ANH
Australian Natural History
Winter 1991 Volume 23 Number 9 $7.95

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Front Cover
The stomatopod *Gonodactylus smithii* has dramatic purple spots on the insides of its raptorial appendages (claws). These are displayed to approaching intruders and may signal aggression and/or provide information about species identity. Photo by Roy Caldwell.

EDITORIAL

REBURIAL: NOT JUST A BLACK & WHITE ISSUE

BY FIONA DOIG
MANAGING EDITOR

When unidentified Aboriginal human remains more than 30 years old are discovered in New South Wales, law requires they be sent to the Australian Museum. Were the remains of European origin, however, they would be buried in a pauper's grave. In the USA, indigenous burial sites are being pillaged; some collectors describe the sites as 'art farms'! Skeletal remains are often tossed aside in favour of the more valuable artefacts found with them. There is no law in the USA that prevents American Indian remains from being dug up. (Disturbing human remains of any racial group is illegal in Australia without a permit.)

Such contrasts governing the exhumation of indigenous human remains seem extremely discriminatory. They don't help in resolving disagreements over the maintenance and handling of collections of human remains housed in research institutions, especially when a number of such places are *not* working with cultural groups to determine the future of such material.

In Australia there are approximately 4,500 Aboriginal skeletal remains held in scientific collections. In the USA, the Smithsonian Institution (Natural History) alone holds about a quarter of a million American Indian remains. And the Museum of Mankind, part of the British Museum (Natural History), holds remains of known individuals.

Some of these collections contain remains that form valuable scientific records of an otherwise unknown past and, in some cases, may be the only record of prehistoric peoples. Some indigenous people are insisting that entire collections be returned, such as the Murray Black collection (see ANH vol. 23, no. 1, 1989). But what happens when a cultural group desires the return of remains that are *of little scientific value*?

Over the last few years, many museums have proved willing to return such material when claimed by a legitimate group. Unfortunately, not all museums are doing this. Some are not even considering returning *any* human material. They fear that, if one thing is returned, everything else must also be returned.

It is very disturbing to think that this unyielding attitude is occurring today in some very well-respected research institutions. One large US institution devoted only a single day to review its policy. Other institutions have only begrudgingly returned a few things under pressure.

When human remains are from a living culture, this 'all-or-nothing' attitude shows a complete lack of concern for human dignity.

Of great concern to these institutions is the maintenance and study of human remains that *are* of scientific value. But a significant number of indigenous people actually *do* want to obtain scientific information on their past and are willing to cooperate where material of scientific value is concerned. An example is New Zealand, where some museums have retained important scientific material through arrangement with Maori people. They have also developed policies recognising the cultural importance of material and some has already been returned. The emphasis is on communication and I firmly believe that, by listening to a culture's needs, a level of understanding and respect can be built up. This is important if understanding is to be mutual.

But those institutions that continue to hold a 'hands off, its mine' approach are cutting their own throats when it comes to important material, because the indigenous people in question are likely to react by maintaining a similar vice-like stance regarding reburial. It is a no-win situation.

Fortunately museums and universities in Australia are not taking such a black-and-white attitude. The Council of Australian Museum Directors passed resolutions in 1982 that skeletal material would not be displayed in public and that human remains would be returned to those who could show patrilineal relationship. Since then, all Australian museums have formulated policies regarding material of human origin and a significant amount of material has already been returned for reburial.

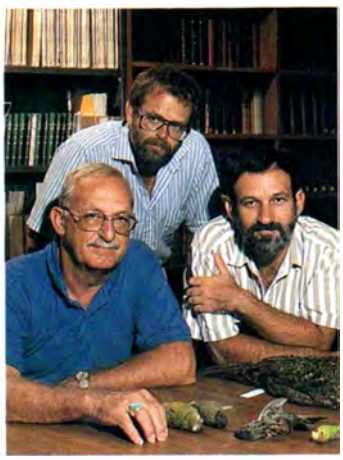
So why don't all research institutions follow this lead? Surely if their function is to facilitate understanding between cultural groups, they need to display some respect for those groups. To *not* to do so is excessively hypocritical and risks the loss of communication with the very cultures that the institution prides itself on understanding. If we are to study death in the context of a living culture, surely that culture has some rights in making the rules. ■

IN THIS ISSUE

BY GEORGINA HICKEY
SCIENTIFIC EDITOR

FINDING A GREAT COVER SHOT FOR THIS ISSUE PROVED an unusually easy task, for a change! The photos of these curious crustaceans by visiting researcher Professor Roy Caldwell were so exquisite that selecting just a handful for the article was a challenge, albeit a pleasant one. From the University of California at Berkeley, Roy is the first inaugural recipient of the Qantas Lizard Island Fellowship. His article and photos introduce us to the colourful world of stomatopods, better known as mantis shrimp.

The pictured trio is Australian Museum Birdman Walter Boles (centre), Queensland Museum's Wayne Longmore (left) and visiting fellow Max Thompson (from Southwestern College in Kansas, USA).



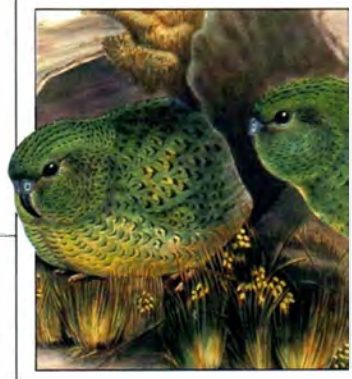
Together they relate the story behind the recent rediscovery of Australia's enigmatic Night Parrot. With no hard evidence of its existence for nearly 80 years, they literally stumbled upon a dead bird by the roadside. It was a little worse for wear but, in terms of what it can tell us about this most elusive of species, this specimen is a mine of information.

Another tale of serendipity is told by University of Melbourne's Rick Willis. In the Archives section, Rick explains how he recently happened to come across the first known painting of an Australian bird. The bird is the Rainbow Lorikeet; the artist, Moses Griffith; and the year, 1772.

In the other articles Tim Flannery (Australian Museum) gives us his theory on why Australia and other 'Meganesian' countries have so few mammalian meat-eaters; John Alcock (Arizona State University) describes the amazingly similar mate-finding strategies of two quite distantly related bees; and Leo Joseph (University of Queensland) describes how important the study of genetics is towards successful conservation.

Also in this issue are articles about the world's largest land crab, Aboriginal medicines, 'missing links' and the merits of popular science. The poster in this issue is a 19th-century French illustration of arachnids.

Articles



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PROFESSOR OF EVERYTHING

George Seddon believes it is counter-productive to destroy the faith of young people in their own society.

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STILL EVOLVING

RETICULATING THE TREE OF LIFE

Horizontal gene transfer acts as a kind of small-scale hybridisation between branches of the phylogenetic tree.

BY RALPH MOLNAR & GLEN INGRAM

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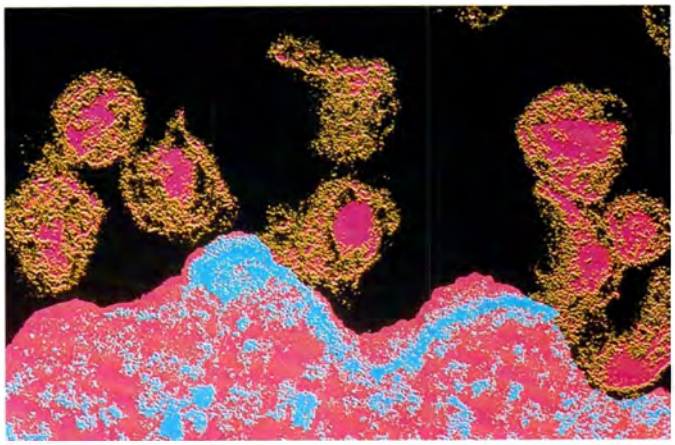

PHOTOART

SCULPTURES BY THE SEA

Pitted 'sandscapes' occupy this photographer's viewfinder.

BY ANTHONY FARR

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THE LINKS THAT BIND

The links that bind reptiles and mammals are certainly not 'missing' in the fossil record. And neither are they in the land of the living: why else would baby bandicoots suck with their ears?

BY MICHAEL ARCHER

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THE LAST WORD

A POPULAR MISCONCEPTION?

Popularising science is no longer given the thumbs down. Indeed, it is seen as a necessary and important part of the scientist's job.

BY ROBYN WILLIAMS

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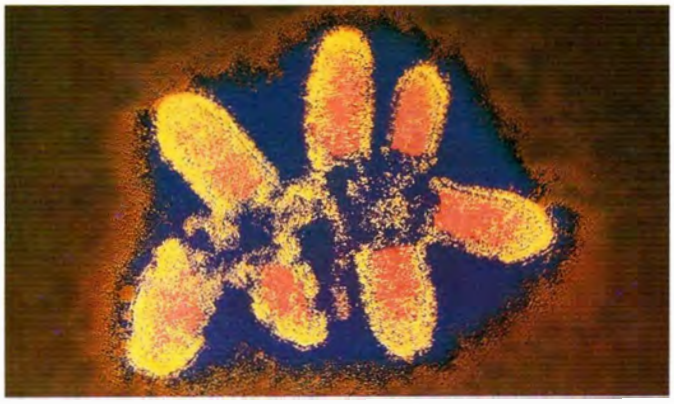
LETTERS

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



HORIZON/SPL

Electron micrograph of the rabies virus: are viruses living or not?

Virile Viruses

I look forward to receipt of your fine periodical with eager anticipation each quarter. There is a very interesting and challenging article by Glen Ingram and Ralph Molnar in the Winter issue (ANH vol. 23, no. 5, 1990). However, it contains a statement with which I must disagree. In reference to viruses, the authors state "...they are probably not living...".

Although the taxonomic classification of viruses is still a contentious matter, there is little doubt that they do live. In fact, the authors imply as much by stating that viruses "are almost certainly more closely related to their hosts than they are to each other". The scientific literature reports many laboratory results demonstrating that viruses do indeed live. For example, *Nature* (345: 572–573; 1990) reports, for one group of viruses, that "Progress in molecular biology has been particularly impressive—genomes have been sequenced...".

Ingram and Molnar also state, in reference to beetles, "God loved them according to Darwin". Perhaps they were thinking of J.B.S. Haldane's statement, when he was questioned about evidence of a god's intent in creating life on Earth, "He must have had an inordinate fondness for beetles"? Did the authors inadvertently attribute that statement to Darwin?

—Joseph K. Slap
California, USA

One can view viruses in several ways. They can be seen as living, albeit degenerate, organisms that were once much more complex but have 'devolved' into little more than nuclear material. One can also view them as rampant nucleic acids spawned at some stage by their 'hosts'. This latter view explains simply why viruses are so similar genetically to their hosts and indicates why they are so hard to combat: it is difficult to target them separately from their hosts without deleteriously affecting the hosts.

The quote is Haldane's and probably the simplest explanation is that such misquotes are viral. That is, someone makes an error with respect to a memorable statement and, because of its memorableness, the statement is perpetuated and the error rides with it, de facto. It is not the error that is doing the perpetuating, but it will multiply. Like others before us, we are an important part of the propagating process. And those that follow will cooperate, too, when they use our misquote as their own.

—Glen Ingram
Queensland Museum

Population the Problem, not Race

"Conservation and Aboriginal Land Rights" (ANH vol. 23, no. 6, 1990) was a timely article, but only touched lightly upon the main problem involved: overpopulation.

All people of all races are greedy, lazy and comfort-seeking. Why would Aborigines be any exception? Given the means, they will wipe out just as much flora and fauna as Europeans have done.

It is a tragedy that Aborigines have been so terribly treated over the last two centuries by the 'white invader', but the past can't be changed and now, for better or worse, they have to submit to being treated as ordinary Australians. If we are to preserve parts of our environment, then access to those parts must be severely limited to humans, Aboriginal and otherwise.

Instead of worrying about the effects of the human population explosion, conservationists should be directing their efforts to limit human growth. By all means grant the Aboriginal people land rights but keep *all* people out of areas the nation (as a whole) wants to preserve.

—D.H. Crakanthorp
Broulee, NSW

No Plastic Please

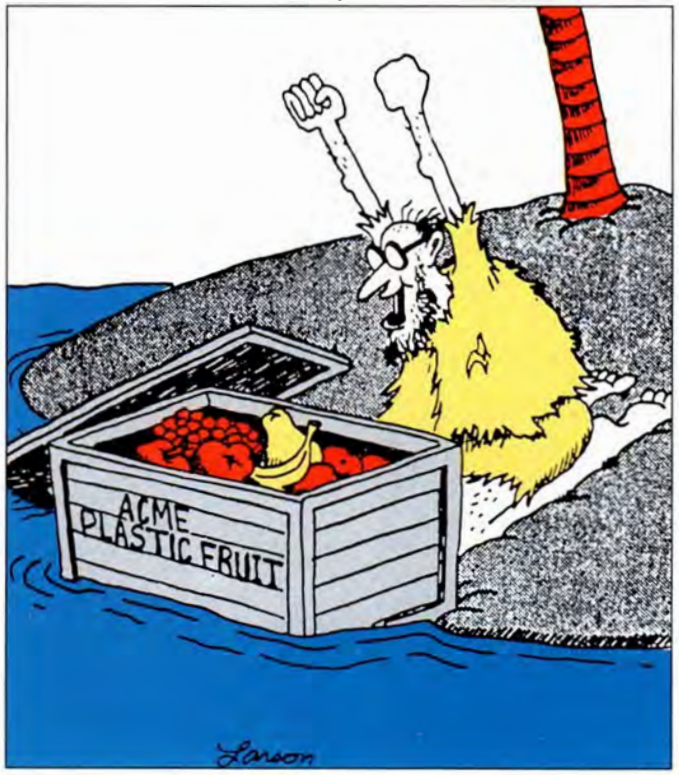
As an avid reader of ANH I would like to question why we receive our copy of this excellent publication enclosed in plastic.

For a magazine supporting conservation and ecological principles, isn't it a bit incongruous that it is packaged in a non-renewable, polluting bag?

Let's lead by example instead of preaching from a position of privilege. I for one would like to know the rationale behind the change from paper to plastic. If it is more expensive to use paper I would be more than happy to pay extra for my subscription.

—John Hunter
Wandiligong, Vic.

Subscriber copies of ANH have been delivered in plastic in recent years because it is far more cost-effective than envelopes, quicker to wrap and



distribute and, most importantly, it protects the magazine. We still constantly replace rain-damaged magazines that have been sent in paper envelopes.

Plastics are recyclable but no-one seems to be arguing much for plastic recycling. We are all on the paper-recycling bandwagon and have lost sight of our original intentions—to reduce our impact on the environment.

I would prefer to send magazines out with a simple, addressed paper band (as home-delivered newspapers once were). Unfortunately, magazines rarely fit into letter boxes, making them vulnerable to the elements. Minimum-size letterbox standards —to the point where all mail is well-protected from the elements—could make envelopes obsolete and enable reinstatement of seals on letters instead. Think of all the paper and plastic that would not be wasted worldwide in a single day!

—Ed.

Conservation Vandal

Dr Rick Shine's article "The Broad-Headed Snake" (ANH vol. 23, no. 6, 1990) addresses the familiar theme of a species threatened by habitat destruction, with the multi-pronged solutions of education, habitat reserves and research to help conserve this threatened species. I was staggered, however, to read his specific suggestion of using "old fallen logs" as "an aesthetically pleasing alternative" to the decorative garden use of weathered bush rock from sandstone outcrops, a microhabitat for this snake. What does he think fallen logs are? Generations of wood-eating invertebrates and saprophytic fungi utilise those logs, eventually recycling the nutrients tied up in the wood.

His suggestion smacks of individually targeted conservation of a species, not of the whole ecosystem as he initially suggests—so back up that flatbed truck and put the logs back as well!

—Ian Loch
Australian Museum

More on 'Cockies'

I have found the 'banana bottle' is a great way to catch cockroaches before they enter the house or while they are inside.

Take a jam jar, any size, and smear vaseline, olive oil or any slippery substance around the inside rim of the bottle. Place cut up banana, two or three slices to each jar, and put in different spots in the house. I have two jars at my back door, two downstairs near the garbage bin and several dotted around the unit (in the toilet and bathroom never fails). Cockroaches love banana (as do I). I then pour boiling water on them and empty the bottles onto the garden bed—no poison needed.

—V.M. McIntyre
Gold Coast, Qld

GREGORY MILLEN/AUSTRALIAN MUSEUM

Put those fallen logs back, too!

Zapped!

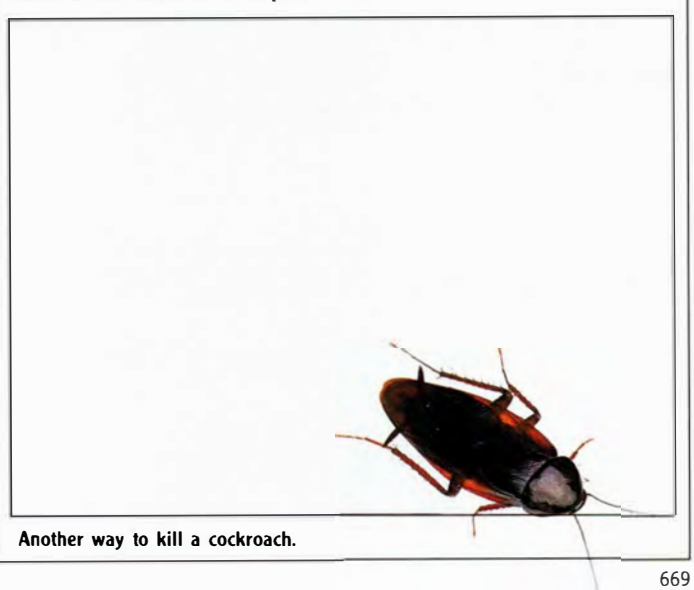
I am concerned about the use of electronic insect killers in unenclosed areas. I routinely utilise black and mercury vapour lights in my survey work in regional rainforests and appreciate that a great variety of insects can be attracted from a wide area by such lights.

I have been involved with the restoration of a remnant rainforest of outstanding scientific importance, Wingham Brush, for the past decade (see ANH vol. 23, no. 5, 1990). This remnant forest is located within the township of Wingham and borders suburban residences. A number of exciting entomological discoveries have been made at the Brush recently, including species new to science, one beetle apparently confined to this small area of rainforest. I have also established a patch of rainforest on my residential property near Wingham Brush and have made exciting finds at home.

I was therefore dismayed when an adjacent neighbour mounted an electronic insect killer on the outside of his house, which is continuously run. Although my neighbour has been made aware of my objections, he persists in the use of this device. After listening to insects being zapped all night long, I decided to investigate.

The devices are being marketed as environmentally friendly, although they attract and destroy insects indiscriminately, even including outright beneficial groups like mantids and dung beetles. The advertising brochure for "Yard Guard" encourages its use in backyards and on holidays in the bush, stating that it protects wildlife but allows the entry and destruction of wide-winged insects. Unfortunately, Australian insects are by far the largest, most diverse part of our wildlife and an integral part of the natural environment.

I dispute the statement that "Yard Guard is the answer to the ecological objection to harmful sprays and poisons", as claimed in the brochure. Modern insecticides can usually be safely applied and are either specific to the areas being sprayed or to a range of pest species within the area being sprayed. By contrast, these electronic insect killers are non-selective and impact adjoining properties. The analogy can be drawn to advertising a device designed to eradicate sparrows that



DAVID ROCHE/HORIZON

Another way to kill a cockroach.

JOHN STOCKARD

For many beetles, like this rare and as yet undescribed species of rhipiphorid found at Wingham Brush, outdoor electronic insect killers are a fatal attraction.

also destroys all other birds as being environmentally friendly.

The use and potential proliferation of these devices is of particular concern to the managers and restorationists of urban bushland, like myself, as well as the National Parks and Wildlife Service, where camping is permitted in or adjacent to their reserves.

I believe the use of these devices, as they are presently designed, should be restricted to indoor areas. Their use outdoors is irresponsible from an environmental point of view and I am disappointed that manufacturers would encourage such clearly inappropriate use of their products with misleading advertising.

—J.D. Stockard
Wingham, NSW

Classic Article

As a classics student who failed in all her university applications, even to read Persian (as it then was) at Durham University and who opted out of biology at the first possible opportunity, I have to tell you that I had a delicious time reading Mike Archer's article "Coming to Grips with Male Nipples" (ANH vol. 23, no. 6, 1991). Thanks!

—Countess of Stradbroke
Darlington, Vic.
(Failed student, mother of seven and wicked stepmother to seven more.)

How to Save the World Before Lunch

The Reverend Malthus proposed four methods that tend to reduce population:

1. War. This can be emotionally very satisfying, but the effects tend to be short-lived as populations bounce back after a good bloodletting.

2. Plague. Disease can be a major inhibitor of population growth. But our scientific understanding has grown to such an extent that a recurrence of the Black Death seems unlikely.

3. Moral persuasion. Even Malthus was inclined to dismiss this as an effective method—and it was his profession.

4. Starvation. Any population that reaches the limits of its natural resources encounters not just a mild restraint but a potential collapse. The Easter Islanders found this out about 250 years ago.

Of the four methods the only morally acceptable one is persuasion, yet it appears to be the least effective. You can persuade some people to remain childless, or to have a limited number of children; but never enough. Hence my suggestion:

It is within our current abilities to develop a method that would ensure that parents could select the sex of their progeny. I have no doubt that the overwhelming majority of the Earth's population would choose to have male children. And perhaps if I were an African subsistence farmer I would too. Such a 'male pill' would be highly desired by the great majority of humans, who see male children as being more useful. It does not matter whether they are right or wrong. With such deep-seated conviction held by a large proportion of the world's population, the marketing of a 'male pill' would be more successful than the digital watch. The effect on the second and third generations would be a severe reduction in the world's total population.

There is nothing to suggest that a population composed largely of males would be any more war-like, or that such a population would have more homosexuals or be in any way significantly different from today. Of the four methods of population control it is the only one that is likely to be effective, could conceivably save the planet, and from which a single inventive genius could make several

CARL BENTO

HORIZON/SPL

Farming in Australia: reliant on specialist scientific research.

million dollars. Of course this doesn't solve the problem of the greater environmental impact that industrialised nations have than populations of subsistence farmers. And it is populations of subsistence farmers that are most likely to buy the 'male pill'. But I'll solve that problem after lunch!

—P. Warner
Roseville, NSW

Primarily Brains

The Editorial in the summer issue (ANH vol. 23, no. 7, 1990–91) paints a picture of Australia as a bucolic backwater, relying primarily on primary produce for export income rather than harnessing its collective intelligence to emulate the likes of Switzerland and Japan.

Ignored is the fact that Australian agriculture relies heavily on new and highly developed technology for its existence. Also, today's farmers must make difficult management decisions based on analysis of market information from around the world. To imply that the rural sector is involved only in activities like "minding the sheep" is an insult to the people who are responsible for keeping our farm export industries alive in the face of cut-throat international competition.

Australia has reason to be proud of the performance of its rural industries—and the considerable research and development backing their success. Just because these industries are resource-based does not exclude them from being brain-based as well.

I suspect the mining industries may also have good reason to be incensed by this Editorial.

—E.F. Henzell
CSIRO Inst. Plant Production & Processing
Dickson, ACT

The intent of the Editorial was to put down the lack of incentive offered to scientists in this country, regardless of whether their background is agricultural, mining, biology or physics. They are offered more to move overseas. 'Minding the sheep' is only an expression and was not intended as an insult aimed at farmers. The point was that we are clever at producing resource-based raw materials but stop there. Our heavy reliance on a resource-based economy makes us vulnerable. Take, for example, the problem with wool sales. We have the best raw material in the world but, if the overseas prices are down, we're stuck with produce for which we do not have adequate facilities or expertise to use to our benefit.

—Ed.

Oops!

In my response to Mr Russell's letter, "Dynamically Speaking" (ANH vol. 23, no. 7, 1990–91), there has been an unfortunate error. The fourth sentence should read: "Living organisms are not in equilibrium with their environment—when they are they are no longer living..." The second occurrence of "they are" was inadvertently omitted, giving the incorrect impression that even in death organisms do not come to equilibrium with the environment. But of course they do, hence my comment regarding equilibrium thermodynamics as the realm of the dead.

—Ralph Molnar
Queensland Museum

ANH welcomes letters for publication and requests that they are 400 words maximum length and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter.

QUIPS, QUOTES & CURIOS

COMPILED BY GEORGINA HICKEY

SCIENTIFIC EDITOR

'Monkeying' Around with Drugs?

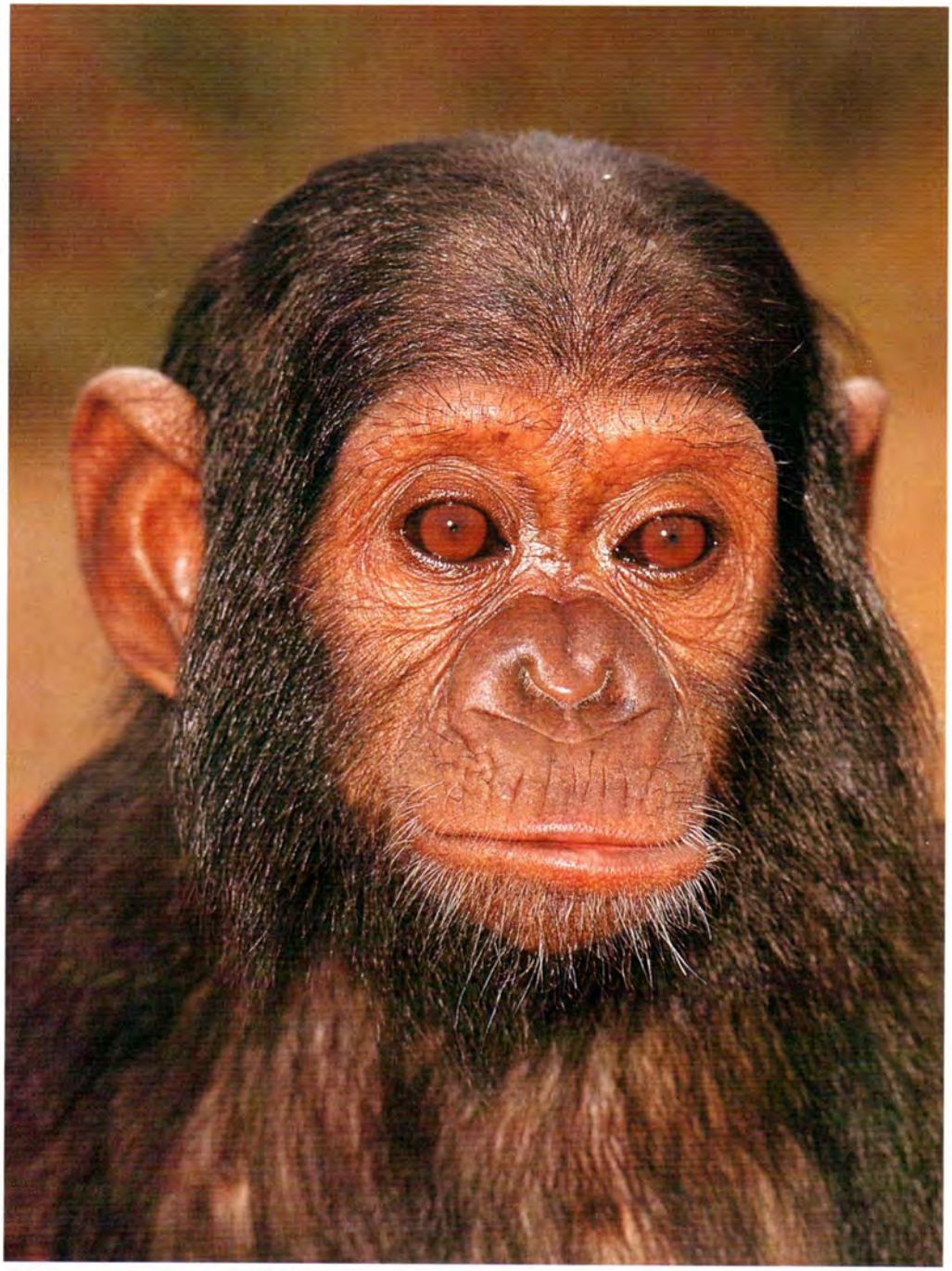
It's the morning after a swinging fermented fruit party in the trees of Tanzania and the Chimps (*Pan troglodytes*) are not looking too bright—except for Peter ('Tie-one-on') *Pan* who is searching for the leaves of a special tree his father told him about when he was a big-eyed baby apeling. Finding it, he plucks a leaf with shaky fingers, shoves it in his mouth, and waits for his hairy head to clear.

Have these Tanzanian Chimps found a forest pharmacy? Apparently yes; but it may be more remarkable than that. Paul Newton (University of Oxford, UK) and Toshisuda Nashida (University of Kyoto, Japan) report that wild Tanzanian Chimps deliberately massage the leaves of *Aspilia* spp. and *Lippia plicata* between the tongue and the inside of their cheek (*Anim. Behav.* 39: 798–800; 1990). Evidently these leaves contain high concentrations of a potent antibacterial, antifungal and antihelminthic agent (thiarubrine A). Presumably for the same reason, *Aspilia* leaves are also widely used in the local medicines of humans. But why would the Chimps suck the leaves rather than chew and gulp them? Newton and Nashida speculate that the drugs the Chimps are after may be inactivated by stomach acid. If so, absorbtion via the skin of the mouth might be the only way the drug could be taken in.

Buccal administration of therapeutic drugs (sucked under the tongue or between the cheek and tongue) has been an 'accepted' medical practice since 1879. Only in this way can some therapeutic drugs such as nitroglycerine be readily absorbed into the circulatory system without first having to survive inactivation by the acids of the gut or the detoxification processes of the liver. Stimulants such as cocoa products, snuff and smokeless tobacco are also 'sucked in' in this way, knowledge of the mouth route having been shared by tropical forest peoples for many generations.

Newton and Nashida also noted another curious fact: the Chimps generally mouth-sucked the leaves in the morning rather than in the afternoon when they normally foraged for food. Could it be that sought-after drugs were more concentrated in the leaves in the morning, or that overnight their blood levels of this substance fell so low that it had to be replenished first thing in the morning? Perhaps more likely, as Newton and Nashida suggest, leaf-sucking is simply the equivalent of a stiff cup of black coffee in the morning.

—Michael Archer
University of NSW



Chimpanzees may have found a way to give them that extra lift they need in the morning.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Where Did You Get That Tusk?

Illegal trading in elephant ivory reached alarming proportions in the last decade, seriously threatening the survival of the African Elephant (*Loxodonta africana*). The crisis culminated in an international ban on the ivory trade at the October 1989 meeting of CITES (Council for International Trade in Endangered Species). The ban was seen by many as the only way to save elephants from extinction. But will it? A blanket ban may only send black market prices skyrocketing and increase poaching pressure, as occurred with rhino horn. And, unlike the situation in East and central Africa, elephant populations are actually increasing in southern Africa. The issue is more complex than it appears at first.

In southern Africa, elephants have been better managed and protected. In Botswana, for instance, numbers have increased substantially over the last decade and culling is necessary to prevent irreparable damage to their habitats. The southern African countries (Zimbabwe, Botswana, Namibia, South Africa etc.) opposed the ban, arguing that culling is essential and that financially pressed conservation bodies need the funds generated from the sale of ivory. In some areas, local people are included in management decisions and reap some of the benefits, effectively turning potential poachers into wildlife conservationists. This kind of policy will probably be the only way of ensuring the survival of elephants in the long term, since the main threat is actually human encroachment.

Clearly, however, limited trading under CITES control hasn't worked either. Burundi, which has no elephants, became a major exporter of ivory! The CITES quota system could be circumvented because it was impossible to distinguish between culled and poached ivory once it reached the market. But legitimately culled ivory comes from only a few regions, mainly in southern Africa. A method for accurately tracing the

A new method has been devised that can pinpoint the source of culled ivory.

source of ivory offers the solution to the problem. Based on our earlier work on carbon isotopes and elephant diets (*African J. Ecol.* 26: 163–172; 1988), Nick van der Merwe and I believed this could be done using a method we called trivariate isotopic analysis.

Animal tissues are constructed from elements in food, and the stable isotope ratios of carbon (^{13}C:^{12}C) and nitrogen (^{15}N:^{14}N) present in food are also reflected in the tissues, including bones and teeth. And tusks are really just teeth. Carbon isotope ratios in elephant bone or tooth reflect the density of tree cover in the region, via the proportions of browse and grass in the diet. Elephants from deep forests are easily identified by exceptionally low amounts of the heavier isotope, ^{13}C. Nitrogen isotopes vary inversely with rainfall. These two isotopes reflect two environmental variables of the region and should usually be sufficient to determine the area in which the elephant lived. To pinpoint the area more exactly, we also analysed for strontium isotopes (^{87}Sr:^{86}Sr), which directly reflect the age of the geological substrate of the region. In combination, these three variables should not coincide for different areas.

We set out to test this, using 100 pieces of elephant bones and ivory, from all over Africa. Happily, the results, which have recently been reported in *Nature* (346: 744–746; 1990) show the patterns we predicted; the three isotopes clearly discriminate between all the areas we sampled. In fact, the results from Etosha in Namibia and the Kruger Park in South Africa show that we can even distinguish between elephants from different parts of the same park.

How can this method help in practice? If a control method can be devised to market the culled ivory, it would relieve some of the demand and reduce poaching pressure, as well as benefit the conservation efforts of the southern African countries. The problem is first to ensure that marketed ivory is legitimately culled, and second to guard against the sale of poached ivory. In the first instance, the solution may be based on the detailed isotopic results available for southern Africa. A marketing system with a central auction authority in Botswana is envisaged, where only legitimately culled ivory may be sold. Each pair of tusks would be provided with a certificate detailing the isotopic values. These values may be spot-checked by customs authorities in ivory-importing countries. The second problem requires the establishment of a continent-wide database of elephant 'isoprints'. The difficulty lies in obtaining accurately sourced samples to construct the master chart, and the expense of the analyses. Once this is done, however, ivory may be isotopically checked at any point along the trade route to determine whether or not it came from parks with legitimate culling programs.

