to go with Capt Bunker of the Ship Albion, the convoyer of this letter who in his passage to England will leave me there, which will give me a time of two month to stay at the Island, when the Investigators Ship will be finishis, and come to remove the rattens with whom I shall return to Port Jackson &c.

with the skill of the accomplished artist, to a degree which has been only equalled by his brother Ferdinand."

In 1843 Bauer's first biographer, Jan Lhotsky, wrote confidently: "His own name recorded as it is by his superior botanical designs, commemorated by the genus *Bauera* in the annals of Botany, and . . . in those also of geography, will long live in the recollections of posterity." With hindsight we can see that he would have done better to have expressed this as a hope rather than as a foregone conclusion. Ferdinand Bauer, acclaimed by his contemporaries as the greatest of botanical artists, seems to have been ignored soon after his death. In fact, Lhotsky's avowed purpose in writing the biography for the Linnean Society in London was to revive interest in a man whom he so much admired and felt to have been unjustly forgotten. He wanted to put the record straight and "to plant, as it were, a cypress on the grave of the man with whom

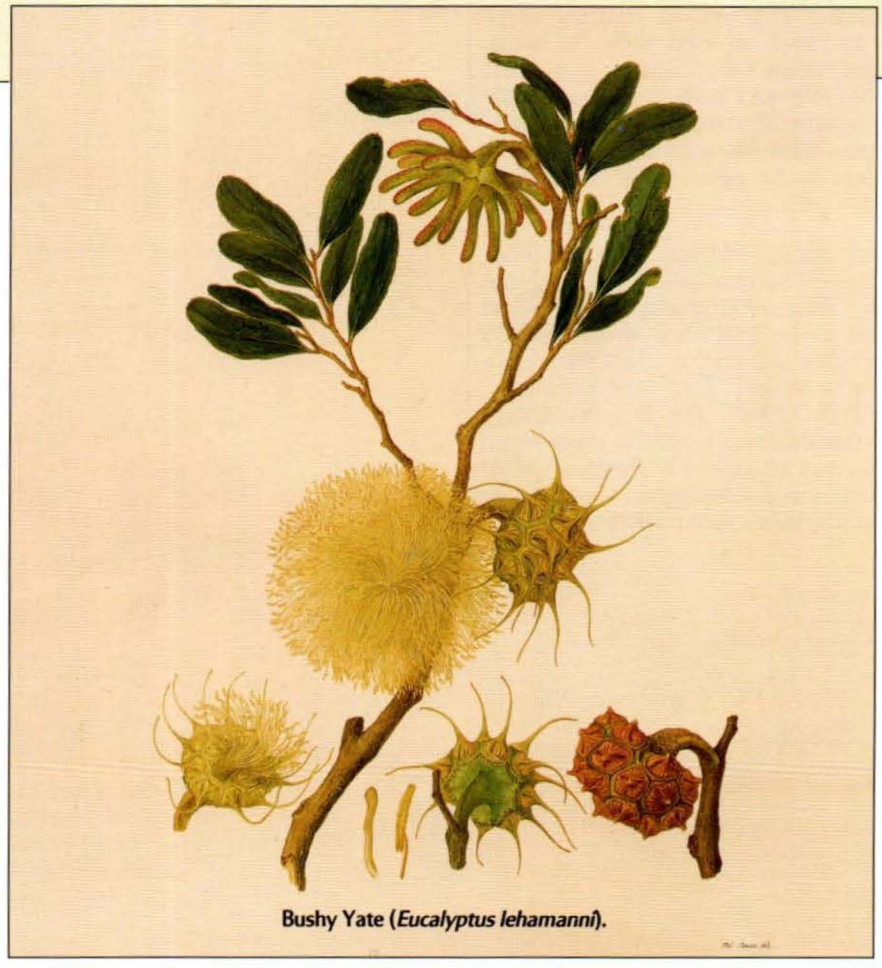
Facsimile of the last page of Bauer's letter to Sir Joseph Banks, 27 August 1804, announcing his visit to Norfolk Island. Ferdinand was not a keen letter writer, particularly in English. It took him almost four years to compose a letter to his patron. His original spelling makes his Austrian accent audible—here, 'pense' for 'pains', elsewhere 'Moden Bird' for Mutton Bird, 'poart' for 'port' and 'Pay' for 'Bay'.



I may also claim kindred as my countryman and fellow-traveller in Australia".

Jan Lhotsky did redeem Ferdinand Bauer from complete oblivion but his brief biography remained the only source of information about the naturalist–painter for the next 100 years. The sparse references to Ferdinand in biographical dictionaries and the like all quoted or misquoted Lhotsky and no-one ever made use of the primary sources on which his biography had originally drawn. These consisted of the seven letters that Ferdinand had written from Australia to his brother Franz, then botanical artist at Kew Gardens in London, and the letter he had written to his brother Joseph, Director of the Liechtenstein Art Gallery in Vienna. Lhotsky probably obtained these letters from Franz Bauer and later deposited them in the Linnean Library where, according to library records, they appear to have lain unread until the 1980s. Ferdinand also wrote two letters to Sir Joseph Banks.

ONE CAN ONLY SPECULATE ON THE reasons for Ferdinand Bauer's long years in the historical wilderness. His return to England in 1805 and his attempt to publish his Australian paintings at his own expense coincided with a new period in the Napoleonic Wars that placed a frighten-



Bushy Yate (*Eucalyptus lehamanni*).

BRITISH MUSEUM (NATURAL HISTORY)

ing financial burden on the nation; the taste in art was changing, with romantic landscapes beginning to be favoured over naturalistic portrayals; his two periods in Austria interrupted by 27 years in England (and five in Australia) meant that he was promoted by none of these countries and virtually forgotten by all; and his Australian works were divided between England and Austria so that the finished watercolours were almost all deposited in the British Museum (Natural History) while most of the sketches were acquired by the Natural History Museum in Vienna. No joint catalogue ever appeared. The unnatural separation of sketch and completed painting seemed, somehow, symbolic of the way his life was rent between two countries—Austria and England—and their two cultures. Finally, Ferdinand Bauer was single-minded—one might say obsessional—about his work and seems to have had no time or talent for self-promotion. Because he was not claimed by the art world (unlike Westall, the landscape painter on the *Investigator*) but, instead, assiduously filed away by the botanists, his potential audience was even further reduced. James Britten, writing in *The Journal of Botany* in 1909 in an article entitled "Ferdinand Bauer's drawings of Australian plants", did provide a list of the drawings held by the British Museum (Natural History). Yet even his careful research did not seem to prompt a demand for Bauer's work, even by the botanists.

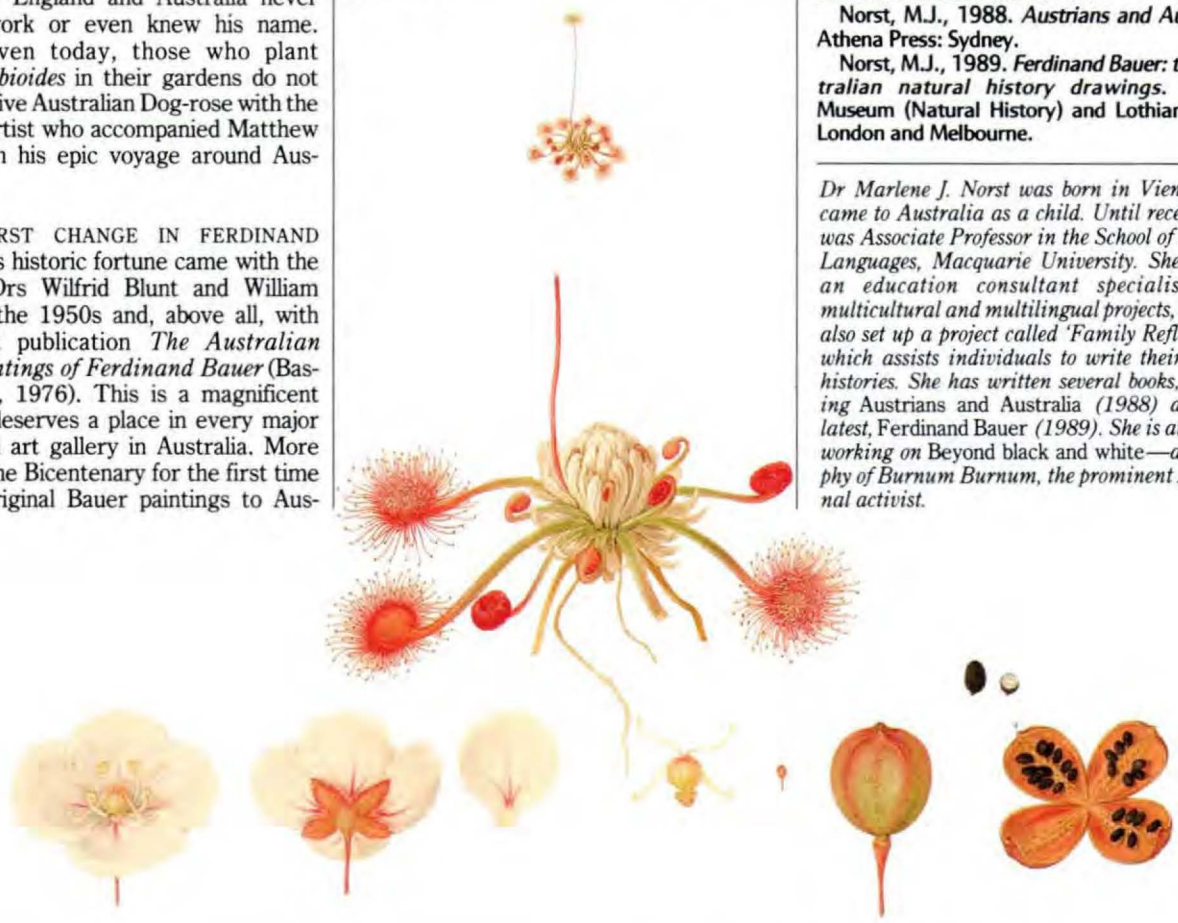
It is little wonder that the general public in Austria, England and Australia never saw his work or even knew his name. Indeed, even today, those who plant *Bauera rubioides* in their gardens do not link the native Australian Dog-rose with the Austrian artist who accompanied Matthew Flinders on his epic voyage around Australia.

THE FIRST CHANGE IN FERDINAND Bauer's historic fortune came with the work of Drs Wilfrid Blunt and William Stearn in the 1950s and, above all, with their joint publication *The Australian flower paintings of Ferdinand Bauer* (Basilisk Press, 1976). This is a magnificent folio that deserves a place in every major library and art gallery in Australia. More recently, the Bicentenary for the first time brought original Bauer paintings to Australia, where they were shown in three major exhibitions, including "First Impressions" produced by the British Museum (Natural History) and shown at the Australian Museum in 1988. In April 1989 the first monograph about Ferdinand Bauer's Australian voyage appeared. Entitled *Ferdinand Bauer: the Australian natural history drawings*, it draws on both the English and Austrian collections and reproduces all of Bauer's extant letters in translation for the first time. It had long been known that over 100 uncatalogued animal sketches by Bauer were missing. By a stroke of good luck these came to light in Vienna in 1985, so that some of them could be included in the book. A file on Ferdinand Bauer held in the Town Hall Archives in Vienna was a further researcher's bonus. It contained Bauer's last will and testament and a detailed inventory of his house, including his artistic work, naturalist collections and all the titles in his extensive library.

Ferdinand Bauer's work is astonishing because of his superb craftsmanship, aesthetic sense and meticulous scientific accuracy. He was one of the very first to show the complete reproductive system of each plant, incorporating its elements artistically in the finished picture. The illustrations reproduced here attempt to give some idea of his vast range, both in subject matter and expression. He depicts the fish and the spider, the robust *Banksia coccinea* and the delicate *Drosera pygmaea* with an equally sure touch. In his essay on flower painting written in 1817, Johann Wolfgang Goethe, who was himself a talented naturalist, devotes two pages to an analysis of Bauer's depiction of the pine tree in Lambert's *A description of the genus Pinus*. On this evidence alone he considers Bauer's illustrations to be the epitome of all that is best in botanical drawing and a model to be followed by others: " . . . we are enchanted at the sight of these leaves: nature is revealed, art concealed, great in its precision, gentle in its execution, decisive and satisfying in its appearance".

Ferdinand Bauer's recognition and renaissance is long overdue and Australia should take the lead in honouring him for his services to art and science. While Flinders provided navigational charts so accurate that mariners today can still rely on them, Ferdinand Bauer for the first time mapped the flora and fauna of the Australian coast and Norfolk Island. He has left a magnificent record to delight and inspire all who are concerned with Australia's natural heritage. ■

The delicate Pygmy Sundew (*Drosera pygmaea*).



BRITISH MUSEUM (NATURAL HISTORY)

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Dr Marlene J. Norst was born in Vienna and came to Australia as a child. Until recently she was Associate Professor in the School of Modern Languages, Macquarie University. She is now an education consultant specialising in multicultural and multilingual projects, and has also set up a project called 'Family Reflections', which assists individuals to write their family histories. She has written several books, including Austrians and Australia *(1988) and, her latest,* Ferdinand Bauer *(1989). She is at present working on* Beyond black and white*—a biography of Burnum Burnum, the prominent Aboriginal activist.*

The Scarlet Banksia (*Banksia coccinea*) with its various elements artistically incorporated into the final picture.

BRITISH MUSEUM (NATURAL HISTORY)

MORE THAN A HOME FOR WHITE ANTS

KATHIE ATKINSON

Besides being a good place to sunbake, Perenties (*Varanus giganteus*) have been known to incubate eggs in above-ground termitaria. Termitaria are particularly abundant in the wet–dry tropics but occur throughout most of Australia. These termitaria are on Barrow Island, Western Australia.

"Termitaria are not the inert tombstones they appear to be. They are stationary cows. They are a vacuum cleaner . . . They are the pithead of a miniature mine . . ."

BY RICHARD BRAITHWAITE
CSIRO DIVISION OF WILDLIFE AND ECOLOGY, DARWIN

THE HARD CLAYEY SHELL OF the termite colony has been viewed in a very practical way, such as surfacing for pre-World War II tennis courts, or in a semi-mystical way as the exoskeleton of a superorganism. While some philosophers have been concerned with the soul of the termite superorganism, the termite colony has been busy contributing much to the ecology of the whole community of plants and animals of the tropics. There are over 2,000 termite (or white ant) species worldwide, and about 200 in Australia, 80–90 of these occurring in the Northern Territory. Their large and abundant homes dominate the landscape in the wet–dry tropics. These small social insects, whose colonies may vary from a few hundred to several million individuals, are responsible for processing and concentrating nutrients and making them available for plant growth. Their success as herbivores and decomposers in areas of infertile tropical soils makes them an abundant food item and therefore a mainstay of the animal communities. Their efforts to decrease the vulnerability of their pale puny bodies to being eaten has

resulted in the construction of a wide variety of housing, which is in turn used by animal species of all shapes and sizes.

ABOUT A THIRD OF THE 60 SPECIES OF termites of the Top End build a free-standing nest or termitarium made of various proportions of clay and woody material. Termites sometimes burrow many metres deep into the sub-soil to obtain the clay building material and also water. They bring clay particles with attached mineral ions from the sub-soil to the surface, thereby enriching the soil. This process is the reverse of the leaching of nutrients, which occurs due to the heavy rain of the tropics. Thus termites play an essential role in maintaining the meagre nutrients in the biologically active topsoil. Further they concentrate the nutrients and, when a termitarium breaks down, some plants benefit from the accumulation of nutrients and grow near the termitarium taking up the nutrients as they become available.

In addition to these soil-building activities, termites also physically and chemically break down leaf litter, making the nutrients available for new plant growth. The savannas of northern Australia grow on infertile, shallow soils and are so unproductive that even cattle find the going tough through the long dry season. In contrast, termites are able to harvest and store the abundant nutritious grass of the early wet season and feed on it throughout the year, along with recently harvested dead grass, leaves and twigs. They also fix atmospheric nitrogen using microorganisms in their hindguts, enabling them to tolerate unnutritious forage. The part of Australia where termites dominate the ecosystem more than anywhere else is likely to be the transition zone between the wet–dry tropics and the arid zone, such as in the Larrimah area in the Northern Territory. Here there are virtually no mammals, not even cattle. The termites appear to have it almost to themselves.

The success of termites and other herbivorous invertebrates in the hot but infertile conditions of the wet–dry tropics creates numerous feeding opportunities for insectivorous birds, mammals, reptiles and frogs. Many vertebrate species feed on the vulnerable swarms of primary reproductives (alates) of the early wet season, as they fly off to find a mate and form a new colony. As much as 50 per cent of the termites produced each year can go off into these nuptial flights. This easy set of feasts probably gives a kick-start to the reproductive season of many vertebrate species. In the Australian arid zone, much of the extraordinary diversity of lizards there feeds on termites throughout the year. Unlike the non-social insects, termites provide a consistent year-round supply of food for termite-eating specialists. Surprisingly, however, few Top End ver-

Cross-section of a *Nasutitermes triodiae* mound. Note the spinifex chaffed by the termites.

KATHIE ATKINSON

The wood-eating termites *Coptotermes acinaciformis* may reach colony sizes of more than a million individuals. Shown here are the workers, which forage for food, build and repair the termitarium and tend the queen, king, soliders, nymphs and young.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

tebrates specialise on termites—most eat the spiders and ants that feed on them. The only termite specialists we know of in the Top End are the Short-beaked Echidna (*Tachyglossus aculeatus*) and tiny *Uperoleia* frogs.