An internationally recognised system for detecting poached ivory must be in place by 1992 when the ban is reviewed. Some southern African countries have already given notice that they intend to reintroduce the sale of culled ivory. Any limited trading agreement must include recognised safeguards such as the one outlined here, or there will inevitably be a return to the disastrous situation we have recently witnessed.

—Julia A. Lee-Thorp
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FIONA DOIG

Orang-utan Boost

A recent survey of the Orang-utan population of the Malaysian State of Sabah has shown that, although decreasing in numbers, Orang-utans are nowhere near as close to extinction as has been feared.

The solitary, arboreal habit of the Orang-utan (*Pongo pygmaeus*), together with population numbers long known to be small and diminishing, has always made it difficult to accurately survey their numbers. Previous estimates have ranged widely from a conservative 5,000 to an over-optimistic 150,000.

The most recent study was conducted in 1988 in Sabah by World Wide Fund for Nature (Malaysia) scientist Dr Junaidi Payne (*Orang-utan conservation in Sabah*, WWFNM). It is based on aerial nest-count data and has put the Orang-utan population in Sabah alone at between 10,000 and 20,000 individuals.

Dr Payne's study is confined to Sabah, which makes up around ten per cent of the land area in Borneo and Sumatra known to be potential Orang-utan territory. Extrapolating from the results, he believes there are fewer than 100,000 animals worldwide, but certainly several tens of thousands.

The highest population density was found to be in freshwater swamp forests, especially close to big rivers such as the Kinabatangan in eastern Sabah. There was a gradual decrease in numbers with distance from the coast, the numbers of Orangs found in mountainous inland areas being ten times fewer than those found on the coast.

The study showed that Orang-utan populations have not declined in areas logged in the last 20 years and has thus called into doubt the popular theory that it is primarily degradation of their natural environment through logging of rainforest timbers that has brought about the Orang-utan's demise.

It may not be fashionable to exonerate loggers but Dr Payne believes that environmental destruction through clearing the forest for agriculture, rather than felling trees for timber, is indeed the reason for declining numbers of Orang-utans.

Lowland habitat, destroyed to make way for oil palm and cocoa plantations from the early 1980s, forces Orangs into the more mountainous regions where their reproduction rate falls and thus their numbers diminish. Although he agrees that habitat destruction is far more insidious than simply removing the food source, Dr Payne maintains that the trees felled by loggers are not those that bear fruit (such as figs, durian and jackfruit) eaten by Orang-utans.

On a world basis, Dr Payne considers Orangs to be rare but not endangered. He said the rate of decline should slow down with the fall in world prices for oil palm and cocoa; the rate of development of plantations is now decreasing as investors turn to other more lucrative pursuits. And, with the strict enforcement of the 27-year-old Sabah Wildlife Protection Law banning the keeping of baby Orangs as pets, the trade in hunting and poaching, which usually involves the slaughter of the mother Orang-utan, seems to have all but ceased, at least in Sabah.

—Jane Mundy

Orangs in Sabah are better off than we thought.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

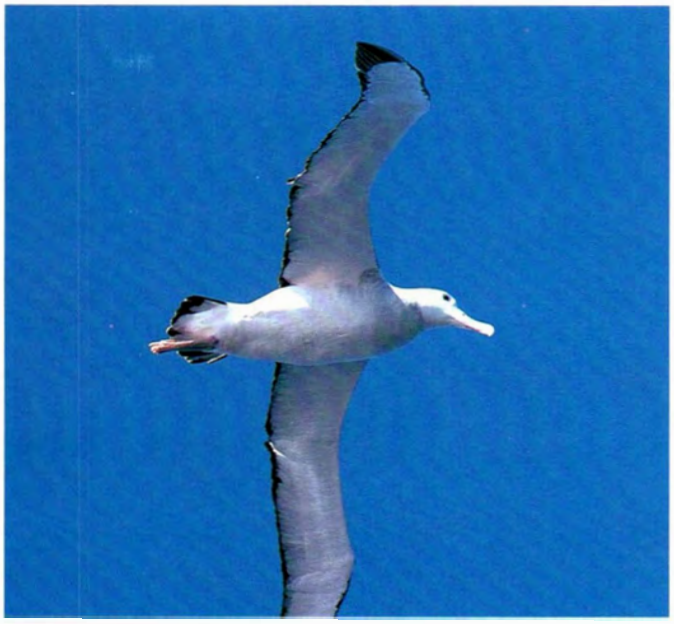
Widely Wandering Albatrosses Break All Records

Wandering Albatrosses (*Diomedea exulans*) have long been recognised as one of the most widely ranging of all sea birds—travelling up to 1,800 kilometres from the nest when foraging. However, recent research has shown that these birds cover even more staggering distances of between 3,600 and 15,000 kilometres in a single foraging trip! French scientists Pierre Jouventin and Henri Weimerskirch, from the CNRS (National Centre for Scientific Research) at Beauvoir, satellite-tracked Wandering Albatrosses in the Southern Ocean and found that distances covered and long-distance flight speeds are much higher than the highest estimates for this or any other species of bird (*Nature* 343: 746–748; 1990).

Six male Wandering Albatrosses (weighing 10–12 kilograms and with wingspans of 3.0–3.2 metres) were fitted with radio transmitters and satellite-tracked while breeding on Possession Island in Crozet Archipelago (south-western Indian Ocean). While their female partners remained at home on the island incubating the pair's egg, males went on foraging trips lasting between two and 33 days. The albatrosses travelled at speeds of up to 80 kilometres per hour and over distances of up to 900 kilometres per day, sustaining high average speeds over long distances (one bird averaged some 56 kilometres per hour over 800 kilometres). The birds undertook long-distance flights only in the daytime (distances of up to 936 kilometres were recorded), and much shorter distances at night (generally less than 50 kilometres), tending to fly further on moonlit than moonless nights.

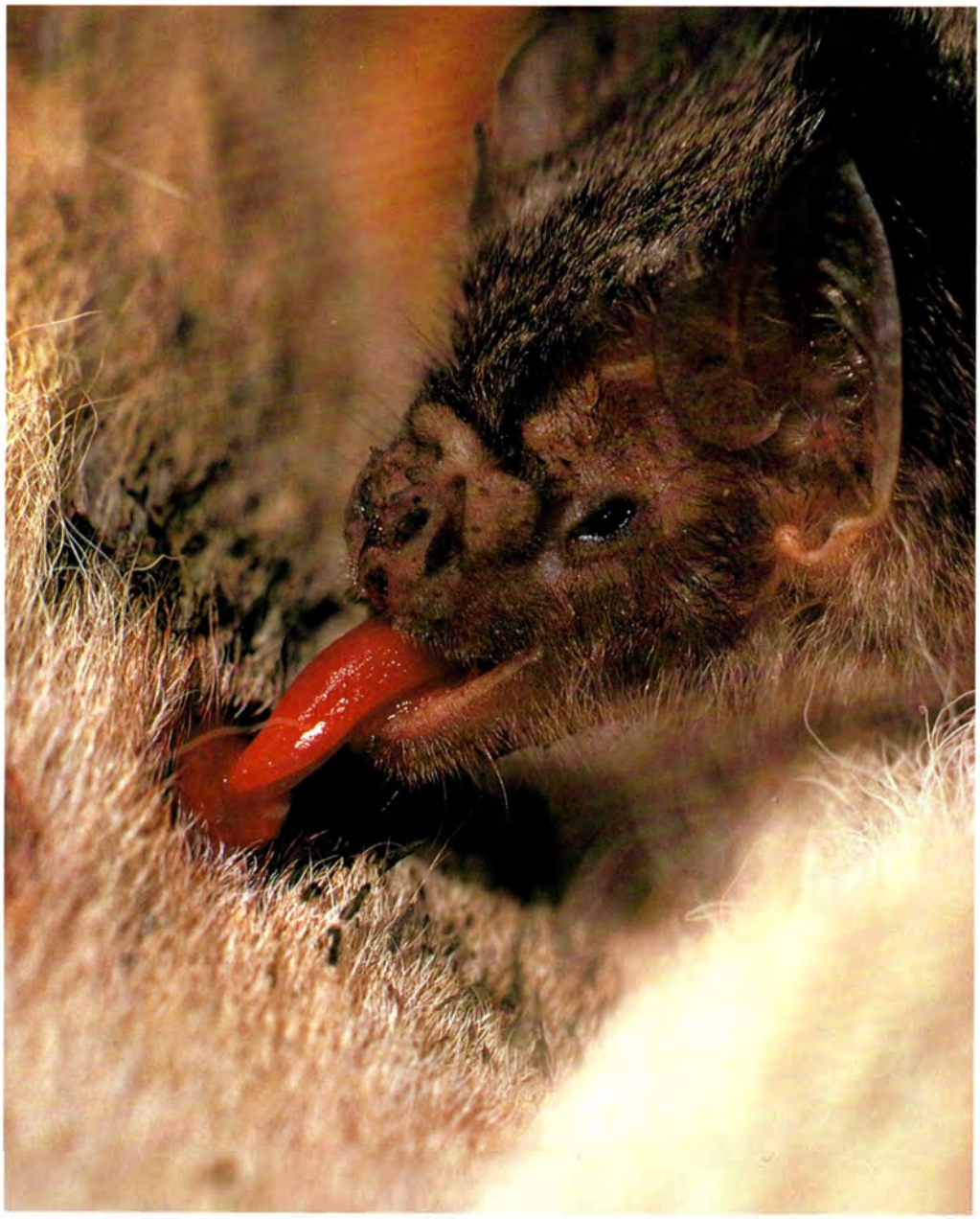
Wandering Albatrosses make the most of the Southern Ocean weather conditions by taking maximum advantage of prevailing winds on the outward journey and probably facing the wind on the return trip, either tacking in towards the home island in a long zigzag route or looping around it until they encounter favourable winds. High-pressure systems (resulting in an absence of wind) can prolong foraging trips by days or weeks, but partners will fast as long as 55 days before deserting the egg.

In the foraging zone of the Wandering Albatross, between 30° and 60° South, low-pressure systems follow one another at short, regular intervals. The researchers believe that the evolution and survival of Earth's largest flying seabird has been possible only in this region, which is subject to stronger and more regular winds than in any other part of the world. **—S.H.**



Wandering Albatrosses have broken their own flight records.

D.S. HORNING



BRUCE DALE © 1973 NATIONAL GEOGRAPHIC SOCIETY

Common Vampire Bats will die if they fail to receive a blood meal for more than two nights in a row.

The Vampire's Kiss of Life

Tentatively she approaches, first licking under her roostmate's wing then, moving closer, gliding her tongue over the other's lips. In this way, a hungry Common Vampire Bat (*Desmodus rotundus*) solicits regurgitated blood from a roostmate to fend off starvation for another day.

The Common Vampire Bat of central and South America—one of only three bat species to live solely off blood—will die if it fails to feed for two nights in a row. To avoid death, it must consume 20–30 millilitres of blood every 60 hours—the equivalent of 50–100 per cent of its body weight every night. Normally a vampire feeds from warm-blooded prey by making a small incision with its razor-sharp incisor teeth and, with help of an anticoagulant in its saliva, laps blood for 20–30 minutes. If by dawn the vampire is unsuccessful, it must depend for its life on a blood gift from a relative or long-term associate.

Food sharing of this kind (in which individuals provide food for other members of the group) is very rare in mammals, and true altruism—where a donor gives up food vital for it and its offspring to a non-related recipient, whose survival chances are increased at no apparent cost to itself—has never been recorded outside of human society. Gerald S. Wilkinson of the University of Maryland at College Park in the United States studied vampires in their natural habitat in north-western Costa Rica to test whether the vampire's food sharing was a form of altruistic behaviour or, rather, a kind of kin selection (*Sci. Amer.* Feb. 1990: 64–70). In other words, he set out to show whether blood sharing was as common between non-related individuals as between relatives, or whether blood was thicker than water.

Wilkinson found Costa Rican vampire society to be made up of groups of 8–12 adult females and an equal number of pups. These are guarded by a dominant male, while two to three subordinate males also occupy the roost (usually a hollow tree or cave). Often the groups are further subdivided into smaller clusters. Although the groups are generally stable, the composition of clusters making up each group varies continually, with the females (and sometimes their pups) shifting roosts once or twice a week, thus exposing themselves to new males with whom they sometimes mate. Adult females prefer to roost with certain other females, which are not necessarily relatives, and have the opportunity to form long, stable relationships with each other. At least two of the females studied were known to have roosted together for more than 12 years.

Over the five-year period of Wilkinson's study, he and his assistants found that 7–30 per cent of vampires in a cluster fail to obtain a blood meal on any given night, and observed 110 instances of blood sharing by regurgitation. Seventy per cent of instances were between mother and pup, while 30 per cent involved adult females feeding young other than their own, adult females feeding other adult females and, on two occasions, adult males feeding offspring.

Wilkinson found that only closely related bats or bats that have had a long-term association give blood to each other. Such associations among females enable vampires to regurgitate blood to one another on a regular basis (a kind of buddy system) and so significantly increase their chances of survival. Although this behaviour puts the donor at risk, the recipient is likely to survive the night and individuals that exchange blood gain immediate advantage in terms of increasing their own survival and sometimes the survival of relatives. Hence, in vampire society both kin selection (where the acts take place between relatives) and reciprocal altruism (where individuals exchange resources on a more or less equal basis) appear to be operating—as an insurance policy against bloody hard times. **—S.H.**

Rock-crunching Snails

In 1987, three scientists made an extraordinary discovery in Israel's rocky limestone Negev Desert. Moshe Shachak and Yigal Granot (from Ben-Gurion University of the Negev), and Clive Jones (from the New York Botanical Garden), reported an unusual form of herbivory in two species of snail (*Euchondrus albulus* and *E. desertorum*). These snails, which are less than a centimetre long, consume endolithic lichens—lichens that grow *below* the surface of the rock—and, in the process, ingest an enormous amount of substrate each year.

Feeding behaviour of the snails was observed on videotape. After moving over the rock in what appeared to be searching behaviour, the snails would manoeuvre themselves into a near-vertical position, and then make quick side-to-side movements for about 20 minutes, leaving behind a white gouge mark in the rock. The teeth of the snails were often damaged as a result of this rock-crunching activity but, as in other snail species, are continually replaced.

Comparison of the calcium content in the rock and in the snail faeces was almost identical, confirming that the snails do ingest rock as they eat. Field experiments revealed that each snail removes about four per cent of the rock surface to a depth of one millimetre per year, feeding at a rate of nine cubic millimetres per day. Extrapolating these data for the whole Negev Desert, the authors estimate that the rate of biological weathering of rock by snails is between 695 and 1,104 kilograms per hectare per year!

About 30 per cent of the Negev Desert is soil, the other 70 per cent being limestone rock. It had always been thought that the main source of soil for the Negev Desert was due to dust deposition blown in from other areas, such as the Arabian and Sinai Peninsulas. The authors calculated the rate of dust deposition by wind in the same general area in which the snails were studied to be 360 kilograms per hectare per year—less than half that provided by biological weathering by snails. Although the snails consume around the same amount of food as other snails in less hostile environments, these desert snails have a disproportionate impact on the ecosystem because they must physically disrupt the rock substrate to get at their food.

Since this study, further work by Jones and Shachak has revealed another beneficial role for these rock-crunching snails: that of fertilising the desert with nitrogen (*Nature* 346: 839–841; 1990).

The snails feed on the endolithic lichens in the early morning and at night when dew is present, resting by day under rocks and depositing their faeces there. The snails remove the nitrogen from the lichens, which absorb airborne nutrients, and transfer these to the soil in their faeces. A small amount of nitrogen is retained by the snails, presumably for shell growth. The authors calculate that each year the faeces contribute about 24 milligrams of nitrogen per square metre of soil (240 kilograms per hectare), which is 11 per cent of the total nitrogen input for the Negev Desert and 18 per cent of the net input (taking into account loss of nitrogen through soil erosion and run-off from rain). And, because the snails deposit their faeces beneath rocks where they are less likely to be washed away by rain and where the roots of desert shrubs such as saltbush occur, plant growth is boosted.

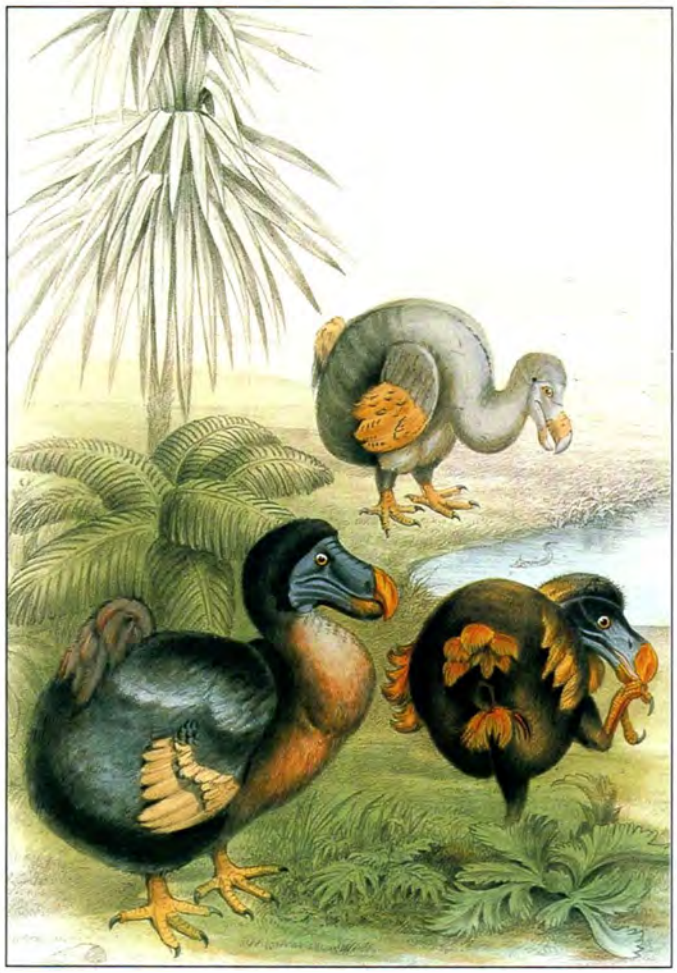
The authors believe that these desert snails provide an important link between the lichen–rock and plant–soil ecosystems. Without the snails, the nutrients absorbed by lichens would be trapped in the rock, unable to be utilised by higher plants in the soil.

—G.H.

Image of Dodo Goes on a Diet

The popular image of the extinct Dodo (*Raphus cucullatus*) of Mauritius as an exceedingly fat, flightless bird may be unfair. According to Andrew Kitchener, Curator of Birds and Mammals at the Royal Museum of Scotland in Edinburgh (*BBC Wildlife* Aug. 1990: 512–514), in the wild the bird might actually have been slim, elegant, perhaps even athletically built. How could the European artists have got it so wrong, particularly when the first illustrations of the bird—those made before 1626 by artists who had actually been to Mauritius—showed a reasonably slender bird? Apparently later illustrations, the ones that came to dominate European literature, were of captive birds that had had constant feeding and no exercise—couch potato Dodos.

When Kitchener was asked by the museum to "Do us a Dodo" for an exhibit, he gathered all of the writings and drawings he could find. Because historical paintings were contradictory about the Dodo's waistline, Kitchener decided to examine any grisly bits of bird that might have survived the three centuries since its extinction in the 1660s—less than 200 years after the first humans set foot on Mauritius.



Our chubby image of the Dodo may not be correct after all.

What he found was a paltry pile of bits: bones, a dried head and the cast of a foot—a whole stuffed bird having been unceremoniously tossed on a bonfire at Oxford's appropriately named Ashmolean Museum in 1755. Bones collected in 1865 from a Mauritian swamp had been pieced together by the famous anatomist Sir Richard Owen of the British Museum (Natural History). After Kitchener had exhaustively measured each and every bone, he built a wire skeleton and added plasticine muscles, having studied the shape and disposition of muscles in other birds. When he stood back to see what he had wrought, lo and behold: the skinny Dodo.

Then, by studying the relationship between the weight of pigeons (close relatives of the Dodo) and the length of one of their leg bones, he determined that his slim and trim Dodo would have weighed, in contrast to the 30 kilograms for the usually 'fat' model, only about 13.5 kilograms, roughly the weight of a swan.

"Dead as a Dodo" the Dodo may be, but its persona has been given a new lease of life. Its old, familiar image as the huffing, puffing fatty of Lewis Carrol's *Alice's Adventures in Wonderland* has been radically trimmed, and the Dodo should now strut through history as a new bird.

—S.H.

Calling Caterpillars Mimic Ants

Caterpillars of some butterflies form special relationships with ants. In these symbiotic associations, the caterpillars provide ants with food (protein and sugar secretions) in exchange for protection against predators, such as wasps. Philip J. DeVries, an entomologist at the University of Texas, has found that a number of these caterpillar species actually 'call' ants to them, thus helping to maintain the association (*Science* 248: 1104–1106; 1990). DeVries has managed to record the subtle calls of the Panamanian butterfly caterpillar *Thisbe irenea*, which seems to be exploiting a communication system normally used among ants.

The Imperial Blue Butterfly (*Jalmenus evagorus*) is one of 14 species tested whose larvae mimic the calls of their attendant ants.

KATHIE ATKINSON

Many ants produce and respond to stridulations and vibrations as part of their important short-distance communication system. In his study, DeVries found that caterpillars mimicking these substrate-born vibrations were likely to elicit an investigative response from ants. In cases where caterpillars needed ants to survive the attacks of predators, they used these calls (together with chemical signals) to attract and maintain the presence of the protective ants.

In *Thisbe irenea*, the calls are produced by vibratory papillae, a pair of ridged, rod-shaped organs located behind the head. When rubbed against the edge of the head, as the caterpillar pulls its head in and out, they produce a rasping sound that travels as vibrations through the ground, leaves, stems or bark beneath them. The caterpillars call almost constantly as they move about.

Calling caterpillars, DeVries found, receive better protection from enemies than mute ones (in which the papillae were removed). DeVries also detected the ability to call in 13 other species of ant-associated caterpillars, all of which made calls that were similar to those of their ant associates; closely related species that did not associate with ants were silent. A number of other species also produce calls but do not have vibrational papillae. These produce sound more like the calls of tropical frogs, but how they are made is not yet known.

—S.H.

Did the Neanderthals Bury their Dead?

The question as to whether or not the Neanderthals intentionally buried their dead is the subject of a recent paper by Robert Gargett from the University of California at Berkeley (*Curr. Anthrop.* 30: 157–190; 1989). Earlier interpretations of the archaeological evidence from six Middle Palaeolithic sites (La Chapelle-aux-Saints, Le Moustier, La Ferrassie and Regourdou in France, Teshik-Tash in the USSR, and Shanidar in Iraq) posited the association of human skeletal remains with the apparent remains of features such as flower offerings or circles of goat horns as evidence of intentional burial. If such interpretations are correct, then these sites constitute the earliest evidence of the human capacity for symbolic or ritualistic behaviour, an extremely significant adaptation within the behavioural evolution of our species.

Gargett, however, prefers to consider the evidence derived from these six Neanderthal sites within a geoarchaeological framework. His basic proposition is that the inference of mortuary ritual from archaeological deposits requires non-human agents to be ruled out. In other words "It is not enough to say that humans *could have* produced a given deposit; it must be shown that nature could not." His re-examination of these sites leads him to conclude that, in every case, processes other than purposeful human behaviour could have resulted in the formation of the deposits in question.

For example, the La Chapelle-aux-Saints 'burial' is reinterpreted as an accidental interment within a natural cave-floor depression. The flexed position of the skeleton of La Ferrassie I is just as likely to have been the result of natural death during sleep as it was the result of a mortuary ritual. The stone arrangement excavated near the base of the skeleton at Regourdou, initially interpreted as a carefully constructed coffer, is seen by Gargett as the result of natural roof fall. The pollen and anthers recovered from the 'burial' of Shanidar 4 and interpreted as the remains of a flower offering may also have been blown into the cave, transported in by animals or simply have grown in the immediate vicinity of the burial.

A nearly complete Neanderthal adult, La Ferrassie I (France), *in situ*, 1909.

Gargett concludes that, in many cases of inferred Neanderthal burial, "simple and likely explanations have been ignored in favour of complex scenarios invoking enigmatic purposeful behaviour". Unless other Neanderthal sites can provide evidence contrary to his position and withstand the test of geoarchaeological interpretation, then we must presume that the Neanderthals did not intentionally bury their dead.

As we might expect, Gargett is not without his critics. At the end of his paper, following *Current Anthropology* style, are the solicited responses of 11 groups of authors. While a few concede that earlier descriptions of inferred mortuary ritual may have overextended the archaeological evidence, some argue that even these early excavations reveal strong evidence for intentional burial. For example, D.W. Frayer and A. Montet-White from the University of Kansas, commenting on the La Chapelle-aux-Saints burial, observe that they do not know of a single example of a "naturally produced rectangular, straight-walled, flat-bottomed pit in the middle of a karstic shelter". C. Gamble (University of Southhampton), P. Ossa (La Trobe University) and E. Trinkaus (University of New Mexico), along with Frayer and Montet-White, all comment that more recent excavations not discussed by Gargett (such as Saint-Césaire, Kebara and Roc de Marsal in France, and Amud in Israel) indicate beyond doubt the intentional burial of humans possessing a Neanderthal morphology.

Also debated by Gargett and his critics is the extremely fragmented nature of human skeletal remains found in Europe prior to the last interglacial and the fact that nearly complete skeletons do not appear until the time of the Neanderthals during the last glacial. If burial cannot account for the preservation of these complete skeletons, what can? Gargett does not offer an alternative.

—Michael K. Green
Victoria Archaeological Survey

COURTESY ROB GARGETT

"A Rainbow Lorikeet was apparently taken alive at Botany Bay and became the pet of the Tahitian priest Tupaia."

PORTRAIT OF A PET: AN AUSTRALIAN FIRST

BY RICK WILLIS

INSTITUTE OF EDUCATION, UNIVERSITY OF MELBOURNE

IN JANUARY 1987 I BEGAN A PERIOD OF sabbatical study at the British Museum (Natural History) in London. Often I would walk down Brompton Road at lunchtime to windowshop or to salivate in the food hall at Harrods. One wintry day, as I emerged from Harrods, I stopped at one of the rather expensive and intimidating antique shops in the area. Through the window I could see the usual range of decorator antique bird prints, but one image seemed strangely unfamiliar to me. I entered the shop with some trepidation, as I noticed the price ticket on one armchair read £13,000.

I edged my way toward this curious picture, which was titled on the mount "A Green Parrot". The picture was in fact a fine gouache on vellum, and was signed Moses Griffiths and dated 1772. However, the subject was not your ordinary green or 'Amazon' parrot but, as evident in the orange beak, was a lorikeet and, on closer examination, was likely a Rainbow Lorikeet (*Trichoglossus haematodus*). Here, before my eyes, was the first known painting of an Australian bird! It was too good to be true. How had this obscure artist, Moses Griffiths (better known as Griffith), come to paint such a bird at the time of Cook's First Voyage?

I decided to take the plunge and I bought the painting on the condition that it was genuine; however, I had to wait for funds to arrive from my bank in Australia. In the meantime, I began the detective work of piecing together the various threads of the story. First, ornithological experts at the British Museum (Natural History) agreed the portrait was indeed of *Trichoglossus haematodus moluccanus* or the Rainbow Lorikeet found along the eastern coast of Australia. Although not recorded in the journals of Cook or Banks, a Rainbow Lorikeet was apparently taken alive at Botany Bay and became the pet of the Tahitian priest Tupaia who had chosen to join the voyage for its completion. Nothing further is known about this, except that the bird, then known as a "blue-bellied parrot", apparently ended up as a stuffed specimen in one of London's contemporary private museums, the Tunstall Museum whose records provide the link between Tupaia and the Rainbow Lorikeet. This specimen has long since been lost or destroyed by the ravages of time. However, it is distinctly possible that the pet lorikeet survived the voyage and was then painted in 1772. Certainly, in Griffith's painting, the gleam of the eye and the posture of the bird are painted more like those of a live bird, than is commonly found in images of that era. A Rainbow Lorikeet also features in what is often regarded as the first published illustration of an Australian bird, in Brown's *New Illustrations of Zoology* (1776); however, the bird illustrated as the "blue-bellied parrot" does not appear to be the same individual painted by Griffith.

Who was Moses Griffith? He was a Welshman who was the servant and travelling companion of Thomas Pennant, another Welshman who made numerous important contributions to zoology, including *British Zoology* and *Genera of Birds*. As such, Pennant was an acquaintance of Joseph Banks. In his autobiography, Pennant records that in

COURTESY RICK WILLIS

The first known painting of an Australian bird: the Rainbow Lorikeet.

September 1771 he visited Joseph Banks and Daniel Solander in London, shortly following their triumphal return from their epic voyage around the world. Although nothing is specifically mentioned in this passage about the presence of Moses Griffith or the lorikeet, Griffith travelled everywhere with his master, and would have likely had the opportunity to paint for Pennant the beautiful Rainbow Lorikeet, previously unknown to science.

Thus the pieces began to fall into place. However, I still had personal doubts that the image was of the Australian race of *Trichoglossus haematodus*, as numerous other races exist north of Australia. Eventually I was able to collect the painting from the antique shop, and I quickly transported it back to the British Museum (Natural History) to be properly photographed. I had to remove the picture from its frame and was delighted to find written on the back of the painting, in a fine 18th-century script akin to that of Pennant, "from New Holland". Subsequent expert examination of the painting has shown that the vellum is of a type produced in the 18th century.

This picture ranks as one of the great finds in Australian zoological art. The only surviving image of an Australian bird from Cook's First Voyage is the rather faint pencil sketch of a Red-tailed Black Cockatoo by the botanical artist Sydney Parkinson, who accompanied Banks and Solander. The Griffith painting of the Rainbow Lorikeet is thus historically comparable to the much celebrated painting of the kangaroo by the well-known English artist George Stubbs. The kangaroo painting was executed in London in either 1772 or early 1773, and was based on a skull and pelt, and some of Parkinson's pencil sketches brought back on board the *Endeavour*. It is now accepted that Stubbs also produced at about the same time a rather less convincing portrait of a Dingo, based only on a pelt.

The Griffith painting of the Rainbow Lorikeet is today housed in a private collection. It is anticipated, however, that it will be exhibited in the near future. People are often curious as to what such a unique painting would be worth and, while there is nothing comparable on the market, an estimate of $100,000 is probably fairly realistic. ■

Suggested Reading

Willis, R.J., 1988. The earliest known Australian bird painting: a rainbow lorikeet, *Trichoglossus haematodus moluccanus* (Gmelin) by Moses Griffith, painted in 1772. *Arch. Nat. Hist.* 15(3): 323–329.

Dr Rick Willis lectures in botany and general biology in the Institute of Education at the University of Melbourne. His main research interests include early Australian natural history and the chemical interactions of plants.

"In Vanuatu they command high prices in hotels and restaurants and are caught in large numbers."

COCONUT CRABS

BY ROGER T. SPRINGTHORPE

CRUSTACEAN SECTION, AUSTRALIAN MUSEUM

THE COCONUT CRAB (*BIRGUS LATRO*) IS the largest terrestrial crustacean known. Unlike other members of the land hermit crab family Coenobitidae, the adult Coconut Crab no longer requires the protection of a gastropod shell. By abandoning the shell-carrying habit it can grow to relatively gigantic proportions. Crabs in excess of three kilograms and measuring one metre from leg tip to leg tip are not unusual. Throughout its range it is considered a delicacy and in some places its abdominal fat is regarded as an aphrodisiac.

The Coconut Crab is distributed widely throughout the tropical Indo-Pacific region on oceanic islands or small islets adjacent to large continental islands. By day they live in burrows dug in porous limestone, soil or sand, or hide among *Pandanus* roots and fallen coconut fronds. By night they scavenge on organic matter including rotting fallen coconuts (hence their common name) and fallen leaves and fruits of *Pandanus*. Reports of the crabs picking coconuts and smashing them open on the ground are unsubstantiated. Coconut Crabs eat their moulted exoskeleton, an important source of calcium, and have been known to feed on turtle hatchlings. Competition over food items between two crabs may result in the death and consumption of the loser. Coconut Crabs are basically asocial.

Copulation occurs on land and the fertilised eggs are carried beneath the female's abdomen. When ready for hatching, the eggs are released into the ocean, where development of the various planktonic larval stages is at the mercy of wind and current. Settlement occurs after several weeks followed by an amphibious phase in which the young crabs migrate onto land. Crabs continue to moult and grow and, when a size of two to three centimetres across the carapace is reached, the shell-carrying habit is abandoned. At this point the crab will be over two years old. Coconut crabs are slow growers. After five years they may be ten centimetres across the carapace and a large adult may be more than 40 years old. Recruitment is irregular and unpredictable.

MICHAEL McCOY

The Coconut Crab is the world's largest land crab.

The survival of *Birgus latro* is threatened primarily as a result of human interference. It has been exterminated in many areas as a result of intensive hunting by island inhabitants. Crabs are readily attracted to bait and captured by hand. Consequently a valuable and highly marketable luxury food item can be harvested in areas where opportunities for cash flow are severely limited. In recent years the expanding tourist industry, coupled with a downturn in local copra-based economies, has increased the economic importance of the Coconut Crab. In Vanuatu, for example, they command high prices in hotels and restaurants and are caught in large numbers; populations there are declining. It no longer occurs on most islands of the Seychelles and the decline of its range along the Indian coast similarly is due to overexploitation and disturbance from expanding human settlement. Coconut Crab populations on Guam can no longer satisfy demand and crabs are imported from the Marianas.

Dried and mounted specimens are popular as tourist souvenirs, and introduced pigs, rats, monitor lizards and monkeys have been implicated in Coconut Crab predation, having a significant effect on the smaller members of the population. The development of coastal zones during recent years has destroyed much of the Coconut Crab's preferred habitats, reduced access to the ocean for gravid females and inhibited recolonisation by juvenile crabs.

Recognition of these factors by various governments has seen the introduction of conservation measures such as export bans on tourist curios from Christmas Island; in the northern Marianas sale of Coconut Crabs for any purpose other than human consumption and the taking of undersized crabs are prohibited; in Vanuatu females are fully protected and minimum legal size limits for taking males have been imposed. Size limits also exist in Guam but evidently there is no mechanism in place to monitor the effects of this legislation.

The Vanuatu Government, in conjunction with the Australian Centre for International Agricultural Research, is investigating the feasibility of artificially culturing or farming Coconut Crabs for the market. Preliminary results indicate that careful management of existing stocks is essential to ensure the survival of natural populations throughout its range in the Indo-Pacific. The particularly slow growth rates, sporadic recruitment and probably rather delicate larvae suggest a resource that is extremely susceptible to overexploitation and a poor candidate for artificial culture. Provided the techniques for rearing juvenile crabs can be developed, however, it may be feasible to release large numbers of land-adapted juveniles into their natural environment, thus providing some degree of control over recruitment.

Unless the problems of regulating the exploitation of the world's largest terrestrial crab are addressed and acted upon, there is little doubt that these animals will, for all intents and purposes, be taken off life's menu for good. ■

Roger Springthorpe has been a technical officer in the Crustacean Section of the Australian Museum since 1980.

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"Lemon grasses were very popular remedies for a wide range of ailments."

SPICES OF THE FUTURE?

BY TIM LOW

NATURE WRITER

AUSTRALIA LIES JUST SOUTH OF THE fabled spice islands (in Indonesia), and our northern forests contain many plants closely related to the spices. Our fruit-bearing lilly pillies (*Syzygium* species), for example, are placed in the same genus as the Clove Tree (*S. aromaticum*) and some have clove-smelling leaves. Cloves themselves are dried buds but, if left on the tree, they flower and develop into red edible 'lilly pilly' fruits.

Australia's native nutmeg (*Myristica insipida*) is a close relative of true nutmeg (*M. fragrans*), and was used as a nutmeg substitute in Queensland, although it is less aromatic (hence the name *insipida*). Similarly, one of our native cinnamons (*Cinnamomum oliveri*) has been used as a substitute for traditional cinnamon (*C. verum*).

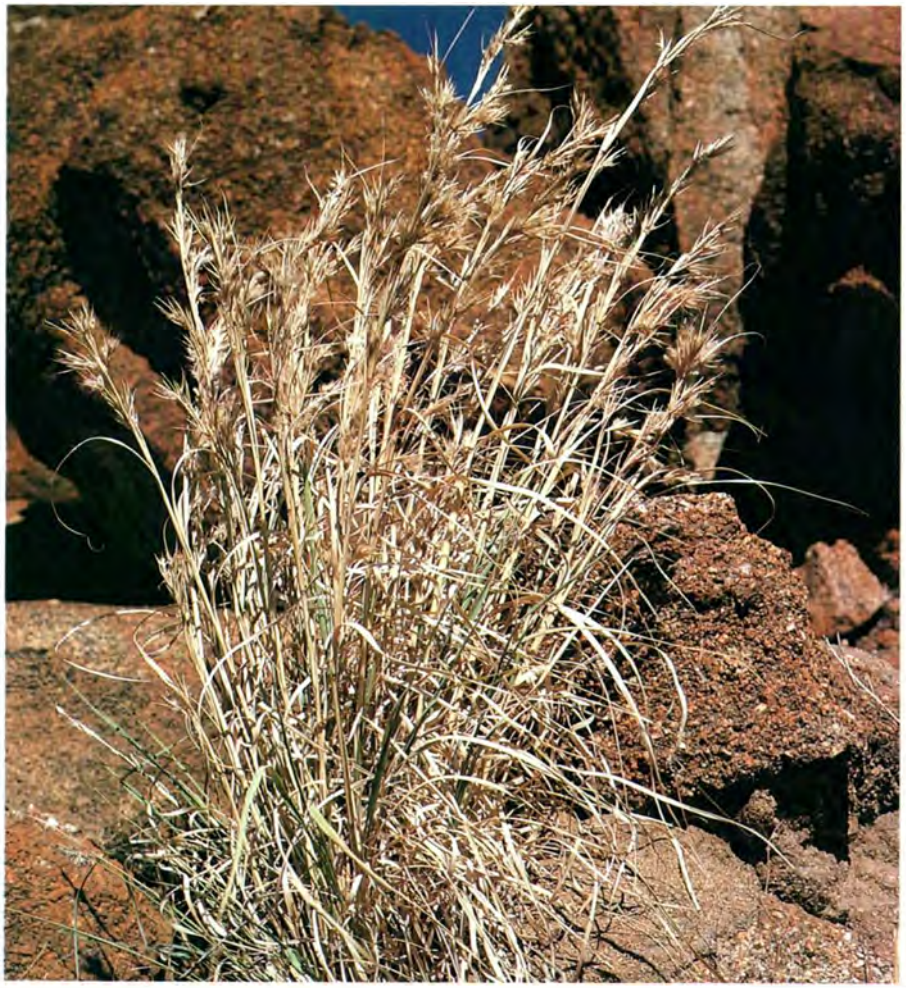
Australia also has plants in the same genus as pepper, turmeric and lemon grass. The culinary potential of these plants has been almost completely ignored, despite the current fascination with wild foods.

The native lemon grasses (*Cymbopogon* species) interest me especially. There are no less than ten native species, occurring across northern and outback Australia in rocky and sandy soils. They vary in form from small slender tussocks to large coarse clumps, but all have aromatic leaves and stems, with a lemon or ginger scent.

When I first learned about these grasses I was curious about their culinary potential. But I have been able to find only two accounts of their use as flavourings, both by Aborigines. Vai Stanton, an interesting and knowledgeable Koongarukunj woman originally from Katherine, Northern Territory, told me her parents used to flavour beef with a wild lemon grass. They also burnt bundles of this grass to ward off mosquitoes. (Citronella oil extracted from Asian lemon grasses is a popular insecticide.) The other record comes from Uluru (Ayers Rock) where Aborigines are known to sometimes add the lemon grass called Silky Heads (*C. obtectus*) to their tea. Neither of these can be considered a traditional practice, although both may derive from it.

There are probably a number of reasons why lemon grasses were not more popular. They are not a part of traditional European cuisine, which could explain why white settlers did not take to them. And, among Aborigines, the use of herbs or spices for flavouring was not widespread. They appear to have been significant only in the Top End of the Northern Territory, where at least 14 kinds of leaves were cooked with meats and shellfish. Some of these flavouring leaves, like those of the Peanut Tree (*Sterculia quadrifida*) and *Gardenia fucata*, have no pronounced aroma and probably impart only a subtle flavour, comparable to that of banana leaves in Asian cooking. Others, notably the tea-trees (*Melaleuca acacioides, M. argentea, M. minutifolia, M. viridiflora*) are strongly aromatic. But apart from Vai Stanton's anecdote I can find no evidence that lemon grasses were used.

A look at Aboriginal medicine provides an explanation why. Lemon grasses were very popular remedies for a wide range of ailments. At least five species (*C. ambiguus, C. bombycinus, C. obtectus, C. procerus* and *C. refractus*) were used, in the form of infusions or as sniffing herbs, to treat ills as varied as sores, colds, fevers, muscle cramps and sore eyes. Vai Stanton, for example, told me of using one wild lemon grass to treat colds: "We'd douse it in boiling water and you'd see the oil droplets coming off. It was good for cleansing the head, for people with colds". Vai said this was a



PHOTOS: TIM LOW

Among the boulders of the Devil's Marbles in central Australia, Lemon-scented Grass is one of the most common plants.

Silky Heads (*Cymbopogon obtectus*) is most effective as a medicine when green and lush. This plant is growing at the base of Ayers Rock.

different kind of lemon grass from the one used in cooking.

The Northern Territory Pharmocopeia Project analysed the composition of oils in four native lemon grasses and found a range of aromatic compounds, including camphene, borneol and alpha-pinene, but no citral, the main flavouring component of lemons, the Asian lemon grass *C. citratus* and Lemon-scented Tea-tree (*Leptospermum petersonii*). Furthermore, Silky Oilgrass (*C. bombycinus*) tested strongly for the presence of triterpenes or steroids when the Liebermann-Burchard test was applied. It is clear that, although the Australian lemon grasses smell lemony, they are chemically very different from Asian lemon grasses (and lemons). They may well be unsafe to use as flavourings.

Evidence for this idea comes from Alice Springs ethno-botanist Peter Latz, who told of an unpleasant encounter with Lemon-scented Grass (*C. ambiguus*). Aborigines usually apply their remedies externally, but the Warlpiri people north-east of Alice Springs sometimes drink an infusion of Lemon-scented Grass—sparingly—to soothe colds. Latz reported: "When I tried a decoction of the leaves of this plant one evening I suffered from an almost continuous stream of vivid nightmares throughout the night!" If Australia's lemon grasses produce effects like these, no wonder they have not found a place in bush cuisine! ■

Agnes Lippo of Belyuen Aboriginal Community near Darwin identifies 'Bu' (*Cymbopogon procerus*), an old-time remedy for sores and headache.

Suggested Reading

Barr, A. (ed.), 1988. *Traditional bush medicines: an Aboriginal pharmacopeia*. Greenhouse Publications: Melbourne.

Latz, P.K., 1982. *Bushfires and bushtucker: Aborigines and plants in central Australia*. M.A. thesis: University of New England, Armidale.

Low, T., 1990. *Bush medicine*. Angus & Robertson: Sydney.

Tim Low is a fulltime nature writer living in Brisbane. He is the author of four books about plant use, the most recent of which are Bush tucker *and* Bush medicine *(Angus & Robertson).*

"George Seddon is an intellectual who likes to shock, but does so with a great sense of fun."

PROFESSOR OF EVERYTHING

BY ROBYN WILLIAMS
ABC RADIO SCIENCE SHOW

A FAVOURITE PHOTOGRAPH OF WHAT looks like two old hobos: one is genial and bearded like a poet; the other slightly mischievous and squinty, beaming through his spectacles. They are Dr Frank Talbot, once Director of the Australian Museum, now in charge of the Smithsonian Institute (Natural History) in Washington, known internationally for his work on coral reefs. The other is George Seddon, Professor of Everything. Together they are pictured strolling through the Australian bush, looking somewhat smug as if they've discovered something we don't know about.

Frank Talbot has a famous record as a museum chief and defender of Pacific ecosystems from rapacious developers. But more about him another time. George Seddon is less well known. In his time he has been a professor of geology (in Oregon); of history and philosophy of science (University of New South Wales); of environmental science, Director of the Centre for Environmental Studies and, for six years, Dean of the Faculty of Architecture and Planning (all at the University of Melbourne); and he has now returned to the English Department at the University of Western Australia, which he left 20 years ago. Can there be another professor in the world with such a promiscuous record?

But there is sense in the diversity. George Seddon loves language. He takes words to the landscape, to rocks, buildings and ideas, and comes up with revelations. What do we mean by 'bush'? Is it an unending vista of dreary scrub, as many of the first Europeans in Australia believed, or is it a wonderfully varied cornucopia of animals and plants, spectacular in display, if only your eye knew how to look properly? What is a 'gum tree'? What is a eucalypt? Is it simply the rangy silver-and-green form growing everywhere from Bankstown to Broome, or is it a huge group of botanically diverse individuals that, in Europe, would have qualified for a much larger category of classification?

"What do we mean by...?" The question comes up again and again when you talk to George Seddon. He tells the tale of a British ecologist who came to look at Kakadu and kept asking "where are the large carnivores. the lions or the tigers?"

Two old hobos: Frank Talbot and George Seddon.

"Well, they are in a different place!" George had to explain to his bewildered guest, "look at the ground." The man looked but saw nothing. "Termites" said George Seddon,"billions of them, shifting the living matter like trucks, turning it over faster than a big cat ever could: it is an insect-driven ecology!" It's a different way of looking at the landscape, a way that's inspired by words, by escaping from the old, wrong labels put there largely by European tradition.

Seddon now lives in Perth, based in The Centre for the Study of Australian Literature at the University of Western Australia; and he travels once a year to Venice to give a course on environmental planning. The Italians, having taken nature for granted too long, are now looking as far afield as Australia for experience in environmental management.

His books on Australian themes give some idea of Seddon's range: *Swan River landscapes*; *A sense of place*; *Man and landscape in Australia*; and *A city and its setting: images of Perth*. The latest, which has taken too long to write, is about the Snowy River. He has canoed down its white-water rapids more times than he can count and, in a way, it's that very familiarity that has formed a block to the finishing of the book. You want to do justice to the one you love. But the other problem was the historical tangle of the Snowy Mountains Scheme itself. Who today can fathom the vision, the certitude and the sheer scale of what those Australians were prepared to do, in the middle of this century, to achieve irrigation and a power supply? It was one of history's greatest exercises in earth engineering and it transformed Australia. But, at a time now when large schemes such as the Multi Function Polis, the Very Fast Train, the Space Port and the extension of Sydney Airport cause such environmental ructions, it seems incredible that the Snowy Mountains Scheme came to pass, was finished, and yet has left the Mountains themselves, as Seddon puts it, "relatively intact in the public view".

He likes to examine this change in perceptions, from times then, when we welcomed 'progress', to ones today when we seem to be suspicious of it. "Any act has physical consequences only part of which stem from the intention...The man who invented DDT did not intend to weaken the egg-shell of the American eagle any more than Prof. McHarg intended to contribute to atmospheric pollution by flying from Philadelphia to Sydney."

George Seddon is a slim, handsome, athletic man; an intellectual who likes to shock, but does so with a great sense of fun. As an elder statesman of environmental concern he can provide some thoughts to bridge the old approach (seen in the Snowy) and the present stalemate of NIMBY (not in my backyard).

"Rhetoric that induces despair and hence inaction will not help us. Contempt for and alienation from Western society may be productive to the extent that it produces critical self-awareness, but many go beyond that. Western society has, historically, been self-reforming to a degree unmatched by any other, and it is not dead yet. It is counter-productive to destroy the faith of young people in their own society. Extreme rhetoric is socially divisive, and it is sure to provoke ecological backlash. It debases the quality of public debate. For all these reasons, it should be eschewed."

Not perhaps the rally cry to use when facing the tractors at a demo in the forest but, who knows, maybe the key to fundamental change in the long haul. ■

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

COURTESY GEORGE SEDDON

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"Just as one should not judge a book by its cover, the value of this inauspicious little carcass should not be dismissed."

THE FLY-BY-NIGHT PARROT

BY WALTER BOLES, WAYNE LONGMORE & MAX THOMPSON

DIVISION OF VERTEBRATE ZOOLOGY (BIRDS), AUSTRALIAN MUSEUM
DEPARTMENT OF ORNITHOLOGY, QUEENSLAND MUSEUM
DEPARTMENT OF BIOLOGY, SOUTHWESTERN COLLEGE, WINFIELD, KANSAS, USA

MANY COUNTRIES HAVE ANIMALS THAT have acquired almost legendary status. Unlike fantastic beasts such as Bigfoot or the Loch Ness Monster, however, their existence has been proved. They have been well documented by scientists, and specimens are preserved in museums. Despite this, they remain mysterious and elusive. In the years since their discovery, they have become 'lost', seeming to slip into the realm of extinction—or possibly not.

The legend of a 'lost' species is perpetuated by the presence of regular reports and the absence of documentation in the form of photographs or specimens. These reports are sure to spark discussion over their validity and whether or not the 'lost' species even exists. Such debates are not limited to scientific circles; they capture the public imagination, becoming familiar to people with little other interest in wildlife.

Australia's unenviable record of

The authors and discoverers of the 1990 Night Parrot specimen (left to right): Walter Boles, Max Thompson and Wayne Longmore.

animals 'lost' since European invasion makes it a fertile location for legendary species. The foremost among these must be the Thylacine or Tasmanian Tiger (*Thylacinus cynocephalus*); however, by no means are they limited to mammals. Birds provide several prominent examples. Since Captain Cook's arrival, no mainland species of birds are conclusively known to have become extinct. In recent years, some of those thought to have suffered this fate have been rediscovered, for example the Noisy Scrub-bird (*Atrichornis clamosus*) and Eyrean Grasswren (*Amytornis goyderi*). Two 'lost' species hold the premier position in the debate. The Paradise Parrot (*Psephotus pulcherrimus*) has not been reliably documented since 1924, but every year there are reports from suitable parts of its former range (see ANH vol. 23, no. 1, 1989). The other enigmatic bird is the Night Parrot (*Geopsittacus occidentalis*).

Unlike the striking Paradise Parrot, the Night Parrot is a rather subdued mixture of green, yellow and black. Yet for many reasons this is a most unusual species among parrots. As its common name suggests "the most extraordinary circumstance connected with this bird is, that it is nocturnal!" (comments written by Dr Ferdinand von Müller, when he forwarded a bird to the Zoological Gardens, London, in 1867). The Night Parrot is also terrestrial, living more like a quail than a parrot. It spends the day in a burrow in the ground. Its distribution spreads across the arid regions of Australia, including some of the least visited sections of the country. The natural history of this species remains one of the least known of any Australian bird.

The Night Parrot has achieved its legendary status from these odd biological characteristics and from its rather sudden disappearance. It was discovered in 1845 by John McDouall Stuart, a participant in Charles Sturt's central Australian expedition, who collected a bird north of Cooper's Creek, South Australia. This individual was overlooked and the species was eventually named by John Gould in 1861 from another individual taken in Western Australia in 1854. Frederick W. Andrews, a collector for the South Australian Museum, had the greatest success in obtaining specimens. He collected up to 16 birds from the area of the Gawler Ranges and Lake Eyre during the early 1870s. After his time, few other birds were collected. The last, and only one in the 20th century, came from Western Australia in 1912. In all, only 22 specimens of the Night Parrot are known to have existed, but the present whereabouts of some of these is unknown.

Painting from John Gould's *The birds of Australia* (1840–1869) of the Night Parrot. The subject of both figures was the type specimen, taken in Western Australia in 1861.

When no more specimens or sightings were forthcoming from known collecting localities, ornithologists of the time soon began to speculate on the demise of the Night Parrot. Archibald J. Campbell (1915) noted that "my friend, Mr. Albert Walker, who resided at Innamincka, Cooper's Creek, for over 25 years, has frequently seen the bird, but he states that of recent years, according to the testimony of both whites and blacks, the bird has entirely disappeared". Campbell concluded that "evidently this parrot has been exterminated."

Gregory Mathews, in his extensive *The birds of Australia* (1910–1927), opened the account of the Night Parrot with the comment "There is little to record concerning this unique generic form save that it is now impossible to add much more, the absolute extinction of the species apparently being complete." Mathews goes on to quote Captain Samuel A. White, one of his most authorative correspondents: "We have hunted for years now over the old haunts [in South Australia] where they were once found, but cannot find a trace of the bird, which makes one think that it is close upon extermination if not already exterminated."

Some international conservation organisations have adopted a pragmatic definition of extinctions: if the species has not been recorded for 50 years, it is considered extinct. However the IUCN's *Red data book of rare and endangered birds* and the RAOU's *Threatened birds of Australia* list the Night Parrot as 'indeterminate', a reflection of the present uncertainty.

Rediscovery of 'lost' species, like many pursuits in science, is a combination of planned action and serendipity. Of the deliberate attempts to find the Night Parrot, the most successful of late was in 1979, when Shane Parker of the South Australian Museum set out from Adelaide to Cooper's Creek. He flushed four birds believed to be this species. That most searches have come back empty-handed has not discouraged subsequent expeditions. A monetary reward was even offered as an enticement for expanded efforts.

Yet many discoveries in science depend on chance rather than a predetermined course of action. Many apparent observations have been incidental to the activities at the time. Stockmen working at night are among the most frequent non-ornithologists glimpsing the bird. And, in the 1970s, about 20 scattered but unsubstantiated reports of Night Parrots were made by amateur bird watchers while preparing surveys for the RAOU's *The atlas of Australian birds*. Our rediscovery of the Night Parrot in October 1990, confirmed by a specimen, was the outcome of a serendipitous sequence of events.

The location of the 1990 Night Parrot north of Boulia, Queensland (red). Other recent records are shown in grey. (Adapted from Schodde and Mason 1980.)

THE AUSTRALIAN MUSEUM HAD PLANNED an extensive trip through northern Australia, where Walter Boles, ornithologist at the Museum, and Ross Sadlier, one of the Museum's herpetologists, would work on birds and reptiles respectively. Walter invited Wayne Longmore, an Associate of the Australian Museum, currently employed at the Queensland Museum, and Max Thompson, Professor of Biology at Southwestern College, Kansas (USA), to join the trip. Heading out in two Australian Museum vehicles, our trip took us from Sydney to Broome, Western Australia, through the Kimberley, and into the Top End of the Northern Territory. Ross returned to Sydney midway through the trip.

After six weeks, we started our return through western Queensland. Rather than taking a direct route back, we headed south from Mt Isa along the Diamantina Developmental Road (Highway 83). On 17 October 1990, 36 kilometres north of Boulia, we stopped at the side of the road to look at some Australian Pratincoles (*Stiltia isabella*). When the birds flew and landed down the road behind the vehicles, Max turned one vehicle around to follow them for a better look. Wayne and Walter remained parked on the side of the road in the other vehicle so as to reduce the disturbance to the birds. After obtaining a suitable look, Max returned, pulling up and parking behind the first vehicle. Walter got out and walked back to speak to Max through the window of the passenger's door. After speaking, he turned away from the vehicle and happened to look down. There, next to his foot on the roadside, was the carcass of a Night Parrot. He picked it up and handed it through the vehicle window to Wayne, then returned to tell Max what he had found. The discovery was made without overt demonstrations of excitement, tempered no doubt by a combination of disbelief and another week of field work in hot, dry conditions still to come. The thrill and wonder of the find surfaced only during breaks in our other activities.

A comparison of the tails and claws of the Ground Parrot (left) and Night Parrot. In the former bird, both features are noticeably longer.

Because the specimen was found in Queensland, it will eventually be housed in the Queensland Museum. In the interim we have been fortunate to be able to study and exhibit it at the Australian Museum.

Confirmation of the identity is a logical but not difficult starting point. Very few parrots bear any resemblance to the Night Parrot, other than for the obvious features that characterise this group everywhere. It bears a superficial resemblance to an over-sized Budgerigar (*Melopsittacus undulatus*), but no-one would ever confuse them. The only Australian parrot for which it could possibly be mistaken is the endangered Ground Parrot (*Pezoporus wallicus*). In addition to the differences in habitat (the Ground Parrot is a bird of wet coastal heathlands), the Night Parrot can be easily separated by the short

The Budgerigar of arid Australia resembles a small, more brightly coloured Night Parrot.

CARL BENTO/AUSTRALIAN MUSEUM

L. ROBINSON/NPIAW

The 1990 specimen of the Night Parrot *in situ* as found at the side of the road north of Boulia, Queensland.

MAX THOMPSON

L.F. & O.G. SCHICK

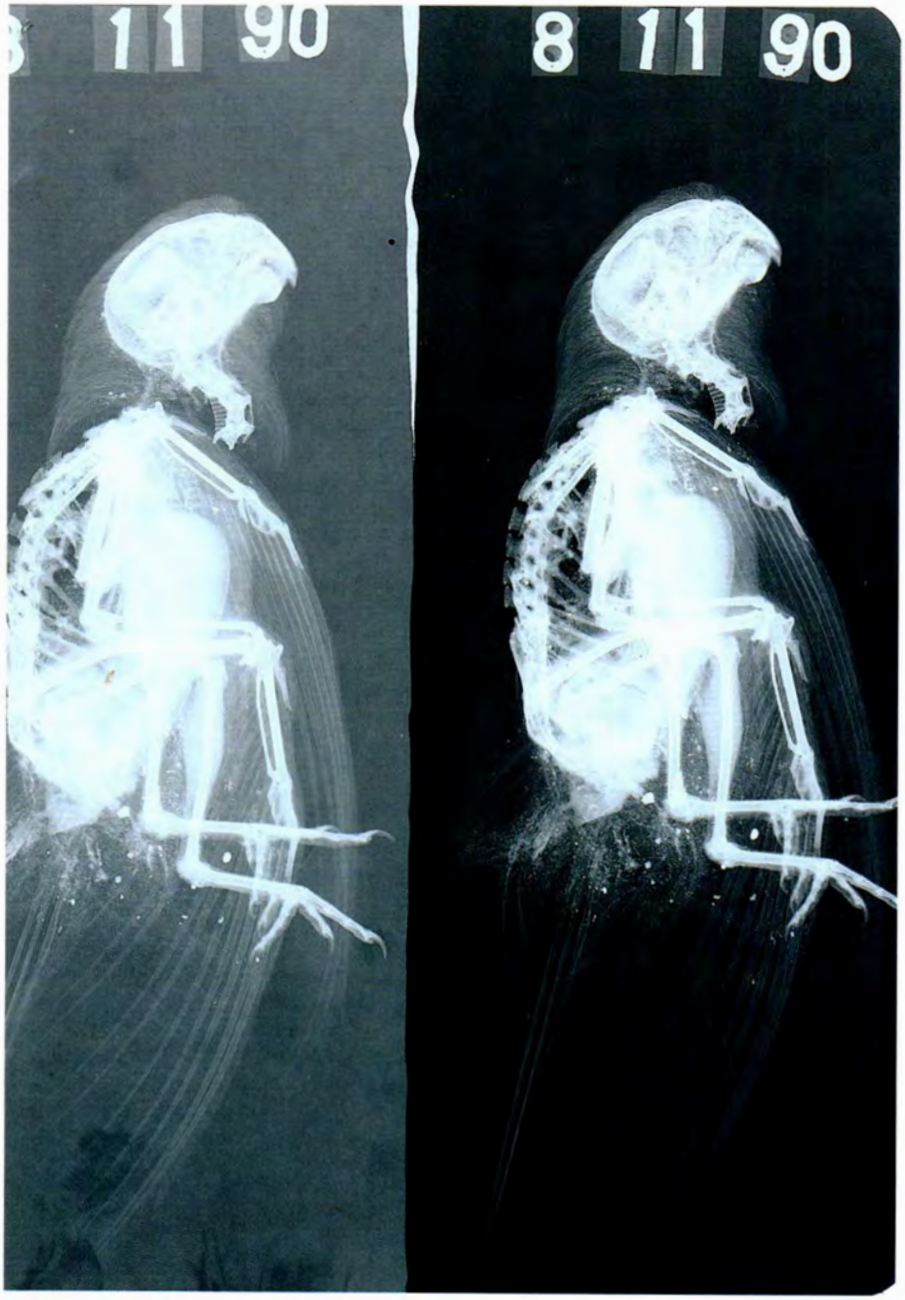
The Ground Parrot of coastal south-eastern and south-western mainland Australia and Tasmania. This species is considered by many scientists to be the closest relative of the Night Parrot.

claws, absence of an orange forehead, short tail, unbarred belly and swollen cere (fleshy covering at the base of the upper mandible).

The value of the specimen may not be immediately obvious. It was not fresh when found. Ants had removed much of the soft tissue and what remained had been desiccated. It is laterally flattened and the left side, where it lay on the ground, is dishevelled. The head has become detached, much of the tail is missing and feathers have been lost from the upper back. Most of the plumage, the wings and the legs show little damage. Just as one should not judge a book by its cover, the value of this inauspicious little carcass should not be dismissed. It offers us the opportunity to find out much about the Night Parrot.

MANY SCIENTISTS CONSIDER THE GROUND Parrot to be the Night Parrot's closest relative. In New Zealand there is another possible candidate: the bizarre Kakapo or Owl Parrot (*Strigops habroptilus*). Its large size, flightlessness and communal breeding system make it the most distinctive parrot in the world. It has a similar plumage to that of the Night Parrot, is nocturnal, lives in burrows, and shares some anatomical peculiarities. Scientists are far from agreement over whether these similarities are merely coincidental or not. We hope to help resolve this problem with the assistance of our newly found Night Parrot. Using a small sample of muscle tissue from the back and recently developed biochemical techiques, we should be able to compare the DNA of these and other parrots to find out how they are related to one another.

X-rays of the 1990 specimen of the Night Parrot. The head is detached but most of the skeleton is intact. This is the only preserved skeleton of this species.



HELEN PINELLI/AUSTRALIAN MUSUEM

The new specimen will also enable us to study its bones, as none of the skeletons of previous specimens was preserved. Apart from some minor damage to some of the ribs, the skeleton of our Night Parrot appears to be intact. We can also examine the skull, which was omitted from the only study carried out on a dissected specimen.

Without doubt this individual was killed by a motor vehicle. We cannot be sure whether the parrot died at the location where it was found, or was transported in the grill of the vehicle for some indeterminate distance before falling by the roadside. Nor are we able to judge with certainty how much time had separated its death and discovery. Dr Paul Canfield, a veterinary pathologist from the University of Sydney, has estimated the period to be between three and 12 months. The weather at the time and for some days preceding the discovery was hot and dry, which would have promoted desiccation of the specimen.

The plumage is faded when compared to specimens in the Australian Museum and it is probable that this occurred as the carcass lay on the roadside. Most of the plumage appears fresh and little worn; only the head retains old feathers. Where the plumage has been protected from the sun, the colours are quite vivid. Scattered new feathers had started to appear on the head, their bright green colour contrasting with the pale remnants of the previous plumage. Yellow pigments in feathers are quite susceptible to prolonged light exposure, so they could have faded in a relatively short time. We can tell that the bird was an adult but, in the absence of internal organs, are unable to determine the sex

with confidence. It has been suggested that males have slightly larger bills and longer wings than females. If this is so, our specimen is a male.

The Night Parrot has been reported from two different habitats. Many published records from last century and subsequent books associate it with porcupine grass (*Triodia* spp.), particularly in stony country. Other reports describe the primary habitat as low chenopod shrub (saltbush, bluebush or burr) country, usually associated with lake systems, with birds moving into porcupine grass when it seeds. We found the most recent carcass in an area of low, dry mitchell grass (*Astrelba*), burr-daisy (*Calotis*) and chenopods with areas of bare gibber. There were no trees in the immediate vicinity except along a dry watercourse a few kilometres away. There was little standing water for some distance in either direction along the road, except possibly for bores and dams (which were seen from the road but not investigated). No porcupine grass was apparent in the immediate vicinity.

Needless to say, the events that made this find possible are the results of considerable coincidence and luck. A host of potential destructive forces spared the carcass, including scavengers such as the very efficient Black Kites (*Milvus migrans*). Conversely ants may have assisted in its preservation by removing much of the soft tissue.

THE SPECIMEN CONFIRMS THAT THE NIGHT Parrot still exists. But what does it mean for the conservation of this species? What management program should be adopted, particularly when so little is known about it? And how many resources should be directed towards Night Parrot conservation, particularly if other endangered species might be better served?

The countryside in which the 1990 specimen of the Night Parrot was found. It is sparsely vegetated, with large expanses of gibber.

There seems little value in setting aside reserves for the Night Parrot. It appears nomadic, moving as necessary to locate changing supplies of water and food and making its presence unpredictable. The concentration of Night Parrots found in South Australia in the 1870s has been attributed to a localised immigration of the species. Yet ornithologists were quick to announce its extermination once the influx had passed. Such an area of abundance, if found today, would seem an ideal site to be set aside for the species, but in most years it may not support the bird at all.

To rigorously study the biology of the Night Parrot will require a large commitment of resources and time. Extensive surveys are needed to find it; but these may be like looking for a needle in a haystack. Much of its range, and maybe even its stronghold, is sparsely populated and not easily traversed. A possible tool for selecting survey sites might be satellite remote sensing, if it permitted identification of selected vegetation types at the right stages of growth. Surveys might make a quick discovery, or they might not. Once the birds are located, radio-tracking methods would be required to follow them during their nightly routines and larger-scale shifts. Such a project should extend for several years if we are to understand the movements and ecological requirements of this species.

Eventually the question of the Night Parrot's status needs to be considered. Is it teetering on the brink of extinction? Some scientists have instead suggested it may not even be very rare. Nonetheless it was probably never common and, most likely, has suffered a decrease in numbers because of European agricultural and livestock management practices, and introduced predators such as foxes and cats. The Night Parrot is no doubt extirpated from parts of its former range. It is possibly endangered. Unfortunately our knowledge of this species is too scanty to permit more than speculation about its abundance.

Regardless of the outcome of future efforts, the Night Parrot will never lose its mystique. Even its reappearance on a large scale would only add another chapter to its intriguing story. ■

The Kakapo of New Zealand. Although a much larger bird than the Night Parrot, it shares a number of characteristics and is sometimes thought to be closely related. (Illustrated by J.G. Keulemans in W.L. Buller's *A history of the birds of New Zealand*, vol. 1, 2nd ed., 1888.)

AUSTRALIAN MUSEUM RESEARCH LIBRARY

Suggested Reading

Blakers, M., Davies, S.J.J.F. & Reilly, P.N., 1984. *The atlas of Australian birds*. RAOU and Melbourne University Press: Melbourne.

Brouwer, J. & Garnett, S., 1990. Threatened birds of Australia. An annotated list. *Roy. Austral. Ornithol. Union Rep.* No. 68.

Campbell, A.J., 1915. Missing birds. *Emu* 14: 167–168.

Forshaw, J.M., 1981. *Australian parrots*. 2nd rev. ed. Lansdowne: Melbourne.

Forshaw, J.M., Fullagar, P.J. & Harris, J.I., 1976. Specimens of the Night Parrot in museums throughout the world. *Emu* 76: 120–126.

Gould, J., 1861. On a new genus and species of parrakeet from Western Australia. *Proc. Zool. Soc. Lond.* 1861: 100–101.

Mathews, G.M., 1916–1917. *The birds of Australia*. Vol. 6. Witherby & Co.: London.

Murie, J., 1868. On the nocturnal Ground-Parakeet (*Geopsittacus occidentalis*, Gould). *Proc. Zool. Soc. Lond.* 1868: 158–165.

Schodde, R. & Mason, I.J., 1980. *Nocturnal birds of Australia*. Lansdowne: Melbourne.

Wilson, H., 1937. Notes on the Night Parrot, with references to recent occurrences. *Emu* 37: 79–87.

Walter Boles is the Collection Manager of Birds at the Australian Museum. His major research interests are the Riversleigh fossil bird fauna and systematics of Australo-Papuan songbirds. Wayne Longmore is an Associate of the Australian Museum and is currently employed by the Ornithology Department of the Queensland Museum. He is the author of the forthcoming National Photographic Index book Honeyeaters and allies of Australia. *Max Thompson joined the expedition while on sabbatical leave from his position as Professor of Biology, Southwestern College. In addition to his long-standing involvement with birds, he is a prize-winning horticulturalist, with a special interest in orchids.*

MAX THOMPSON

"Evolution does not occur in a vacuum. The development of a smashing appendage has far-reaching consequences affecting almost every aspect of the biology of the species. Here I discuss just one: vision."