SOME TERMITES, SUCH AS *COPTOTERMES acinaciformis*, eat wood, dead or alive. They initially gain entrance through a fire scar at the base of a tree. The colony is built both inside and beside the nursery tree, and when the tree eventually collapses the colony continues life as a free-standing termitarium. However, the colony by that stage will usually have feeding tunnels leading into perhaps another six to ten trees scattered over a quarter of a hectare. The initially colonised tree always houses the nursery. Such trees can be recognised by the protruding bumps on the bole. These bumps have small holes that can be opened and shut by the termites to allow the release of alates. This procedure may also be used for the regulation of temperature inside the nursery, given that internal temperatures remain relatively constant.

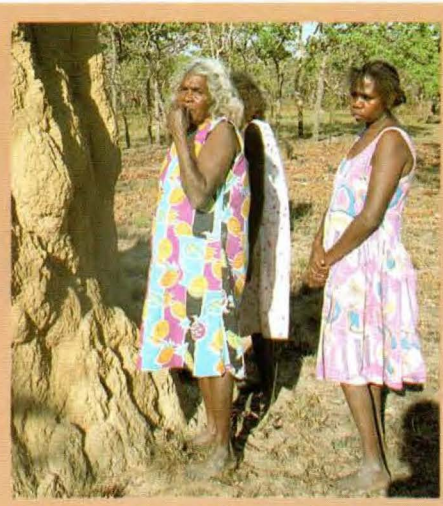
Some wood-eating termites appear to

ABORIGINAL DRUGSTORES

The Aboriginal practice of eating termite mound material may at first seem a bit peculiar or, for some people, even revolting. However, there may not be a lot of difference between eating termitaria, which are rich in clay, and the European use of kaolin (a type of clay) to cure diarrhoea.

Termite mound material is known to be used widely for the treatment of diarrhoea in communities from central Australia to Bathurst Island, north-west of Darwin. It is also eaten by women for abdominal pains, menstrual pains, upset stomachs; or during pregnancy. In other regions it is used to alleviate symptoms attributed to mineral deficiencies, or to retain moisture in and improve the flavour of meat and fish. Traditional ways of preparing termitaria for consumption vary from community to community with every family having its own 'recipe'. Pieces of the outer casing may be crushed between the hands and eaten; or heated in a fire, placed in water, crushed and then the extract drunk.

To find out more about the therapeutic use of termitaria, scientists from the Northern Territory University are studying termite mounds used by different Aboriginal communities in the Northern Territory. *Nasutitermes triodiae* mounds used by Aborigines from the Daly River community were shown to have higher concentrations of calcium, potassium, sodium and magnesium than the adjacent soils. This is considered to be due to the incorporation of saliva and faecal material from the digestion of plant tissue with the soil used for construction of the mound. However, although the freshly built parts of the mound are preferred, fresh and old sections of samples from the same mound did not show any significant differences in total element concentrations.



Termite mound material is eaten by Aborigines for the treatment of diarrhoea, and abdominal and menstrual pains. It may also be eaten by pregnant women or to stimulate milk production.

F. FOTI

Clay or soil eating (pica) is well known in many parts of the world and capsules of dirt and clay are being marketed in health food stores for their mineral content and as remedies for certain stomach and intestinal ailments. The treatment of these disorders, including diarrhoea, may be related to the clay content of the termitaria; that is, it may have physicochemical benefit. It has also been suggested that clay eating is related to iron-deficiency anaemia, which would correlate with the use of termitaria by pregnant women. Although the total iron concentration in termitaria is high, analysis of the *Nasutitermes triodiae* mounds showed it was not significantly higher than the adjacent soil, and very little of the iron in the termitaria was in the bioavailable (that is, ionisable) form.

Another mound studied was that of *Amitermes vitiosus*. Aborigines from the Elliott community use the water extract to cure diarrhoea and stomach ache and to stimulate milk production in lactating women. This process was shown to extract only a small percentage of the elements analysed, except for calcium (38 per cent). This level of calcium may be significant with respect to use by lactating women.

Over the next two years, the project will continue to investigate the bioavailability of elements in termitaria, particularly calcium and iron, and the distribution of elements within and between termite mounds in the same and different areas of the Northern Territory. We are indebted to the Aboriginal communities that have shared their knowledge with us and, in the very least, this study will make Australians more aware of the value of Aboriginal culture.

—Francoise Foti
Northern Territory University

R. BRAITHWAITE

HANS & JUDY BESTE/AUSCAPE INTERNATIONAL

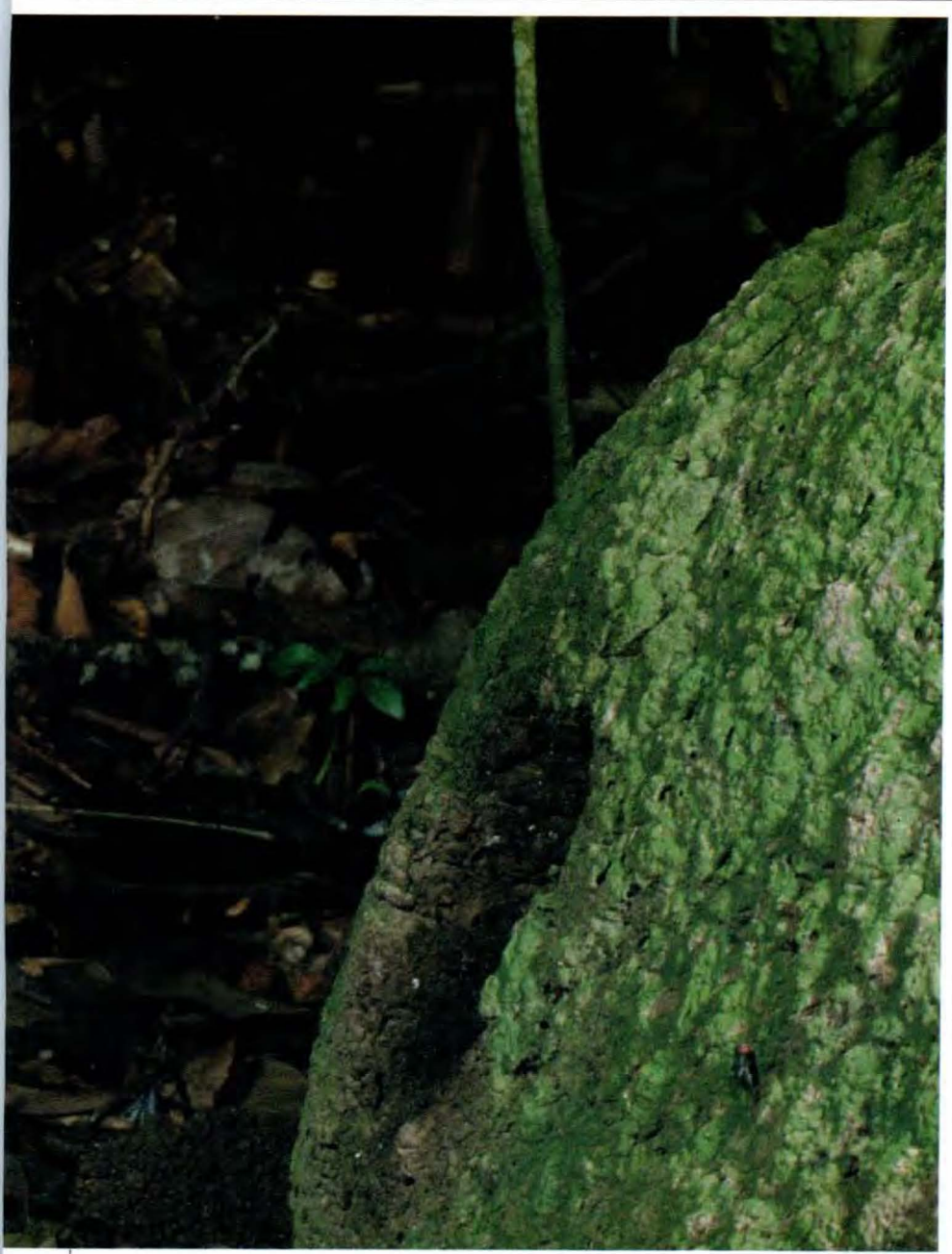
Birds are common inhabitants of termitaria. A White-tailed Kingfisher (*Tanysiptera sylvia*) visits its nest. Inset: The aboreal termitaria of *Nasutitermes graveolus* are used as nests for Forest Kingfishers (*Halcyon macleayii*).

provide a service to the trees that they hollow out. They free up nutrients locked away in dead tissue (the heartwood) but more importantly they provide homes for many animals, which inadvertently provide fertiliser to the tree. In the Top End, about one-fifth of bird and amphibian species, half the mammals and a quarter of the reptile species use hollows for some purpose. The magnitude of the contribution of nutrients to the tree by various animal species varies with their abundance, body size, toilet habits, mortality rate of young, whether the hollow is used just for nesting or for regular roosting as well, and the level of metabolic activity. Of the many species involved, parrots like the Little Corella (*Cacatua sanguinea*), Varied Lorikeet (*Psitteuteles versicolor*), Northern Rosella (*Platycercus venustus*), Red-collared Lorikeet (*Trichoglossus rubritorquis*), Red-tailed Black-cockatoo (*Calyptorhynchus magnificus*) and Sulphur-crested Cockatoo (*Cacatua galerita*) are the most important. The Black-tailed Treecreeper (*Climacteris melanura*) is another major user of hollows. A wide range of mammals, reptiles and amphibians also use the hollows but contribute less nutrient to the tree.

A male Hooded Parrot visits its nest in the side of a large termitarium.

J.A. ESTBERGS

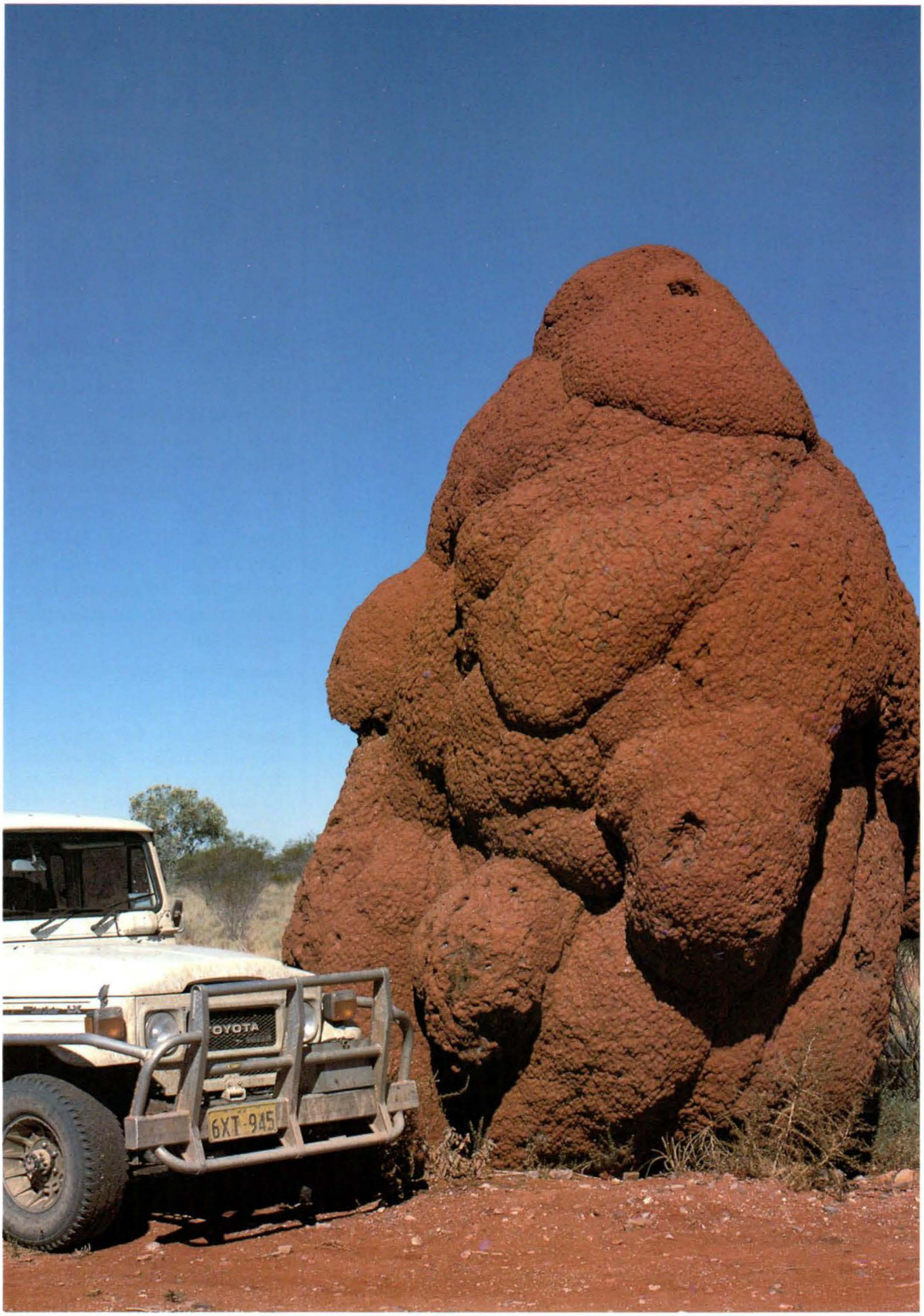
JUST AS ABORIGINAL PEOPLE USE THE termite-hollowed branches as musical drone pipes, various animals also use the acoustic properties of the tree hollows. The Northern Tree-frog (*Litoria caerulea*) croaks resonantly during the wet season, and the large tree rats and possums appear to use the acoustics of the hollows to amplify their vocalised threats.



Termitaria external to the trees are also used in the social system of some species. The tops of many large termitaria have faeces deposits of Northern Native-cats (*Dasyurus hallucatus*), indicating a social importance to that species. The nests of Masked Finches (*Poephila personata*) are generally built next to termitaria in grass less than a metre above ground. It is likely that the birds use the termitaria to help locate their nest in the dense tall grass.

The termitaria provide homes to a surprising range of animals. Early in the life of a termitarium other insects share the anthill with its builders. Huge numbers of invertebrate species have been recorded in termitaria, particularly aphids, silverfish, slater-like crustaceans, and beetles and flies and their larvae. Among the specialist 'termitophiles' are a number of termite species that never build their own termitaria. Two genera are totally dependent on *Coptotermes acinaciformis*. *Ahamitermes* species eat only the waste 'carton' material that *C. acinaciformis* deposit in their nests as internal structure, and *Incolitermes pumilis* is restricted to the nursery region of *C. acinaciformis* nests where they eat only the internal partitions of the host nursery. *Coptotermes*, *Ahamitermes* and *Incolitermes* species live in completely different parts of the termitarium. While *Ahamitermes* species have a separate exit, *Incolitermes pumilis* has lost the power of releasing its own alates, this being done by the normally hostile workers of the host species when they open the exit holes to release their own alates.

Inside termitaria, ant species also have a variety of relationships with termites, ranging from aggressive predation to complete indifference. Generally termites wall out such undesirables, but gradually species of ants manage to take over parts of termitaria. The dominant *Iridomyrmex* species are prominent in this role. As parts of a termitarium are lost or abandoned by



JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

the building species to other insects, the fine structure of the apartment building begins to decay, creating larger spaces suitable for small vertebrates inside the termitarium. Small terrestrial geckoes (such as *Heteronotia binoei*), frogs (*Uperoleia* species), legless lizards (*Delma borea*) and small snakes (Red-naped Snake, *Furina ornata*; Anthill Python, *Liasis stimsoni*) are found in reasonably intact termitaria.

The mass of termites within both tree hollows and external termitaria generates a lot of heat. The colony seems to be able to maintain a reasonably constant temperature in the nursery area all year round. It is likely that the various vertebrates use the temperature gradients within the structure. Ectothermic animals like reptiles and amphibians can maintain themselves in an active state using such gradients. Even endotherms like birds could use this heat source to incubate eggs and obviate the need to spend as much time on the nest.

The next stage in this succession of occupants during the history of a termitarium is that of the slightly larger vertebrates. The Hooded Parrot (*Psephotus dissimilis*) nests in a burrow in a large termite mound. Sometimes kingfishers such as the Red-backed Kingfisher (*Todiramphis pyrrhopyguis*) use a ground termite mound but they generally use the soft cardboard-like arboreal termitaria of *Nasutitermes graveolus*. This is because kingfishers open up a hole by flying at the termitarium head-on, occasionally with such force that on rare occasions they die from the impact. Burrowing rodents like the Pale Field-rat (*Rattus tunneyi*) and the Delicate Mouse (*Pseudomys delicatulus*) excavate at the base of the termitaria and family groups occupy part of a mound. Piles of rat faeces can be seen outside the entrances to the 'rat cities'. It is likely that these burrowing rodents prefer the above-ground termitaria as locations for nests, for they are less likely to be flooded out during the wet season. Goannas (*Varanus gouldii*) on the edge of the floodplains do much the same.

Later the much larger Northern Native-cat opens up a bigger hole in the termitarium and will begin to use it. Larger snakes also use termitaria at this stage. Later still, when the termitarium consists of a clay shell with large holes and little internal structure remains, the Northern Bandicoot (*Isoodon macrourus*) will move in. The decaying termitarium offers protection from fires. During actual fires many small terrestrial vertebrates take shelter in the 'ruins' of termitaria. Finally the remains of such decaying termitaria are eventually spread by animals, wind and water and can add as much as 0.1 millimetres of top soil a year.