STOMATOPODS: THE BETTER TO SEE YOU WITH MY DEAR

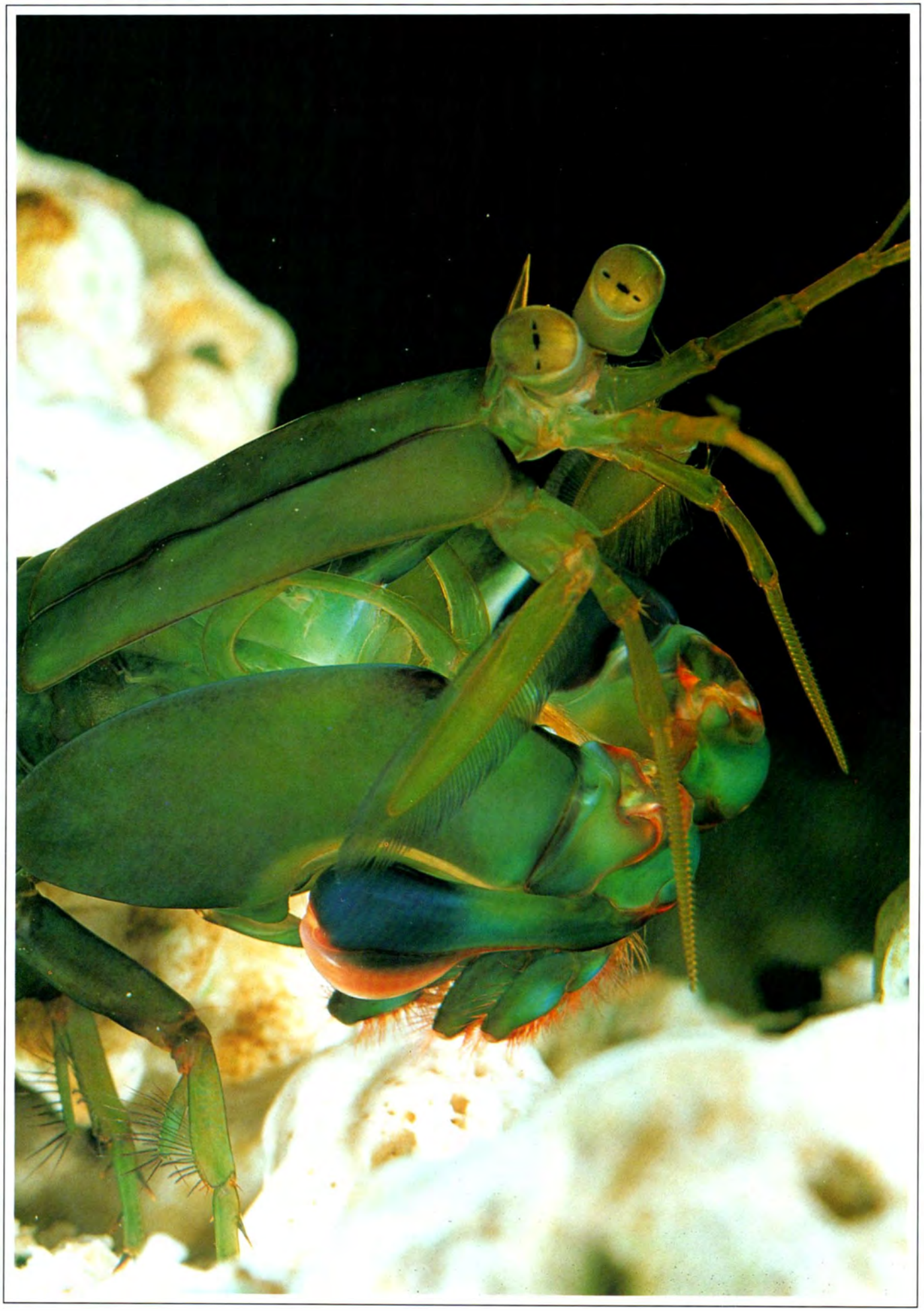
TEXT AND PHOTOGRAPHY BY ROY L. CALDWELL

DEPARTMENT OF INTEGRATIVE BIOLOGY,
UNIVERSITY OF CALIFORNIA AT BERKELEY, USA

COCONUT BEACH IS ONE OF MY FAVOURITE retreats. Nestled behind the reptilian head of Lizard Island, its white sands stretch northward nearly a kilometre from the massive cliffs along the Lizard's neck. At low tide, the entire reef flat extending 300 metres outward from the beach will be exposed. Walking along the sand and out across the emerging flat, no icons of civilisation intrude. Armed with net and gloves, I start my daily search for the animals that I have come to study—stomatopod crustaceans, more commonly known as mantis shrimp. For the next three hours until the tide returns, this patchwork field of corals and sponges, algae and clams, becomes my hunting ground. But as I scan the sand flats, rocky beaches and tide pools to catch a glimpse of one of these secretive creatures, I am well aware that many sets of remarkable eyes are tracking my every move. Several hundred thousand stomatopods, representing at least 13

NORMAN QUINN

Having eyes on stalks enables stomatopods to peer out of holes and around corners. Here two *Gonodactylus* attempt to size each other up as they prepare to fight for a cavity. The author near the Lizard Island Research Station, where he studied these curious crustaceans.



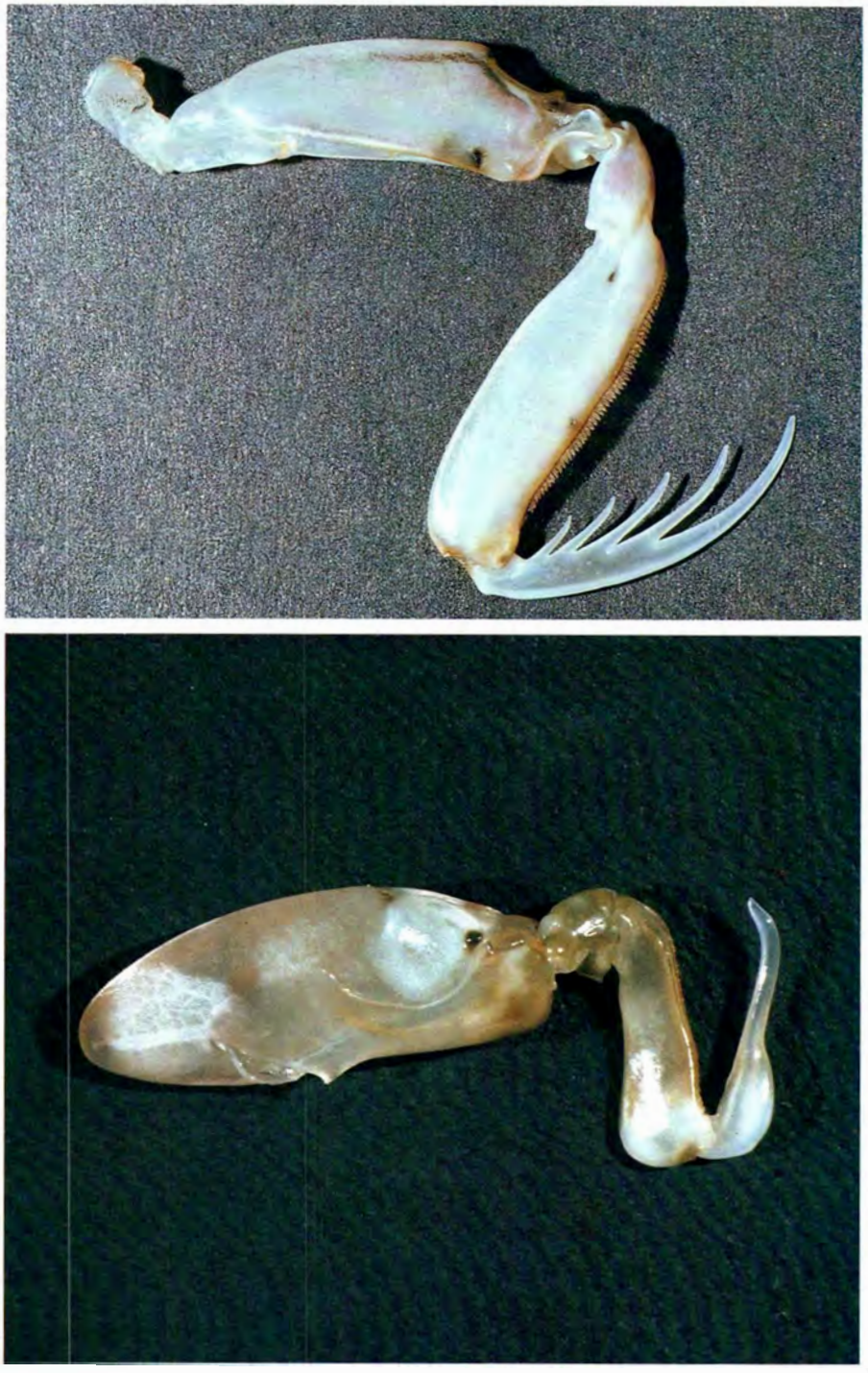
species, live at Coconut Beach. This afternoon, I'll be lucky to catch a dozen.

But why travel all the way from Berkeley, California, to spend weeks prowling the reefs of Lizard Island in search of this elusive quarry? Beyond the aesthetic pleasures of such research (and the relief from classrooms, telephones and endless committee meetings) lies the growing satisfaction and occasional excitement of unravelling the biology of one of the most remarkable groups of animals I know. Studying the morphology, behaviour and ecology of stomatopods has helped me understand the interdependence of each in the evolution of the whole.

STOMATOPODS ARE A SMALL BUT DIVERSE group of marine predators with about 400 species representing 14 families and 74 genera. Only distantly related to more familiar crabs and prawns, the stomatopod lineage split off from other crustaceans 400 million years ago. Most species are restricted to shallow tropical and subtropical seas. Stomatopods can be found in just about any subtidal habitat surrounding Lizard Island. Several species live in cavities in live or dead coral, coralline algae or rock. Others excavate burrows in sand or mud. A few occur only at depths greater than 20 metres, while some live well into the intertidal zone. After several visits to the Lizard Island Research Station, I have learned where each of the 21 species I have collected around the island might be found. And each new expedition yields at least one or two additional species, often new to science.

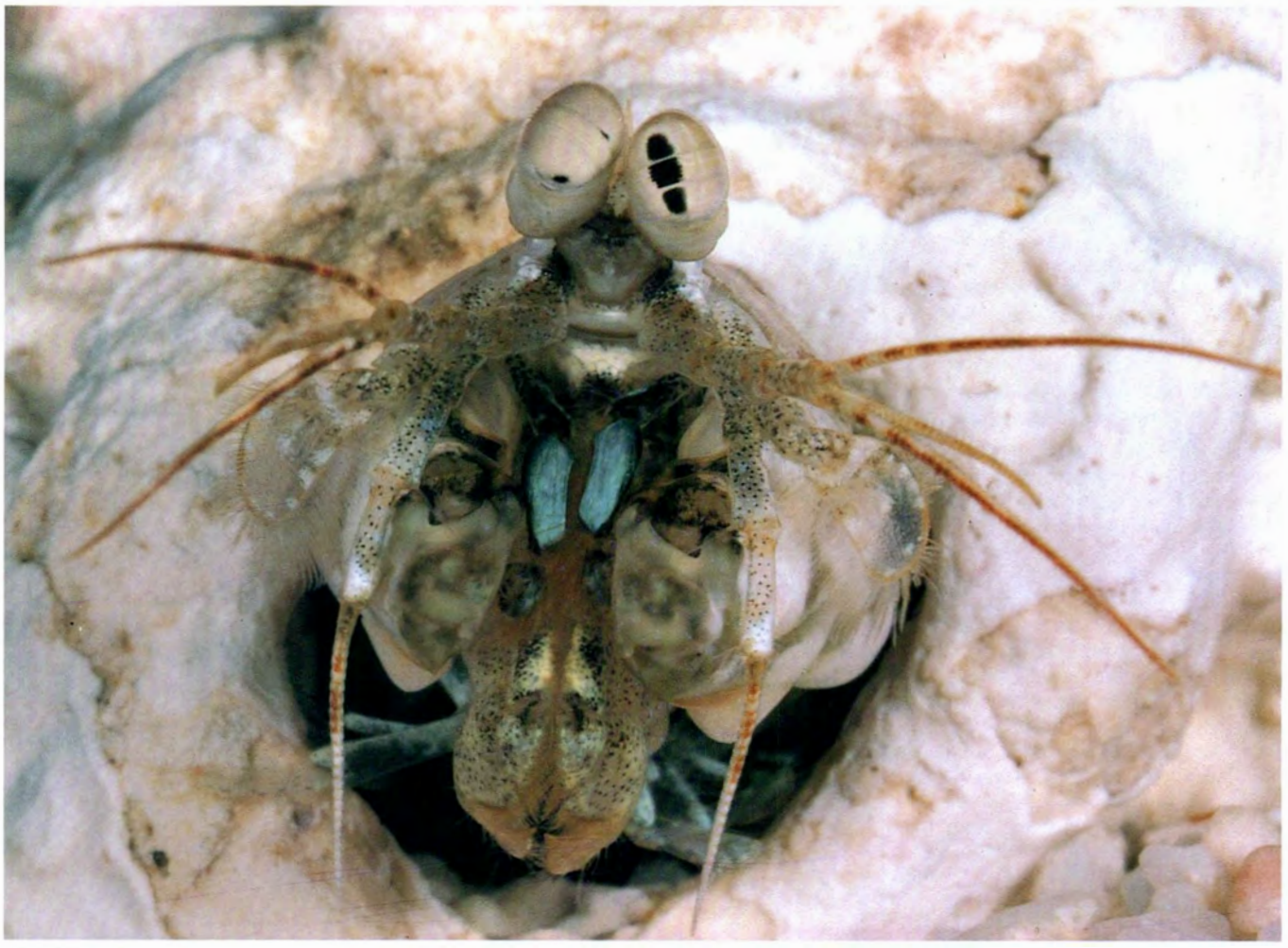
The most unique feature of stomatopods is their pair of enlarged raptorial appendages carried folded beneath the head. They are analogous to the forelimbs used by praying mantises to seize prey and it is this similarity that gives stomatopods their common name of mantis shrimp. One difference is that mantids strike overhand, trapping their prey from above, useful for catching insects attempting to take flight. Stomatopods strike underhand, hitting their victims from below where prey such as prawns and fish are more vulnerable. A more impressive difference is the speed of the strike. Full extension of a stomatopod raptorial appendage takes as little as three milliseconds, several times faster than the strike of a praying mantis. Finally, the raptorial forelimbs of mantids are designed to grasp prey, holding it firmly with the aid of spines lining the two distal segments that fold together. The situation is somewhat different in stomatopods, which I have divided into two functional groups—spearers and smashers. In spearers, the distal segment of the raptorial appendage, or dactyl, is armed with two to 17 spines. Spearers strike with the dactyls unfolded, impaling soft-bodied prey such as fish or prawns on the needle-sharp spines. In smashers, the dactyl is usually unarmed but has a greatly inflated and heavily calcified heel. Strikes are delivered with the dactyl tightly folded back against the next segment, hitting the target with the blunt, hammer-like heel. Such a strike is particularly effective against armoured prey such as crabs and snails, which are literally broken apart by repeated blows.

It is the evolution of the smashers that has particularly intrigued me. From the fossil record we know that the first stomatopods were spearers. Their ancestors used five pairs of small thoracic limbs to sift food from muddy bottoms. Gradually, animals with longer, hooked appendages appeared that were better able to seize more mobile prey. Around 200 million years ago, animals appeared with the second



Comparison of the raptorial appendages (or dactyls) of a spearing stomatopod (top) with that of a smasher (bottom). Both are shown in the open position. Spearers typically strike with the dactyl in the open position, impaling soft-bodied prey on the sharp barbs. Smashers, on the other hand, strike with the dactyl folded, hitting their armoured prey with the blunt heel.

The raptorial appendages of the common smasher *Gonodactylus smithii* are greatly enlarged and carried tightly folded beneath the head. The terminal pink dactyl with its heavily calcified heel can be seen tightly folded against the blue and purple next-to-last segment, the propodus, which swings out when a blow is delivered.



Haptosquilla trispinosa **commonly lives in deep water where there is little light. In the area of greatest visual acuity, the compound eye is modified to have many visual elements (ommatidia) pointing in the same direction. This results in larger pseudopupils. Here the three pseudopupils can be clearly distinguished.**

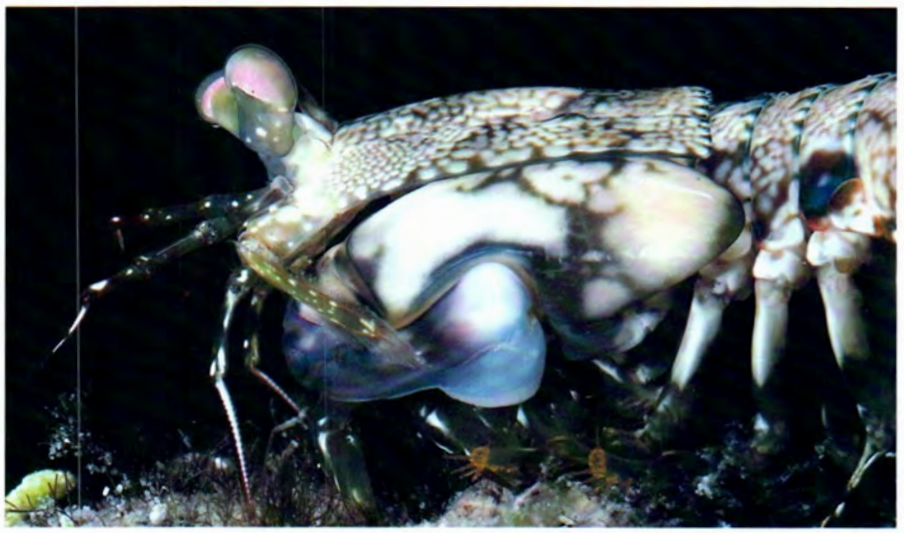
pair of these appendages greatly enlarged and modified for spearing. These were the first true stomatopods. We currently recognise four major groups of modern stomatopods, the bathysquilloids, squilloids, lysiosquilloids and gonodactyloids. The bathysquilloids and squilloids are nearly all spearers but, in the other two groups, and particularly in the gonodactyloids, smashing has evolved several times and in several different lineages.

By studying the behaviour of modern spearers, it is possible to construct an evolutionary scenario of how this might have occurred. While spearers usually eat soft, unarmoured prey that they impale on the dactyl spines, I have observed individuals of some species feeding on weakly armoured animals such as thin-shelled clams. Attempting to open a clam, the dactyl spines are useless. However, by striking with the dactyl closed, they can use the elbow as a hammer, cracking the thin shell. Should such prey be particularly abundant, it is easy to see how selection could favour individuals with the largest and strongest hammers capable of opening prey more efficiently. As the size and power of the smashing appendage evolved, some individuals would have been able to break or kill still more heavily armoured prey, opening up further rounds of escalation in the evolution of smashing raptorial appendages. Eventually, the muscles that power the strike would have enlarged, the heel of the dactyl become heavily calcified to add mass and prevent self-damage, and the dactyl spines reduced or lost since they would have been ineffective in capturing armoured food and could have been damaged when striking such prey.

But evolution does not occur in a vacuum. The development of a smashing appendage has far-reaching consequences affecting almost every aspect of the biology of the species. Here I will briefly discuss just one: vision. How is it that such a seemingly unrelated trait can be influenced by the evolution of the smashing appendage?

ALL STOMATOPODS HAVE A PAIR OF compound eyes mounted on movable stalks, although in the bathysquilloids, which live at great depths, the eyes are greatly reduced. In the other three superfamilies, up to 10,000 visual elements, or ommatidia, make up an eye. Each ommatidium views the world through a separate lens pointed in a different direction, although the visual fields of adjacent ommatidia frequently overlap, particularly in the areas of highest visual acuity, which are usually directed forward. An unusual feature of the stomatopod eye, however, is its functional concavity, with different regions of the same eye responding to the same point. The eye is bisected by a central band made up of a few rows of ommatidia that each point straight out on the equatorial plane. However, on either side of the central band, some ommatidia are tipped toward the centre. Consequently, a point directly in front of the eye is viewed by ommatidia from three different regions, some in the central band, some from the dorsal and some from the ventral hemispheres. This can be seen by peering into the eye of a stomatopod. When you look directly down the barrel of an ommatidium, it appears black because incident light is absorbed. Off axis, an ommatidium appears bright because light is reflected. If you are directly in front of the eye, you will see three dark spots or pseudopupils, each consisting of several ommatidia pointing directly at your eye (or in the case of a photograph, directly at the camera lens). If you move slightly to the side, only two pseudopupils remain, one from the dorsal and one from the ventral hemisphere. A single eye effectively has 'binocular', or even 'trinocular' vision,

This female squillid is curled on her side laying eggs. The eggs are then mixed with a cement and kneaded into a ball, which she will guard in her burrow and frequently carry in her mouth parts until they hatch weeks later. Note the broad peanut-shaped eye and bright eye shine, typical of nocturnal spearing stomatopods.



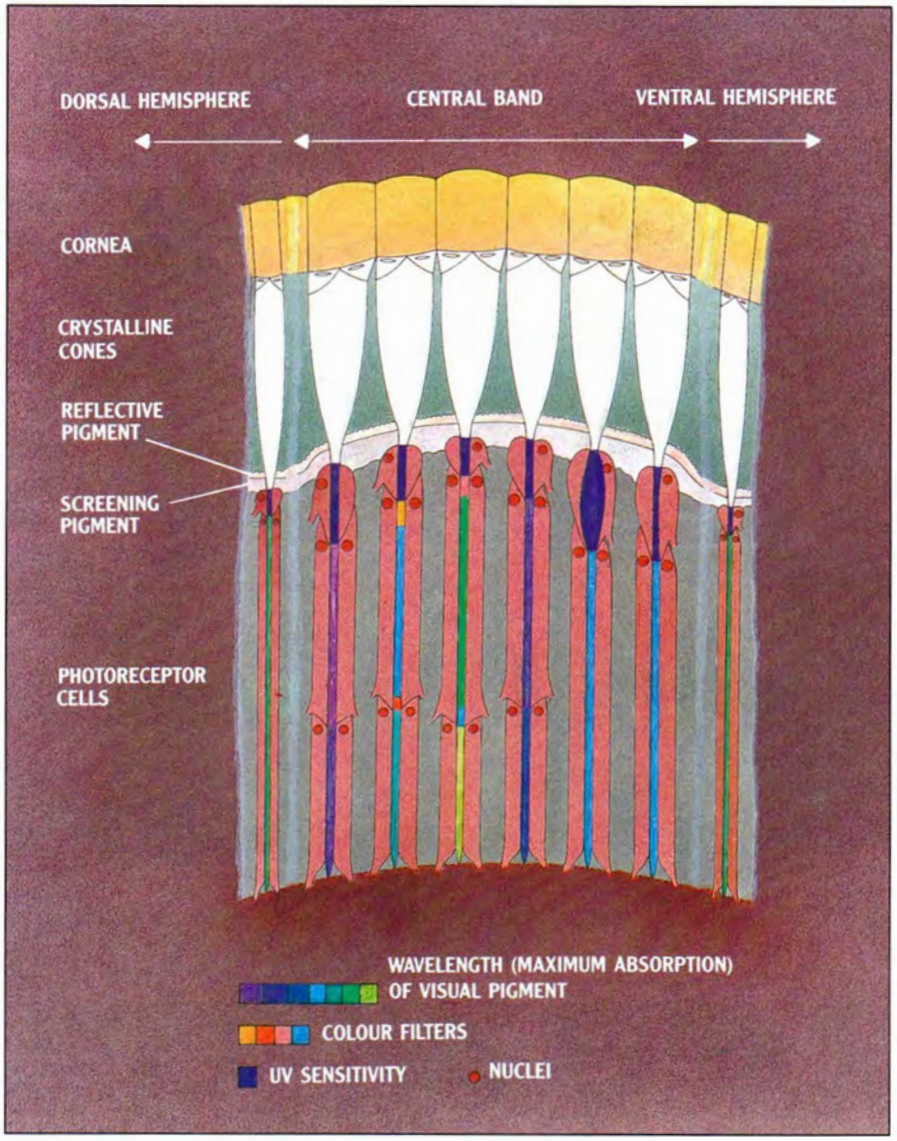
Gonodactylus platysoma **is one of the most common stomatopods encountered throughout the Indo-Pacific. This eight-centimetre smasher can be seen on the reef flat darting from coral head to coral head during low tide.**

which can be used for range-finding. If both eyes are brought to bear on a target, the stomatopod has 'hexnocular' vision.

In some species, and particularly in spearers such as *Lysiosquilla* that must hit moving prey at a distance, the eye has become broad and peanut-shaped, moving the pseudopupils further apart. This increases the parallax (the apparent change in the position of an object resulting from the change in the position from which it is viewed) and thereby increases the ability to determine the distance to an object. Obviously, being able to accurately judge distance in an animal that strikes out with raptorial appendages is important and stomatopods have evolved one of the most complex range-finding systems known.

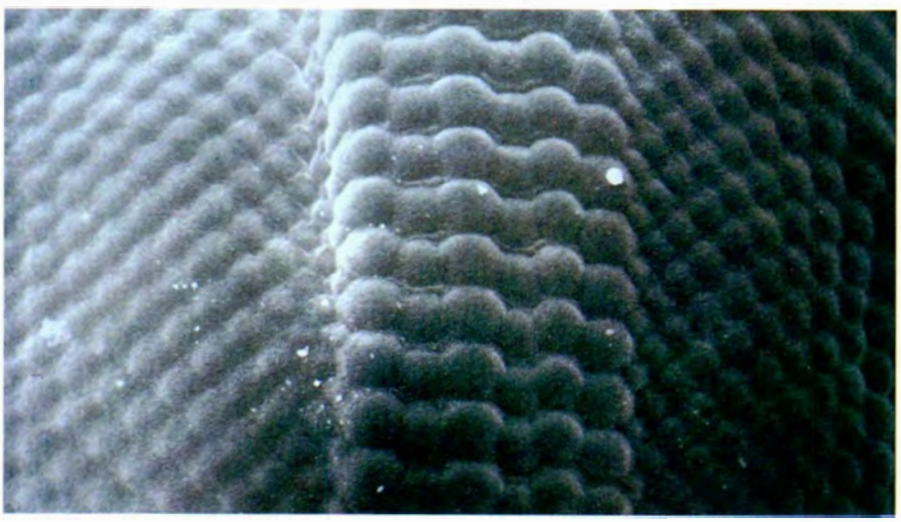
Let me return to the analogy with preying mantises. Mantids rely entirely on simple binocular disparity to gauge depth and must orient their entire head directly towards an object to determine its distance. Why should stomatopods evolve an elaborate, one-eyed range-finding system? In contrast to mantids that have their eyes fixed in their head, stomatopods have highly mobile eyes mounted on stalks that continually scan the environment. Furthermore, they frequently look out from the confines of a burrow entrance, which does not permit the animal to turn its head to orient toward an object. The ability to determine distance using a single eye allows stomatopods to quickly respond to potential predators, competitors or prey, even if they are approaching from the side. It also means that, should a stomatopod lose an eye, which occasionally happens during fights, it is still capable of capturing prey and so is not doomed.

But the complexity of the stomatopod eye does not end here. Many spearers are sit-and-wait predators, ambushing passing prey from burrow entrances. They hunt at night or in dim, murky waters and their eyes are designed to



IAN FAULKNER

Central band of a typical gonodactyloid eye, comprising six rows (1–6) of specialised ommatidia. (The dorsal and ventral hemispheres, only partially shown, continue either side.) The photoreceptor cells of rows 5 and 6 contain only a single visual pigment and may be adapted for detecting polarised light. Rows 1–4, however, are made up of two distinct tiers, each with a unique visual pigment maximally sensitive to wavelengths of light ranging from violet to green. The system is made even more sensitive with the existence in rows 2 and 3 of coloured filters (shown here as yellow, orange, pink and blue) that cap each tier of photoreceptor cells. Each ommatidium is also apparently sensitive to ultraviolet light (although shown here as darkest purple). (Adapted from Cronin and Marshall 1989.)

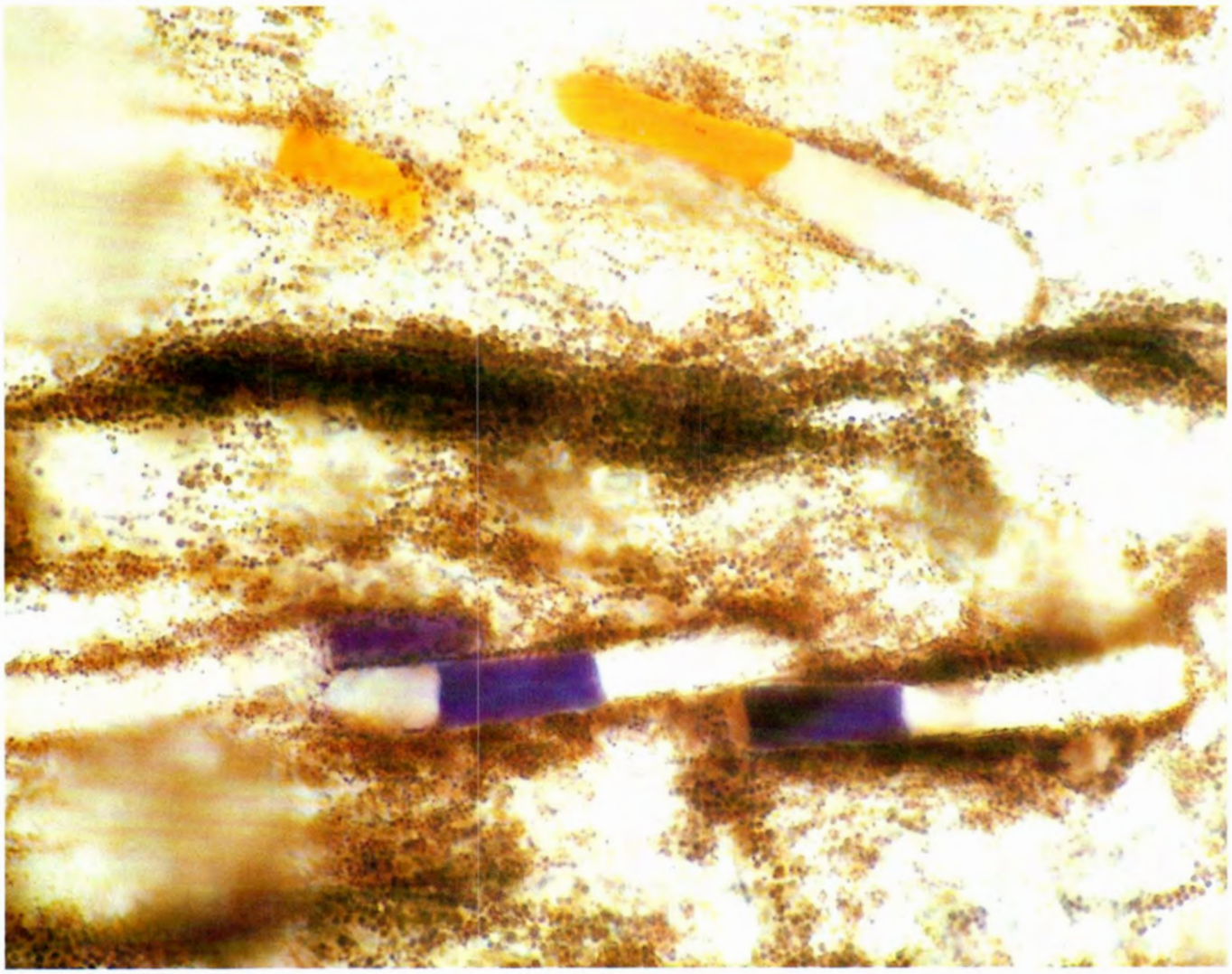


Scanning Electron Micrograph of the eye of a juvenile *Gonodactylus*. The central band containing the six rows of ommatidia specialised to discriminate among colours and to detect polarised light are visible.

gather light. The few species studied to date possess only a single visual pigment, which would prevent them from distinguishing colours. Most smashers, on the other hand, live in clear, shallow water and are active during the day, making frequent forays from their cavities to hunt. Because of their colourful body markings, I have suspected that at least some of these stomatopods use colour vision in their interactions with one another. Recently, Dr Tom Cronin of the University of Maryland and Mr Justin Marshall of the University of Sussex have shown that the eyes of the major group of stomatopods containing most smasher species, the gonodactyloids, appear capable of sophisticated colour analysis.

But even in gonodactyloid eyes, the ommatidia of the dorsal and ventral hemispheres contain only one visual pigment and are similar to those of other stomatopods. However, the central band in the gonodactyloids is more complex. In species without colour vision, the central band contains only two rows of rather ordinary crustacean ommatidia, but the central bands of groups that appear capable of colour discrimination have six rows of specialised ommatidia, each serving a different function. Rows 5 and 6 contain a single visual pigment and have structures that appear adapted for detecting polarised light, each sensitive to perpendicular planes of polarisation. For what purpose, we can only speculate, but a possibility is homing. Stomatopods that travel far from their cavities, as many smashers do, might use polarisation cues to determine which direction is home, just as Honeybees use the polarised sky to help them return to their hive.

Rows 1 through 4 are very different. Within each ommatidium, the photoreceptor cells form two tiers. The resulting eight different regions each contain a unique visual pigment with a peak sensitivity to wavelengths of light ranging from violet to green. In addition, in rows 2 and 3, the receptor cells of each tier are capped by a coloured filter that further tunes the sensitivity of the system. The filters in row 2 are mostly yellow and orange, while those in row 3 may be red, purple or blue. The outer tier of each ommatidium is sensitive to shorter wavelengths than is the inner one, and the outer filters pass shorter wavelengths than do the deep filters. The result is fours pairs of receptors, each with a pair of narrow spectral sensitivity curves separated by 50 to 75 nanometres (thousand-millionths of a metre) that cover the spectrum from the near ultraviolet to red. Furthermore, physiological tests have shown that these stomatopods also have another visual pigment in the central band maximally sensitive well into the ultraviolet.



JUSTIN MARSHALL

The eyes of gonodactyloid stomatopods have colour filters that increase the animal's sensitivity to colour. These occur in rows 2 (yellow) and 3 (purple) of the central band of ommatidia.

With at least ten visual pigments plus several colour filters, this system is vastly more complex than our own colour vision based on three visual pigments, or even that of some birds, turtles and fish that may have up to five visual pigments and one coloured filter.

But why? Prey and predator detection while moving through their complex visual worlds probably accounts for part of the reason, but I suspect that the rest of the answer concerns the evolution of the smashing raptorial appendage and the danger it poses to other stomatopods.

THE SMASHING APPENDAGE IS NOT ONLY effective in capturing and processing prey, it is also a lethal offensive and defensive weapon. Even though they

***Odontodactylus scyllarus* is one of the largest (18 centimetres) and most brilliantly coloured of all smashing stomatopods. It is commonly collected and sold in the aquarium trade but buyers beware: a large specimen can easily crack the side of a glass aquarium with its smashing strike and prized fish probably won't survive the first night! Here a female carries her large clutch of pink eggs.**

have evolved heavy protective body armour, many smashers are capable of severely injuring or even killing another stomatopod with a single blow. Most smashers live in natural cavities in coral or rock that are easier to defend than the burrows excavated by spearers. Cavities provide protection from predators, a place from which to hunt and process prey, and safe haven when brooding eggs and larvae or when moulting. An animal without a cavity has little chance of survival. Suitable homes are often in short supply and competition for them is intense, leading to frequent and often violent contests. Fighting is an extremely dangerous business and smashers have evolved elaborate behaviours that aid in assessing the fighting ability of an opponent as well as the likelihood that it will attack or flee. Threats displaying the raptorial weapons signal the apparent ability to strike as well as the willingness to attack. Probing tactics to determine an opponent's strength invite blows to the well-armoured telson (or 'tail'). But, most surprising, I have discovered that some smashers are capable of recognising individuals with which they have previously fought and use information on the outcome of that contest to determine whether to fight or run. My initial studies showed that these stomatopods used odour to recognise individuals, but recent work suggests that vision may also play an important role, particularly at a distance where chemically based information is unavailable. Many species that appear to have colour vision are highly variable with respect to colour and pattern, while species that do not have colour vision are typically colour monomorphic. I suspect colour vision functions in part to detect and identify other stomatopods.

In animals where it is dangerous to approach too closely, the recognition of potential mates can present problems, and here too colour vision may play a role. On the inner surface of the raptorial appendage, stomatopods have a large spot. These are displayed by spreading the raptorial appendages when an individual threatens or during courtship. Within a species, the spots are always the same colour, even if the colour of the rest of the body varies. In smashers, the spots are often brilliantly coloured—purple, red, yellow or blue. Typically, if more than one species occurs in a habitat, they will have different coloured spots. While it remains to be proven, I suspect these spots aid in recognising members of the same species and thus potential mates.

In the field, I have watched stomatopods begin courting members of the opposite sex at distances of over a metre. If the intruders are of the same sex, these same animals hide or give aggressive displays. Since the distance is probably too great for odours to be involved, these stomatopods are most likely using vision to determine the sex of the approaching animal. While subtle differences in posture or movement could announce an animal's sex, none is apparent to me. In a few species, there are marked colour differences between males and females that serve to identify sex. For example, in a smashing species (*Gonodactylus ternatensis*) from Thailand, males and females are similarly coloured except for their antennal scales—large flaps that extend out from the side of the head. Males have blue scales, females orange. Behavioural tests show that males recognise females by the colour of their scales. Colour differences between males and females of most species, however, are barely detectable to the human eye. Still, given the colour-analysing potential of these animals, it may well be that stomatopods use colour hue or pattern or both to identify potential mates.

Twenty-five years ago when I first stalked stomatopods on the reefs of Bermuda, I had no idea that their pursuit would become my passion and lead me around the globe to such places as Lizard Island. I did know that they were difficult to catch. Now we are beginning to understand why. Their remarkable eyes are useful not only for detecting a prowling biologist and escaping his net, but also for capturing prey and distinguishing potential mate from cavity usurper. ■

Smashing stomatopods frequently have heavy body armour to ward off the blows of an attacker. Here a cornered *Gonodactylus smithii* assumes a defensive coil, using its tail as a shield against the blows of an enemy. In this species, bright red spots on either side of the tail are typically displayed during such encounters and may provide information on species identity.

Suggested Reading

Caldwell, R., 1987. Assessment strategies in stomatopods. *Bull. Mar. Sci.* 41: 135–150.

Caldwell, R. & Dingle, H., 1976. Stomatopods. *Sci. Amer.* 234: 80–89.

Cronin, T. & Marshall, N., 1989. Multiple spectral classes of photoreceptors in the retinas of gonodactyloid stomatopod crustaceans. *J. Comp. Physiol. A* 166: 261–275.

Marshall, N., 1988. A unique colour and polarization vision system in mantis shrimps. *Nature* 333: 557–560.

Dr Roy Caldwell is a Professor of Integrative Biology at the University of California at Berkeley, USA where he teaches animal behaviour. Most of his research centres on the biology of stomatopods with recent studies concentrating on the evolution of mating systems, foraging behaviour and visual discrimination. As a recipient of the Qantas Lizard Island Fellowship, Qantas provided the author with a return international airfare. The Fellowship is part of the company's commitment to science.

"Genetics is not a cure-all in conservation but should be seen as a complement to ecology, natural history and demography."

GENETICS AND CONSERVATION

BY LEO JOSEPH

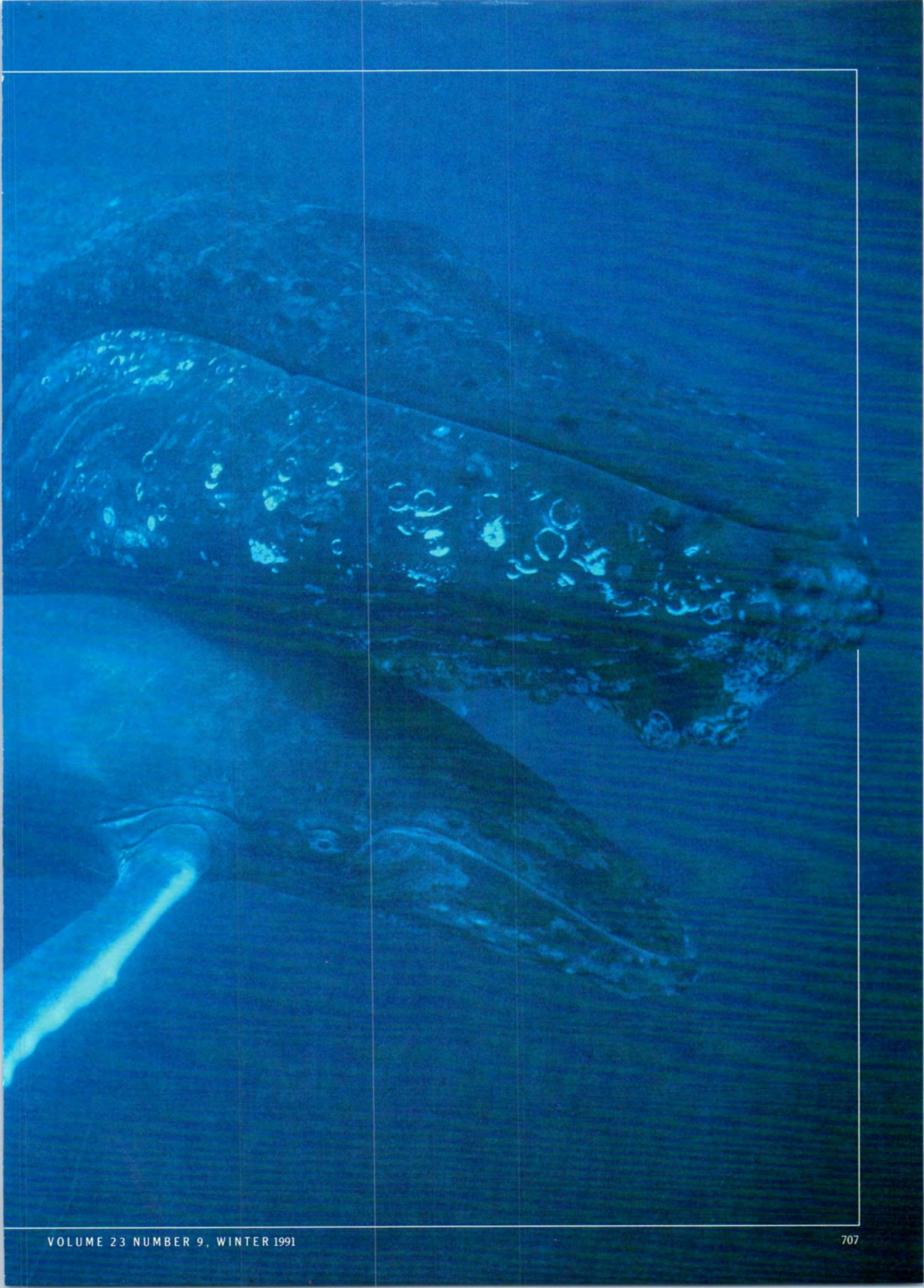
DEPARTMENT OF ZOOLOGY, UNIVERSITY OF QUEENSLAND

AS A NATURALIST SPECIALLY INTERESTED in birds, I have been led by my wanderings in the bush to interests in conservation and evolution, particularly its genetic basis and how that relates to ecology. Perhaps inevitably I came to the conclusion that, if conservation is our attempt to allow evolution to proceed in as unhindered a manner as possible, and if genetics provides the nuts and bolts of evolution, then surely we need to understand not just ecology, natural history, demography and non-biotic processes that make up the ecosystems we want to conserve, but also the genetics of the species in those ecosystems. In other words, I see conservation as the means by which we achieve the goal of continued evolution.

Arguably the most fundamental concerns in conservation are deciding what needs to be conserved and how to go about it. Traditionally, these

A female Humpback Whale and her calf. Study of species that undergo long-distance migration can be difficult because of the low recovery rate of marked individuals. Genetic studies, however, offer a potentially rapid means of unravelling the movements of some of these animals and so provide an example of the powerful tools that genetics can offer to conservation biology.

MIKE OSMOND/AUSCAPE INTERNATIONAL



decisions have been made after looking at the morphological or phenotypic variation in any given species (or group of species) throughout its range, and relating that to ecology and natural history. However, phenotypic variation reflects only a tiny proportion of the genetic variation in species (see box), and so this approach is often inadequate. Consider the following problems.

Managers of some rare and threatened species have translocated individuals from existing populations to other areas of habitat to set up new populations. Which individuals should be selected for translocation? Some species may be genuinely rare, but others may in fact be the result of occasional natural hybridisation between two common species and so not be valid species at all. How do we resolve the debate when their very rarity hinders us from finding and studying them? Various populations of some animals (such as marine turtles, whales and waterfowl) have different breeding grounds and migrate over vast distances to share common feeding grounds. Attempts to trace the movements of the various populations by physically marking individuals can be inadequate because of the typically low rate of recovery of marked animals. How will we know whether threats such as overhunting or deforestation on feeding and wintering grounds affect all or only some breeding populations of these species?

Genetics can provide answers to all of these questions—quickly and usually unambiguously. Potentially, each separate population of a species has, in the DNA of its component individuals, diagnostic 'tags' or markers that allow these problems to be solved (see box). However, other problems are more complicated and the value of genetics relative to ecology and demography seems to vary from one species to another. The easiest way to appreciate the use of genetics in conservation is to look at some actual and potential applications.

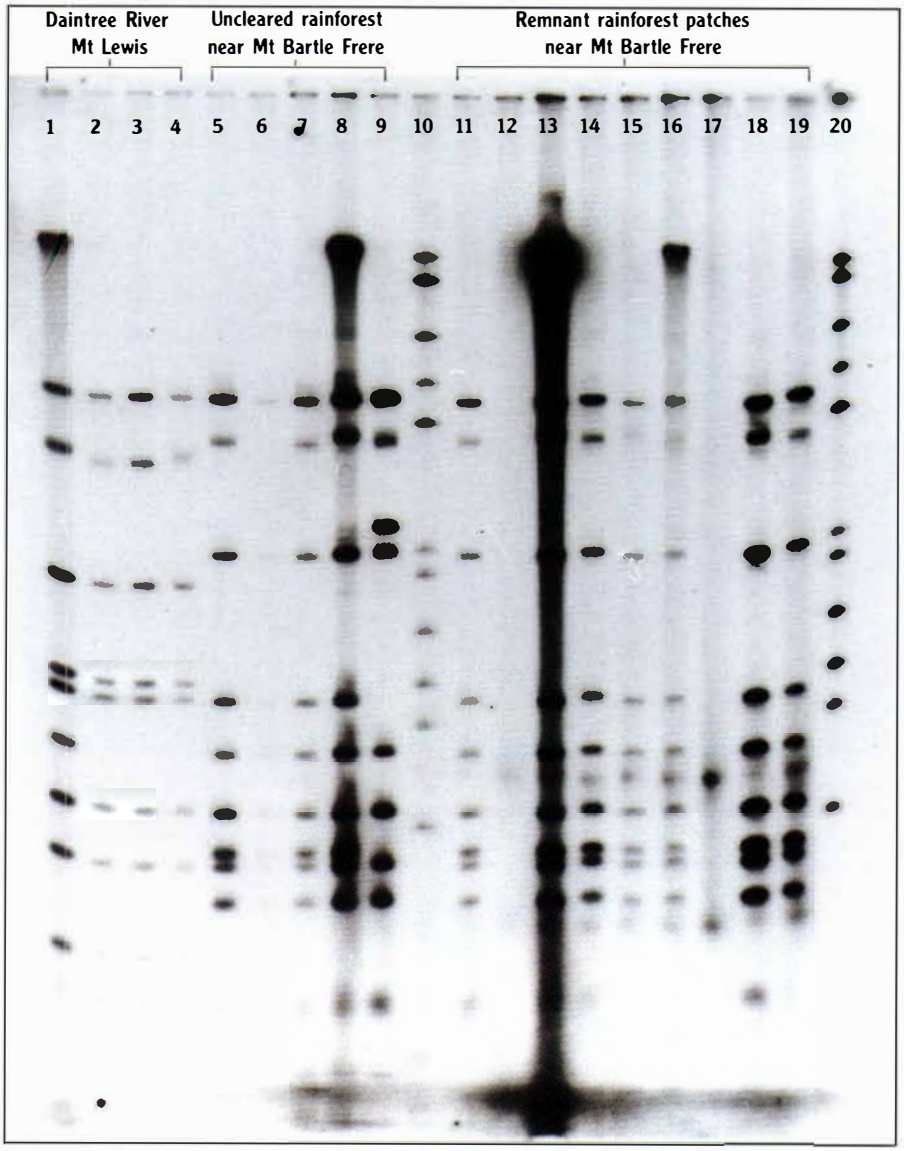
THE SEASIDE SPARROW (*AMMODRAMUS maritimus*) has several subspecies along the coasts of the Atlantic Ocean and Gulf of Mexico in the south-eastern United States. One of these subspecies, the Dusky Seaside Sparrow (*A. m. nigrescens*), recently declined to the point where only five males existed. Before the last of them died, a hybridisation program was set up to try to salvage the genetic constitution of the endangered subspecies. Females of those subspecies whose phenotypes were most similar to the Dusky Seaside Sparrow were used. Later studies of how genetic variation was distributed between the various subspecies of the Seaside Sparrow (this included samples from the last Dusky male) showed that those along the Atlantic coast comprised one discrete group and those along the Gulf of Mexico comprised another. The Dusky Seaside Sparrow was one of the former.

The Yellow- (top) and Orange-fronted (bottom) Parakeets: two valid species or just colour morphs of the one species? Genetic studies may provide the answer.

L.E. & O.G. SCHICK

The New Zealand subspecies of Boobook Owl has been used in a hybridisation program to rescue the near-extinct subspecies from Norfolk Island.

GEOFF MOON/AUSCAPE INTERNATIONAL



The method of gel electrophoresis is used to compare the DNA between individual Prickly Skinks (*Tropidophorus queenslandiae*) from four different areas in northern Queensland. Each column represents an individual, except for columns 10 and 20, which are standards for comparison. Columns 1–4 are from the northern part of the skink's range, north of Cairns, while the remainder are from south of Cairns near Mt Bartle Frere; those in columns 5–9 are from uncleared, extensive rainforest and those in 11–19 are from isolated remnant patches of rainforest. Differences (that is, genetic variation) can be seen not only between the northern and southern individuals but also among the northern and southern individuals themselves. None of this variation, however, is apparent from the outward appearance of the skinks.

The hybridisation program, which used Gulf of Mexico females, would have been better conducted with females from other Atlantic Coast populations. In many cases, however, we simply do not have the data to make decisions like this and so we have to use existing taxonomy, which is itself often the only available estimate of genetic variation within and between populations.

A similar example closer to home is the Norfolk Island Boobook Owl (*Ninox novaeseelandiae royana*) of which one last female remains. Hybridisation with males of the New Zealand subspecies (*N. n. novaeseelandiae*) has been conducted successfully. (The Boobook Owl from nearby Lord Howe Island, the subspecies *N. n. albaria*, would probably have been the better population to use in a hybridisation program but is already extinct.

Are some rare species natural hybrids, rare morphs of common species, or genuinely rare? Ornithologists from Australia and New Zealand are familiar with two examples that illustrate this type of problem: Cox's Sandpiper (*Calidris paramelanotos*), which may be the result of natural hybridisation between other *Calidris* sandpipers, and the Orange-fronted Parakeet (*Cyanoramphus malherbi*), which may be just a colour morph of the Yellow-fronted Parakeet (*C. auriceps*). Genetic methods can assay the supposed parental species of *Calidris* sandpipers for genetic tags diagnostic to each species. If the problematic Cox's Sandpiper consistently shares the tags of different species, we can argue that it is a natural hybrid. If it lacks them and has its own diagnostic tags, we can argue that it is indeed a species. Similarly, with the Orange-fronted Parakeet, more work is needed to see whether it too might share genetic tags with the Yellow-fronted Parakeet and thus be argued to be a different plumage morph of the Yellow-fronted. In both cases, genetics can potentially resolve whether these two birds are valid species and thus whether we need to worry about their conservation.

Which individuals should be selected

Genetic Variation

I think that most people can intuitively see some merit in the oft-mentioned value to conservation of conserving genetic variation. But what exactly does 'genetic variation' mean?

DNA is the genetic material in the cells of the individuals that make up a population. It is shaped like a coiled ladder and the 'rungs' of this ladder are a linear array of chemicals called bases. There are four bases involved and we can abbreviate their names as A, C, G and T. As many as 10^9 (a thousand million) bases are in the DNA of every cell of organisms such as birds and mammals; the humble *E. coli* has about 10^6. Often this DNA is not one continuous coil per cell but is instead parcelled up into chromosomes. In humans, for example, there are normally 46 chromosomes in each cell (except sperm and eggs which have 23). A gene is a *particular* long sequence of bases located at a *particular* part of a *particular* chromosome. The sequence of bases in a gene is a code that, in simple terms, enables the chemical machinery of an organism to determine some observable characteristic of the individual carrying that gene.

A lot of DNA is of uncertain, if any, function and is not part of the code of a gene. This so-called non-coding DNA is worth considering because its sequence of bases usually varies a lot from one individual to the next. It is this large variation between individuals in these sequences that makes it so useful in the study of genetics in conservation.

In summary, the DNA of each chromosome is arranged into a particular sequence of coding and non-coding regions alternating along the length of the chromosome and characteristic of that chromosome.

Now we are in a position to see that genetic variation refers to differences between individuals in the sequence of the bases A, C, G and T within some defined part(s) of a chromosome, be it in a coding region of a gene or in a non-coding region. We might study a certain gene in 50 individuals of a population and find that 20 have one variant of that gene and 28 have another, while only two have a third variant.

Evolution, upon which I have hinged my definition of conservation, is often thought of and described in terms of how the frequencies of different variants of particular genes and non-coding regions change in different generations of a population or, at a different level, how they are now distributed within and between the species under study.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Genetic studies of Green Turtles have shown that separate breeding populations in the Caribbean share their feeding grounds, where the turtles are harvested, off the Atlantic coast of Brazil. Therefore, by genetically identifying turtles on their feeding grounds, we can determine the extent to which harvesting may be affecting the various breeding populations.

to establish new populations of critically endangered species? The species recovery plan for the Gila Topminnow (*Poeciliopsis occidentalis*), an endangered fish of streams, springs and marshes in the deserts of Arizona and Mexico, originally relied on restocking from a hatchery stock. This was abandoned on the basis of genetic and demographic considerations; for the hatchery-bred fish used for restocking lacked genetic variation and produced less offspring compared with other Arizonan populations, and they may have been adapted to the thermally stable conditions of the hatchery and therefore incapable of dealing with more variable conditions of desert streams. In its place a natural stock was used that had three important attributes: it came from thermally more variable springs and streams, it had higher genetic variation, and it produced more offspring than the hatchery stock. The new populations are still being monitored.

Genetic studies of species undergoing long-distance migrations can shortcut the years of tedious, unrewarding studies required by using physically marked individuals to trace migration routes. Studies of genetic variation in Humpback Whales (*Megaptera novaeangliae*), for example, quickly confirmed routes of migration between feeding and breeding grounds that had been worked out arduously using marked individuals. Similarly, genetic studies of Green Turtles (*Chelonia mydas*) revealed sharing of feeding grounds off the coast of Brazil by populations with discrete breeding grounds in the Caribbean. The stage is set for these same techniques to be applied to other populations of these and other species, where priorities about which breeding populations to protect have to be worked out.

Loss of genetic variation seems to affect different species in different ways. The Northern Elephant Seal (*Mirounga angustirostris*) underwent a population crash last century but has since recovered in numbers. Relatively insensitive assays of genetic variation in the 1960s showed no variation in the recovered population yet the species is doing fine. Possibly, the seals do not need a lot of variation in their present environments but, if that's the case, who's to say that they will not need variation to deal with environmental change (such as in ambient temperature, chemical pollutants in fish consumed by the seals) in the future? Or perhaps the relatively limited, insensitive survey that was used simply missed a lot of variation.

A less equivocal example of the problems associated with loss of genetic variation concerns African Cheetahs (*Acinonyx jubatus*) and Asiatic Lions (*Panthera leo persica*), seriously endangered animals in which there seems to be virtually no genetic variation *at all*, especially in South African Cheetahs (*A. j. jubatus*). A major group of genes involved in immune responses, including the rejection of skin grafts between unrelated

Cheetahs exhibit virtually no genetic variation. Already seriously endangered, they provide a challenge to the conservationist.

and therefore genetically distinct individuals, is normally among the most variable in mammals, yet those that have been studied in these cats are invariant. Even skin grafts between unrelated cheetahs are not rejected. Males of these cats have low sperm counts and some captive populations of cheetahs have already been devastated by disease perhaps in large part due to the lack of variation in these genes. Their successful conservation is likely to be a major challenge.

These examples of elephant seals, cheetahs and lions have all had one thing in common. Sudden reductions in population size at some time in the past and gradual increases thereafter, called population bottlenecks, have been documented or proposed in each case. Mathematical aspects of genetics predict that it is not so much the size to which a population is reduced that

Y. ARTHUS – BERTRAND/AUSCAPE INTERNATIONAL

influences how much genetic variation will eventually be restored but the rate at which the population recovers its size and how much variation is actually lost during the bottleneck. When population size is relatively small, it will be more likely that closely related individuals will mate and produce offspring. This phenomenon, called inbreeding, reduces overall genetic variation and tends to increase the frequency with which deleterious genetic traits occur in a population.

Having looked at some populations that have recovered from bottlenecks, we can now examine species that have been studied while their population sizes were down to critically low levels. One such species is the Chatham Island Black Robin (*Petroica traversi*), which declined to seven individuals (two pairs

JOHN CANCALOSI/AUSCAPE INTERNATIONAL

Studies on recovered populations of Northern Elephant Seals revealed no genetic variation between individuals. Although the species seems to be doing well, perhaps it could be threatened by changes in environmental conditions in the future.

D. WATTS/NPIAW

and three males) in 1976. By 1988–1989 it had recovered rapidly to number 98. One female contributed a large proportion of offspring to the recovery yet there have been no apparent adverse effects of inbreeding, which has been intense. There are other examples of island populations of vertebrates that, despite inbreeding and lack of variation, are seemingly unaffected. On the other hand, captive populations of large ungulates in zoos often are adversely affected by close inbreeding, resulting in poor survival of offspring.

An explanation for these differing susceptibilities to inbreeding arose out of work done by the geneticist Sewall Wright who experimentally inbred several lines of guinea pigs. Some lines died out due to the expression of deleterious genes, others survived. Applying his results to the present problem, we can suggest that the original populations of the island species were distributed on more than one island and so were like Wright's separate lines of guinea pigs. Perhaps, therefore, they have already been through episodes of inbreeding, and deleterious genes affecting survival may have already been expressed in some or all of their populations; the individuals that survived were the lucky few that managed to get through periods of inbreeding devoid of the deleterious genes. If this were so, they and their descendant populations would be relatively unaffected by later episodes of inbreeding. Natural populations of species affected by inbreeding in captivity can often be shown to have had little geographical structuring and so are less likely to have this genetic 'protection' from inbreeding. Also, they are often species in which the amount of inbreeding has changed suddenly and drastically from that with which they have evolved. Here we should not overlook the important role that human intervention has played in rescuing the Black Robin and other species that have declined to critically low numbers.

The Orange-bellied Parrot (*Neophema chrysogaster*) of south-eastern Australia is another rare and highly endangered species (now numbering less than 200 individuals) facing a number of ecological threats. It breeds in Tasmania in spring–summer and migrates to coastal Victoria and south-eastern South Australia in autumn–winter. Genetic data would add a fascinating perspective to its story by telling us how inbred the population is and how much variation it has. New techniques are available for assessing the amount of genetic variation in museum specimens and so we could estimate whether Orange-bellied Parrots have lost genetic variation, at least in this century.

The Orange-bellied Parrot from south-eastern Australia is rare and endangered. It would greatly benefit from genetic studies into the amount of inbreeding that has occurred in the population.

GENETICS IS NOT A CURE-ALL IN conservation but should be seen as a complement to ecology, natural history and demography that has, until now, been largely unexplored in the context of conservation. It offers powerful new tools in conservation biology. At the community or ecosystem level, much remains to be studied, such as the genetics of long-lived vertebrates, and there are important areas I have not referred to, namely, the genetic diversity in plants and the oceans, and what they may mean for our own conservation.

We need to continue describing the patterns of genetic variation in natural populations so as to understand the processes that are at work and that have worked in the past to shape those patterns, and to better understand the genetic structuring within species. Ecology and demography may be more important in the short term but an understanding of genetics may be crucial in the long term.

There seem to be few 'recipes' for genetics in conservation; but that reflects the diversity we want to conserve. Now, therefore, is the time to start addressing genetic problems and, in so doing, assess the magnitude of the problems and how much of our resources we need to channel into genetic research. ■

Suggested Reading

Avise, J.C. & Nelson, W.S., 1989. Molecular genetic relationships of the extinct Dusky Seaside Sparrow. *Science* 243: 646–648.

Baker, C.S., Palumbi, S.R., Lambertsen, R.H., Weinrich, M.T., Calambokidis, J. & O'Brien, S.J., 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA in humpback whales. *Nature* 344: 238–240.

Cohn, J., 1990. Genetics for wildlife conservation. *BioSci.* 40: 167–171.

Meffe, G.K. & Vrijenhoek, R.C., 1988. Conservation genetics in the management of desert fishes. *Conserv. Biol.* 2: 157–169.

Meylan, A.B., Bowen, B.W. & Avise, J.C., 1990. A genetic test for the natal homing versus social facilitation models for green turtle migration. *Science* 248: 724–727.

Prober, S., Pompkins, C., Moran, G.S. & Bell, J.C., 1990. The conservation genetics of *Eucalyptus paliformis* L. Johnson et Blaxell and *E. parvifolia* Cambage, two rare species from south-eastern Australia. *Aust. J. Bot.* 38: 79–85.

Yuhki, N. & O'Brien, S., 1990. DNA variation of the mammalian major histocompatibility complex reflects genomic diversity and population history. *Proc. Natl Acad. Sci. USA* 87: 836–840.

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"The two bees have independently evolved similar solutions that help individuals find virgins fast and defend them from other males."

GETTING IN ON THE GROUND FLOOR

BY JOHN ALCOCK

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THERE IS AN INVASION OF BEES ON THIS August morning in Western Australia. Dawson's Burrowing Bees (*Amegilla dawsoni*) appear to have taken over Meeberrie Homestead. You flinch as the big bees zoom noisily past, cruising by the hundreds over the flat claypan in the wide flood plain of the Murchison River. They are not only big bees but handsome ones, with black wings, a dark tan abdomen and pale tan thorax that seem colour-coordinated with the rusty red soil of the area.

A tiny hole forms in the earth amidst the gravel covering this patch of the barren flood plain. The hole grows as something nibbles away at the opening from below. Some males, which have been skimming over the ground, now turn and come zig-zagging in toward the break in the soil. The first male lands by the hole and watches, apparently

The nesting and emergence site of Dawson's Burrowing Bee in the Murchison River flood plain of Western Australia. Left: a male Dawson's Burrowing Bee poised by an emergence tunnel constructed by a recently metamorphosed adult female.

A.G. WELLS

A.G. WELLS

The flowers of the poverty bush *Eremophila laani* provide nectar and pollen used to provide the underground nests of female Dawson's Burrowing Bees.

intently, as an emerging female pokes her head to the surface. Having spent the better part of a year as a dormant immature grub in an underground brood cell, the female has chosen today to metamorphose into an adult and to gnaw her way up to the surface.

As the female pulls herself out of the ground, the first male lunges to meet her just as a bevy of rival males rushes to the spot. In an instant, a tumbling bundle of males forms around the female, whirring and buzzing and biting, as the males struggle to carry off the female. Finally, out of the melee emerges a pair, the male mounted on the female, which seems none the worse for the tussle. They half-fly, half-run across the ground away from the mob of buzzing males that has already begun to break up, now that the female has gone. Once well removed from the others, the pair perches on the ground and copulates briefly before the male releases his partner.

She flies away, no longer receptive to ardent male suitors now that she has mated. Instead she will devote the rest of her life to building a nest with underground chambers, which she will stock with provisions from the blossoms of a poverty bush (*Eremophila laani*). Her emergence, along with that of thousands of other females, has been timed beautifully to coincide with the flowering season of this species of poverty bush, which grows in abundance on these hard plains. Each provisioned cell within her nest receives an egg. To fertilise an egg before laying it, the female uses sperm from the supply she has stored in a special organ (the spermatheca) after her first and only mating. The offspring that result will spend a year underground in the red soil of Western Australia before emerging for a brief round of mating and nesting when the poverty bushes bloom again.

Now the behaviour of Dawson's Burrowing Bees is full of remarkable features—especially the male's ability to find virgin females that are about to emerge and the male's readiness to

A bundle of male Dawson's Burrowing Bees has formed around a recently emerged female as the males fight for her possession.

A.G. WELLS

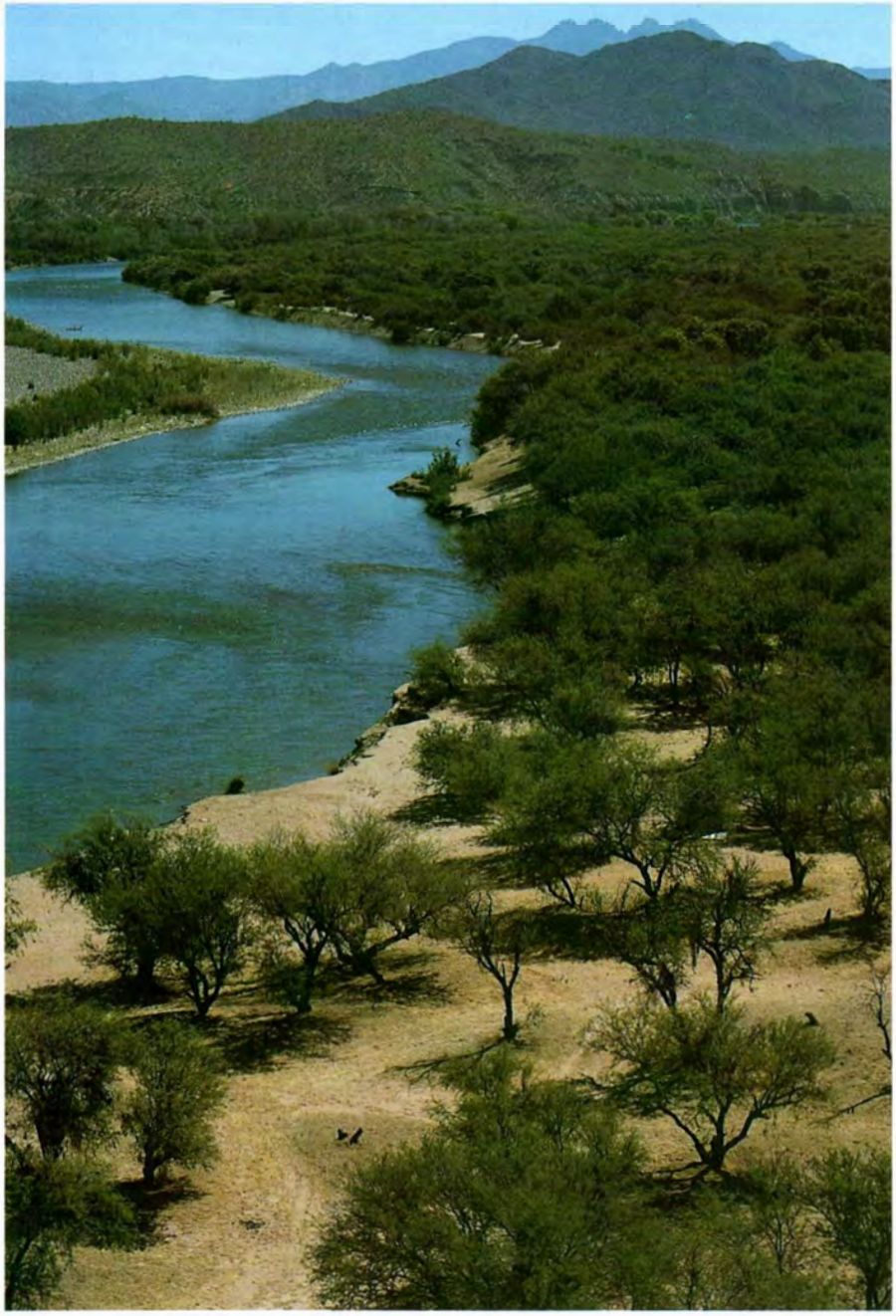
engage in all-out war in the effort to secure a virgin mate. Australia is, however, filled with remarkable animals and we might be tempted simply to acknowledge that the bee offers one more amazing bit of biology that non-Australians can only envy. But before we do that, let's move a good way around the world and north across the equator to Arizona where, in the flood plain of the Salt River on a morning in May, you might see male Digger Bees (*Centris pallida*) behaving in almost exactly the same fashion as male Dawson's Burrowing Bees.