Clearly the activities of termites affect the whole ecosystem. Termitaria are not the inert tombstones they appear to be. They are stationary cows. They are a vacuum cleaner removing the natural debris of the ecosystem. They are the pithead of a miniature mine that brings nutrients to the surface. They are an incubation chamber. They are a dependable larder to insectivores. They are a secure home to a wide range of vertebrates and invertebrates. Indeed it would be difficult to overstate their importance. They are a lifeblood of the system. ■

Termite mounds can vary enormously in size and shape. Some reach immense proportions — up to seven metres. This giant termitarium, located east of Harts Range in the Northern Territory, dwarfs the vehicle in the foreground.

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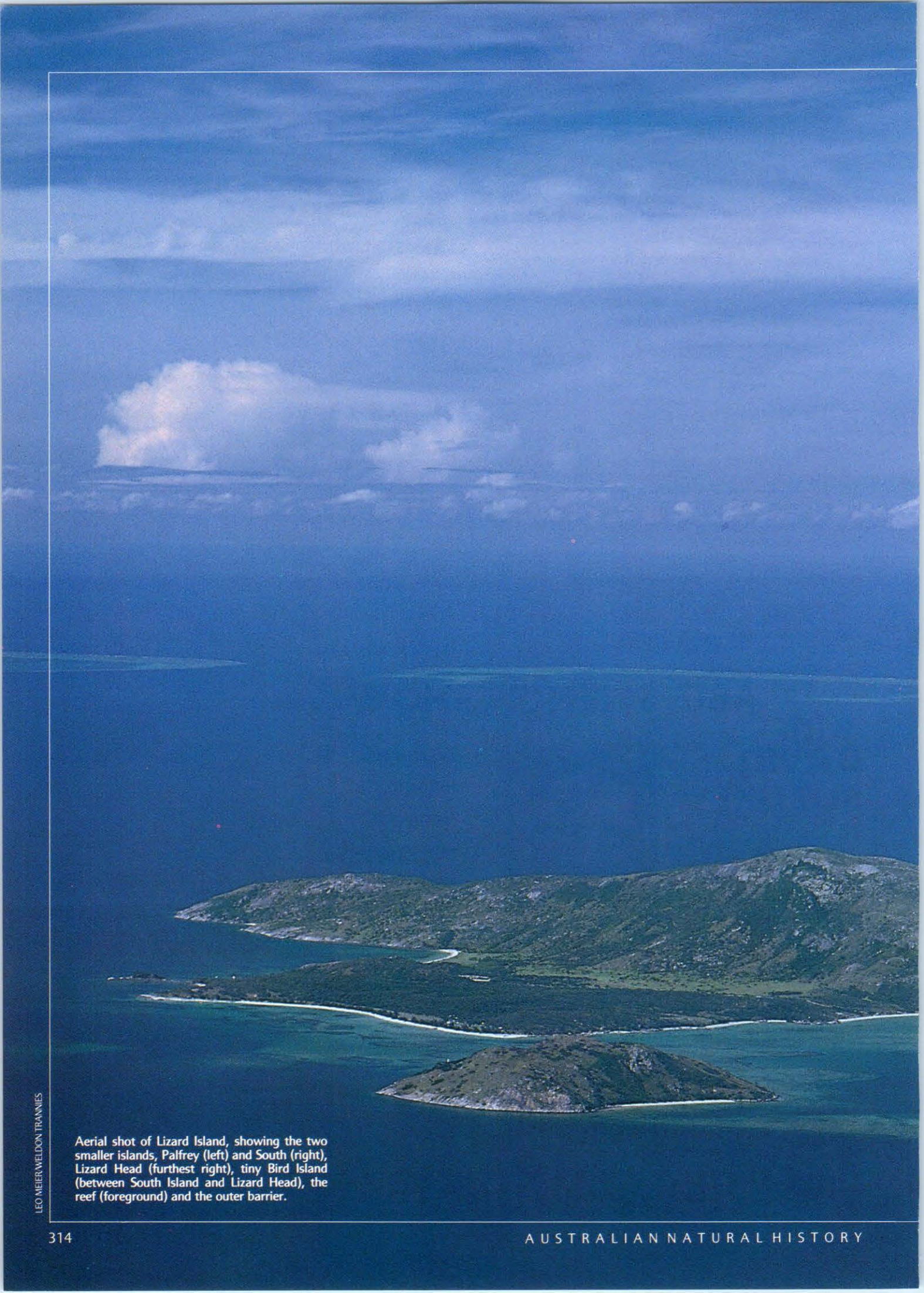
Dr Richard Braithwaite is a Principal Research Scientist with the CSIRO Division of Wildlife and Ecology in Darwin. He has previously studied small mammals in Queensland, Victoria and North America. Since coming to Darwin in 1980, Dick has worked on ecological problems concerning fire, surveys, exotic plants and animals, rare and endangered species, and habitat selection, using a wide variety of animals and plants.



Aerial shot of Lizard Island, showing the two smaller islands, Palfrey (left) and South (right), Lizard Head (furthest right), tiny Bird Island (between South Island and Lizard Head), the reef (foreground) and the outer barrier.

LEO MEIER WELDON TRANNIES

"We cannot afford to be complacent. The more we learn about the working of coral reef systems, the better we can understand the pathways and effects of pollutants and minimise human disturbance."

LORE FROM THE LIZARD:

LIZARD ISLAND RESEARCH STATION

LENNOX COWEN

The authors rest near Cook's Look, the highest point on the island, overlooking Mrs Watsons Beach and the resort.

DISCOVERED IN 1770 BY CAPTAIN JAMES Cook, Lizard Island was periodically used as a base for collecting and research for more than 200 years. Following the establishment of the Lizard Island Research Station in 1973, its potential was more widely acknowledged and it now makes a more significant contribution to scientific investigations on the northern Great Barrier Reef.

The island, about 30 kilometres off Cooktown, Queensland (14°38′ S), is one of approximately 1,000 continental islands found throughout the Great Barrier Reef. Covering an area of about seven square kilometres, its highest point, known as Cook's Look, reaches 370 metres above sea level. It was from this point that Cook and his party plotted their course through the treacherous reef, via what is now

BY JENNY GATES & PETER HOYLE
COMMUNITY RELATIONS, THE AUSTRALIAN MUSEUM

known as Cook's Passage, to the open sea beyond the outer barrier. While collecting on the island, they claimed "the only animals we saw were lizards" and named the island accordingly.

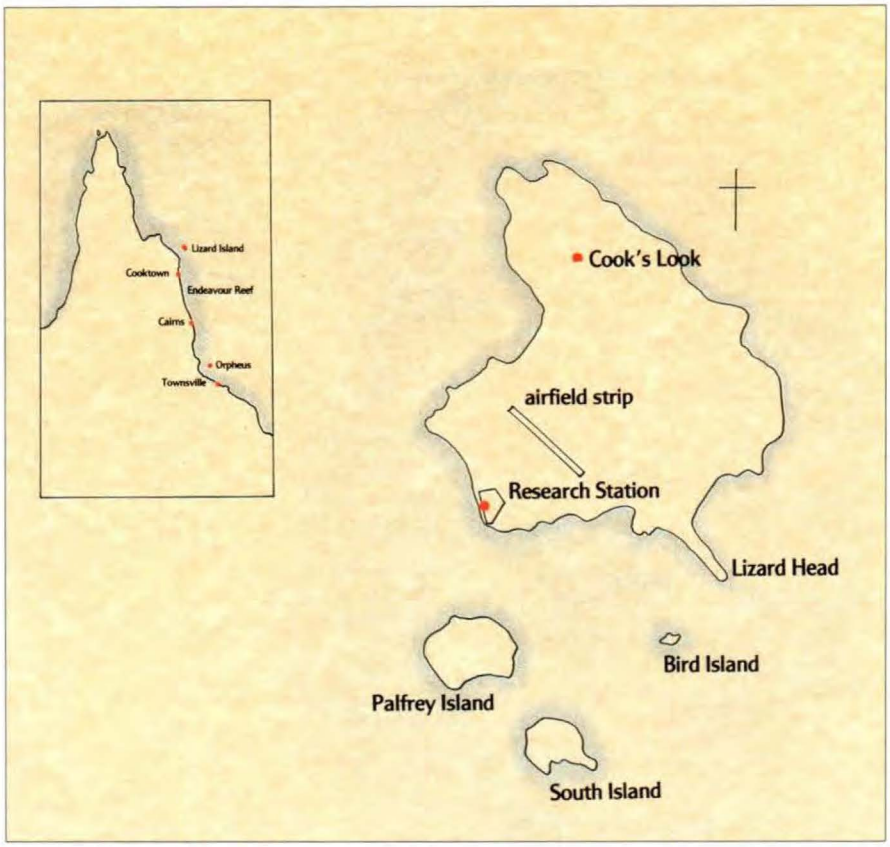
Lizard is joined to two smaller islands, Palfrey and South, by a 12-metre-deep lagoon. At the main entrance to the lagoon is tiny Bird Island, which is populated by nesting terns and other seabirds, and Lizard Head, named after its shape rather than its residents. There are more than 20 beaches scattered around the island with most of the 16-kilometre coastline dropping directly to the sea. The sand spit associated with nearby MacGillivray's Reef disappears on spring high tides, and only 16 kilometres away is the outer barrier, keenly researched and dived by scientists and laymen alike.

Much of the history of Lizard since its European discovery has centred around research. Cook and Banks were the first scientists, collecting new species of plants and animals, and they were followed by Thomas Huxley and John MacGillivray in 1852 and MacGillivray again in 1861. Between 1928 and 1967 three major expeditions visited Lizard for collecting and research. In 1973 the *Marco Polo* brought delegates of the Second International Coral Reef Symposium for several days stay and, in that same year, one of the most acclaimed research stations in the world—the Lizard Island Research Station—was established by the Australian Museum.

Lizard Island is part of the Cairns Section of the Great Barrier Reef Marine Park and its opportunities for research are widely recognised. The majority of research carried out on the island is marine orientated. However, Lizard Island also boasts a wide variety of terrestrial habitats such as wide open grasslands and woodlands, pandanus and mangrove swamps, and eucalyptus scrub and patches of tropical rainforest. This variety of habitats encourages a wide variety of terrestrial fauna.

In all, more than 130 bird species, including at least 15 species of seabirds, are represented. One of the most conspicuous is the tiny Yellow-bellied Sunbird (*Nectarinia jugularis*) which, in its characteristic spindle-shaped nest, is as much at home hanging from the beams in the maintenance shed or outside the residential buildings as in the surrounding scrub. At least ten species of lizards, including geckos and Gould's Goanna (*Varanus gouldii*), and five species of nocturnal snakes, of which only one is thought to be venomous, are known. The island also supports a rich and abundant insect and spider population. The only native mammals known are bats—the Black Flying Fox (*Pteropus alecto*) and the Dusky Horseshoe Bat (*Hipposideros ater*).

As with many areas along the approximately 2,000-kilometre stretch of the Great Barrier Reef, the reefs and waters around Lizard Island play host to an enor-



CATHY MCGAHEY

KATHIE ATKINSON

A common sight is the Yellow-bellied Sunbird with its spindle-shaped nest.

Coral Trout are familiar companions on dives.

WILLIAM GLADSTONE

Nudibranches, like this *Nembrotha nigerrima*, are collected at Lizard Island by the Australian Museum.

JENNY GATES

Gould's Goanna is one of the ten lizard species represented on Lizard.

WILLIAM GLADSTONE

mous variety of marine life. Coral bombies and micro-atolls support whole communities of fishes, corals and other invertebrates, and often serve as *in situ* laboratory sites for habitat biologists. In excess of 350 species of corals and 1,000 species of tropical fishes alone are recorded. Coral Trout (*Plectropomus maculatus*), angelfish, damsels and parrotfish are familiar companions on any dive.

The macro-invertebrate fauna, such as tubeworms, seaslugs (nudibranchs), molluscs and shrimps, is well represented as is the abundant microfauna that coexists with it. The micro-fauna, however, is largely apparent only to those scientific researchers who study these organisms at Lizard.

APART FROM ITS OBVIOUS BEAUTY AND tranquility, which attract hundreds of visitors each year to the Lizard Island Resort, the island is acclaimed worldwide as a centre for reef research. Over the past 15 years the Research Station has become increasingly involved in major research programs on the reef. A facility of the Australian Museum, the Station is supported by the Lizard Island Reef Research Foundation whose primary objective is to gain financial support for the Station and the work done there.

The Lizard Island Research Station is the most northerly located of four such facilities operating on the Great Barrier Reef. Other stations are at Orpheus Island, approximately 420 kilometres south of Lizard (18°38′ S), and One Tree and Heron Islands in the Capricorn Group off Rockhampton (23°27′–30′ S). Together they provide researchers with an efficient base for research and act as stable and important research facilities, giving the best possible access to the reef.

Lizard Island Research Station is directed by Drs Barbara Kojis and Norman Quinn who are both actively involved in their own research as well as assisting visiting researchers. One of the principal objectives is to support and encourage long-term ecological and behavioural studies on coral reefs. The Station attracts scientists and students from many parts of the world, providing excellent facilities to support their work in the 'real laboratory'—the Great Barrier Reef. The RV *Sunbird* is a 14.1-metre aluminium motor-sailor six-berth catamaran used mainly for research. Initially her size and range improved researchers' access to the outer barrier and inshore reefs in the vicinity of Lizard Island. Her primary role now is to provide researchers access to study sites on the northern reef, although she has made trips from the Capricorn–Bunker group in the south to Papua New Guinea in the north. The Station also relies heavily on the non-researchers who volunteer their time in return for free accommodation on the island. In 1988–1989, 33 volunteers carried out general maintenance and construction, and assisted in research projects.

But why all the concern for research? In this rapidly progressing world we are made aware, all too often and usually too late, of the damage we inflict on our environment. Most areas of the Great Barrier Reef, however, are so far relatively unaffected by the many side effects of human activities, but for how long? Robert Olafson, formerly of the Australian Institute of Marine Science, has examined the reefs adjacent to and surrounding Lizard Island and found

them to be free of pesticides, and industrial and agricultural by-products. Yet with increasing human populations, greater mobility and the increased awareness of what the reef has to offer, there is greater usage of, and pressure on, the natural resources of the Great Barrier Reef and we need to ensure a balance between this usage and preservation of the reef ecosystem.

The location and relative remoteness of Lizard means that it is the least touched by humans and the least under threat. Work done at Lizard Island and the reefs to the north of it can provide a baseline, both to compare with the more human-impacted areas to the south and to monitor changes in northerly reefs as settlement and development steadily advances. Consequently an increasing number of studies at the Research Station have targeted environmental issues and impacts, and reef management. The study of coral reefs is relatively young and they are therefore poorly understood. If we are to ensure their survival we have to first understand the factors that constitute and maintain reef ecosystems, such as the fundamental processes of reef formation, nutrient cycling, the natural mechanisms for maintaining stability, recruitment of juveniles, competition for space, and methods of recovery from structural and environmental damage. Only then are we able to monitor changes in these factors, determine what is human-related, and do something before it is too late. Much of the information we need is provided by research.

The quantity and wide diversity of research projects that have been conducted since the establishment of the Station have attracted worldwide recognition. In 1988–1989 alone over 150 Australian and overseas scientists, postgraduate students and assistants undertook 58 separate projects. While many projects are dedicated to the taxonomy and biology of the reef inhabitants or are specific to the Lizard environs, others are much broader based and more widely applicable along the extent of the Great Barrier Reef and to other reef systems throughout the world.

For example, Julian Cayley (Sydney University) was awarded the Lizard Island Doctoral Fellowship for 1988–1989 to study disturbance in the structure of biological reef communities and the effect of predators and competitors on the abundance and distribution of coral reef fishes. Also, Mary Stafford-Smith (University of York) is studying sedimentation effects on corals, which involves the identification of particularly sensitive coral species that could act as early indicators of community stress under man-made sediment impact. Results from both these projects relates to the overall concern for the effect of pollution and human-induced disturbance on the reef as a whole.

Other projects that target individual communities of reef organisms may at the same time relate to more far-reaching aspects of the reef ecosystem. Joel Elliott (University of Florida), first recipient of the

Pat Hutchings, head of the Worms Section of the Australian Museum, is pictured laying blocks of dead coral substrate on a steel grid attached to the reef floor. This was done as part of a four-year study investigating the seasonal and annual variation in recruitment of polychaetes to coral substrates. Recruitment of polychaetes is via pelagic larvae and so differences were expected (and indeed were shown) to exist between leeward and windward sites. This study is important because polychaetes are initial agents of bioerosion of the reef.

A TRAGIC STORY

One of the more tragic visitors to the island was Mary Watson, a governess from Cooktown who went to Lizard in 1880 where her husband, Captain Robert Watson, had established a bêche-de-mer curing station. After some time, Watson and his partner sailed north seeking new fishing grounds, leaving Mary, three-month-old baby Ferrier and two Chinese servants alone on the island. All was well until Aborigines from the nearby coast crossed to the island, killing one servant and wounding the other. After driving the natives off, and in a desperate bid to escape a possible second attack, Mary and the remaining servant dragged a disused ship's water tank, used for boiling the bêche-de-mer, down to the sea. Taking Ferrier with them, they sailed away from Lizard to a nearby island where they died from lack of water nine days later. They had reached No. 5 Island in the Howick Group and Mary managed to record the tragic events of their last days in her diary. The diary and water tank are on display at the Townsville Branch of the Queensland Museum.

Mrs Mary Watson.

P.B. BERENTS

J.M. LEIS

WILLIAM GLADSTONE

How do clown fishes avoid being stung by their host anemones? Studies at Lizard Island will provide insight into the successful relationships between seemingly incompatible organisms.

Qantas–Lizard Island Travel Fellowship, is studying clown fishes in the genus *Amphiprion* to establish how they avoid being stung by their host anemones. His work will provide new insights into the successful interaction of seemingly incompatible organisms in the struggle for survival.

Jeff Leis (Australian Museum) has been studying various aspects of the ecology of larval fishes in and around Lizard for the past nine years. Jeff's work involves determining the location of larvae of certain taxa with respect to the reef, dispersal of pelagic eggs and larvae, and examining the early life histories of fishes from egg to juvenile. Similarly Mark McCormick (James Cook University) has received the Australian Museum's Lizard Island Doctoral Fellowship for 1989 for research on the early life stages of a specific group of reef fishes (goatfishes), and is primarily looking at the pelagic individuals before settlement and newly settled individuals on the reef. Both these projects have important applications for reef fish management.

A major issue that has been a primary focus of both the scientific and lay communities is the impact of the Crown of Thorns Starfish (*Acanthaster planci*). Although Lizard does not report severe infestations of the starfish, having had only one major outbreak in the early '80s, several studies there have investigated various aspects of its biology. The populations at Lizard are largely removed from factors such as destruction of natural predators and the influence of pollutants, which may or may not have a bearing on the occurrence and control of *Acanthaster* outbreaks. Work carried out at the Research Station may result in some answers that have not to date been attainable elsewhere.

Plankton nets being washed on the RV "Sunbird". The nets have been towed through the water and the plankton collected at the 'codend' for later sorting.

IN ORDER TO MAINTAIN LIZARD AS a viable and consistent base for research, continued financial support must be provided. Several fellowships have been instigated to provide monetary assistance to researchers. Various other groups and individuals have provided goods, services and financial assistance, and this is hoped to increase in the future. In 1980 Suntory Limited, through the Japan Foundation, generously donated $360,000 over a five-year period towards research at Lizard. The *Sunbird* ('torii' means bird in Japanese) was purchased with this funding. Similarly NQEA (North Queensland Engineers and Agents) recently donated two 7.2-metre aluminium dories in excess of $100,000.

Although researchers pay fees to help cover costs and the Australian Museum provides financial backing, funding is largely by donations generated by the Reef Research Foundation. Donations made to the Lizard Island Reef Research Foundation are tax deductible and enquiries should be directed to the Australian Museum. Funding for continued maintenance, updated equipment and expansion of facilities at the Research Station are necessary if they are to continue in their efforts to increase research on the Great Barrier Reef in the future.

And what of the future? The Lizard Island Research Station was initially established to take up the challenge of the need for knowledge—of the reef, its inhabitants, its history and its survival. Fifteen years on it has more than adequately achieved its goal. However, we cannot afford to be complacent. The more we can learn about the working of coral reef systems, the better we can understand the pathways and effects of pollutants and minimise human disturbance. Lizard Island Research Station is dedicated to improving our knowledge of the reef so that this information can be used to help everyone understand and protect it. ■

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Jenny Gates is the Assistant Editor of Records of the Australian Museum *and worked as a research assistant at Lizard in 1981. Peter Hoyle is a Technical Consultant for Westpac Computer Centre, Sydney, and has a keen interest in coral reefs and underwater photography. Both are accomplished scuba divers. They wish to dedicate this article to Lennox Cowen who was killed shortly after their trip to Lizard Island.*

CLIVE MINTON

A TALE OF THREE SPECIES: THE STILT, THE SHRIMP

CLIVE MINTON

The Banded Stilt is easily identified by its white plumage, black wings and broad chestnut band across the breast. Shown here is one incubating its eggs.

BY HUGO PHILLIPPS
VICTORIAN WADER STUDY GROUP

CLIVE MINTON IS A SCIENTIFIC CONsultant and wader enthusiast. His work is in Melbourne but his pleasure takes him to various stretches of the Victorian coast that have the mudflats and sewage treatment ponds where waders, or shorebirds, like to feed. In order to find out more about their lives, he heads a team of amateur ornithologists that makes regular catches of the birds at their

AND THE SCIENTIST...

roosts; these are then measured, banded and released. A few may be caught again, perhaps years later, on the Siberian tundra, the rice paddies of Java or in the mountains of New Zealand, to provide another fragment of information about how they live.

Waders are well named. Most have long legs for wading in shallow water. They have long beaks for probing soft mud and the non-breeding birds usually have a mottled grey and white plumage that makes them difficult for casual observers to tell apart. Most Australian waders do not breed here; they are seasonal refugees from the Arctic

"They were surrounded by the sound of an avian metropolis, a pleasantly murmurous and sociable babble. It was as if the two humans were intruders in an alien world."

A colony of breeding Banded Stilts was discovered for the first time in nearly 60 years in South Australia on an island in the recently flooded Lake Torrens.

WILDNATURE/ANT PHOTO LIBRARY

Flamingos are, in an ecological sense, most similar to Banded Stilts. Both utilise hypersaline lakes, their movements are sudden and unpredictable, their chicks form creches and they form large colonies.

winter. There are a few exceptions, the most numerous and yet most mysterious example being the Banded Stilt.

The Banded Stilt (*Cladorhynchus leucocephalus*) was formally described in 1816 and it is familiar to many birdwatchers of the southern cities of Australia, on saltworks and the briny waters of coastal lagoons such as the Coorong in South Australia. It is easily identified by its striking white plumage with black wings and broad chestnut band across the breast. Unlike migratory waders the plumage does not vary in the breeding season. Another name for it is the Rottnest Snipe, since it appears in large numbers every summer on the salt lakes of Rottnest Island near Perth. Here, late last century, it was considered good sport for the Governor of Western Australia, whose select party of cronies shot the birds from specially built hides.

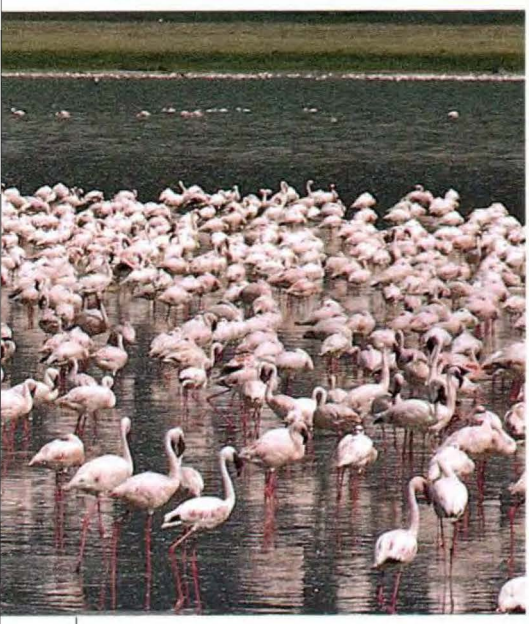
Although it is indeed Australia's most numerous resident wader species, it has always been something of an enigma. Its breeding habits were unknown until the discovery in 1930 of breeding colonies at Lake Grace in Western Australia and Lake Callabonna in South Australia. Ornithologists were astonished by their size and congestion. Virtually no other wader breeds in colonies, certainly none at the density of the Banded Stilt. Also mysterious was the discovery that the eggs lack camouflage and the chicks form creches.

The birds most ecologically similar to the Banded Stilt are the flamingos. They also utilise hypersaline or soda lakes, although they filter-feed on the bloom of small organisms rather than probe. Their chicks form creches and their movements are often sudden and unpredictable. Fossil remains of flamingos have been found in Australia and it seems likely that these birds would have used much the same habitat as the Banded Stilts, being able to coexist because of temporarily superabundant resources and difference in feeding methods. Why they became extinct is unknown. Possibly the introduction of the Dingo around 6,000 years ago had something to do with it. The stilts seem to breed on smaller, more inaccessible areas and perhaps were not as exposed to this form of predation. Certainly breeding flamingos in East Africa are preyed on by hyenas. But maybe the vagaries of the climate became just a little too much for them and the Banded Stilt was better adapted to random fluctuations. Perhaps the smaller size of the individual stilts, as well as the possibly smaller biomass of a viable breeding colony and the shorter breeding cycle compared with that of flamingos, enabled the former to use smaller and more ephemeral lakes during a period of increasing aridity.

Since the 1930 discoveries not a lot more was learnt. No breeding stilts had been recorded since then in South Australia, and only occasional colonies had been sighted in the west, although these were usually after they had been abandoned, leaving only deserted eggs and dead chicks.

Ian May having finally fulfilled his dream of finding breeding Banded Stilts.

CLIVE MINTON

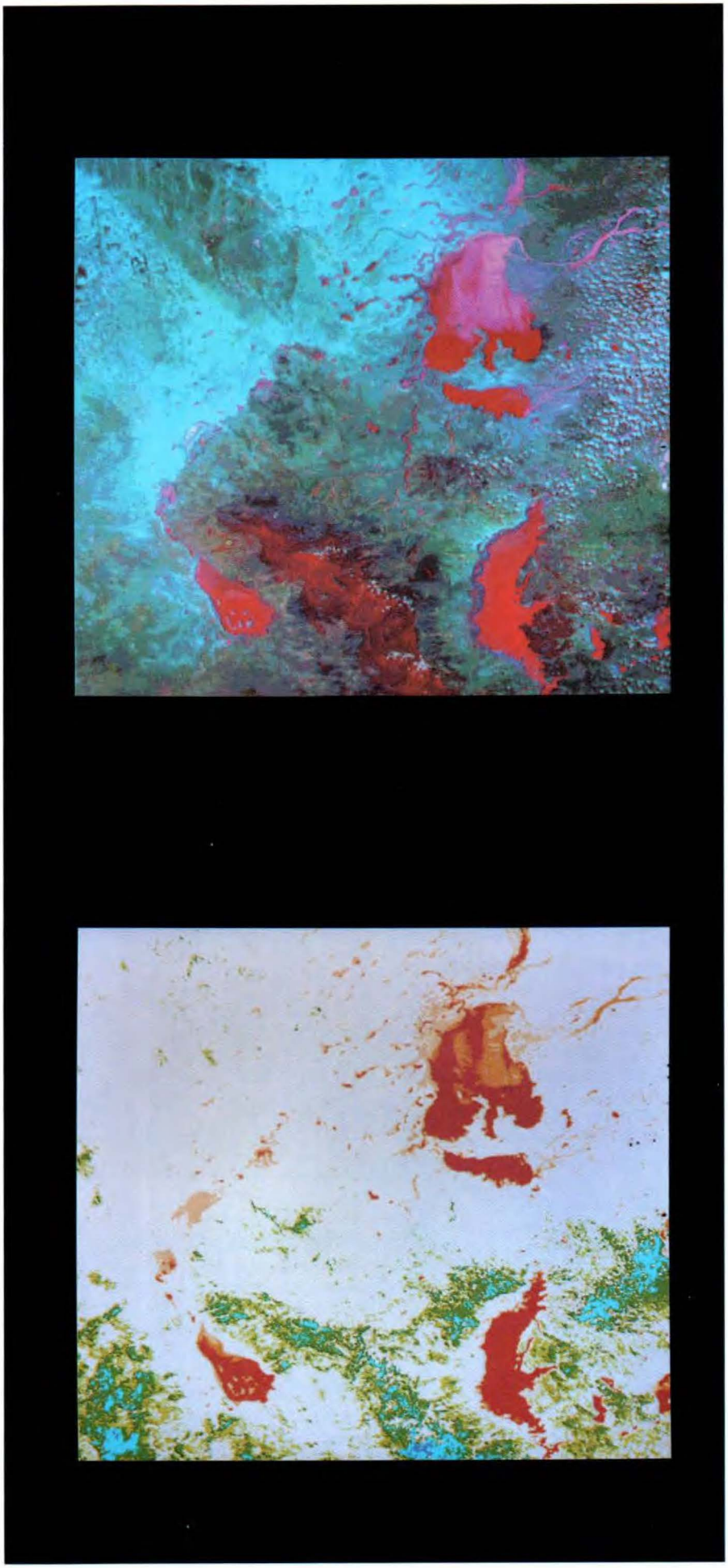


Nobody had managed to follow an entire breeding cycle from laying to fledging and the Banded Stilt remained largely an enigma.

AFTER THE UNUSUALLY HEAVY RAINS that drenched central Australia in March 1989 and filled Lake Eyre to its highest level for 15 years, Clive Minton started thinking about Banded Stilts. Studying a breeding colony had become a life-long dream and one he had thought he'd not have time to pursue until after retirement. He jumped at the sudden opportunity.

Clive and six other wader enthusiasts took the ANZAC day long weekend in late April to survey, both from the air and the ground, the salt lakes east of the Flinders Ranges in South Australia. In conjunction with them, Ian May, the South Australian National Parks and Wildlife ranger at Leigh Creek, had surveyed Lake Eyre and the area north of the Flinders Ranges. There was plenty of bird life but no Banded Stilts. The very lack of stilts was, however, a strong indication that they were breeding somewhere. They had disappeared from all their usual non-breeding haunts along the coast in a mysterious response to rains hundreds or thousands of kilometres away. Moreover, they did this within days of the rains occurring, and even before the lakes had filled.

Back in Melbourne, Clive heard from Ian May again. Ian also had a long-held dream of finding breeding Banded Stilts and had been searching, off and on, for some 20 years. In April he spent 65 flying hours searching the Lake Eyre region, with little



Two NOAA 11 Satellite images taken about two weeks after the heavy rains in March 1989 filled Lake Eyre to its highest level in 15 years. The top image has been enhanced to show the water-filled salt lakes in red, areas of wet soil in orange, and areas of new plant growth in green and blue. The top two lakes are Lake Eyre North and South; directly below this is Lake Torrens, and to the left is Lake Gairdner.

COURTESY MICHAEL FLEMING/CONT

KATHIE ATKINSON

Australian brine-shrimp (*Parartemia*) are tiny crustaceans. As soon as the rains come and lakes are filled, they hatch from their thick-shelled eggs and reproduce parthenogenetically.

success until 24 April when he discovered Banded Stilts nesting on three islands in the recently filled Lake Torrens, west of the Flinders Ranges. It was the first such find in South Australia for nearly 60 years and a dramatic moment for Ian.

Two of the islands were only about 50 metres in diameter and were completely covered with breeding stilts. The third island was some 500 metres across, with a broad strip of stilts across its western shore, opposite the other occupied islets. Ian estimated that there was a total of about 100,000 birds and further surveys indicated that the colony was increasing. The dead heart of Australia was throbbing with life.

To call the arid regions of inland Australia the 'dead heart' is, perhaps, an overworked metaphor. Centralia, or the inland, is certainly never totally dead, and most of the time it flutters almost imperceptibly. Instead, the term refers to the striking difference between it and the lush green rim where most of us live. This difference is not so much in the average amount of rainfall but in the unpredictability of quantity and timing. Along the coast the seasons pulse as steadily as a pacemaker while the inland undergoes great convulsions between long periods of torpor.

As the water saturates the soil with its soluble nutrients, it also soaks the dry spores, seeds and eggs that have been waiting for years for the start of their short

CLIVE MINTON

Banded Stilt chick.

and furious lives. Energy from the sun feeds the diatoms and bacteria in the water, making it a murky vegetable broth; and in and on this broth live the brine-shrimp. Australian brine-shrimp (*Parartemia* spp.) are tiny crustaceans only a few millimetres long. As soon as they hatch from their thick-shelled eggs they start to feed and breed. In the broth they reproduce parthenogenetically (without the need for sexual reproduction), laying thin-shelled eggs that contain clones of themselves. The pace is frantic and, within days, the broth has become a shrimp and vegetable soup. On this soup lives the Banded Stilt. Adult stilts seem to be able to maintain themselves on other kinds of small aquatic life, but growing chicks apparently require brine-shrimp.

Events followed fast upon Ian's discovery. Clive returned to South Australia and on 6 May he and Ian made the 30-kilometre journey to the islands in a small aluminium boat, skimming water that was mostly less than a metre deep. The horizon was featureless except for the distant backdrop of the Flinders Ranges seen from a rare viewpoint and against which the islands of the stilts eventually appeared. Ian and Clive reached one of the small islets, a low expanse of sandy earth with the dominant vegetation being some scattered

Most of the nests contained three or four eggs, but some had five, an unusual number for a wader but probably a consequence of the rich supply of food.

CLIVE MINTON

glassworts (*Salicornia* spp.). The small nesting scrapes covered the ground at a density of about 12 to the square metre, but they were empty. The thousands of eggs they had contained had hatched, the chicks were gone and the islet had been taken over by breeding Silver Gulls (*Larus novaehollandiae*).

They then took the boat round to the eastern side of the nearby larger island and there they found what were probably the missing chicks—fluffy white balls with black legs and beaks—in creches attended by adults, paddling their way through the nourishing shrimp soup towards the distant eastern shore of the lake. Landing on the large island, they found the main colony of stilts still active. In a strip 400 metres long by 30 or 40 metres across there were about 50,000 birds—remarkably tame, not even moving from their nests until approached closely. Most nests contained three or four eggs, but some had five, a most unusual number for a wader and a consequence of the rich supply of brine-shrimp. Some of the clutches were hatching and, as they hatched, the chicks started forming the small creches seen earlier and heading east. Revealed for the first time was the fact that, while it was mainly the female stilts that brooded the eggs, it was mostly the males that accompanied the creches of chicks.

Clive and Ian stood among breeding stilts, two out of only a small handful of people ever to have done so. They were surrounded by the sound of an avian metropolis, a pleasantly murmurous and sociable babble, not the raucous aggression of a gull colony. It was as if the two humans were intruders in an alien world. Time was strictly limited, so they had to get down to the business of counting, measuring and taking photographs, but their senses were saturated with enough elation and wonder to last the rest of their lives.