The large handsome males decked out in greys and tans with striking green eyes are everywhere, filling the air with the hum of their wings. One of the buzzing horde drops to the hard-packed ground and begins to bite at the soil with his jaws. Soon he is kicking earth energetically out of a small pit. The male pauses for a moment and, as he does so, a female comes scrabbling upward out of the emergence hole that the male has found and opened from above.

As the female exits, several other males come sailing into the picture and a bundle of Digger Bees forms to tumble over the desert floor until one male can assert himself sufficiently to mount the female and fly away with her, leaving his rivals in the dust.

Once mating is completed far from the madding crowd in the quiet of a mesquite (*Prosopis*) or paloverde (*Cercidium*) tree, the female becomes non-receptive. She, like her Australian counterpart, has stored sufficient sperm to suffice for her short adult life. During the next few weeks, she will dig underground burrows and stock brood cells with pollen and nectar from the abundant paloverdes and Ironwoods (*Olynea tesota*), which undergo a highly ephemeral burst of flowering at this time of year in the desert.

The nesting and emergence site of the Digger Bee in the Salt River flood plain of central Arizona.



JOHN ALCOCK

THERE ARE THOUSANDS OF SPECIES OF BEES in the family Anthophoridae, the family to which both Dawson's Burrowing Bee of Australia and the Digger Bee of Arizona have been assigned. With the exception of the 'carpenter bees', which bore into solid wood or plant pith, all anthophorids are ground nesters. Among the anthophorid bees there are parasitic species, with females that seek out the nests of other bees, and non-parasitic ones whose females build burrow nests in the ground (or in the wood) with brood cells that they provision entirely by themselves. No anthophorid bee has evolved anything nearly as complex as the social arrangements of certain apoid bees, of which the Honeybee (*Apis mellifera*) is the most familiar example, with its battalions of sterile workers labouring on behalf of a queen. Instead, each adult female anthophorid usually works entirely on her own to find the food resources with which to provision her larval offspring.

The diversity of female behaviour that exists within the Anthophoridae is modest compared to the variety of male mating tactics. There are many species whose males non-aggressively patrol the pollen- and nectar-producing flowers that nesting females visit to gather provisions for their larval offspring. When a male of these bees spots a female in his wanderings, he pounces upon her and attempts to mate. In other species, however, males set up little territories by a particularly rich patch of flowers, driving rivals away in order to be the only male present, able and willing when sexually receptive females come foraging. Counterintuitive though it may be, still other anthophorid males defend hovering stations at plants *without* flowers, particularly at trees or bushes growing on prominent hilltops or at other conspicuous landmarks. In these species, females search males out, rather than the other way round.

The list of anthophorid mate-finding strategies also includes the tactic of searching for emergence sites, as is exhibited by Dawson's Burrowing Bee and the Digger Bee. But in most of the bees in this category, males pursue females only after their potential mates have come out of the ground rather than locating them *prior* to their emergence. Why should Dawson's Burrowing Bee and the Digger Bee be such similar exceptions to the rule?

The two species are members of the same family and therefore may have simply inherited the fundamental mat-

A male Digger Bee digs down to meet a virgin adult female that is burrowing up to the surface.

JOHN CANCALOSI/AUSCAPE INTERNATIONAL

JOHN ALCOCK

A male Digger Bee mounts a virgin female upon her emergence from the ground.

JOHN ALCOCK

A fighting mass of male Digger Bees surrounds a virgin female.

ing tactics of the anthophorid bee that happened to be their common ancestor. However, the diversity of mating systems exhibited within the Anthophoridae, and the overall rarity of the ability to locate pre-emergent females, make this an unlikely explanation for the shared behaviour of the two super mate-finders. Furthermore, the two bees belong to different genera and indeed to different major subgroups within the Anthophoridae: the Arizona *Centris pallida* is a member of the Centrini, an exclusively New World lineage, whereas the Australian *Amegilla dawsoni* belongs to a genus that has no New World representatives and has been placed in a different anthophorid lineage, the Anthophorini. These factors suggest that each species has independently evolved its unusual, yet similar, method of competing for mates. The fact that the males of the two bees are not absolutely identical in their behaviour, in that one male actively excavates the females he finds whereas the other does not, is also consistent with the hypothesis of independent evolution.

If we rule out shared ancestry as the reason for their behavioural similarity, what might have caused these two species on different sides of the world to adopt convergent mate-locating tactics? Let's try to answer this question by imagining what would happen if, by chance, a male in either species arose with a hereditary tendency to look for mates at sites other than the emergence area. Given the special features of female reproduction in these species, particularly the loss of sexual receptivity following mating, it is hard to see how such a male could hope to have many descendants in a population that contained rivals searching for emerging virgins. Once recently emerged virgin females have been found and mated, they will not mate again, making it hard for males elsewhere to have offspring that would carry on their distinctive mate-finding tactics in future generations.

On the other hand, any chance mutation that enabled a male to compete more effectively with the hundreds (or thousands) of other males in emergence sites for access to virgins

JOHN ALCOCK

A primary food plant for the Digger Bee is the Ironwood, which flowers abundantly during the limited flight season of the bee.

might well raise the reproductive output of such a male. If the novel male left more offspring, his genes would be better represented in the next generation and his behavioural abilities would be correspondingly more common. For example, males willing to battle violently for possession of a virgin female might well have a better chance to mate, leave descendants and propagate their special genes than males that conceded virgins to their original discoverer. Furthermore, males able to detect the odour of a virgin might have had the reproductive edge over males that used visual cues alone to find mates.

In the case of the Digger Bee, simple experiments have shown that olfactory cues associated with their fellow bees are sufficient to permit males to detect females even *before* they have reached the surface of the ground. The bees can find and excavate dead females or even parts of females that have been experimentally buried under a centimetre or two of soil.

Thus, the fact that females of both bees mate just once and nest in large companies creates the 'rules' that determine what reproductive tactics will work best for males in the competition with many rivals. Within this framework, males of the two bees have independently evolved similar solutions that help individuals find virgins fast and defend them from other males. One wonders if Dawson's Burrowing Bees will eventually evolve the same ability to detect (and uncover) *buried* virgin females on the basis of scent alone, completing the behavioural convergence between the two species.

THE REALLY CLASSIC EXAMPLES OF convergent evolution, familiar to many who have survived an introductory course in biology at the university level, include certain Australian marsupials that are matched with other amazingly similar placental mammals from elsewhere in the world. For example, the now-extinct marsupial Thylacine, also known as the Tasmanian Wolf or Tiger, was a dead ringer for the placental wolves that range from the Arctic tundra down through the mountains of Europe and North America. Despite their different ancestors and very different modes of reproduction, the two 'wolves' independently converged upon similar attributes, like powerful jaws, shearing teeth and great running ability, that facilitate the capture of other large mammals.

The existence of these kinds of matched pairs of structurally similar but unrelated mammals thrills evolutionary biologists because they provide powerful evidence that evolution by natural selection has occurred. The convergent marsupials–placentals suggest there is one best way to make a certain kind of living. Natural selection acting on different continents has evidently favoured members of each species that happened to have the most reproductively effective characteristics, even if the species had little or nothing in common genetically at the start (or finish) of the process.

Which brings us back to Dawson's Burrowing Bee and the Digger Bee. The names of these creatures will not revive a faint memory of a lecture once endured in introductory biology. Even professional biologists are unlikely to have heard of these bees but, in their own way, they illustrate the principle of convergent evolution almost as forcefully as do the two 'wolves'. Although they are both members of the Anthophoridae, they are not terribly close relatives judging from the systematists' decision to place them in different genera and tribes. Separated by thousands of kilometres and their different evolutionary histories, they nevertheless exhibit remarkably similar mating behaviour. Males of both species have independently evolved a particularly effective set of behavioural tactics for leaving descendants given that the females of their species occur abundantly at emergence sites and will mate only once. Convergent evolution is not, therefore, limited to placental and marsupial mammals on different continents but applies with equal strength to the small and less conspicuous members of the living world. Vive la similarité! ■

Suggested Reading

Alcock, J., Jones, C.E. & Buchmann, S.L., 1977. Male mating strategies in the bee *Centris pallida* Fox (Hymenoptera: Anthophoridae). *Amer. Natur.* 111: 145–155.

Alcock, J., 1990. *Sonoran Desert summer.* University of Arizona Press: Tucson.

Thornhill, R. & Alcock, J., 1983. *The evolution of insect mating systems.* Harvard University Press: Cambridge.

John Alcock is a Professor of Zoology at Arizona State University in the heart of the Sonoran Desert, homeland of the Digger Bee. He has devoted two study leaves to research insects in Australia and has written about his experiences with Australian animals in a book entitled The kookaburras' song *(1988, University of Arizona Press).*

"Biologists have long speculated on the cause of this great imbalance in the Meganesian mammal fauna."

THE MYSTERY OF THE MEGANESIAN MEAT-EATERS

BY TIM FLANNERY

MAMMAL SECTION, AUSTRALIAN MUSEUM

MEGANESIA ONLY EXISTS AS A SINGLE landmass during ice ages when the sea-level is low. At these times it includes Australia, Tasmania, New Guinea and many smaller islands, and covers an area of over ten million square kilometres. The name is not yet in common usage but is very useful because these islands, although quite diverse, share a common heritage resulting from their frequent and intimate interconnections. All rest upon a single tectonic plate that, over millions of years, has drifted across the face of the planet, giving the landmass a common geological and climatic history. One of the most striking features of every part of Meganesia is an extraordinary paucity of large mammalian carnivores. Just how anomalous is this situation in a world context, and what does it tell us about what may be the world's most unusual biogeographic realm?

To gain an idea of the number of large mammalian carnivores in the 'natural' Meganesian biota we need to understand the fauna of some 40,000 years ago, before the arrival of humans dramatically altered the land. We know this fauna fairly well now and it seems clear that, out of approximately 60 mammal species that weighed in excess of ten kilograms, there were only two, or possibly three, carnivores: the long extinct Marsupial Lion (*Thylacoleo carnifex*), the recently extinct Thylacine (*Thylacinus cynocephalus*), and possibly the Giant Rat-kangaroo (*Propleopus oscillans*). Only two other Meganesian carnivores, the extant Tasmanian Devil (*Sarcophilus harrisii*) and the Spotted-tailed Quoll (*Dasyurus maculatus*), exceeded five kilograms in weight.

Each of these four or five species fills a somewhat different ecological niche. The Thylacine was a generalised dog-like carnivore, the Tasmanian Devil is a generalised scavenger and the Spotted-tailed Quoll a viverrid- or civet-like species. The Marsupial Lion is one of the few carnivores to have arisen from herbivorous ancestors, and its dentition is highly unusual. The large slicing premolars led some 19th-century scientists to speculate that it may have fed upon melons, but discovery of an articulated hand has

Australia's extinct Marsupial Lion being reconstructed by Peter Keszei for the Australian Museum's "Dreamtime to Dust" gallery. At 50–70 kilograms, this was the largest warm-blooded carnivore ever to exist in Australia.

ANTHONY FARR/AUSTRALIAN MUSEUM

FORD KRISTO

Australia's largest living meat-eating marsupial, the Tasmanian Devil, is an efficient scavenger.

NEVILLE PLEDGE/SOUTH AUSTRALIAN MUSEUM

The undersides of two skulls and a lower jaw of the extinct Marsupial Lion. Note the greatly enlarged premolars used to slice through flesh.

revealed a large and hooded claw, which was doubtless used in killing, and it is now universally considered as a specialised leopard-like carnivore. The ecology of the extinct Giant Rat-kangaroo is even more enigmatic. About the size of a female Eastern Grey Kangaroo, it had a dentition similar to that of much smaller insectivores. It existed throughout eastern Australia during the last ice age, even in areas of grass steppe. It may well have been omnivorous, eating plant matter and scavenging, opportunistically taking bird eggs and small vertebrates.

In the entire Australasian region, therefore, there was only one mammal species filling each of the broad ecological niches of dog-like, cat-like, civet-like and scavenging species. Just how unusual this situation is in a worldwide context is best shown by referring to the table in which the larger carnivores of Meganesia, East Africa, Thailand and the United States of America (chosen as representative of their region because good references were available) are sorted according to their broad ecological niches. (The category 'civet-like and other' is a catch-all for unusual carnivores, from

otters to civets and bears. The ecological niche of the Giant Rat-kangaroo remains unknown but it was clearly different to the others. For convenience it is listed in this category.) It is obvious from this list that Meganesia is grossly depauperate in carnivores. Generally the cat-like and dog-like niches are subdivided according to size, prey type and habitat, allowing many species to coexist. There are also large numbers of specialised or unusual species (the catch-all category). Indeed Thailand, with 24 species, dwarfs Meganesia with its four or five, even though its land area is less than one-fifteenth the size.

Even expressed as a ratio of the number of carnivores in excess of five kilograms to herbivores in excess of ten kilograms, the difference still holds. For example, East Africa has around 77 herbivorous or insectivorous mammal species that weigh over ten kilograms (there may be additional species that became extinct in the Pleistocene, bringing the number to approximately 80 species). This gives a ratio of 0.26, or just over one carnivore for every four herbivores. For Australia the ratio is 0.07, or one carnivore for every 15 herbivores!

BIOLOGISTS HAVE LONG SPECULATED ON the cause of this great imbalance in the Meganesian mammal fauna. One idea that has been discussed from time to time is that marsupials, for some reason, have found it difficult to evolve into truly predatory species, perhaps because of their relatively small brains (placental carnivores only recently—in the last 40,000 years—reached Australia). However, a quick look at the fossil record of South America disproves this hypothesis, since many species of dog-like marsupials of the subfamily Borhyaeninae evolved there during the Tertiary. These ranged in size from that of a bear to that of a civet. A second, even more remarkable subfamily of South American carnivorous marsupials, the Thylacosmylinae, evolved into animals resembling sabre-tooth cats and were probably capable of killing the largest of prey. A third subfamily, the Sparassocyninae, related to the living didelphids (such as the American Opossum), also included large flesh-eaters. All of these carnivorous marsupials became extinct upon the arrival of placental carnivores in South America over the past five million years, but what is remarkable is that they thrived for many millions of years, preying mainly upon large placental mammals!

There being no intrinsic bar to carnivory in marsupials, we should look to the environment for an explanation of Meganesia's paucity of large carnivores. Large warm-blooded carnivores sit at the apex of a broad-based food pyramid and are thus the most vulnerable of life

The possibly carnivorous Giant Rat-kangaroo, which inhabited eastern Australia until 20,000–40,000 years ago.

	Meganesia	East Africa	North America	Thailand
dog-like	1	5	6	2
cat-like	1	7	9	8
scavenger	1	2	1	0
civet-like and other	1 or 2	6	11	14
TOTAL	4 or 5	20	27	24

The number of species of mammalian carnivores that exceed five kilograms in weight from four regions of the world. The table includes species that became extinct upon the arrival of humans, and the category 'civet-like and other' is a catch-all category for a whole range of unusual carnivorous species. The Australian species included here are the Spotted-tailed Quoll and the extinct Giant Rat-kangaroo (*Propleopus oscillans*).

COURTESY MUSEUM OF VICTORIA/FRANK KNIGHT/KADIMAKARA

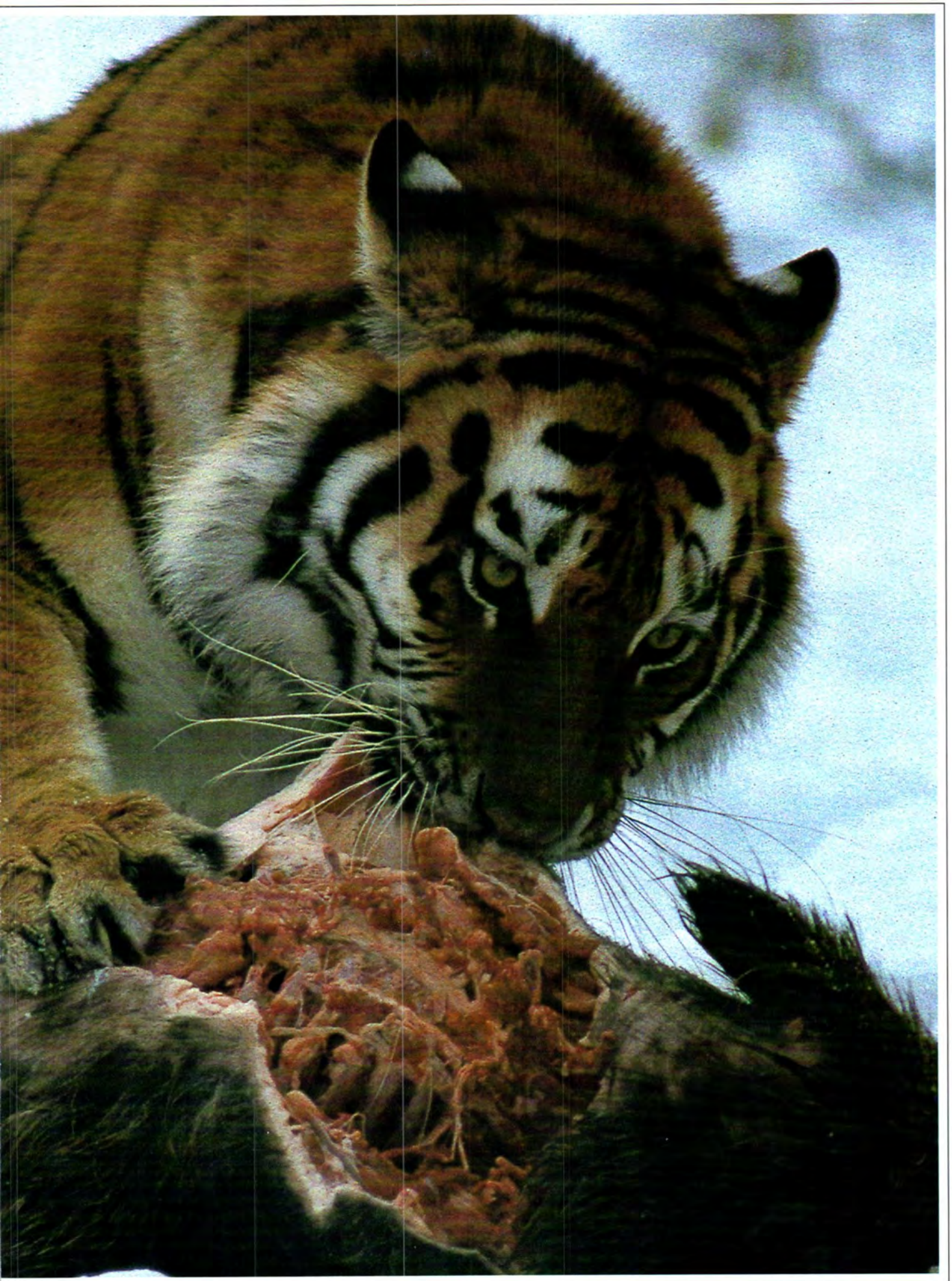
The landmass of Meganesia as it existed during ice ages when sea-level was up to 160 metres lower than at present. The darker areas show the principal islands as they exist today.

forms to disturbance in the food chain. As an example, an area of grassland that supports billions of individual grasses may be able to support a few thousand large herbivores. These in turn may be able to support less than 100 large carnivores. If the environment is poor, large herbivores will be rare and spread thinly, and a critical point is reached where the density of prey is so low that a self-sustaining population of large carnivores cannot be supported. Likewise, if during a period of environmental change 90 per cent of the grasses of an area are destroyed, then almost certainly only a few tens of herbivores would survive. This in turn would be insufficient to support *any* large carnivores. Similar factors affect large carnivores on islands, where the resource base is meagre simply because the land area is small. For example, the New Guinea Harpy Eagle (*Harpyopsis novaeguineae*), which is the largest avian predator of New Guinea, is not found on a single offshore island, even though many were connected with the mainland during the last ice age. This is because it is only on a very large island such as New Guinea that the resource base is sufficient to support a viable population of these carnivores.

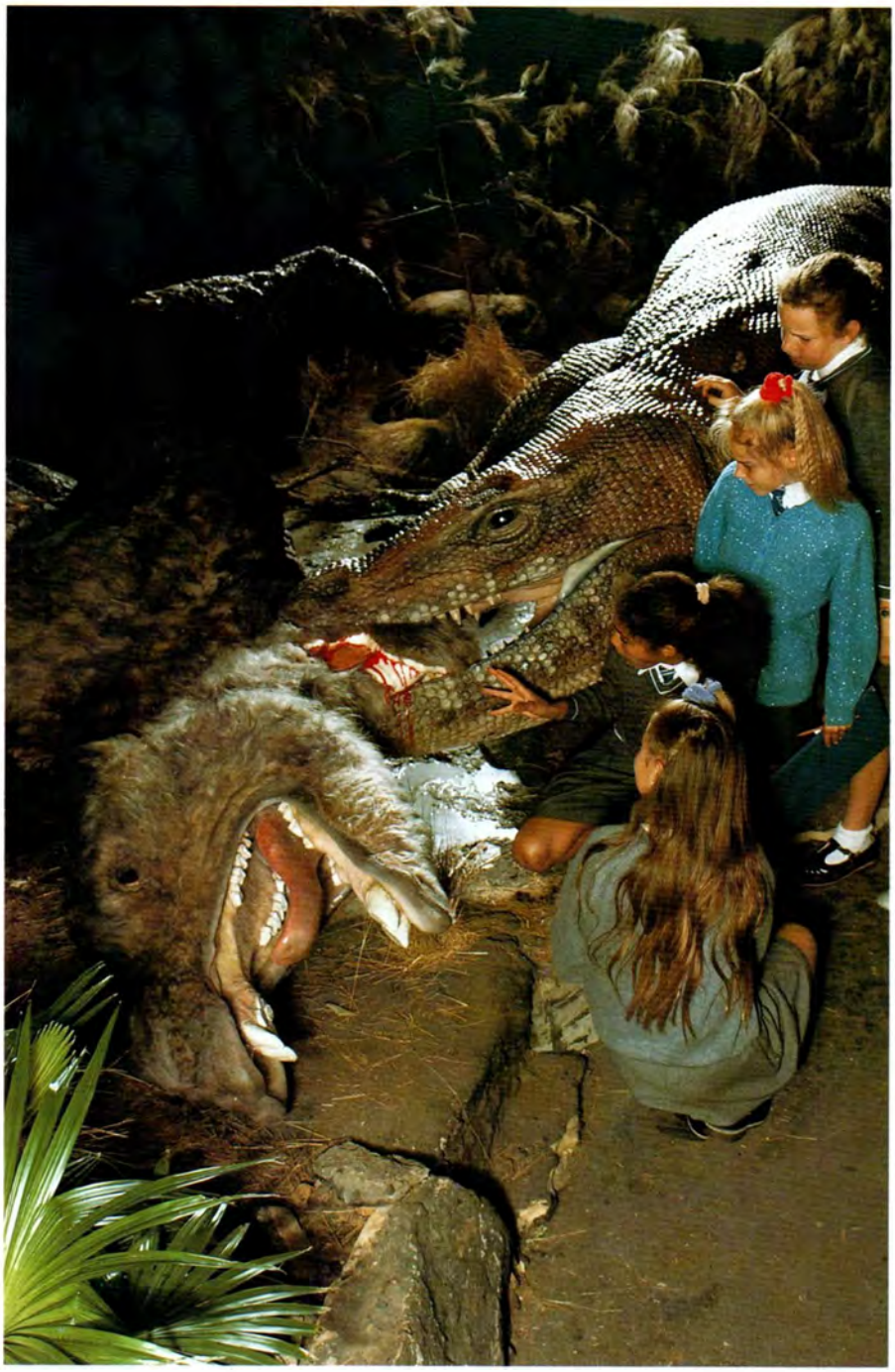
To explain the paucity of large mammal carnivores in Meganesia in these terms we would need evidence that Meganesian environments are extremely resource-poor or very variable, with long periods of low productivity. Information that this is indeed the case has been gathered steadily over the past few years. It is now clear that, by world standards, Australian soils are exceptionally poor and thin. For example, soils in Australia's semiarid zone have around half the levels of nitrates and phosphates of equivalent soils elsewhere. The amount and quality of arable land is another good measure of productivity. There are around 77 million hectares of arable land (ten per cent of the total Australian land area) but most of this is extremely marginal when compared with that overseas. Other indications come from Australia's plants, which have developed a wide variety of strategies (including slow average growth rates) to cope with the nutrient-poor environment. A second important factor has also recently been recognised. This is the impact of the El Nino–Southern Oscillation (ENSO) cycle, which influences rainfall with a periodicity of roughly a decade. In some years (such as 1990) Australia receives high rainfall and thus experiences peak productivity. However, in El Nino years rainfall is reduced and prolonged droughts are frequent. It is now known that Australia is unique in the degree to which the cycle influences the entire continent. Its effect can readily be seen in the high degree of nomadism and non-seasonal breeding in Australian animals, particularly birds. When such variability in productivity is superimposed on a system that is already low in productivity, it seems likely that top-order carnivores would be particularly stressed.

Although these arguments appear to have some validity for the drier parts of Meganesia, what of the rainforests, where the effect of the ENSO cycle is probably less severe and where biomass productivity may be higher? The largest rainforest block in the region is found in New Guinea, which is, if anything, more remarkable for its lack of mammalian predators than Australia. Here we have no evidence of indigenous cat-like, scavenging or civet-like predators. The only large carnivore present before humans came was the Thylacine, and this was in a fauna of around 200 species of mammalian herbivores and insectivores! One possible explanation may lie in the size distribution of mammal species in pre-human New Guinea. Unlike Australia, there were few large herbivores. Indeed, only seven herbivorous species that weighed over ten kilograms are presently known (although one or two more may remain to be discovered). This again is strikingly different from rainforests elsewhere, which harbour mammals such as elephants, rhinos, tapirs, okapis and many others. These observations indicate that Meganesia's

The Tiger (*Panthera tigris*) was once widely distributed—from Eastern Europe to Bali. So prolific were they last century that A.R. Wallace wrote "There are always a few tigers roaming about Singapore, and they kill on average a Chinaman every day" (*The Malay Archipelago*, vol. 1, 2nd ed., Macmillan and Co, London, 1869). Such large warm-blooded carnivores have never existed in Australia because the continent is too resource poor.



FERRERO/LABAT/AUSCAPE INTERNATIONAL



The giant goanna *Megalania prisca* was the largest land carnivore in Meganesia until its extinction 20,000–40,000 years ago. Here it is shown in the Australian Museum's "Dreamtime to Dust" exhibition, eating a *Diprotodon*.

RIC BOLZAN/AUSTRALIAN MUSEUM

rainforests may also be environments of relatively low productivity compared to rainforests elsewhere. It may well be that the inherently nutrient-poor soils of Meganesia have an impact even in these most favourable areas.

If large mammalian carnivores are disadvantaged in a low-productivity system such as Meganesia, what would the consequences be for other carnivores? Perhaps carnivores that are otherwise less 'fit' may be advantaged. There is indeed evidence that this has occurred, for Australia has produced a remarkable assemblage of carnivorous reptiles. Before the arrival of humans, a gigantic goanna (*Megalania prisca*) and a land crocodile (*Quinkana fortirostrum*) were the largest carnivores in the region. Both exceeded 200 kilograms in weight and would have been capable of killing the largest of marsupials. There was also a very large (over 50 kilograms) python (*Wonambi narracoortensis*) that inhabited southern Australia. Additionally, among surviving varanids, there are at least ten Meganesian species that exceed five kilograms in weight, and a further ten species of pythons in the same size range. This remarkable assemblage of large, predatory and land-based reptiles has no parallel outside Meganesia. But why should large reptilian land carnivores be so uniquely advantaged? An obvious difference between reptiles and mammals is that reptiles are cold-blooded. Because they do not need to burn energy to create heat, they need to eat a great deal less frequently than warm-blooded species. This means they can survive long periods of food shortage and can exist at higher densities relative to their prey. These factors may well have given them an advantage over mammal predators in resource-poor Meganesia.

Armed with this knowledge we can look back over the Australian fossil record to investigate if there were periods when Australia supported a greater number of mammalian carnivores, thus indicating a significantly greater biological productivity. Unfortunately much relevant data remain unpublished but it appears possible that at least two species of dog-like carnivores (thylacinids) coexisted at Riversleigh (north-western Queensland) during the Miocene, around 20 million years ago; and it is known that both a large and small species of marsupial lion coexisted in eastern New South Wales in the Pliocene period, five to two million years ago. Even given this slight increase in carnivore diversity in earlier times, the number does not compare with those that have existed on every other continent (except Antarctica) throughout the age of mammals. It seems possible that Meganesia has, at least for the past 20 million years, been a resource-poor land, and that it has suffered perhaps a further decrease over the past two million years.

A FINAL QUESTION NEEDS TO BE RAISED concerning the success of the larger, recently introduced carnivores. Three species are most important: humans dogs and foxes. All three of these species have thrived since their arrival in Australia, suggesting that mammalian carnivores can be successful here. However, a closer analysis of the situation reveals an interesting story. Doubtless humans present the least understood and most controversial case, yet there is some evidence that, when they arrived in Australia some 40,000 years ago, they were spectacularly successful predators, leading to the extinction of all terrestrial vertebrate species that exceeded them in size. This included all of the land carnivores larger than the Thylacine. Thus, in part, humans must be seen as a replacement of and not an addition to the carnivore assemblage of Australia. Also, by world standards, the human population size in Australia has always been small, and humans are omnivorous. The ability to fall back on marine or plant resources may have given humans an advantage when land-based protein resources were sparse.

Dogs have also been successful. However, when the Dingo was introduced around 3,500 years ago it also led

Preparator Alison Titchen putting the finishing touches on the reconstruction of the giant snake *Wonambi narracoortensis*, which now features in the Australian Museum's "Dreamtime to Dust" gallery. Up to six metres long and 30 centimetres thick, it once lived in southern Australia — an unusually cold habitat for such a large reptile.

to a decrease in carnivore diversity rather than an increase. This is because it apparently drove both the Thylacine and Tasmanian Devil to extinction on mainland Australia, so it too is a replacement, not an addition.

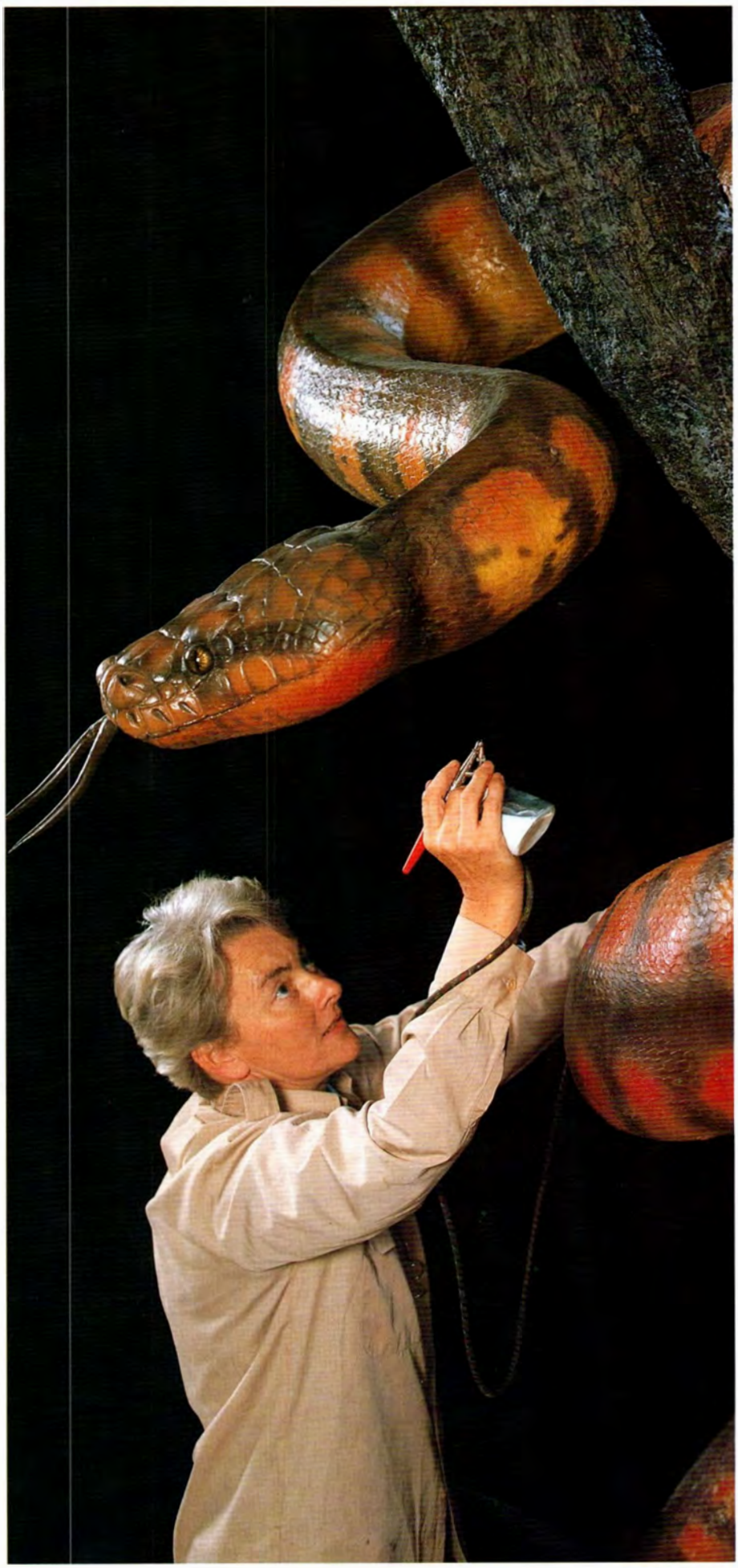
The case of the fox is intriguing, for it has been extraordinarily successful since its introduction in the 1850s. Its diet, like that of humans, is remarkably broad. It can survive on insects and berries if no vertebrate prey are available, and it can also kill animals as large as young Euros (weighing around 20 kilograms). A large part of the fox's success may be due to the abundance of rabbits in Australia. The rabbit itself may only be so successful because of the prior extinction of many species, which left abundant niches vacant in the Australian landscape. Thus the fox and rabbit may be utilising production that otherwise would have fuelled a whole megafauna. Furthermore, the smaller marsupial carnivores (quolls) have declined wherever foxes are present. Overall, I feel that the success of these introduced carnivores does not detract from the idea that Meganesia is generally a hostile environment for mammalian carnivores because, by and large, they have been replacements for the few existing species.