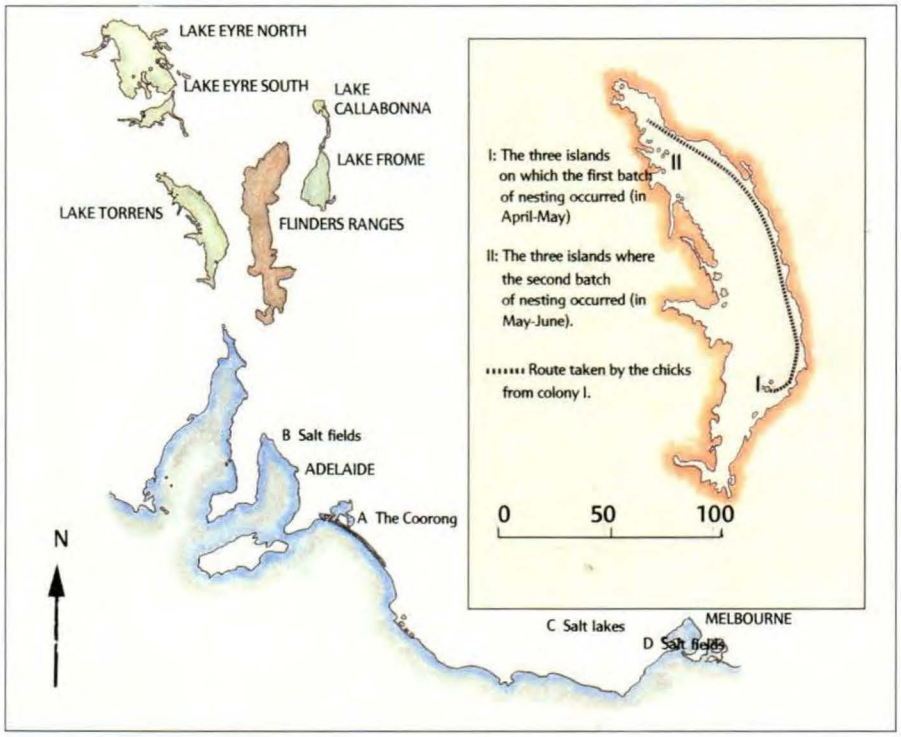
They left the islands after a frustratingly brief four-hour visit, taking with them the first comprehensive colour photographs of breeding Banded Stilts. Later, Keith Bellchambers and Graham Carpenter were recruited by the South Australian National Parks and Wildlife Service to record the final chapter in the story of the colony. They found that it gradually diminished in size over the next two weeks as the chicks and adults departed by swimming eastwards. The number of Silver Gulls, however, was increasing and, when there were only some 2,000 stilts left, the gulls pushed them off their scrapes and took the remaining eggs, causing the abrupt end of that colony.

CLIVE MINTON

CLIVE MINTON

Chicks were seen swimming away from the island in Lake Torrens to the distant shore in creches attended by adults (usually the males). While the males attend the chicks, the females can renest, thus facilitating the rapid production of additional clutches. The habit of forming creches, which is unusual in birds, seems vital for the continued survival of these birds in such an unpredictable environment.

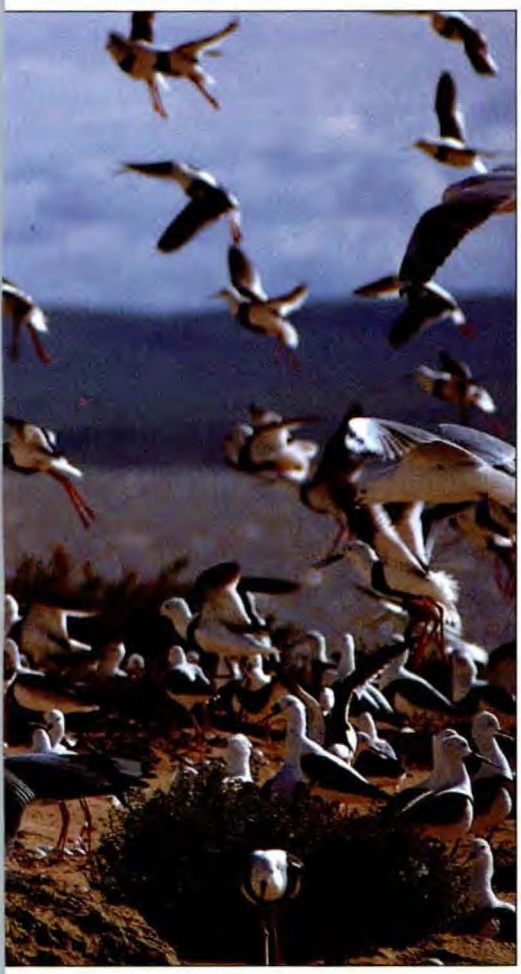
CATHY MCGAHEY



The Lake Eyre and Lake Torrens region of South Australia, with Lake Torrens enlarged, showing the location of the nesting Banded Stilts and their movements. Principle sites inhabited by these birds when they are not breeding are marked A, B, C, D. The species is almost unknown in eastern Victoria, Tasmania and New South Wales. The Western Australia population is thought to be self-contained.

Ian May continued to follow the fate of the chicks by aerial survey and found that they did not land on the eastern shore but turned northwards until they reached the end of the lake, travelling 130 kilometres in six days. There, he estimated, were 150,000 chicks, some of which were ready to fly only three weeks after they had hatched. Many of the adults had left and the small creches had amalgamated such that there were thousands of chicks in each.

The next discovery was that the adult birds were preparing to nest again on different islands in the lake, about 100 kilometres to the north, and only two weeks after the first clutches had hatched. This emphasised one of the main distinguishing characteristics of the Banded Stilt: their amazingly short breeding cycle. Laying one egg each day until the clutch is complete, followed by roughly three weeks of incu-



As the Banded Stilt colony decreased in size, the number of Silver Gulls increased, until finally they pushed the final few thousand Stilts off their scrapes, bringing an end to the colony.

bation and another three weeks or so until fledging, the cycle is only about seven weeks. It is now clear that even this period can be shortened if the females renest while the males attend the flotillas of fluffy, yet rapidly growing, chicks. Indeed, it seems that the habit of forming creches, which is unusual in birds, is to facilitate the rapid production of additional clutches.

WHAT WILL THE STILTS DO NOW? Presumably they will continue to breed as long as there is a plentiful supply of brine-shrimp. Lake Torrens has now begun to dry out and the birds have left. They may move to Lake Eyre or some other lake where the waters will take longer to evaporate, but there is a danger that the rising number of gulls will cause increasingly heavy predation on further turns of the breeding cycle.

Eventually the level of salinity in the lakes will rise towards nine or ten times that of seawater and the brine-shrimp will lay their sexually produced thick-shelled eggs and die. At that point the stilts will break the cycle and abandon eggs or young, moving back to the coastal saltworks and lagoons. Although their longevity is unknown, it is assumed that they are long-lived birds, for it may be a decade or more before the inland floods again and they become aware (somehow) of distant rains.

This is a story of opportunism, of waiting patiently for the chance of a lifetime and then grasping it without hesitation. The Banded Stilt is adapted to the irregular pluvial spasms of central Australia. Even though much of the population may spend most of their lives near the coast, they do not seem able to breed there. The brine-shrimp, too, although able to survive in seawater, do not appear able to persist in such a stable environment. As for the scientists, there are still some who dream of experiencing the magical and unpredictable phenomenon of life unleashed when, for a short time, there is no check to its wild exuberance. ■

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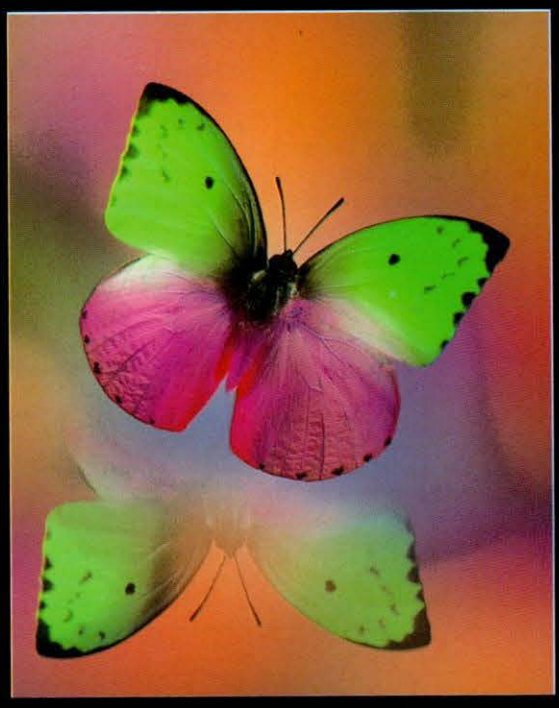
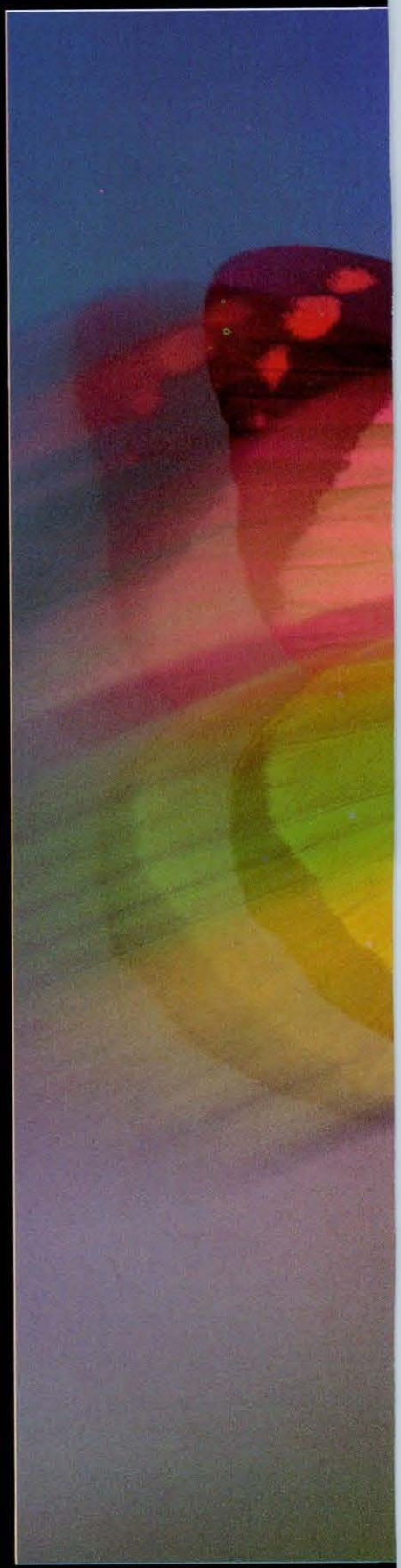
Mr Hugo Phillipps is an ex-journalist and freelance writer who is especially interested in the field of Australian natural history. He is also an active member of the Victorian Wader Study Group, which is affiliated to the RAOU.

FLIGHTS OF FANTASY

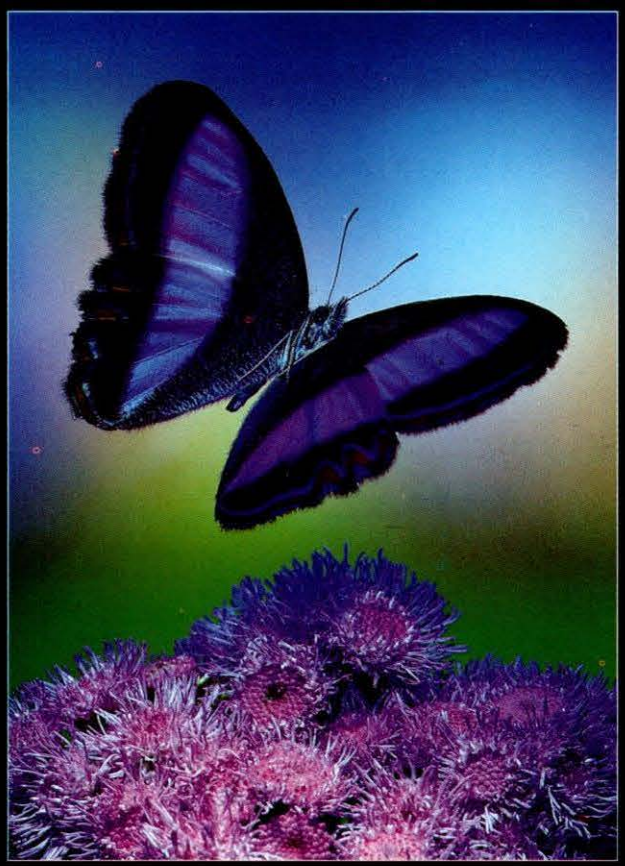




Jim Frazier's lifelong interest in the world of insects and his innovative skills as a photographer are well known. Using a multitude of techniques developed over many years, he recently produced a portfolio of brilliant images that he calls his 'Fantasy Butterflies'. Taking the aesthetic qualities of real butterflies as a starting point, Jim set out deliberately to enhance and elaborate on their forms and colours, in this way expressing his own personal feelings about these beautiful insects.

BY JIM FRAZIER
MANTIS WILDLIFE FILMS

FLIGHTS OF FANTASY



"All science is inevitably a self-checking system driven, ironically, by the avarice of scientists themselves."

THE MUDDLED MOLAR MYSTERY OF RIVERSLEIGH

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

WITH SWEAT STREAMING INTO MY eyes, I belted the boulder yet again with 'Conan' the monster seven-kilo sledge, infamous on Riversleigh expeditions for laying low the macho and muscles of mortals foolish enough to swing this juggernaut more than once. Unfortunately, some of Riversleigh's 20-million-year-old fossil-rich limestones are uncommonly hard and few can be 'opened' with anything less brutal than a sledge.

Trying to appear nonchalant after the futile siege, while in fact leaning on Conan for support and surreptitiously gasping for breath, a sideways glance reminded me of the expectations of the visiting dignitaries who had come for the day. Given the richness of Riversleigh's fossil deposits, it is normally easy to pluck from the solid rock, on demand, a weird but comprehensible denizen of Queensland's rainforested past, but *this* boulder's defiance, the hot sun, hundreds of 'sticky' flies and Conan's fabled strength-sucking ability, had put the feat beyond my reach.

So it was with distinct relief that I saw Syp Praeseuthsouk running up the rise of Godthelp Hill, clutching in his hand what was obviously a 'goodie' of some kind. Because he was famous on Riversleigh expeditions for his ability to find exquisite specimens that almost invariably shattered preconceptions, I presumed this was another being couriered up the hill. Yet when he arrived, it was with atypical calm that he handed over the pale yellow lump of Riversleigh limestone while mumbling something about its discovery in 'Camel Sputum Quarry'. Too weary to be wary, I flipped it over to see what it was in this particular rock that had entitled it to VIP treatment and caused Syp's mysterious lack of enthusiasm.

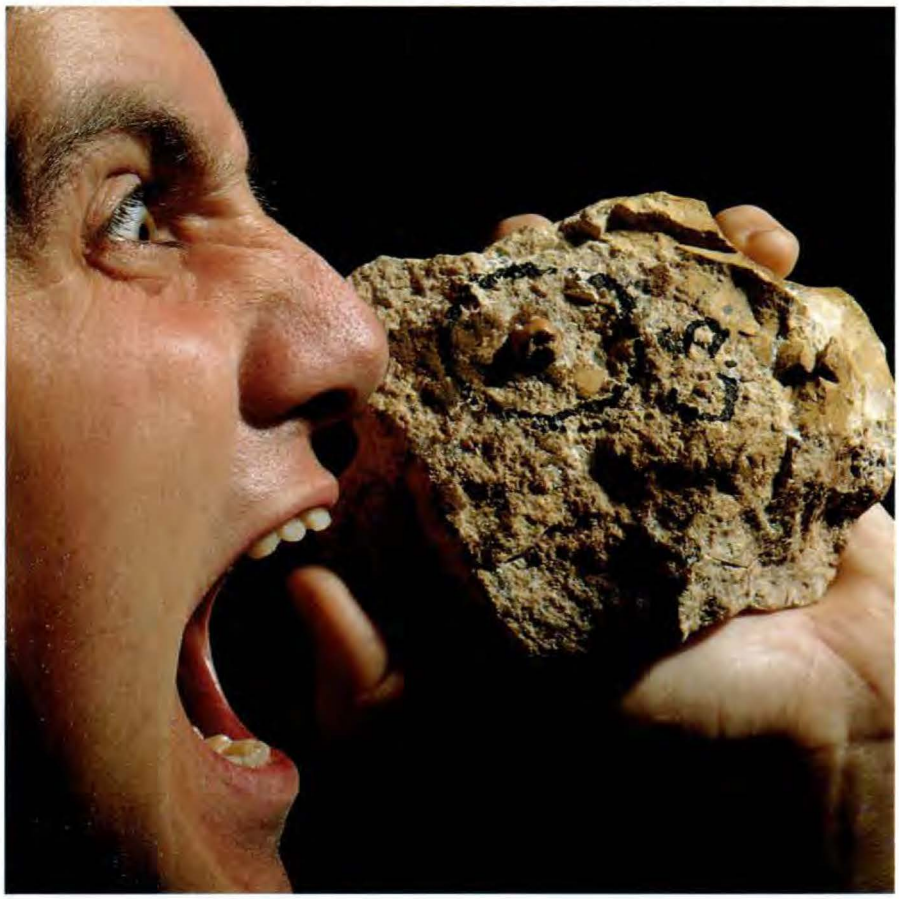
I saw it. My mind struggled with the image but within seconds I felt the bottom begin to fall out of the world I had come to understand. This was *nothing* like anything that had ever been found at Riversleigh before. Here, with its fragile white roots obviously still firmly embedded in the piece of Riversleigh limestone and most of its square-centimetre caramel-coloured crown standing proud of the rock's surface, was a beautiful and characteristically well-preserved tooth.