The hypothesis developed here is a useful one in that it allows us to examine many other questions. Could it be, for example, that our herbivores are (and were) especially susceptible to predation by placental carnivores because, before people arrived, they only had to deal with 'thick-witted' reptiles? Additionally, does the hypothesis tell us anything about the relative abundance of species of megafauna? Are there other resource-limited places, such as islands, where reptiles have become the dominant predators (Komodo Island and its dragons, and New Caledonia and its newly discovered extinct large varanid come to mind)? Whatever the case, the mystery of the Meganesian meat-eaters reminds us again of what a strange corner of the world we live in, and just how little we understand it. ■

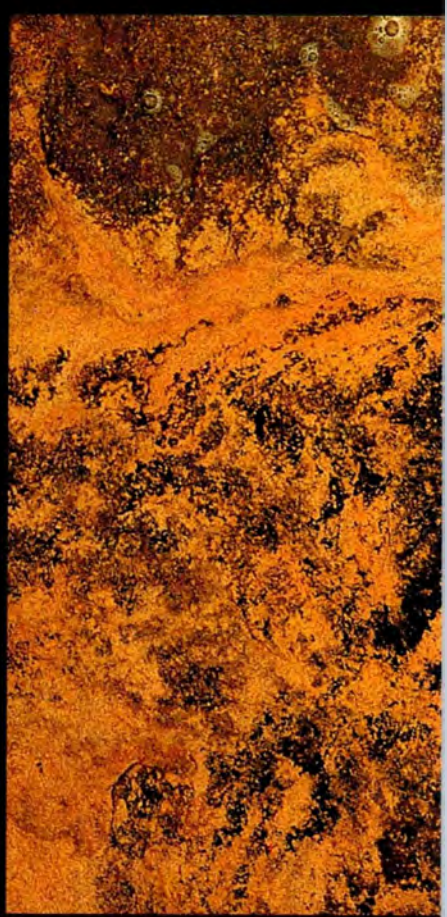
Suggested Reading

Flannery, T., 1989. Who killed Kirlilpi? *Aust. Nat. Hist.* 23(3): 234–241.

Dr Tim Flannery is head of the Mammal Section at the Australian Museum. He is interested in many aspects of Australasian ecology and prehistory.



ANTHONY FARR/AUSTRALIAN MUSEUM



SCULPTURES BY THE SEA

TAFONI?

Isn't that a kind of vegetarian ice cream?

In fact tafoni is very likely the most common form of erosion you will ever see. It is the honeycomb or dimpled effect found wherever rocks, air and water meet. Rain or sea water, with a low mineral content, will draw the rock's natural bonding agents to the surface by the action of osmosis. This creates a pattern of tough, mineral-enriched areas interrupted by mineral-depleted, highly erodible pockets. Years of wetting and drying cycles eventually create the intricate patterns that are found around the world; by the sea, in deserts, on mountains and even on ancient man-made structures.

Anthony Farr's work is well known to *Australian Natural History* readers. As a former staff photographer he has in

BY ANTHONY FARR

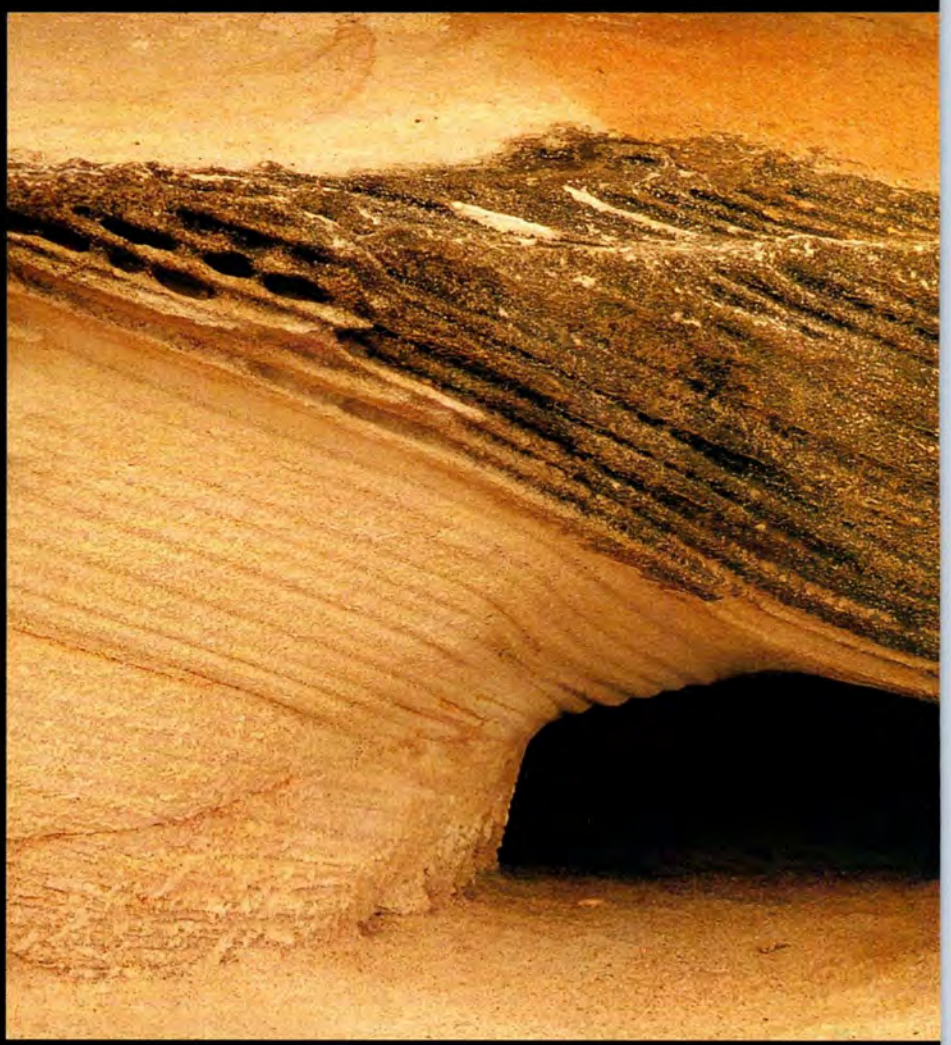
FARR SIGHT PHOTOGRAPHY

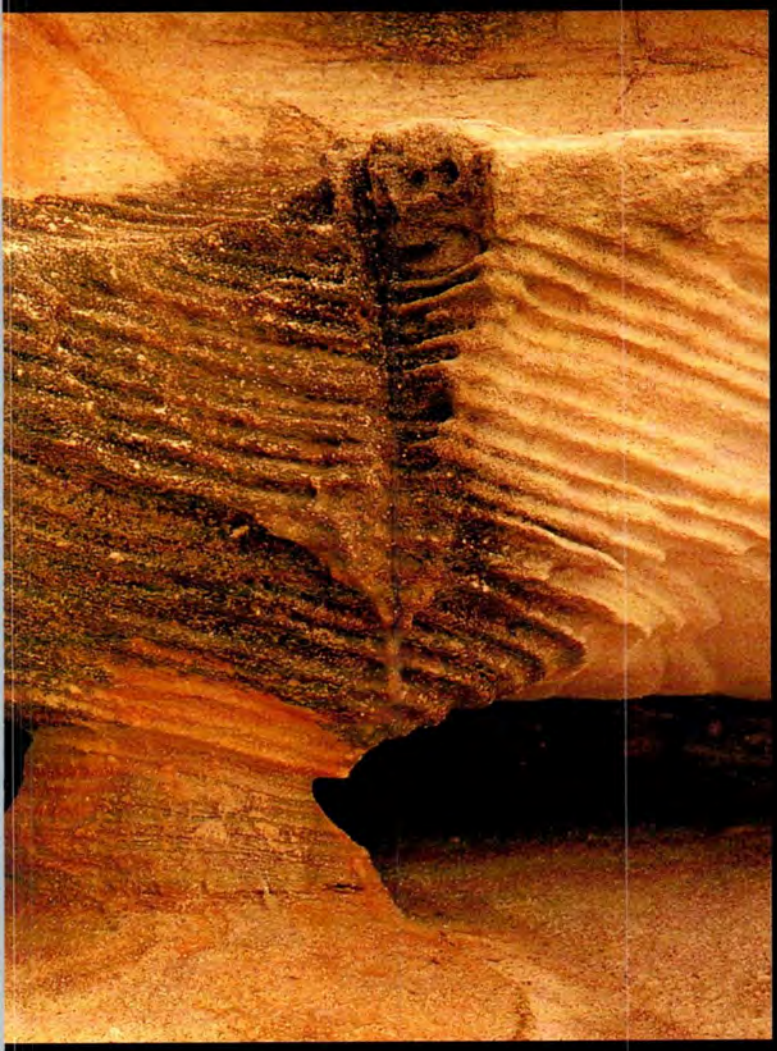
recent years worked on photographs for articles as diverse as Lapita Pottery, Miklouho-Maclay and the "Tracks Through Time" supplement. He is now a freelance photographer based in Sydney.

"My philosophy of colour is based on a person's earliest conceptions. Give a child a box of coloured pencils and the sky will be blue, the grass will be green and rocks will be brown. Throughout life one's perceptions of colour will be filtered through these childhood preconceptions. Matching these makes a viewer comfortable with an image; from that viewpoint the images' content can then be freely explored."

"I believe that stark unnatural colour effects throw up barriers to an image's accessibility." ■

SCULPTURES BY THE SEA





"When it opens its mouth for the second time in its life, it does so as a bona fide mammal."

THE LINKS THAT BIND

BY MICHAEL ARCHER

SCHOOL OF BIOLOGICAL SCIENCE, UNIVERSITY OF NEW SOUTH WALES

FEISTY GEOLOGIST PROFESSOR IAN Plimer, Australian champion of rationality and untiring terrier at the throat of Creation 'Science', was just getting into his debating stride. In response to the declaration by fundamentalist Dr Duane T. Gish, San Diego Creation 'Scientist' extraordinaire, that evolution was nonsense because no-one had actually *seen* one species evolve into another, Plimer plugged in an electric cord and calmly presented the exposed end to Gish. I was too far back in the audience to hear exactly what Plimer said but it was in effect: 'Dr Gish, no-one has ever *seen* electricity, but if not seeing something is sufficient basis for concluding it does not exist, you surely won't mind touching the ends of these wires!' Gish reeled back in horror—needless to say, he was a true believer in the electricity he had never seen—and Plimer, albeit flamboyantly, had made his point.

Much more was said in that curious debate held at the University of New South Wales but one of Gish's favourite red herrings brought *my* blood to boil: "The fossil record reveals no 'missing links' between the different kinds of creatures—because they were *created* as different kinds". Gish has declared many times that, if such links could be demonstrated, it would put paid to any literal interpretation of Genesis, this conviction being the keystone of Creation 'Science'.

When the time came for questions, I vigorously waved my hands. "Dr Gish, you said there are no links between the different kinds of organisms. How then do you account for the Cambrian *Pikaea gracilens*, which is structurally intermediate between invertebrates and vertebrates; the Jurassic *Archaeopteryx lithographica*, which links reptiles and birds; and mammal-like reptiles such as the Triassic *Probainognathus jenseni*, which is a perfect intermediate between reptiles and mammals?". His response was "What?" I repeated the question but he still seemed hard of hearing.

Although I have no doubt that Gish knew about *Archaeopteryx*, I suspected he had never heard of *Pikaea*, nor been able or willing to understand the evolutionary significance of mammal-like reptiles. Understanding about this last series of 'missing' links is particularly important. First, the transition is well-documented by the fossil record. Second, it is supported by a vast body of data arising from the study of the anatomy and development of living animals. Third, it involves our ancestors and is thus relevant to understanding our origins. And fourth, it is a useful antidote of evolutionary rationality when biblical fundamentalists come knocking!

"Darwin's ghostly chuckle ought to have sent a chill down Gish's back."

All modern mammals have a single bone on each side of the lower jaw, the *dentary*. The dentary articulates with the *squamosal* bone of the skull. If you put your fingers in or just in front of the lower half of your ears and say 'jaw joint!', you will feel the ball (or condyle) of the dentary bone moving in the overhead socket (or glenoid fossa) of the squamosal bone. This jaw joint is a trademark of all mammals.

In reptiles, the dentary bone carries teeth, as it also does in mammals, but it does *not* make contact with the squamosal and is not in any way involved in articulating the lower jaw to the skull. Similarly, the squamosal of the reptile is a relatively small bone on the side wall of the braincase, much too far away to be involved in jaw articulation. Instead, the reptile's *articular* bone, the last of a series of small bones forming the back of its lower jaw, articulates with the *quadrate* bone of the skull—this jaw joint being the trademark of reptiles.

Gish declares absurd the idea of a gradual evolutionary transition between the reptilian and mammalian conditions. His 'logic' here is that *before* the mammalian condition could develop, the articulating bones of the reptile, which appear to prevent contact between the dentary and squamosal, had to first vanish. This would require an impossible intermediate condition because there must have been a 'moment' of evolutionary time, as the quadrate and articular bones were finally vanishing, when the lower jaw wasn't hinged to the skull at all! To the many gullible souls who have been sucked in by his 'logic', this *sounds* like a reasonable objection.

Unfortunately for Gish's argument, the fossil record demonstrates a long and diverse parade of mammal-like reptiles that ruled Earth in Permian and Triassic times, before the dinosaurs usurped the throne. Known technically as synapsids, they provide the solution to Gish's anti-evolutionary paradox by demonstrating how the reptilian jaw articulation system gradually evolved into that which characterises the mammals.

In the older synapsids, the dentary and squamosal bones were widely separated as in other reptiles. Their jaws were articulated by the articular and quadrate bones. But gradually, in successively younger forms, the dentary enlarged up and backwards and the squamosal enlarged down and forwards. By middle Triassic time, the dentary of the more 'advanced' mammal-like reptiles, such as *Probainognathus jenseni* from South America, just contacted the squamosal to form a *second* jaw articulating system *outside of and alongside* the still functional articular–quadrate system. As the newly acquired dentary–squamosal articulation continued to enlarge in the primitive late Triassic and early Jurassic mammals, the old reptilian articular–quadrate bones correspondingly decreased in size.

This is how the transition from reptile to mammal jaw took place. *Both* jaw articulation systems operated simultaneously, side by side, one phasing in as the other phased out. Darwin's ghostly chuckle ought to have sent a chill down Gish's back.

But the full record of what happened is even more remarkable than this. There are three bones in the middle ear of mammals: the hammer (or malleus), anvil (or incus) and stirrup (or stapes). The stirrup transmits vibrations to the fluids of the inner ear where the energies of the sounds received are

The fossil record has produced evolutionary intermediates that link reptile-like amphibians (front) to early mammal-like reptiles (right) to advanced mammal-like reptiles (rear) to primitive mammals.

translated and transmitted to the brain for interpretation. This inner-most middle ear bone is clearly the same as the reptilian columella, having persisted throughout the reptile-to-mammal transition. But the hammer and anvil are unique to the middle ears of mammals. They have a complex joint between them unlike the simple one that interfaces the anvil and the stirrup. Where did these two bones originate? As part of God's finished Creation in the Garden of Eden as Gish contends, or from pre-existing bones present in the ancestors of mammals?

In life, the mammalian ear bones occur immediately behind the back end of the lower jaw, which is where you might expect to find remnants of a declining reptilian jaw articulation system. What's more, in developing embryos, the hammer first appears *as part of the lower jaw*. The anvil, in contrast, while developing adjacent to the rear of the developing lower jaw, clearly is part of the skull. These two developing mammalian ear bones closely resemble in shape, position and articulating function the two bones that hinged the jaws of the advanced mammal-like reptiles—the articular and quadrate.

The conclusion is loud and clear in our ear: the mammalian hammer and anvil bones of the middle ear *are* the articular and quadrate bones of the reptile's jaw articulation system. While they no longer hinge the lower jaw in adult mammals as they do in reptiles and mammal-like reptiles, they still continue to articulate with one another, but now as a means for transmitting sounds from the ear drum to the stapes, which was part of their function along with jaw articulation in the advanced mammal-like reptiles.

To punctuate the conclusion, baby bandicoots contribute even more evidence for the reptilian jaw origin of the hammer and anvil. Some bandicoots are born a mere 12.5 days after conception, the shortest gestation period known in any mammal. At birth, the neonate is little more than a pink, blind, pug-nosed head, with stumpy arms and a legless posterior. Yet, despite its little-developed condition, it must climb into the pouch and open its mouth to grab a teat. But at this stage the dentary and squamosal bones, destined to form the bandicoot's normal jaw joint, have only just begun to develop. So how does it open its mouth?

As in all embryonic mammals including ourselves, immediately behind the developing jaw, at the junction of the jaw and the skull, are two relatively large bones. Developing precisely where a jaw hinge ought to be, they are the articular (soon to be the hammer) and quadrate (soon to be the anvil), ready, willing and able to hinge the lower jaw as it opens for the first time; borrowing, as it were, from its reptilian past to ensure its mammalian future. Once teated, the bandicoot baby shuts up and sucks for another 50 days. Then, when it opens its mouth for the second time in its life, to release the teat that brought it this far, it does so as a bona fide mammal, using the now well-developed dentary and squamosal jaw joint.

Perceiving four-dimensional patterns in living creatures and discovering their historical and developmental causes is *one* of the most intensely pleasurable experiences a biologist can have. The intertwined evidences from the fossil record, anatomy and embryology, which converge to provide understanding about the nature of the teensy weensy middle ear bones of mammals, are to biologists what the telescopic visions of the universe were to Galileo. To insist that God made those little articulating mammal ear bones *de nova*, complete with the diverse indications that lead rational minds to see in them a rich legacy of evolutionary history, is a bit like the 16th-century priests' flat refusal to look through Galileo's telescope—because they *knew* what Galileo said he saw simply could not be. Visions of middle ear bones articulating in his dreams surely must give Dr Gish at least a teensy weensy ulcer. ■

Suggested Reading

Archer, M., 1987. The reality of organic evolution: evidence from the living. Pp. 27–40 in *Confronting creationism: defending Darwin*, ed. by D.R. Selkirk and F.J. Burrows. University of NSW Press: Sydney.

Archer, M., 1987. Evidence for evolution from the fossil record. Pp. 72–102 in *Confronting creationism: defending Darwin*, ed. by D.R. Selkirk and F.J. Burrows. University of NSW Press: Sydney.

Kemp, T.S., 1982. *Mammal-like reptiles and the origin of mammals*. Academic Press: London.

MacLean, P.D., Roth, J.J. & Roth, E.C. (eds), 1986. *The ecology and biology of mammal-like reptiles*. Smithsonian Institution Press: Washington.

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

JOHN GURCHE/JOHN READER'S *THE RISE OF LIFE* (COLLINS, 1986)

"If horizontal gene transfer is common among animals then, although the branches of phylogenetic trees would not exactly reunite, some communication could pass between them."

RETICULATING THE TREE OF LIFE

BY RALPH MOLNAR & GLEN INGRAM

VERTEBRATE FOSSILS, QUEENSLAND MUSEUM
VERTEBRATE ZOOLOGY, QUEENSLAND MUSEUM

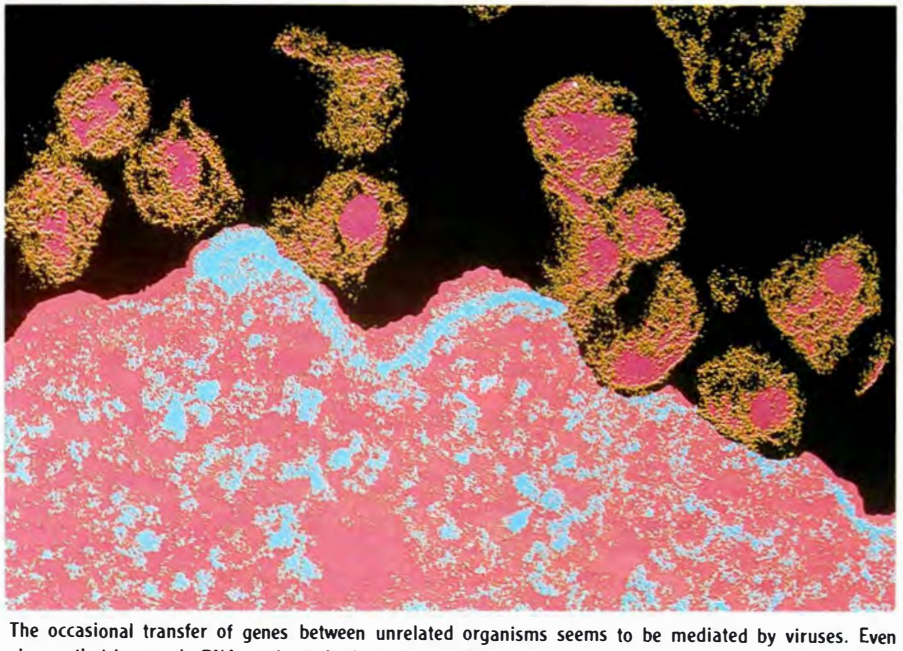
THE MORE SCANDALOUS OF MAGAZINES and newspapers often run stories of sexual adventures, or misadventures; usually salacious, but also unbelievable. You know, the "I dated a Transylvanian vampire" kind of headline. A headline such as "Generic trans-kingdom sex", for those not familiar with biological jargon, would be more expected in such publications than in the prestigious English journal *Nature*. 'Generic' in this context does not refer to sex without a brand name, like generic aspirin, but to the transfer of genes between individuals belonging to different genera. And 'trans-kingdom' signifies that, furthermore, they belong to different biological kingdoms, such as plants and animals. The phenomenon not only verges on the unbelievable but, if it happens with even low frequency, will alter our understanding of evolution.

The story started with a small paper in the same journal 20 years ago entitled "Evolutionary significance of virus infection". This paper proposed horizontal gene transfer. Genes, of course, are inherited by offspring from their parents, and ancestors and offspring are often spoken of in terms of ascent and descent—surely a vertical analogy. So the passage of genes from ancestors to descendants is considered 'vertical gene flow', although this phrase is rarely used. Horizontal gene flow involves the transfer of genes from one individual to another outside the parent–offspring relationship. It has precious little involvement with sex, at least as we know it. In fact, in some opinions, it has more in common with catching a cold; but more about that later.

The best-known, and best-substantiated, example of horizontal gene transfer involves sea-urchins. The two sea-urchins *Strongylocentrotus drobachiensis* and *Psammechinus miliaris* diverged late in the Cretaceous, at about the time of the extinction of the dinosaurs (about 65 million years ago). Nonetheless, a suite of genes, known as 'h19', is remarkably similar in these species. These genes comprise 308 nucleotide bases, but only two of these bases differ between *P. miliaris* and *S. drobachiensis*. Species of the genus *Strongylocentrotus* differ by about 20 bases in the h19 sequence, which is ten times the difference between *S. drobachiensis* and *P. miliaris*.

Is there any other explanation for this? Yes, but a rather less convincing one. The h19 sequence seems to be an untranscribed sequence; that is, it does not code for a protein (or anything else) produced by the cell. It is, in fact, the clone of a gene coding for a histone (histones are proteins that probably act as a structural support for the DNA in chromosomes). Since it does not code for anything used by the organism, very likely it is not subject to natural selection, or at the very least, not strongly. The bases that make up DNA, when not subject to natural selection, are altered at a more or less constant rate. This phenomenon is the so-called molecular clock. But for genes that have no information-bearing function, the rate of slightly under one per cent of bases being changed in 65 million years, as is shown by the h19 gene suite, is very slow. After all, even the corresponding genes in the other species of *Strongylocentrotus* show substantially more difference than that. So, if the h19 genes were altered by the molecular clock, the h19 genes should be much more different than they are. This explanation itself needs an explanation: why is the difference so small between these two specific lineages, and no others?

There is no getting around it; horizontal gene transfer is the best explanation. But how does it actually take place? It is thought that horizontal transfers of genes are mediated by viral infection. The role of infection depends on the mobility of the genes. As discussed in last issue's column, genes may move to different positions on a chromosome or from chromosome to chromosome. They may even become incorporated into the DNA of viruses. And viruses, of course, can be transferred from individual to individual, and sometimes even to individuals of different genera. Once in the new host, the gene can then become incorporated into the host's genome. Certain viruses, the retroviruses, do not carry DNA, but only RNA; one of these viruses is notorious as the cause of AIDS. Retroviruses too can transmit genes, by a process known as retrofection. These viruses use a certain enzyme, reverse transcriptase, to copy the viral genetic information from the viral RNA to DNA within the



HORZON/SPL

The occasional transfer of genes between unrelated organisms seems to be mediated by viruses. Even viruses that have only RNA, such as the infamous AIDS virus seen here, can transmit genes by a process called retrofection.

infected cell. This DNA then becomes active in the cell and directs the construction of new viruses. Sometimes, however, the reverse transcriptase also copies the RNA already within the cell into the DNA of viral origin. Then, when copied back into the viral RNA, it may take with it a gene from the cell. In 1987, Maxine Linial of the Fred Hutchinson Cancer Research Center (in Seattle) showed that retrofection can occur in the laboratory and suggested that it also occurs in nature. The possibility that one might just be getting a beneficial gene with one's illness does make one feel a bit better about catching colds and flu and such—at least to the confirmed optimist.

So horizontal gene transfer occurs, but the question is whether it is of evolutionary significance. There seems no doubt that it is quite common among prokaryotes (bacteria and other unicellular organisms lacking a nucleus). One important implication of this is to call into question the Recognition Concept of Species (this column, ANH vol. 23, no. 3, 1989–90) for prokaryotes, since they do not seem to discriminate reliably between individuals of the same species and those of other species, or even genera. However, we must leave further comments on this topic to Baza the hawk, whose dialogue featured in that issue.

Horizontal gene transfer has also been demonstrated between the bacterium *Agrobacterium tumefaciens* and plants, while *Progenitor cryptoides* seems to be able to acquire genes from humans. However, both these examples involve diseases, *Agrobacterium* causing crown gall in plants and *Progenitor* being associated with tumours in humans. Such examples raise an interesting point. Genes do not exist in a vacuum. They interact with other genes, as well as gene products and other molecules in the cytoplasm. Genes that have evolved together, for example in a moth, might be expected to be integrated with each other. A new gene horizontally transferred from, say, a wombat would disrupt this integration. This might have physiological effects and hence might result in diseases like the tumours mentioned above. We must not only consider how often horizontal gene transfer occurs, but also how often the gene or genes transferred are compatible with those already possessed by the host. As far as I am aware, no-one has yet considered the significance of this aspect of horizontal gene transfer.

Stephen Jay Gould from Harvard University pointed out that the potential importance of horizontal gene transfer is quite out of proportion to its prevalence. In other words, even if it occurs with a relatively low frequency, it is still very significant. This is because it compromises one of the tenets of modern evolutionary theory: that species are individuals. This does not imply that the tenet is incorrect but that sometimes some individuals (like the sea-urchin *Strongylocentrotus drobachiensis*) may incorporate some portion of another individual (like *Psammechinus miliaris*), so that *S. drobachiensis* is just a little bit *P. miliaris*.

The modern concept of animal evolution is that, once a species has formed, it does not ever again merge with any other species. Plants do it differently: hybridisation is more common among them. But, among animals, once a lineage has separated from the 'family tree', it never merges with any other lineage. Phylogenetic trees branch but do not reunite. If horizontal gene transfer is common among animals then, although the branches of phylogenetic trees would not exactly reunite, some communication could pass between them. In a sense, horizontal gene transfer acts as a kind of hybridisation but only for one or two genes at a time, not whole genomes.

Gould has pointed out that we can represent animal evolution well without taking such things into account. This suggests that horizontal gene flow is not important among animals. However, as he admits, it may be very important among fungi and bacteria, where the usual Linnaean classification works only in a makeshift fashion. Indeed, even among animals, convergence (when unrelated organisms show similar structures or biochemistries not known in their common ancestor) can be annoyingly prevalent. Recent work in cladistics and morphology has shown that it is more common than previously thought. Horizontal gene flow might just explain why. ■

Suggested Reading

Anderson, N.G., 1970. Evolutionary significance of virus infection. *Nature* 227: 1346–1347.

Buslinger, M., Rusconi, S. & Birnstiel, M., 1982. An unusual evolutionary behaviour of a sea urchin histone gene cluster. *The EMBO Journal* 1: 27–33.

Gould, S.J., 1986. Linnaean limits. *Natural History* 95(8): 16–23.

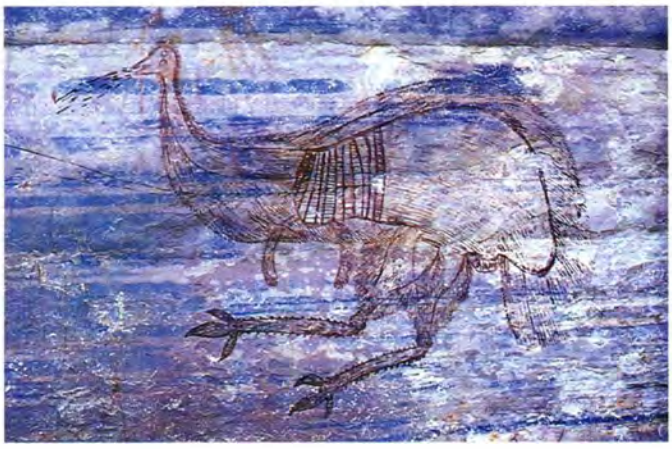
Linial, M., 1987. Creation of a processed pseudogene by retroviral infection. *Cell* 49: 93–102.

Stachel, S.E. & Zambryski, P.C., 1989. Generic trans-kingdom sex? *Nature* 340: 190–191.

Dr Ralph Molnar is Curator of Palaeontology at the Queensland Museum. His research has been directed towards filling the vast gap in knowledge of Australian vertebrate history between the Devonian and Miocene. Dr Glen Ingram is interested in evolution and the philosophy of science. In 1987 he received a special commendation from the BBC Wildlife Nature Writing Awards. Although both Molnar and Ingram are co-authors of the Still Evolving column, each essay is written only by the senior author.

QUESTIONS & ANSWERS

COMPILED BY JENNIFER SAUNDERS
EDITORIAL ASSISTANT



PAUL S.C. TACON

Aboriginal rock painting of an Emu at least 10,000 years old from Kakadu National Park. Originally it may have been many colours but only the red has survived.

Seeing Red

Q. On a recent trip around Australia my wife and I took a particular interest in Aboriginal rock paintings and noticed that most of them are red. I am interested to know if this is because the original pigment was red, or has the pigment changed colour with time? Are we really seeing these rock paintings in their true colours?

—Jane Rice
Wheelers Hill, Vic.

A. At present there is no single answer to your question. A possible explanation is that, although many colours were used in the original artwork, the red pigment is best able to survive the weathering process and so eventually is the only colour left on the rock face. The reason for this is that red ochre, or haematite, is very fine-grained and penetrates into the rock surface deeper than other substances. A recent study of rock paintings near Cloncurry, northwestern Queensland, has revealed that some paints undergo a change on the rock face whereby goethite, a yellow to brown mineral, is converted to the red mineral hematite. Elevated temperatures and dehydration enhance this conversion from yellow to red. As a result of this process many of the rock paintings on open rock surfaces that may have been yellow are now red. The oldest surviving yellow paintings are often those not exposed to sunlight. In most cases, unless the rock art has been protected from the weathering and erosive elements that commonly occur over time, it is doubtful that you are seeing them in their original colours. It is, however, interesting to note that many anthropologists and archaeologists, such as George Chaloupka (Northern Territory Museum), contend that many of the oldest forms and styles of rock art in Kakadu National Park, for example, are complete in one colour—red—and that they have always been this way. In sum, all three of these processes may have contributed to what you recently observed.

—Michelle Neal
ANH

Reptile Cannibalism

Q. I recently observed a common brown snake apparently consuming another adult brown snake. As I watched, the half-coiled predator snake shook its head from side to side, presumably in an attempt to swallow the remaining half a metre or so of its prey. It then became aware of my presence and dragged its victim into a culvert pipe, eventually disappearing through a crack and leaving me not entirely sure if this was a genuine gastronomic orgy or some part of a bizarre mating ritual! A nearby dam abounds with frogs and lizards, so starvation is an unlikely motive. Can you explain? Is cannibalism normal in snakes? If so does it happen with all species and under what conditions?

—David Wakefield
Strathy Creek, Vic.