Camel Sputum is one of about 100 isolated 'quarries' known from Riversleigh and smack in the heart of what we have painstakingly, and through many independent lines of evidence, worked out to be early to middle Miocene age[1], that is between about 23 and 15 million years old. So, what I saw in the rock that Syp handed me simply should *not* be there because, as impossible as it seemed, it was the upper molar of a human, one clearly belonging to our own genus *Homo* and probably even our own species *Homo sapiens*. Nothing about this discovery made sense. Many decades of research had shown Africa to be the ancestral home of humans but even there the oldest known member of our subfamily Homininae is 'Lucy', *Australopithecus afarensis*, a 'primitive' australopithecine barely four to five million years old. And the oldest recognised species of *Homo* is *Homo habilis*, a two-million-year-old African hominine.

When Paul Willis (a University of New South Wales postgraduate student studying Australian fossil crocodiles for his PhD project) arrived, he found me a bit dazed but clearly excited. He asked what the tooth was that Syp had communicated. Not for one moment did I suspect anything untoward about this discovery or Paul's seemingly innocent curiosity. Although I would have preferred more time to consider all reasonable possibilities, he persisted so I gave in. "Well, I don't understand it, but this thing's indistinguishable from a human upper molar—*Human*, not just primate!" With that, everyone around us was alert to the fact that something most extraordinary, perhaps even world-shattering, had just happened.

As the excitement spread through the group, which included a visiting media representative from Mount Isa Mines, other reasonable, less iconoclastic possibilities came to mind. Someone in the group

Paul Willis, engineer of Riversleigh's muddled molar mystery, holding his offensive object.



ROSS ARNETT

suggested "pig?" (no, but as things turned out, not far off the mark). "Perhaps. . .", I tried, "it's some kind of omnivorous marsupial we haven't seen before—one that converged on the human condition?" Many unique Riversleigh animals have already turned up, including a human-sized pre-wombat-like weirdo from this same hill. But *this* was no 'pre-wombat'. It was, if not human, an animal *perfectly* convergent on the human condition—so perfect, however, that it strained credulity. Besides, evolution of the distinctive human dental condition had been a response to the pressures of feeding in African grasslands, while the Camel Sputum Local Fauna represented a rainforest habitat. No, the convergence hypothesis was going to be at best a weak alternative to the Big One.

Then Paul, wicked wretch that he really was, lost control of the grin he had been strangling from the moment he had first set foot on this expedition and began to howl with laughter. The smell of rat began to fill the air. It was *his* bloody wisdom tooth (his left M^3), removed from his mischievous head shortly before the trip, with great pain, I began to hope. He and several as yet unnamed co-conspiritors had spent hours in Sydney carefully grafting the tooth into a gouged-out space in a genuine block of Camel Sputum limestone, gluing the tooth in and, using every technical skill they had, staining this gruesome relic to perfectly resemble genuine Riversleigh fossil teeth from Camel Sputum Site. In the end, they had a spectacularly well-crafted fake. Satisfied and oozing with the joys of anticipation, Paul smuggled the monstrosity to Riversleigh in his pack.

Hoaxes have long been the less serious side of biological science. And, although I hate to admit it, this one *was* very good. Of course I'll have to kill him. . .if I can't first get him back with one better.

But the whole course of events was also food for thought. What if Paul *wasn't* the honest lad that he is? What if he hadn't promptly admitted the truth of the conspiracy? What if the whole thing had gotten out of control and the press, who were there, had radioed out the news: "Palaeontologists rocked: 'modern humans' found in 20,000,000-year-old Queensland rocks!"?

Well, a number of things would probably have happened. In the first place, our 1989 expedition would certainly have diverted all of its energies to Camel Sputum Site and, somewhere along the line, we would probably have made prime bunnies of ourselves by announcing the discovery of 'Austral humanoids or humanoid Australians'. But then, eventually and inevitably, the fabrication would have been discovered because, as the most stunning palaeontological find of the century, the key 'specimen' would have been exhaustively examined—at which time the glues, stains and other devices would have been detected. And at or shortly after this time, Paul Willis would have bought a wig, a padded bra and a one-way ticket to Buenos Aires.

Perhaps a similar chain of events began in 1908 in Piltdown, England, where fragments of a medieval human skull were buried with the artificially aged jaw and filed teeth of an Orang-utan. Perhaps, however, the perpetrator of *this* caper was unable or more likely unwilling, at the crucial moment, to roll on the ground in front of *his* victim, howling out the truth of the matter. Even so, the 'Piltdown Man' hoax did come unstuck, albeit 45 years later, after other more suspicious scientists ran chemical analyses on the bones themselves.

The inevitable *unravelling* of hoaxes is more the point of the Muddled Molar Mystery of Riversleigh than the charade itself. Recent publication in *New Scientist*[2] of cleverly faked photos of the extinct Thylacine, supposedly discovered foraging in the wilds of Western Australia, clearly demonstrated that biological con merchants are themselves far from an extinct species. This particular hoax was exposed within mere months by suspicious readers who noted inconsistencies in the photographic 'evidence'.

In fact, suspicion is so much a part of science that, when genuine weirdos like 'Thingodonta' (from Riversleigh) are reported, wary professionals have a knee-jerk reaction that often presumes mischief before honesty.

Which is just as it *should* be if science is to remain healthy. All science is inevitably a self-checking system driven, ironically, by the avarice of scientists themselves. Scientists, particularly the up and coming generation, secretly delight in discovering flaws in colleagues' published works because, through these discoveries, their own paths to research funding and fame may be found. For this reason, every scientist becomes a kind of bounty hunter in search of 'Rogue Colleagues'.

While announcement of the discovery of a strange fossil from the Himalayas, Yowie footprint or cold fusion can be made with relative ease, if there is the slightest rotten spot in the data, it rarely takes more than one generation of ambitious scientists to ferret it out.

But how do *you*, as the potential victim, know when flimflammery is afoot? With a prior inoculation of virulent scepticism (the Australian Skeptics would be delighted to advise you: call 02-407 2071). As for any perpetrators about to be sprung, woebetide those who haven't already bought one-way tickets to Tibet! ■

[1] **Archer, M., Godthelp, H., Hand, S.J., Megirian, D., 1989. Fossil mammals of Riversleigh, northwestern Queensland: preliminary overview of biostratigraphy, correlation and environmental change. *Aust. Zool.* 25: 29–65.**

[2] **Douglas, A.M., 1986. *New Sci.* 24 Apr. 1986: 44–47; Webster, M., 1986. *New Sci.* 15 May 1986: 76.**

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

THE ORGANISATION OF LIFE: FROM ENTROPY TO EVOLUTION

BY RALPH MOLNAR & GLEN INGRAM

VERTEBRATE FOSSILS, QUEENSLAND MUSEUM
VERTEBRATE ZOOLOGY, QUEENSLAND MUSEUM

ALL AROUND US WE SEE LIVING things. Yet the differences between living and non-living things are so obvious that we rarely think of them. Living things are highly organised structures: this is reflected in what we call them—organisms. They are not uniform, like rocks, but have heads and tails, ears, legs and necks, or roots, stems and leaves. Even at the microscopic scale there are distinct cell and tissue types. Bacteria, although small, are not homogeneous: they, too, are highly organised on the molecular level. Perhaps the chief question of evolution is how this organisation came about. Seemingly, the living world can organise itself but the non-living world only disorganises itself.

How organisms came to be organised is the concern of evolutionary biology. This science studies changes taking place over time and, in this way, is similar to the science of thermodynamics. Both living and non-living things change. And the changes usually cannot be undone, "The Moving Finger writes; and, having writ, Moves on. . ." and all that. Such changes are said to be irreversible and it is irreversible change that marks the passage of time. But, surprisingly, the explanation of irreversible change for non-living things is quite different from that for living things. Evolutionary biology accounts for changes in terms of natural selection, mutation etc. Thermodynamics accounts for changes in terms of entropy and heat flow. When an organism dies, it passes from the realm of evolutionary biology to that of thermodynamics. Thus, in a sense, thermodynamics is the realm of the dead. But this is not the whole story.

THERMODYNAMICS DESCRIBES PROCESSES in terms of its Second Law. This states, more or less, that entropy always increases. And what is entropy? Take the engine of your automobile. It produces both useful work (to move the vehicle) and waste heat. Dividing the amount of heat produced by the temperature at which it is produced gives the entropy. That's all there is to it. The hotter the engine runs, the less entropy is produced, which is why engines tend to run efficiently at high temperature. The often-cited relationship of entropy to increasing disorder is a metaphor, and we don't yet know if it is a good one.

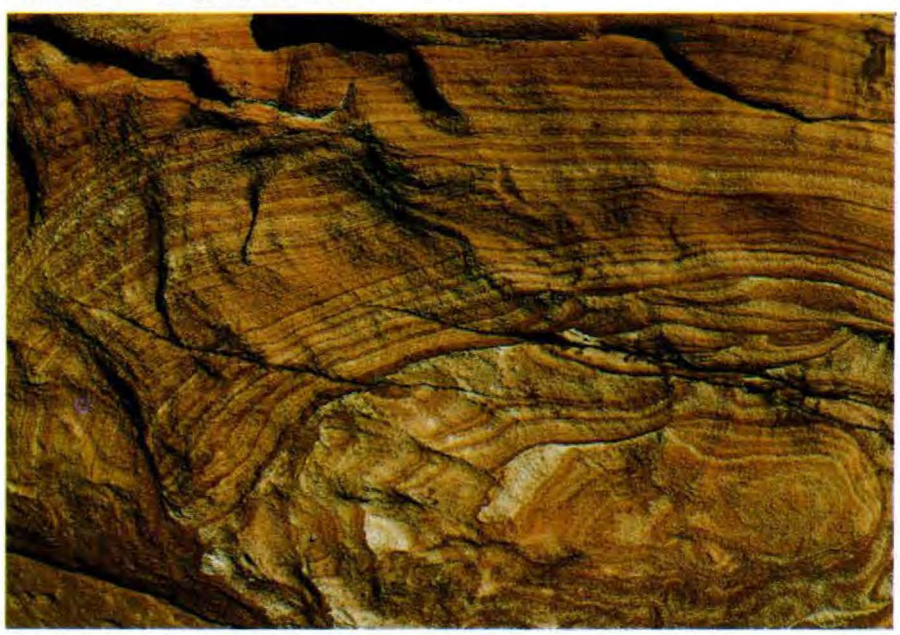
So the Second Law of Thermodynamics states that in a system isolated from the rest of the universe, a so-called closed system, entropy will never decrease. If the temperature is constant, this means an increase in (waste) heat production and a decrease in useful work. Or, in short, things wear out; a kind of universal Murphy's Law. This describes change clearly enough, but not the kind we find in evolution.

The difference between the explanations of change in the living and non-living worlds has troubled philosophers, although rarely scientists. The explanations for this difference appears difficult to find. The problem is that changes in non-living things (their evolution in the pre-Darwinian meaning of the word) involve processes that lead to disintegration (that is, dis-integration). Mountains wear down, machines break down, and we get decrepit with age. Unlike mountains, however, individual organisms must take in energy to remain alive: in animals this is the familiar process of eating. Organisms also dissipate energy in heat and other wastes. So organisms are not closed systems. Changes resulting from biological evolution often lead to increased complexity and integration. Unicellular beings evolved to multicellular animals, eventually to birds, wombats and us. But evolution does not *necessarily* lead to greater complexity. Certain complex crustaceans, for example, evolved into simple sac-like parasites.

Thermodynamic and evolutionary change seem diametrically opposed. However, recent work in thermodynamics indicates that, just as some evolutionary changes do lead 'downhill' to simplicity, some thermodynamic changes lead 'uphill' to complexity and order. The Beloussov–Zhabotinsky reaction, an obscure chemical process, produces expanding spirals of colour from uniformly drab reactants. And a similar reaction probably accounts for concentric coloured bands, called Liesegang rings, sometimes seen in rocks. These processes follow the laws of thermodynamics but produce increases, albeit modest, in organisation. The study of these processes, called irreversible thermodynamics, may help account for the origin of life, but it doesn't play matchmaker to the marriage of evolution and thermodynamics.

Surprisingly, few biologists have lost sleep over this problem. Among those who have are Harold Blum and the team of

The process by which these Liesegang rings were formed is an example of thermodynamic change that leads to increased (rather than decreased) order. Study of such so-called 'irreversible thermodynamics' may help account for the origin of life.



A. OSBORNE

Daniel Brooks and E.O. Wiley. Blum's book, *Time's Arrow and Evolution*, first appeared in 1951 and had quite an impact. But mostly among biochemists (and those interested in the origins of life), because neither Blum nor anyone else could relate thermodynamics to anything more complex than biochemistry. Blum, whose work was competent but unsurprising ("rather humdrum" is one reviewer's description), also was unable to play matchmaker. But Brooks and Wiley's book, *Evolution as Entropy* (1986), takes the dilemma by the horns, although some scientists feel that the dilemma takes those authors by the horns. Brooks and Wiley try to explain biological processes such as speciation in terms of entropy.

They contend that thermodynamics implies the individual animal or plant will produce a minimum of entropy. However, the mechanism linking the production of minimum entropy to evolution is not clear. It involves a digression into several obscure fields of mathematics—topology, information theory and the analysis of networks. Brooks and Wiley claim that thermodynamics implies evolution is the result of the structure, or internal organisation, of the organism. Thus organisms are only tenuously related to the environment: so much for natural selection. They propose that the structure and behaviour of organisms is primarily controlled (or constrained, to use the currently fashionable word) by their history (heredity) and development (ontogeny): "Function follows form and not the reverse". Although doubtless simplifying their ideas, Brooks and Wiley seem to say that, for example, modern horses run fast because they have long legs. This sounds trivial and obvious, but there is more to it. Horses have evolved long legs because of the inherent thermodynamics of the organisation of horse genes, not because those individual ancestors with longer legs could more easily escape predators and so live to reproduce rather than becoming a meal.

So Darwin got the problem wrong when he tried to explain the diversity of animals and plants. The question is not why there are so many kinds of organisms but, given the enormous variety of genes and the great number of their possible combinations, why there are so *few*. The similarity of related organisms follows from their similar sequences of growth from fertilised egg to adult. And these similar sequences are based on the (nonequilibrium) thermodynamics of their embryonic development, not on their similar genes.

Evolutionary change is caused by changes in the organism's developmental program. These changes, in turn, are controlled by the laws of thermodynamics. The role of genes in this is not clear: the developmental programs are governed by the organisation and integration of the genes, not by the genes themselves. And the organisation and integration, in turn, are governed by the laws of thermodynamics. Natural selection is relegated to the role of culling unsuccessful variants. It is not the creator of order, as in Darwinian theory. Developmental constraints lead to long-term stability in species such as horseshoe crabs (in the genus *Tachypleus*), which have remained almost unchanged for the past 150 million years. The constraints imply that not all genetic variability is expressed as variability in the physical structure of horseshoe crabs. Instead the variant animals are eliminated by developmental failures (birth defects) or natural abortions. Horseshoe crabs show high rates of abortion, as predicted.

HOW DO THE IDEAS OF BROOKS AND WILEY compare with those of neo-Darwinism? Neo-Darwinism proposes that variation, which is provided by mutation, recombination and other mechanisms, provides the 'raw material' for natural selection. Brooks and Wiley give a more basic account for the origin of variation. It derives from the thermodynamics of gene integration and is thus limited by history, the history of the particular suite of genes. In agreement with neo-Darwinism, organisms are considered to be adapted to their environments. Adaptation arises, in an unspecified fashion, from the thermodynamics of the genes and development. Organisms adopt a lifestyle suited to their anatomy. Finally, Brooks and Wiley give, in species cohesion, a basic explanation for punctuated equilibrium, the long-term persistence of organisms with little evolutionary change.

What is most significant in the work of Brooks and Wiley is simply that they have recognised the problems of the relationships of evolution to thermodynamics. Many others have been content to say that organisms represent thermodynamically open systems and forget the details. Brooks and Wiley realise that without details there is no understanding. They have examined a new aspect of evolution, and our understanding of evolution will be irreversibly altered. ■

Suggested Reading

Blum, H.F., 1968. *Time's Arrow and Evolution.* (3rd ed.) Princeton University Press: Princeton.

Brooks, D.R. & Wiley, E.O., 1986. *Evolution as Entropy.* The University of Chicago Press: Chicago.

Coster, H.G.L., 1981. *Thermodynamics of Life Processes.* University of New South Wales Press: Kensington.

Weber, B.H., Depew, D.J. & Smith, J.D. (eds), 1988. *Entropy, Information, and Evolution.* MIT Press: Cambridge, USA. [Further aspects of the relationships of thermodynamics to evolution are discussed.]

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

QUESTIONS & ANSWERS

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

Multiple Microwave Massacres

Q: I would like to add to the information supplied by Matthew Feierabend in the Q & A "Microwave Cockroaches" (vol. 23, no. 2, 1989). I had a similar experience with ants. Having left a halved grapefruit in the microwave overnight, and after 45 seconds on full power, I noticed the fruit was covered with ants, dashing about apparently unconcerned as to what I thought should be happening.

—Harry Fenwick
Como, WA

I switched on my microwave to heat a mug of water that had been standing in the oven overnight. As the turntable rotated, a cockroach of the pale fawn flying type was observed having a merry-go-round ride on the mug. Being a sadist when it comes to cockroaches, I allowed the journey to continue until the water boiled. No, the beastie was not zapped but happily darted away once I opened the door. The oven was clean, as were the external surrounds, and the insect was certainly in receipt of the full force of the 'high' setting. What have cockroaches got that they would appear to be able to disregard such high-frequency waves?

—M. Robertson
Armidale, NSW

I have found that cockroaches are not the only things seemingly immune to the effects of microwaves. Recently I cooked a piece of fish on high for two minutes. On removing the bowl from the oven, I found two Common Black Ants happily walking around it, none the worse for wear, apparently unaffected.

Also, last summer, I put an ordinary, kidney-shaped jellyfish in the microwave to see what would happen. I started at 30 seconds and progressed finally to ten minutes. It did not change at all in transparency, consistency or any way that I could define. I would be most interested to hear some opinions on these things.

—Helen J. Kennedy
Port Welshpool, Vic.

A: The original question has certainly stirred up some interest! We took it a little further by asking researchers at the University of Technology in Sydney to help. They recently ran some tests to see what happens when a cockroach is microwaved.

They used ten each of mixed sex adults and nymphs of both the American Cockroach (*Periplaneta americana*) and the German Cockroach (*Blatella germanica*). The microwave oven used was a National (model NN7406, 700 watt output). Each experimental animal was placed in a glass jar along with a cup of water and the oven set on high. Time taken for the cockroach to become totally immobile was recorded. Effects at the centre of the carousel and on the outside edge were also checked to see if there were any differences in the time taken for the cockroaches to be killed.

The results were as follows:

Cockroach	Average time taken to become immobile (seconds)	
	Centre	Edge
German		
adults	19.5	14.5
nymphs	60	50
American		
adults	12	11.7
nymphs	12.5	12.8

It appears that this particular brand and model of microwave kills both species. However, it was found that the glass jar the cockroaches were placed in became quite warm after 20 seconds heating, so the deaths may have been due to the combined effect of temperature and microwaves.

With the German cockroaches, the smaller their size, the longer they took to die (small nymphs lasted up to one minute). These nymphs are only a few millimetres long (the American nymphs are larger than the German adults).

There could be variations between brands of microwave oven (particularly in terms of their power output) but the results indicate that, if microwaved long enough, the cockroaches will die. We tried microwaving some to take SEM photos, we were unable to detect any difference in appearance between the microwaved and non-microwaved cockroaches.

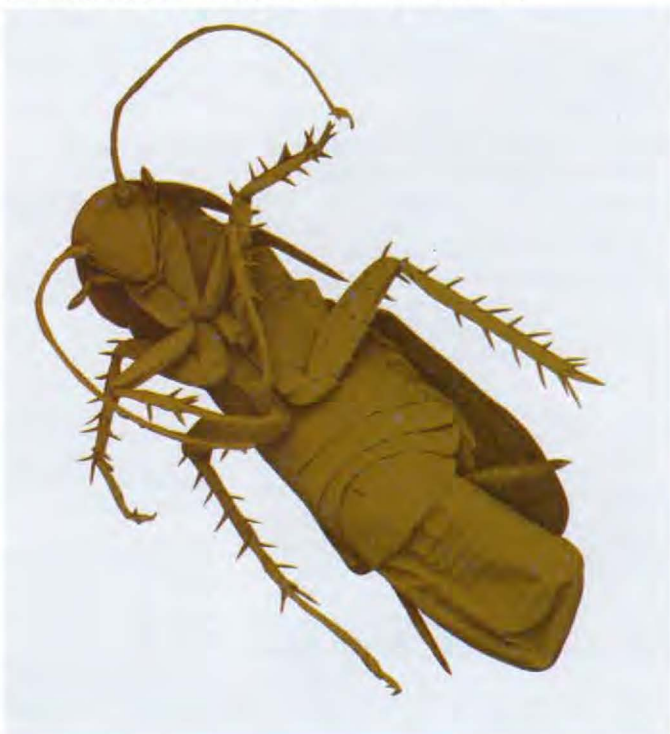
As for ants, another experiement could perhaps be carried out although, going by the results of the cockroach trials, I think their tiny size must have something to do with their resilience.

Apparently the problem of insects surviving microwaves is not unknown to the manufacturers of microwave ovens. There are several points to consider. Firstly there are 'black spots' in the corners of microwave ovens where few microwaves reach. Cockroaches and ants could certainly escape to these to avoid being microwaved. This may have been the case in the original question, as those cockroaches survived four minutes. Secondly, the quantity of water in the item being cooked is important as it absorbs energy from the microwaves. The drier the food, the longer it takes to heat up. Liquids cook much faster than solids. Cockroaches are very dry, especially their hard exoskeleton. Size also makes a difference as the wavelength of the microwave is several centimetres, which probably accounts for the ants' survival and the longer time taken to kill the tiny German nymphs.

The 'jellyfish' described sounds more like a naticid marine snail egg case. These are atypical of marine snail egg cases in that the tiny eggs are scattered throughout a firm, kidney-shaped jelly casing. If this is what was microwaved, then after ten minutes it is surprising that the jelly did not break down, since it is designed to do just that to release the eggs. Of course the trigger in nature is not microwaves—what exactly *were* you expecting anyway? (Perhaps next time you should try cooking it in stock or a nice bearnaise sauce!) We asked the University team to experiment but they were unable to comply—unlike cockroaches, the 14th floor of a university does not appear to be the natural habitat for molluscan egg cases.

—F. D.

It seems that cockroaches are *not* immune to microwaves.



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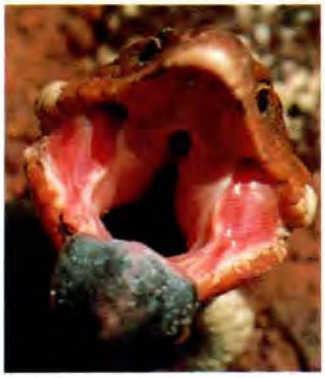


DAVID P. MAITLAND

Exactly what produces the colour blue in a lizard's tongue is uncertain.

Tinted Tongue-twister

Q: What makes a blue-tongue lizard's tongue blue? Does the colour serve a purpose? I thought there was no such thing as a blue pigment.

—Vicky Kapatos
Toorak, Vic.

A: It is not known exactly what produces the blue colour of the tongue of blue-tongue lizards, although it is most likely to be the black pigment, melanin, the colour of which is modified by the overlying tissue. Not all species of blue-tongue lizard (there are seven in total) have the bright blue tongue of eastern Australian species. Some have instead a dark inky blue–black tongue, while a few close relatives of the blue-tongues have a lighter grey tongue. The darkness of the tongue colour is probably due to the density of melanin in the tissues.

The tongue colour of the blue-tongues is probably related to their threat display. Rather than running away when confronted with a potential predator, as do most other skinks, the slow-moving blue-tongues face the threat and open their mouths wide. The sudden flash of a blue tongue against the background of the bright pink mouth lining, together with the increase in the apparent size of the head, may serve to frighten off predators in a similar fashion to the flash colours of some insect larvae.

—Glenn Shea
University of Sydney

Grampians Graffiti

Q: Recently I visited the Grampians National Park in Victoria and was appalled by the sight of graffiti on some Aboriginal rock paintings. Can this be removed without damaging the paintings?

—Caroline Webb
Lane Cove, NSW

A: It is possible in most cases to remove graffiti from Aboriginal paintings without causing further damage. Success depends mainly on the pigments used to form the painting, the subsurface rock type and also whether the painting has already been damaged or scratched by the act of vandalism.

There are quite a number of sites in Australia that have had substantial graffiti removed from them. It is interesting to note that, in most cases, further vandalism has ceased following the clean-up, whereas, if left unchecked, the graffiti tends to attract more.

The methods used are rather complex and need to be carried out by trained people. In the case of the Grampians, most of the graffiti is adjacent to and not on top of the Aboriginal motifs and could most likely be removed with little impact on the site.

—Dave Lambert
National Parks and Wildlife Service,
Gosford, NSW

HOWARD HUGHES/AUSTRALIAN MUSEUM

Graffiti on Aboriginal rock art can be removed.

REVIEWS

Eyewitness Guides Series
Bird *by D. Burnie, 1988;*
Skeleton *by S. Parker, 1988;*
Butterfly & Moth *by P. Whalley, 1988;* Tree *by D. Burnie, 1988;*
Dinosaur *by D. Norman & A. Milner, 1989; Collins Australia, 64pp. and $16.95 each.*

This series of books promises to develop into one of the best natural history libraries available for young people. I first saw a copy in late 1988 while overseas. Even from the first casual inspection, it struck me as a most impressively presented book. Production has now started in Australia and, having had the opportunity to view several others, my admiration for the series remains undiminished.

The range of subjects is currently somewhat eclectic, but new titles have appeared at a steady pace. Some of these are non-biological (*Arms & Armour, Sport, Music*) and have not been considered here. Of the relevant titles presently available I have seen *Bird, Skeleton, Butterfly & Moth, Tree* and *Dinosaur*; others in print are *Mammal, Early People, Rock & Mineral* and *Shell*, with *Fossil, Plant* and *Flag* in preparation.

Their striking impact is due to special photographic presentation of information. Rather than rely on conventional photographs, the chosen image is 'lifted' from its surroundings, then laid out with other images against a white background to create an attractive, clean and uncluttered format, all in full colour. This style allows important features to be easily and clearly indicated and seen.

Each subject area usually occupies two facing pages, with an introductory paragraph presenting the theme. The photographic images are complemented and extended by the use of diagrams and often delightful historical drawings. The theme is further developed by captions to the individual images. This method proves particularly useful in making comparisons (such as vertebrate forelimb skeletons) or presenting stages in a sequence (life cycle of a butterfly, for example).

The effect of visual layout in educational books should not be underestimated. The best written text can fail to capture the reader's interest if the presentation has not been properly considered. It is here that I consider this series to have its initial success. The visual appeal makes people want to pick the book up and look through it.

The second success comes with the range and depth of subjects within each title. These allow for browsing and skipping through the text, so that most young readers should find something to capture their interest. The text is simple and straightforward, avoiding unnecessary technical terms; yet it is not overly simplistic in its level of presentation. Thus it remains challenging enough to be interesting but not so difficult as to be discouraging. Where unfamiliar words are introduced, they are amply explained and illustrated. Although the author for each book varies, the staff of the Natural History Museum in London has served as editorial consultants for them all.

Of the specific titles, *Bird* is the one on which I feel most qualified to comment and so I will use it as a basis to illustrate the coverage of a book's contents.

The book begins with a presentation of what makes a bird a bird, that is, the general structure and systems of the body, with a particular emphasis on the features relating to flight. An overview of the construction of the wing is followed by a selection of the diversity of wing shapes for different types of flight, nicely illustrating the relationship of form with function. Throughout the book an effort is made to relate variations in basic avian characteristics to differences in lifestyle. This appears again in comparing types of feathers with their location on the body, the structure of bills and feet with the food eaten and the choice of habitat, and the shape and colour of eggs with the nest site. These comparisons are quite effective. Other topics include construction of nests, a sequence of hatching and growth of young birds, analysis of owl pellets and a particularly successful demonstration of camouflage. It logically concludes with sections on attracting and studying birds. There are minor points on which I would quibble, such as some specific choices of words or examples, but overall the book serves as an excellent introduction to birds, the best I have seen for those just developing an interest in these animals.

Skeleton also deserves a special mention for its cover-

age. It contrasts vertebrate skeletons and invertebrate exoskeletons, compares homologies of vertebrate limbs and illustrates in detail features of the human skeleton. The presentation of these subjects is again one of the best I have seen.

Another obvious plus of the series is the relatively low price, a bargain for this quality and the amount of colour.

If there are any drawbacks to some of the books, it is the bias towards Northern Hemisphere plants and animals. A subject such as *Skeleton* is sufficiently universal that no problem exists. However *Bird* and *Butterfly & Moth* show evidence of this emphasis, although this does not really prove a problem because numerous examples from elsewhere are freely used. Any species is appropriate to illustrate morphology, life cycles and other general principles. This regional bias does restrict the value of *Tree*: virtually no mention is made of eucalypts. The book does, however, contain a wealth of broadly based information on trees that will be pertinent and thus can still serve as a very useful acquisition.

My enthusiasm for this series should already be apparent and I look forward to the appearance of future titles. I recommend these books to teachers, parents, libraries, nature centres and anyone else who has a role in natural history education, whether on a formal or informal level, or, for that matter, anyone who has an interest in the subject.

—Walter Boles
Australian Museum

Jacques Cousteau: Whales

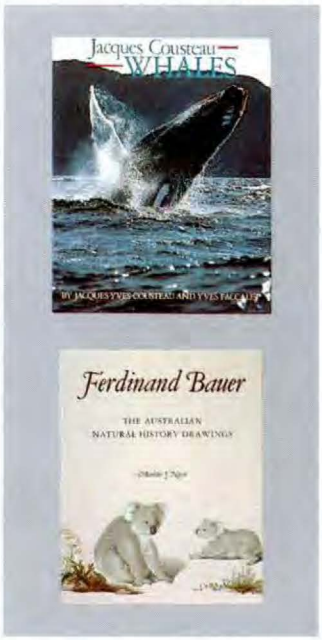
By Jacques Cousteau and Yves Paccalet. Harry N. Abrams Inc., New York, 1988, 280pp. $89.00.

Jacques Cousteau: Whales is an attractive, informative yet unfortunately flawed book. The cover and beautiful illustrations of the first few pages lead the reader to expect a work of art as well as a source of information. Expectations are, however, dashed when one finds on pages 8 and 9 what should have been a truly wonderful photo of a Humpback Whale: it has been reproduced across the centrefold of the two pages in such a way that the whale can hardly be seen, unless one cares to break the book's spine. Further problems are encountered on pages 146–152, where ugly acid streaks marr some lovely photos and make the text difficult to read. I should point out, however, that there are many spectacular and intriguing illustrations in this work, and these are indeed its strong point. It's just that careless production has lessened the aesthetics of the work.

In the first few pages of livid prose, the authors Cousteau and Paccalet (yes, it is a misleading title) define their work. It is "a labour of love—and of anger. It is an indignant outcry against the pointless slaughter and a solemn declaration of unswerving friendship for the nation of the whales". This moralising tone and anthropomorphism carry on throughout the book. Indeed, so anxious are the authors to endow whales with human sentiment they repeatedly quote 18th–19th-century accounts of whale succouring (helping) behaviour to prove their point. Modern, detailed studies of such behaviours, including instances where male whales stay with harpooned females, have shown them in a very different light. In this case, for example, if left long enough, the male often attempts to copulate with the dead or dying female.

Surprisingly, in light of the above, a large amount of fascinating information is given. Anyone who has ever longed to see the erect penis of the California Grey Whale will find their desires at last fulfilled, as will those interested in the whale "Karma Sutra" (the authors' term, not mine!). An intriguing growth chart for whales is given. Incredibly, it seems that the Blue Whale, the largest animal on Earth, reaches puberty at five years of age, and the Sei Whale at three years of age. This is truly amazing information and may explain why the large whales survived through the period of intense whaling activity. It also gives us great hopes of a rapid increase in the stocks of these whales now that predation has ceased. Furthermore, it raises a question that I am sure Cousteau did not intend. In some future world, where humanity is destroying the soil just to feed its billions, and a healthy whale population has been restored, would it be justified to harvest, in a sustainable way, some of those whales in order to preserve a bit of our terrestrial ecosystems?

—Tim Flannery
Australian Museum



Ferdinand Bauer: The Australian Natural History Drawings

By Marlene J. Norst. Lothian Books, Melbourne, 1989, 121 pp. $29.95.

Matthew Flinder's circumnavigation of Australia 1801–1803 is well known to most people in Australia as well as in England. However, his conscientious and outstanding botanical artist during the trip, Ferdinand Bauer, is practically unknown. This beautifully illustrated volume will help close the gap in general and specialist knowledge. The author carried out a most difficult research into the various details of Ferdinand Bauer—from his birth in a small Austrian town in 1760 to his death in 1826. Franz Bauer, his brother, was engaged from his Austrian home as botanist to the Kew Gardens in England. Ferdinand's travel to Greece as botanical artist with Dr John Sibthorp from Oxford in 1786–87 terminated in London. When Sir Joseph Banks arranged the detailed survey of the Australian coast and study of the flora and fauna under Matthew Flinders, Ferdinand Bauer was appointed as the botanic draftsman. His return to London after many years of sketching and collecting specimens in Australia, and finally his return to his native Austria, are recounted in great detail. As Ferdinand Bauer did not have a great ability to communicate through the written word, only a few letters of the artist are in existence. Marlene Norst is to be congratulated on presenting such a full account of his life in this quite exciting narrative.

The written as well as the printed word was, in Ferdinand Bauer's life time, greatly overshadowed by his magnificent expression in his illustrations of the flora and fauna from his travels. So it is appropriate that in this volume about 100 of his extremely detailed sketches and full-colour pictures of Australian plants and animals should predominate. After his return to England, Bauer was directed to make the sketches into 'finished drawings'. Sir Joseph Banks estimated the number of sketches to be as many as 2,073. Bauer achieved the transformation from the sketches to full colour by a remarkable numerical colour coding system, which can be seen in this book. His finished watercolours of his Australian journey went to the natural history section of the British Museum, while the pencil sketches were acquired by the Imperial Natural History Museum in Vienna, Austria. It was only due to the author's great scientific research and persistence that she was able to find the sketches in one location and the matching final drawings in another. The British Museum also distributes this book.

The remarkable accuracy and minute detail of plants and their parts, of animals in various situations and the correct colouring of the final drawing, all reproduced accurately in the book, make this volume a valuable asset. This production is a significant contribution to Australian history, plant biology and zoology. It brings us sketches and pictures produced almost 200 years ago, which today are as fresh and important as when they were first created.