A. Many Australian snakes do eat other snakes as a normal part of their diet. For example, the following species are known to eat snakes of another species: Black Headed Python (*Aspidites melanocephalus*), Common Tree Snake (*Dendrelaphis punctulatus*), Small-eyed Snake (*Cryptophis nigrescens*) and its close relative *Cryptophis pallidiceps*, the Broad-headed Snake (*Hoplocephalus bungaroides*), Mulga Snake, Yellow-bellied Black Snake, Spotted Black Snake and Red-bellied Black Snake (*Pseudechis australis*, *P. butleri*, *P. guttatus* and *P. porphyriacus* respectively), Western and Eastern Brown Snakes (*Pseudonaja nuchalis* and *P. textilis*), Curl Snake (*Suta suta*) and its relative *S. punctata*, Black-headed Snake (*Unechis gouldii*) and Bandy-bandy (*Vermicella annulata*). In all but one of the above cases snakes are taken as only part of a much wider diet of vertebrates. The exception, the Bandy-bandy, appears to feed almost exclusively on blind snakes (*Ramphotyphlops* spp.).

True cannibalism—that is, the eating of the same species—has been observed in the Desert Death Adder (*Acanthropis pyrrhus*), Copperhead (*Austrelaps superbus*), Broad-headed Snake, Red-bellied Black Snake, and Western and Eastern Brown Snakes. Although these very limited observations make it appear as if eating one's own species is less common in snakes than eating other species, no experimental work has been done to determine if any snake shows any tendency to actively avoid eating its own kind.

Beyond these normal feeding habits, should two snakes start feeding at the opposite ends of the same prey animal, one of the two is very likely to engulf the other, as if it failed to distinguish where

HAROLD COGGER

Eastern Brown Snake.

the prey left off and the competitor for the prey began. This seems to be due in part to an apparent obsessiveness evident in many species of snakes to finish feeding once it has begun. This single-mindedness may be related to the relatively infrequent feeding opportunities snakes (and other carnivores) often have: when prey is captured, its consumption becomes an almost total, short-term priority. This accidental eating of another snake is likely to be rare in the wild but can happen easily in captivity when two or more snakes are fed together. This is something that beginner snake keepers should bear in mind.

To answer your question, therefore, the snake you saw, which was almost certainly an Eastern Brown Snake judging from the locality, was either quite normally eating a snake of either its own or another species, or was doing so accidentally as a result of having converged on the same prey as its hapless victim.

It might be worth mentioning that almost everything we know about snake diets comes largely from three sources: the detailed examination of museum specimens, the careful observation of captive specimens, and the chance observation in the field. The first source is a good example of an important role that reptile keepers, who are often 'amateurs', play in adding to our knowledge of the basic biology of our native fauna, and the third shows the importance of serendipitous observations, often made by members of the general public, in advancing scientific understanding.

—Allen Greer
Australian Museum

A Question of Identity

Q. Can you tell me when an Aborigine is an Aborigine? Can quarter- and half-castes still be Aboriginal even if blond hair and blue eyes prevail?

—E.M. Hain
Forestville, NSW

A. A person's Aboriginality is not determined by anything other than that they identify as Aboriginal and are accepted as such by the Aboriginal community.

—Phil Gordon
Australian Museum

Tarnished Tan

Q. Why are light-skinned people more prone to skin cancers than dark-skinned people?

—Simon Paine
Avalon, NSW

A. The two most common skin cancers, basal cell carcinoma and squamous cell carcinoma, develop in light-skinned individuals through chronic exposure to intense UV radiation. Negroes, however, are less susceptible to general solar damage and UV-induced skin cancers than dark-skinned Caucasians who in turn are less susceptible than fair-skinned Caucasians. This is because hair colour and skin pigmentation depend on the amount, type and distribution of melanin, a pigment that photoprotects the skin. Melanin and the distribution of melanosomes (the pigment cells) in the epidermis of heavily melanised skins effectively protect these races from the carcinogenic effects of UV radiation by filtering and attenuating this impinging radiation.

There is strong evidence of this photoprotective role of melanin. In highly pigmented races, squamous cell carcinoma only arises in damaged skin such as old scars or chronic ulcers where the squamous epithelium has regenerated without its pigment and is extremely vulnerable to solar carcinogenesis.

The less common skin cancer, malignant melanoma, is also very rare in heavily melanised skin since it occurs only on the lightly pigmented palm, sole, nail bed or mucous membrane of these individuals. The development of melanoma at these sites is completely unrelated to UV exposure.

—Helen Shaw
Melanoma Unit
Sydney University

Malignant melanoma: fairest-skinned people are most at risk.

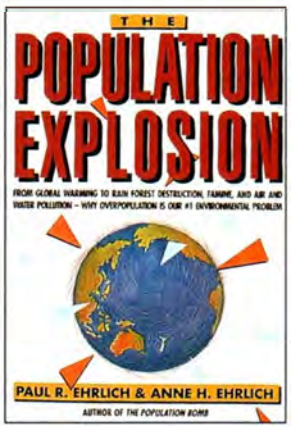
COURTESY WILLIAM McCARTHY/SYDNEY MELANOMA UNIT

Questions for this column may be sent to Jennifer Saunders, Australian Natural History, P.O. Box A258, Sydney South NSW 2000.

REVIEWS

COMPILED BY JENNIFER SAUNDERS

EDITORIAL ASSISTANT



The Population Explosion
By Paul R. Ehrlich and Anne H. Ehrlich. Simon & Schuster, NSW, 1990, 320pp. $16.95.

I read the 320-page-long *Population explosion* in two nights. Its easy style made this possible and its extraordinary message made it a necessity. Having given myself a couple of days to digest and contemplate, I am sure that I am not indulging in hyperbole by suggesting it is the most important work I have ever read.

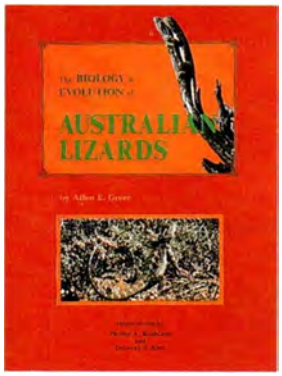
The Ehrlichs state their case succinctly and convincingly. When their earlier work *The population bomb* was published in 1968, the population on Earth was 3.5 billion. Many of their predictions, which then seemed more like wild speculation, have since proved correct. The population today stands at 5.3 billion and increases at 95 million per year. You don't have to be a genius to see we are headed for disaster. I think, however, it is a rare genius indeed who can propose viable solutions to avoid the looming crisis. And it is just such solutions that lie at the heart of *The population explosion*.

Before reading this book I was convinced that overpopulation was essentially a third world problem over which I had no control. This work makes it absolutely clear that I was terribly wrong. How do we know when an area is overpopulated? The answer is when the organisms in question start destroying their resource base. Of course, we might be able to change our ways by adopting different technologies or consuming less, but this book is about practicalities; the here and now. Given this definition, Australia and many other developed nations are overpopulated. In Australia, our rate of growth is so enormous that each of us would have to use ten per cent less each eight years or so, just to keep the levels of environmental degradation steady. It has been argued that our population growth does not matter as most results from immigration and thus is just shuffling people around the Earth. The Ehrlichs say this of immigration: "Net immigration to rich nations is the rough equivalent of natural population increase...it will be important to decide how much of the input side of our population equation is to be made up by natural births and how much by net immigration".

Because citizens of developed nations put a greater strain on environmental life support systems (roughly 100 times more), our population growth is of paramount importance. Australia is the only developed nation that has a rate of population growth similar to that of a third world nation. The utter selfishness of such a situation is pointed out adequately in the book. As the Ehrlichs say, people often feel helpless to solve the world's problems. Even recycling and conserving energy is rendered pointless by continued growth. And yet, the ultimate power to solve these problems has been sitting in our laps all along. If Australia could just undergo a slight decline in the birth rate and halt immigration, we would soon have a declining population. For the first time we would have the spare funds and the breathing space to solve our problems and then help our neighbours. This latter step is crucial. Even if Indonesia's birth control program works at full capacity, there will still be many million additional Indonesians in 50 years time. The 'environmental refugee' problem that this could create for Australia is appalling. Our guns and ships would be helpless against such a flood. The only hope seems to lie in planning and large amounts of appropriate aid.

I must make a plea to all who read this review—please buy a copy of *The population explosion* as soon as possible. Pick up the phone now and ask your local bookshop to order it for you. *You* can save the world, but only if you have this book to help you.

—Tim Flannery
Australian Museum



The Biology and Evolution of Australian Lizards
By Allen Greer. Surrey Beatty & Sons, Sydney, 1990, 264pp. $60.00.

When still a newcomer to the Australian fauna, Allen Greer (now Senior Research Scientist in the Herpetology Section, Australian Museum) was very stimulated by Robert Bustard's 1970 book *Australian lizards*. Nearly 20 years later, Greer has written an excellent successor to Bustard's work in the form of a thoroughly documented review of what we know about Australia's remarkably rich lizard fauna (just on 500 species, with more undescribed).

The text is arranged into seven chapters plus an introduction, covering phylogeny and biogeography. Each of the five Australian lizard families—the dragons (Agamidae), the geckoes (Gekkonidae), the flap-footed lizards (Pygopodidae), the skinks (Scincidae) and the goannas (Varanidae)—has a chapter devoted to it, and the book concludes with a brief chapter summarising the anatomy and possible origins of those lizard cousins, the snakes.

In each of the five main chapters several areas of biology are emphasised (namely morphology, ecology and behaviour) and the state of knowledge of phylogenetic relationships within each family is summarised. At the end of each family chapter there are tables that list aspects of reproduction, diet, anatomy and other factors—a gold mine for researchers. The basic unit for discussion throughout the book is the genus and every Australian genus is covered.

The writing style is more relaxed and accessible than the dry-as-dust prose of scientific papers, but the book is packed with information and demands a fair level of comprehension from the reader. Familiarity with the technical language of biology and the classification of reptiles will make the book easier to use. Appreciating this, the author does recommend several general texts to provide background for the material he covers. At times, the text is relieved by wry humour and in other places waspish criticism of certain areas of reptile biology, notably the critique of much of the zoogeographic speculations concerning Australian lizards.

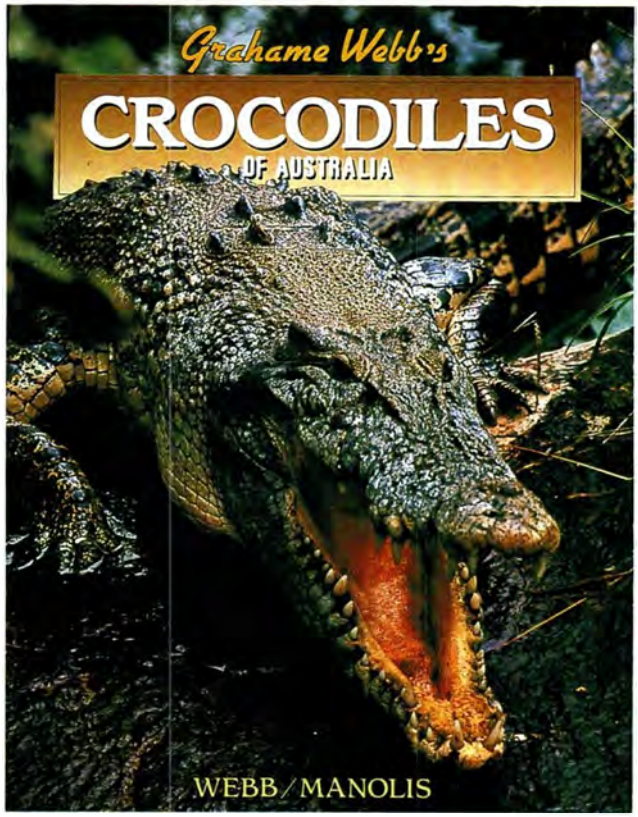
One of the many strengths of the book is the thoroughness with which Greer has drawn together extensive literature citations for many areas of natural history. For too long, as he points out, the same few anecdotes have been recycled. Much of the new documentation comes from the amateur herpetological literature, a source not hitherto drawn on extensively by professionals but shown by Greer to be extremely valuable. Another strength is the high-quality illustrations. The numerous colour photographs have been carefully selected to augment the text, and the line drawings of osteological and scalation features are admirably clear.

A negative feature of the book is Greer's decision to use several generic and specific names that are inadequately diagnosed and being considered for rejection by the International Commission of Zoological Nomenclature. (Examples include *Amphibolurus burnsi*, *Rankinia*, *Claireascincus* and *Egernia mcpheei*.) While work in progress by Greer or others might well validate the biological reality of these taxa, the fact that such work is unpublished, or at best only implicit in this book, makes use of these names premature.

The quality of the book's production is not as good as it should be, with far too many misprints. An erratum slip lists some 78 errors (roughly one every third page) and more are apparent as one reads through. To mention the more glaring of the unlisted errors, all three dust jacket photographs are mislabelled: on the front cover, *Amphibolurus puchalis* should be *Ctenophorus nuchalis*; *Pogona nitticeps* should be *Pogona vitticeps*; and on the back cover *Lampropholis* sp. should be *Saproscincus* sp. Hopefully the next edition will see these mistakes corrected.

These quibbles aside, this is a great piece of work that is very well priced and which should be compulsory for everyone seriously interested in reptiles in general and lizards in particular. For a wide range of other people with a professional or amateur interest in our fauna, *The biology and evolution of Australian lizards* will provide a remarkably thorough and lucid summary of the structure, habits and evolution of one of the most diverse and fascinating groups of Australian vertebrates.

—Mark Hutchinson
South Australian Museum



Crocodiles of Australia

By Grahame Webb and Charlie Manolis. Reed Books, Sydney, 1989, 160pp. $24.95.

Crocodiles are the most unlikely candidates to win a popularity contest. Yet, during the last five years or so, they have become one of the most popular Australian native animals—easily rivalling the Koala, wombats and kangaroos in the attentions of the general public. But, unlike the warm furries, the crocodiles' sudden popularity is not because they are cute and cuddly; quite the opposite. The rise of the crocodile fan club has its roots in films such as "Crocodile Dundee" and an increasing number of savage crocodile attacks since 1980. Crocodiles have become the respectable bad guys rather than the lovable heroes. Many publications have been cashing in on this wave of popularity, most of which have focused on the bloody attacks and gory myths. Suddenly, anybody who had seen a crocodile in the wild was a self-proclaimed expert, capable of writing the next 'definitive' load of crocodile 'fact'!

Crocodiles of Australia is a clean break from other recent books on Australian crocodiles. Indeed, its intention is to present a popular account of the current scientific understanding of these animals. The authorship of Grahame Webb and Charlie Manolis gives this book the hallmark of authority. Both men have worked extensively with the two crocodiles found in Australia—the Saltwater Crocodile (*Crocodylus porosus*) and the Freshwater Crocodile (*C. johnstoni*)—and between them their research has generated most of the current knowledge of these two species. The basis for this book is a translation of their many scientific papers into everyday language and it is a job at which they have succeeded. The text reads well (with the occasional anecdote) and benefits from the authors' familiarity with their subject. Both the photography and graphics are clearly reproduced and of an excellent quality.

While there are the obligatory accounts of crocodile attacks on humans, these are restricted to one chapter and dealt with in a factual manner. There is a chapter that investigates the interactions between crocodiles and humans—from crocodiles as Aboriginal totemic symbols, through the period where crocodiles were considered to be vermin, to the current era where crocodiles are the subjects of scientific research, conservation and farming. The bulk of the book is, however, a detailed account of the biology of the two crocodile species and their habitats. This is where *Crocodiles of Australia* shines above its competitors as it lacks the 'gee whiz' and 'Ooh ah' approach that typifies most other books on crocodiles and instead contains a wealth of detail the others do not provide.

The first chapter is a general introduction to crocodilians and the second a review of all modern crocodilians. They are intended as a precursor to the subsequent chapters but are, in themselves, a useful account of the biology and status of all crocodilians. In short, this is the most accurate and complete popular account of Australian crocodiles currently available.

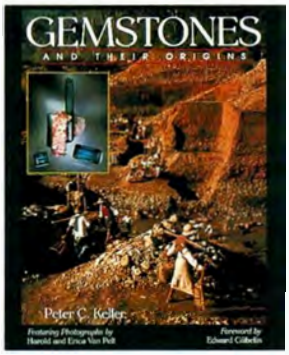
The weaknesses? I'll be showing my bias here because I have to take Webb and Manolis to task over their handling of the history of crocodilians in the first chapter. Much of their information in this section is inaccurate or badly out of date. A pity, because this is the only flaw of any magnitude that I could detect in this otherwise superior pick of the crop of crocodile books.

—Paul Willis
University of NSW

Gemstones and their Origins

By Peter Keller. Van Nostrand Reinhold, USA, 1990, 144pp. $129.95.

Generally, one of the last things that a gemmologist has a good grasp of is the geology of the formation of gemstones. In fact, many geologists–mineralogists who



have an excellent grasp of the mineralogical aspects have very little idea about the special circumstances that cause the occurrences of the gem or precious members of the different mineralogical families.

For the gemmologist, it has always been a matter of searching through a number of different texts and sifting through quite complicated and unfamiliar geological jargon to try to understand the geology of the formation of gemstones.

It is very exciting, therefore, to come across a book such as *Gemstones and their origins* because it fills a void previously not dealt with in gemmological literature by addressing the subject in easily understood language and providing easy access to the important information on the latest theories of gemstone formation.

The book is divided into four sections, each with an introduction that takes a general look at the conditions of gemstone formation and then uses specific gemstones to illustrate the points discussed.

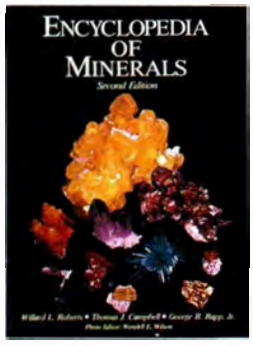
Where the specific gemstones are discussed a very comprehensive treatment is given of the different important geological and geographic locations in which they occur, and the text is beautifully illustrated with photographs of the gemstones themselves and location shots of the mining areas.

The first section discusses the importance of the action of water in the formation and concentration of gemstones. Examples discussed are the extremely rich gem gravels of Sri Lanka and the opal deposits of Australia. The second section illustrates the differences between the hydrothermal formation of gemstones (for example the Columbian emerald deposits) and gemstones from igneous environments (for example the gem pegmatites of Brazil, and the ruby deposits of Thailand). The third section is about gemstones found at very high temperatures and pressures and uses the ruby deposits of Mogok (Burma) and the jadeite deposits of Tawmaw (Burma) to explain how metamorphism results in the formation of precious gems. And the fourth section looks at the different ways gemstones can form at great depths. The peridot deposit in Zabargad Island and the Argyle diamond deposit in Western Australia are used as examples.

The excellent photographs of the different mining localities give the reader a good insight into the different techniques used in various parts of the world today to win the gemstones from the earth.

The book's presentation and writing style make it not only a very useful and informative addition to the serious gemmologist's library, but also a great general interest book for the coffee table.

—Bill Sechos
Gem Studies Laboratory



Encyclopedia of Minerals
By Willard L. Roberts, Thomas J. Campbell and George R. Rapp Jr. Van Nostrand Reinhold Company, 2nd ed., USA, 1990, 979pp. $249.95.

Rapid advances in mineralogy have occurred since the first edition of *Encyclopedia of minerals* was published 16 years ago. Many hundreds of new mineral species have since been discovered so an update of the *Encyclopedia* was inevitable and eagerly awaited. Both editions have an alphabetical listing of mineral species, colour plates of minerals and a glossary of terms. Listed under the mineral name and chemical formula are the definitive physical properties including crystal, x-ray, optical and physical data, with geographical occurrences. Each entry finishes with the best references in English.

The new edition is about 30 per cent larger at 797 pages and adds information on about 400 new mineral species (making a total of about 2,600) with over 3,200 alphabetical entries. All the information has been rechecked in the light of recent research. A book of this type is of course only up-to-date at the time the text is prepared. Comparison with entries in *American Mineralogist* and *Mineralogical Abstracts* indicates that new minerals up to around mid-1987 are included.

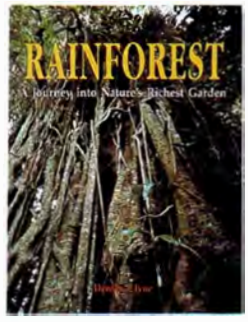
The greatest change is in the number and format of the photos. The first edition used about 940 small colour photos of microminerals, while the new edition has approximately 240 larger colour photos of superbly crystallised, mainly larger-sized specimens.

Interspersed throughout the text are 104 black-and-white photos, 45 crystal drawings and some Scanning Electron Microscope photos. Readers familiar with that doyen of mineral journals *The Mineralogical Record* will recognise the style of many photos and, indeed, the photo editor of this new edition is the editor of *The Mineralalogical Record*.

The change in photo format provides a different emphasis; for, while the new colour plates are undeniably more 'showy', they unfortunately cover a much smaller range of species. This is a pity since the more comprehensive but less spectacular photos of the first edition were used by many collectors to help identify the more uncommon minerals. However, the new photos are certainly stunning and of very high quality. They are also now more evenly divided between common and rarer minerals and their captions include specimen size.

This new edition should continue to fulfil the needs of students and mineral enthusiasts who need a comprehensive and easy-to-use reference. It should also appeal to professionals who like an alphabetical, single-volume summary of mineral species for rapid and convenient checking. There is no other comparable reference book that draws together the essential data for most known mineral species and presents it in a clear and logical format. Keen mineral enthusiasts will have to dig deep into their pockets to add this book to their libraries, but they will find the expense worthwhile.

—Ross Pogson
Australian Museum



Rainforest: A Journey into Nature's Richest Garden
By Densey Clyne. Reed Books, Sydney, 1989, 97pp. $14.95.

Flies butting their 'antlers' like stag deer; spiders camouflaged as bird droppings, minute mites sporting red 'shag pile' coats, plants housing ant colonies. Densey Clyne and her contributors have captured these and many other wonders in *Rainforest: a journey into nature's richest garden*.

This book presents an overview of the rainforest community—the various habitats, types of organisms found and their interactions. It is not a reference book for identification, nor an all encompassing catalogue, but it does contain something of interest to most.

Principally, *Rainforest* is a collection of photographs. Cuddly mammals and colourful birds are of course present, but the 'humbler' spineless inhabitants are shown to be just as fascinating. It is in the realm of microscopic photography that the Clyne/Frazier team are

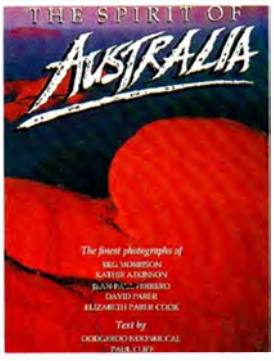
justly renowned and once again their patience, acute eye and skill have been rewarded. Jim Frazier's wizardry with lenses is apparent. *You* try and photograph the full length of a tree trunk in focus!

The dark page colouring provides a sympathetic backdrop for the photographs and the text complements the pictures nicely. It is short enough to invite perusal and, once so drawn, full enough of interesting information to hold the readers' attention.

Just a few criticisms; an arrow would have been handy in linking text with photographs as it is not always evident which text accompanies which figure. Some indication of scale would have added to our understanding and to our appreciation of the technical achievement in the photography. Also, occasionally jargon creeps in without being satisfactorily explained and, as this book is designed for the non-specialist, a glossary may have been helpful.

This 'journey into nature's richest garden' is a visual feast, informative and very readable. Not only do we share in the beauty and strangeness of the rainforest, but in the author's affection and deep understanding of this habitat. Although clearly designed for a generalist audience, this book offers interest and pleasure to all.

—Lynne Albertson
Australian Museum



The Spirit of Australia
Edited by P. Cliff. Golden Press, Sydney, 1989, 128pp. $24.95.

The spirit of Australia, like any other coffee-table picture book, is full of photographs. This book, however, has an advantage over the others as its photography comes from some of Australia's finest wildlife photographers. Reg Morrison, Kathie Atkinson, Jean-Paul Ferrero, David Parer and Elizabeth Parer-Cook all contribute. This is a formidable group and combined produces a comprehensive view of the diversity of life and landform within Australia. As a bonus to all photographic enthusiasts, there is information in the back of the book on how, where and with what equipment the photographs were taken.

The book is divided into "Land Spirit", "Sea Spirit" and "Animal and Tree Spirit". Dodgeroo Noonuccal (Kath Walker) gives us her poetic comments from an Aboriginal perspective throughout the book. Paul Cliff writes the bulk of the text with humour and sensitivity. The total effect is a trilogy of poetic images, photography and information that takes you on a mental sojourn around the continent. The concept of 'The Earth-Mother' becomes clearer as you read through the pages—rock formations, rivers and weather patterns are no longer just scientifically explained occurrences but a part of "the Web of Life of which we are a strand". It is unfortunate that animist notions are often thought of as childish or primitive, while Western philosophy, which separates us from nature by placing us above it, is considered sophisticated. If our planet is to survive, we must learn to regard the environment with the same reverence as the Aborigines do. Australia is one of the oldest continents on Earth and its indigenous people have been around for over 40,000 years. Until recently, its isolation has meant that both the land and the Aboriginal consciousness have held valuable secrets waiting to be discovered. If we are to benefit from this knowledge, we must look at it with an open mind.

This book is aptly named *The spirit of Australia* as the spiritual quality comes through strongly. It contains a wealth of information condensed into a very palatable form, combined with superb photography. I highly recommend it.

—Kate Lowe
Australian Museum

"Good communication is as important in our universities as any claims on original discovery."

A POPULAR MISCONCEPTION?

BY ROBYN WILLIAMS
ABC RADIO SCIENCE SHOW

A FRIEND OF MINE FROM THE UNIVERSITY of Sydney wrote to me earlier this year asking for a reference. He was applying for promotion to the position of associate professor. He said his chances were slim: he'd done little research, concentrating instead on his teaching and on broadcasting. He'd written and presented several superb radio programs for me, one of which has been published as a book here and abroad.

I willingly supported his submission. There is no doubt that good communication is as important in our universities and schools as any claims on original discovery. But there is also no doubt that many a scientist has suffered as a result of forsaking the bench.

The best known instance is, perhaps, Carl Sagan, a humane and forthright person of impeccable scientific accomplishment, who decided years ago to become a TV professor. This was in the series "Cosmos", which he wrote and presented and which also resulted in a book, other spinoffs and even Sagan's countenance on the front cover of *Time* magazine.

My, how the brickbats flew! Remarks were made about everything from the Sagan ego, his political allegiances and even his private life. Now, I don't care (nor should you) about such dross. He may be a swank, a pinko or even a rake. But what matters is his marvellous talent for turning millions of Americans and others all over the globe onto the delights of cosmology. That he also happens to be a decent, conscientious and extremely moral human being makes the snide remarks that much harder to bare. Which is why Sagan has chosen to keep out of the public eye in recent times.

It's easy to understand why scientists prefer to avoid the limelight. In television it may take hours or days to record just a tiny spell on the screen when broadcast. The truncated version of what one said appears glib at best, superficial or wrong at worst. If the scientific face is seen often on TV or in the papers, accusations of vanity, ambition or even worse can be forthcoming. Radio's not so bad. It seems more serious and one is more likely to have time to explain.

The trouble is, to do well it requires practice. Therefore, the scientist needs to appear often and keep doing so. Exposure like this, on any of the media, then brings the risk of being accused of neglecting research. How else could someone keep up with the increasingly irksome demands of the lab with attendant grant applications and seminars?

Despite all this, times have changed. The best scientific institutions now actively encourage their scientists to popularise. There is an annual prize (the Faraday Prize) given by the Royal Society of London for this very purpose. Last year it was won by Oxford's Professor Colin Blakemore for his book and TV series *The mind machine*. This year it was won by Dr Richard Dawkins, also of Oxford, for his books *The selfish gene* and *The blind watchmaker*.

In Australia there is strong support for CSIRO researchers to go public—it's part of the Board policy. At the Australian Museum we invented a prize last year, similar to the Faraday, to boost the promotion of science. The winner of the $10,000, donated by ABC TV and Radio, went to Professor Michael Archer from the University of New South Wales for his books, articles (many in *Australian Natural History*) and appearances on the electronic media. One of the judges, Professor Paul Davies from Adelaide, himself an accomplished performer on the public stage, remarked that Archer manages to combine both a first-class research output, fundraising for his Riversleigh Project to further their lab, research and field work, and an effectively outspoken presence in the public arena.

Other superb performers in Australia include Mike Tyler, the frog man from Adelaide; Ann Henderson-Sellers, the climatologist from Macquarie University; Sir Gustav Nossal, Director of the Walter and Eliza Hall Institute for Medical Research; Ron Strahan from the Australian Museum (not to mention Tim Flannery) and Adrienne Clarke, the botanist from Melbourne University. There are scores more one could mention.

One no longer with us is Peter Mason, once professor of physics at Macquarie University. I remember his first efforts, a book review and an obituary. They were somewhat ordinary. I gave him a few tips, expecting them to be forgotten, as usual. But Mason, who had a splendid record of research behind him then, had decided, on reaching his early 50s, that a change of course was in order. He gave all his energies to teaching and broadcasting. Just days after my casual advice on voice production and writing, he was back. He presented another piece with twice the flair and ten times the impact. From there he went on to whole programs and even several series. Most became books, several published internationally.

Mason was clear about the vital importance of popularising science. He knew that a country like Australia has to face the future with its brains instead of its brawn or bombast. He knew of the pioneering efforts of his mentors in Britain: the geneticist J.B.S. Haldane, novelist and science writer H.G. Wells, J.D. Bernal (The Sage) who helped start X-ray crystallography, with Lawrence Bragg, and set the stage for the revolutions in molecular biology carried out by Watson, Crick, Perutz and Hodgkin. Mason had also admired the efforts of Lawrence Bragg himself (born in Australia 100 years ago) at the Royal Institution, where the Christmas lectures had inspired many a youngster to take up science as an interest for life. It was the Royal Institution that was the stage for Michael Faraday 120 years before, where he gave his own admirable colloquia—hence the naming of the Royal Society Prize.

Our own prize, The Eureka Prize, has overtones both of discovery and Australian history. It was presented at the Australian Museum by the Governor-General, Mr Bill Hayden. When he gave it to Mike Archer, his Excellency remarked on the vital importance of popularising science in the 1990s and that the effort depends, above all, on the scientists themselves. Of that, in these uncertain times, there should no longer be any doubt. ■

Robyn Williams is the Executive Producer of the ABC Radio Science Show. He has received the Michael Daley Award and the Ben Lexcen Award for excellence in science journalism.

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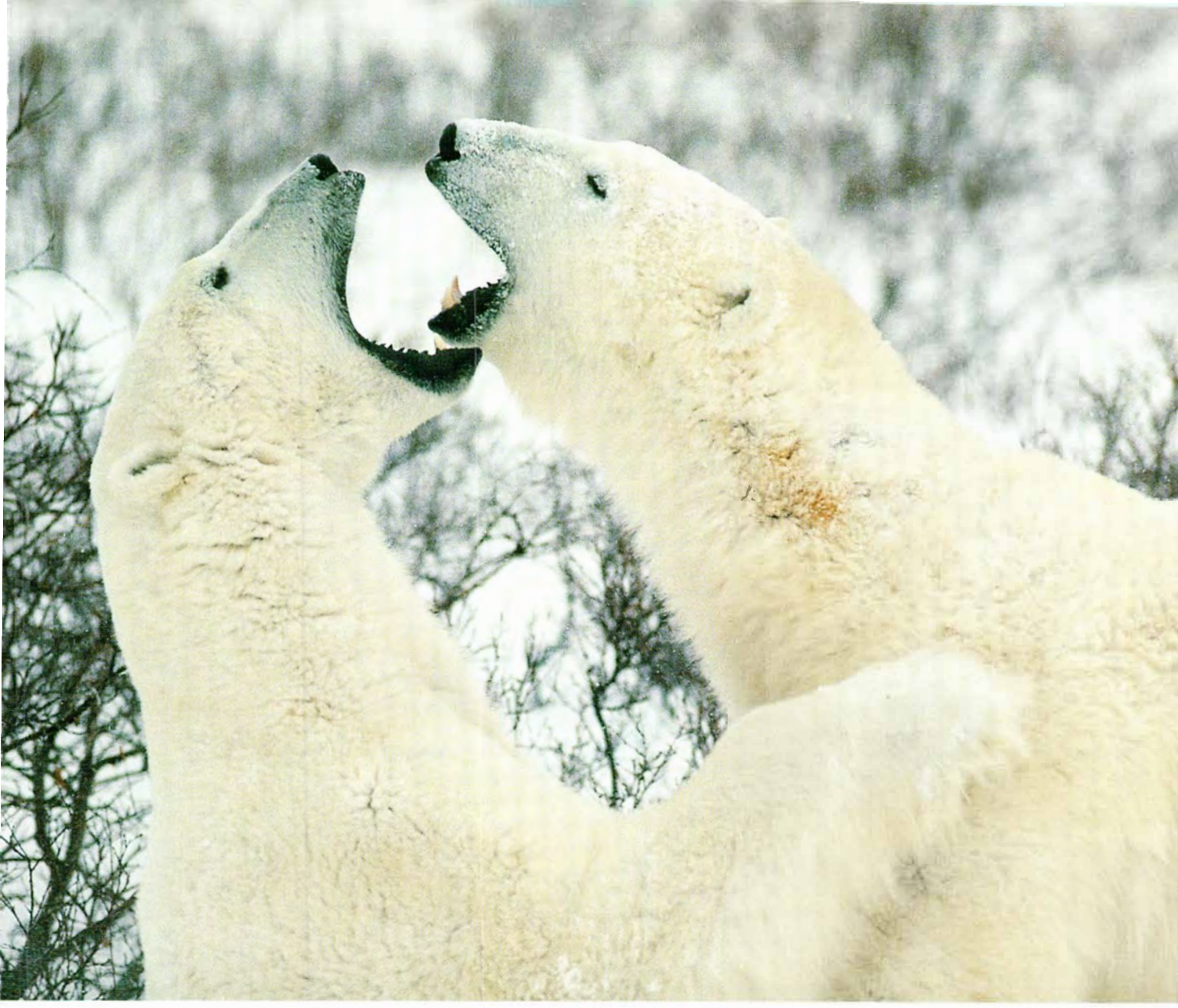

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Photo by Mike Beedell

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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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