The Appendix contains a number of Bauer's letters and his last will and testament, reproduced from the originals and translated into English. Matthew Flinder's map of Australia (1829) is the final illustration in the book. A quote from the final page might further elucidate the contents and value of the book: "Australia can consider itself fortunate that it had in Ferdinand Bauer an artist dedicated to the portrayal of its

native flora and fauna. He was a genius, sensitive to Australia's unique beauty, with the knowledge, aesthetic sense and technical skill required to capture its true image for all time".

—**H. Bandler**

Cathedrals of Science: The Development of Colonial Natural History Museums During the Late Nineteenth Century

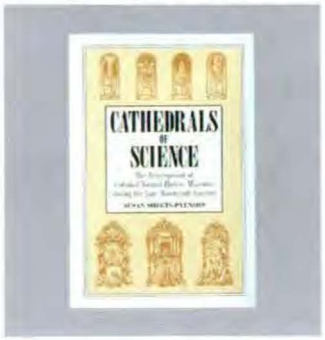
By Susan Sheets-Pyenson. McGill-Queen's University Press, Canada, 1988, 144pp. $US24.95.

Susan Sheets-Pyenson lays out in lively detail the role of "museum builders" during that period of colonial expansion that saw the development of museums in Canada, Australia, New Zealand and South America. Museums then, as today, remain mirrors of social awareness in the context of growing political irrelevancies. Yet, like a mirror, they are fragile, no longer deemed relevant to the workplace but rather items of great indulgence. Such is the image we have inherited from the 19th century, the playgrounds of dilettantes and art collectors.

Sheets-Pyenson outlines the rich and fruitful dialogue of that age of scientific enlightenment, heightened by tension of strong convictions in personalities driven by intense competition and often coloured by deep personal animosities. In the colonial expansion phase, the sheer immensity of the collections to be plundered, bought, cajoled or exchanged at the time of the great Darwinian debate, all contributed to an atmosphere within which the whole philosophy of museology took unconscious shape, driven by the ambitions of Fred McCoy in Melbourne, Julius Haast at Christchurch and John William Dawson in Montreal. McCoy and Dawson, ex-patriots from the British Scientific Establishment, both suffered at the hands of their more aristocratic peers within the intransigent framework of British science.

Driven to jealousy by the much more generously funded, then pubescent, Australian Museum, Sir Fred indulged his Irish charm in blarney, seduction and sheer financial skulduggery to "grow a museum" in the colonies. In so doing, he set the scene for later remarkable developments.

Backed by meticulous and comprehensive notes, the author has produced a scholarly, breezy and very pertinent account of the special relevance of this planet's objects, while potential audiences wait in im-



patient expectations until the millions of objects that make up our heritage may at last be expressed in imaginative educational contexts.

In so doing, she produces some gems from the 19th century that confirm the relevance of the early collectors' acquisition policies and subsequent curatorial dedication. The final product, produced with a mastery of clarity and expression, brings the individuals such as Fred McCoy to life; he who "quibbled for 30 years with the Rev. William Branwhite-Clarke over the dating of New South Wales coal deposits and refused to concede defeat. . ."

In its pages many of the great names of geological science come to life. McCoy was allied with his patron Sedgewick who, supported by Charles Lyell, entered into dispute with Murchison over the Cambrian–Silurian boundary. McCoy contended that Murchison never forgave him for supporting Sedgewick, indeed he went on to assert that Murchison "did him much mischief at times".

It was in the context of such debate in Britain that McCoy's enterprises in Australia took on additional significance. My only regret is that the intensity that fired the great debates and resulted in McCoy's three-hour lecture in Melbourne against the new evolutionary theories of the upstart Darwin, is not reported in more detail. Instead, the sweep of history takes us through the finances, staffing and political frustrations of the institutions themselves, reflecting the state of the colonial society.

Nevertheless, the product recalls events of the 19th century that are as relevant 100 years later as they were when both McCoy and Dawson expressed their fierce antagonism to the notion of Darwinian evolution. Ultimately, in North America, Dawson was to achieve the reputation of being the only scientist in that country who had not "bowed the knee" to evolution.

The challenge for the Des Griffins, Bob Edwards and Lester Russells and other directors of Australian museums today is to lead us into areas of comparable intellectual commitment that enlivened the museum philosophies of the 1880s and '90s. Future chroniclers will ask how our latter-day directors' qualities (?qualifications) measure against those of their 19th-century counterparts ("fiery, impulsive, resilient, unsuited to collective enterprises").

The great institutions, through their collection objects and their abilities to mount dramatic educational programs, must respond with imagination and enterprise. Those who do will be restored to their proper place at the centre of community awareness. Those who do not may remain as magnificent but aging monuments. By placing our museums in their historical context, Susan Sheets-Pyenson has sounded a warning we cannot afford to ignore.

—**Jim Bowler**
Deputy Director
(Natural History)
Museum of Victoria

Banksias, Waratahs & Grevilleas and All Other Plants in the Australian Proteaceae Family

By John W. Wrigley and Murray Fagg. Collins, Australia, Sydney, 1989, 584 pp. $75.00.

Joseph Banks would have been proud of this book. It is a comprehensive account, almost 600 pages in length, of every banksia, grevillea and other Australian member of the vast family Proteaceae.

The Proteaceae well justifies this pampered treatment. As one of the characteristically Australian families (although taking its name from the South African proteas), it has many species of horticultural, ecological and general interest. Important groups include the hakeas, macadamias, geebungs, cone flowers and lomatias.

Wrigley's text provides a detailed description of each species, accompanied by ecological data, a precise distribution map, and comprehensive notes on cultivation. Especially commendable is the inclusion of horticultural varieties such as *Grevillea* 'cascade' and 'Canberra gem'. The 140 colour photos, mostly by Murray Fagg, are sharp and diagnostic. Each genus is illustrated by an excellent line drawing.

Wrigley has gathered together so many fascinating facts about the family one could almost design a Proteaceae Trivial Pursuit game. Did you know that the Coast Banksia (*Banksia integrifolia*) is Australia's most easterly tree, growing at Cape Byron, and that the Silky Oak (*Grevillea robusta*) is known in Hawaii by such names as he-oka, oka-kilika, ha'iki and 'ke'oke'o? Included are illustrations of the dead scientists after whom so many genera are named—Banks (taken from the five-dollar note), Macadam, Persoon, Dryander and even Robyn Gordon, the young girl,

now deceased, after whom the very popular grevillea hybrid is named.

With a timely sensitivity to conservation, Wrigley lists the conservation status of each plant. Of Australia's 860 proteaceous plants, 182 are considered rare and five extinct. Of the latter, *Grevillea batrachioides* is known only from one collection made last century somewhere in Western Australia. Wrigley also discusses the problems of hakeas as weeds, especially in South Africa, where they threaten African species of Proteaceae, and he cautions against growing them in Australia near natural vegetation.

This is not a book without

flaws. There are too few illustrations. Only 17 of the 75 banksia species are illustrated and only about a quarter of the grevilleas. There are no keys or other quick aids for identification. To identify a grevillea in the hand one is obliged to peruse through 330 species descriptions, an impractical task. Sadly, this cannot be considered a book of identification. Alex George's *The Banksia Book* (Kangaroo Press, 1984) is a much better tool for identifying that genus, providing colour photos *and* line drawings of every species.

Nevertheless, *Banksias, Waratahs and Grevilleas* is a very important work, well worth a place in the serious naturalist and gardener's library. Unfortunately the high cover price will deter many readers.

—**Tim Low**

Vampires, Burial, and Death

By Paul Barber, Yale University Press, New Haven, 1988, 236pp. $US25.00.

A book about the likes of Count Dracula would seem to be of limited interest, but don't be put off. This is a book for the strong of stomach for it is Barber's thesis that the folklore of vampires is inspired entirely by observations of bodies decomposing. Interestingly, each of the signs of the folkloric vampire is a feature well known to modern forensic pathologists and others familiar with the decay of dead bodies.

But there is more to the book than this, for Barber explores why features now known to be normal were taken to indicate the presence of the 'undead'. In so doing he explores the ways in which ancient peoples perceived and interpreted the world, some of which are still in favour in modern societies. The idea of the vampire—a corpse risen from the grave to suck the blood of the living—is but one aspect of an apparently general view that corpses can become animated after death. Barber points out that corpses do sometimes 'rise' from the grave, but this has more to do with the physics of water-laden soils and the activities of scavenging animals than with doings of the devil or evil spirits. The present recognition of a natural world subject to impersonal laws, as well as a social world subject to the whims of personalities, is a recent innovation. The alternative viewpoint, that the universe is ruled by personalities in the guise of gods and spirits, used to be universal, and is still widespread.

Barber shows how this view led to a misunderstanding of the world, which in turn resulted in social conflict. Mischief could be (and was) blamed on the reanimated dead, and it is obvious that demands for a body to be dismembered or disinterred and staked might not always be favourably greeted by grieving relatives. It was the overpowering fear that death itself was contagious that led to such behaviour. Of course, as the author points out, death is contagious under certain circumstances, such as epidemics or even some murders. But these circumstances were not understood. This overpowering fear of the dead (or undead) was seemingly common in the ancient world. The early Christians overcame it with their belief in a bodily resurrection and the beneficial effects of relics of the saints. The elimination of this fear by early Christianity may account for its rapid early growth and its success over apparently similar religions such as Mithraism.

This small volume also deals with superstitions still met today: why it is bad luck to break a mirror, and why ghosts cannot cross water, for example. There is some implicit social comment, as in the Lapp custom of sacrificing at the funeral a reindeer that corresponds to the status in life of the deceased; a married man, for example, was represented by a castrated buck. But the book's greatest significance is that it details the evidence that, when misinterpreted in terms of a universe ruled by personalities, may have led people to believe in a 'life after death' in the first place. Such a basic concern of many people may seem a long way from the dank halls of Castle Dracula, but the connection is there. This is a book not only for those interested in folklore and fantasy, but for anyone seeking an understanding of how people perceive their world, their life and, of course, their death.

—**Ralph Molnar**
Queensland Museum

"Support for such work would do much more to protect the Antarctic environment than posturing in the media limelight waving the 'Wilderness' flag."

ANTARCTIC WILDERNESS: A WILD IDEA

BY PHILLIP LAW
DIRECTOR, ANTARCTIC DIVISION, 1949–1966

THERE HAS BEEN MUCH PUBLIC DISCUSSION over the last year or two about threats to the Antarctic environment, culminating in the Australian Government's decision not to sign the Convention for the Regulation of Antarctic Mineral Resources Activities (CRAMRA) proposed by the Antarctic Treaty nations. Instead, the Government has decided to campaign for declaring the whole of Antarctica a "World Wilderness Park". In my view, this is not only quite unnecessary but absolutely impracticable.

A concept developed in populated continents, to preserve certain restricted areas of virgin country from the depredations of an expanding community, has been blown up to encompass a huge continent whose area is equal to the combined areas of Australia and USA. The Antarctic continent is, at present, not at risk and it is most unlikely that it ever will be. More than 99 per cent of it *will always remain a wilderness*, no matter what humans may do, because of its nature and its inaccessibility. If certain *parts* of it are ever threatened, steps can be taken to protect them as in other continents, including the option to declare them 'wilderness areas'. Various conventions, measures and recommendations already cover the conservation of wildlife and historic sites, the disposal of waste and the effects of tourism. The one major gap in these regulations is that pertaining to the exploitation of minerals, and it is to fill this gap that the CRAMRA was drafted.

In order to extend and refine these environmental protection measures, the Treaty nations need more basic data on Antarctic biology and ecology. Much work is proceeding and much thought is being given to conservation problems by the Scientific Committee on Antarctic Research (SCAR), which advises the Treaty group on scientific matters. Support for such work would do much more to protect the Antarctic environment than posturing in the media limelight waving the 'Wilderness' flag. Simplistic romanticism is no substitute for hard work.

The whole treatment of conservation in the Antarctic has been quite one-sided and characterised by emotion, ignorance and exaggeration. The threat posed by mining for minerals is negligible for a number of reasons: economics, no ore bodies near the coast, no life of any kind inland etc. The threat is more real for hydrocarbons but still extremely small and, even in the unlikely event of a major tanker spill (the worst possibility), off-shore winds, oceanic turbulence and the immense geographical scale involved would result in limited and localised damage. To say that it would "destroy the Antarctic environment" is equivalent to stating that an oil spill in Bass Strait would destroy the whole Australian coastline.

Articles on the threat to the Antarctic environment invariably mention rubbish dumps at stations. There are about 35 permanent stations dotted over an area one-and-a-half times that of Australia. If each station had a rubbish dump as large as a city block, such dumps would pose no significant threat to the Antarctic environment. Adequate means of disposing of wastes will demand research and innovation, but ingenuity will undoubtedly solve the problem involved. Returning wastes from our stations to Australia (as we do now) is not only a misuse of taxpayers' money but an abdication of our responsibilities—just stop thinking about it down south and unload the problem on the community back home!

The sheer absurdity of the Antarctic Wilderness proposal would lead us to regard it as something of a joke, if it were not for the fact that support by the Australian Government for this proposal and the Government's decision not to sign the CRAMRA could have very serious consequences.

There is, at present, no way of preventing a nation or a company from prospecting or mining in Antarctica. There is a 'gentlemen's agreement' between the Antarctic Treaty nations for a temporary moratorium on mining, but this does not provide for any legally enforceable measures and does not cover the non-Treaty nations. Surely international agreement for a minerals convention would be preferable to the present vacuum?

It has taken over five years to reach consensus on a document designed to control the issue of licences for mining and to govern the conditions under which it is carried out, should the situation ever arise where such activity becomes economical and practicable. Although the convention is not perfect—consensus documents rarely are—it is one of the best industrial control agreements ever reached by such a large number (22) of participating nations and it provides a fine platform for future improvements. Geological experts believe it is unlikely that mineral ore bodies capable of being mined and of commercial significance will be discovered in Antarctica within the next 50 years. And, although the time frame for the exploitation of hydrocarbon resources is considerably shorter, the world price of these products would have to rise considerably before the marketing of Antarctic oil or gas would be commercially viable. There is thus plenty of time and the treaty nations are quite prepared to continue their deliberations to strengthen the agreement. Australia's unilateral action has jettisoned this idealistic effort.

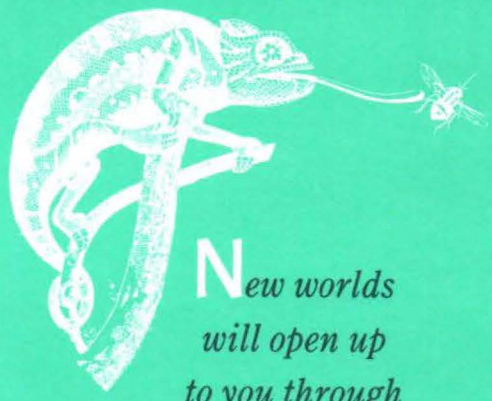
The Australian Conservation Foundation (ACF) has lobbied extensively to gain government support for the Antarctic Wilderness proposal, believing that this 'perfect' way of preventing mining is preferable to the 'imperfect' CRAMRA. But this is a romantic delusion. There is absolutely no chance of the Wilderness idea being internationally accepted. Already the USA, Britain and New Zealand have rejected the idea and others like Chile, Argentina, South Africa, Brazil, China, Uruguay and Japan are likely to be even more blunt. Outside the Treaty nations, there is no way that 'Third World' countries could be persuaded to support it. Their whole concern with Antarctica is how to become involved in any future developments for exploiting its resources. The idea of the 'resource-rich' countries preventing their access to such resources would evoke a furious response.

Regrettably, Australia's refusal to sign the minerals convention has discredited her amongst the Treaty nations and she has been branded as naive, ignorant and obstructive. Worse, it could ultimately weaken the Treaty itself.

Given all this, and the fact that 'politics is the art of the possible', why did our Government reject the CRAMRA? I am cynical enough to believe that our Prime Minister's championing of the Wilderness cause is a shrewd vote-catching bit of grandstanding. He knows quite well that it is impracticable. But he will do the rounds, suffer the rebuffs and then announce to the ACF and other proponents that he is sorry, he did his best but was knocked back.

Meanwhile Antarctic conservation suffers, and Australia's image overseas. ■

Dr Law is Consultant to and Hon. Curator of the Museum of Victoria in regard to Antarctic collections.



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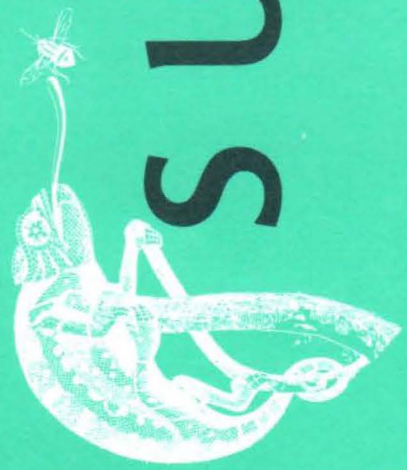

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NATURAL HISTORY OF PARROTS

by François Le Vaillant

Parrots from all parts of the world are featured in this work, first published 1794-1805, which includes Australian parrots at a time when Terra Australis was relatively unexplored. Enlivened by 143 engravings by the acclaimed artist Jacques Barraband the plates reflect vivid colour, expression and spontaneity.

Few complete collections have survived. One folio is unique for 14 magnificent watercolours by Barraband and Barbiers and was a gift by the author to Count Lacépède. In 1989 *Imprimé* published 200 folio copies and 1000 library books, accompanied by an English translation.

The image, text and character of the original have been faithfully reproduced. It is disquieting to note that three of the parrots illustrated are now extinct. Proceeds from this publication will help protect endangered species through construction of a breeding centre in Broome, Western Australia.

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