ANH

Australian Natural History

WINTER 1990 VOLUME 23 NUMBER 5

INSECT FLIGHT
New Discovery

RAINFOREST SAVED
Battle of Wingham Brush

HONEYBEES
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CHRISTMAS ISLAND
A Tragic Rat Tale

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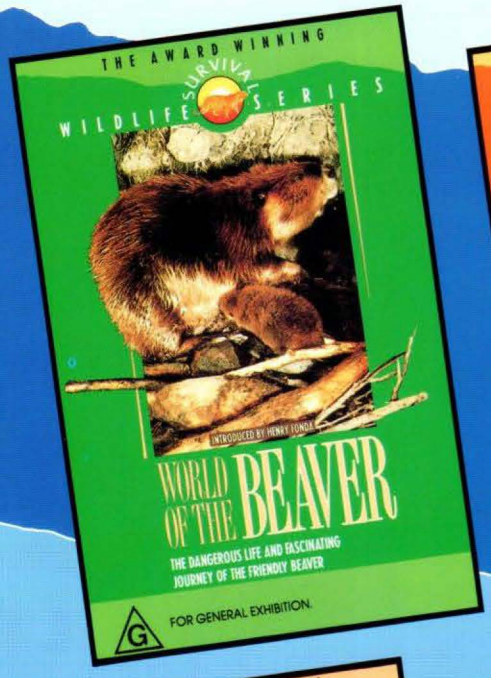

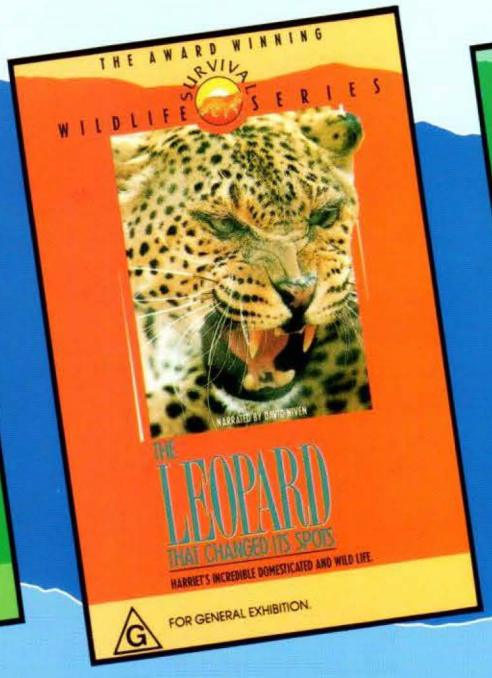

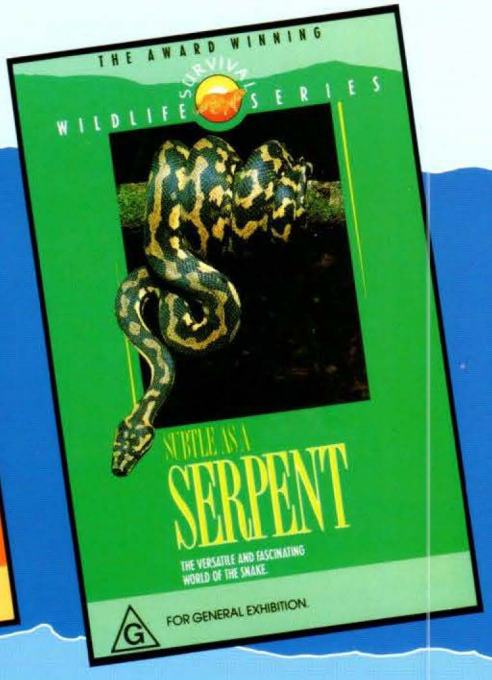

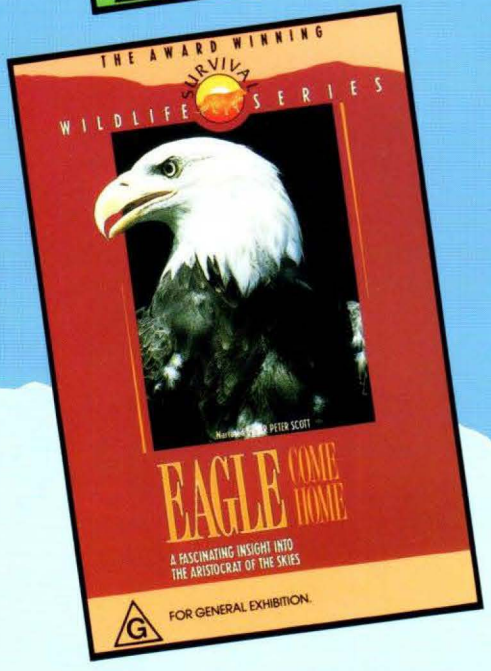

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ANH
Australian Natural History

Winter 1990
Volume 23 Number 5
Published by
The Australian Museum Trust
6-8 College Street,
Sydney, NSW 2000
Phone: (02) 339 8111
Trust President: Robyn Williams
Museum Director: Desmond Griffin
EDITOR
Fiona Doig
SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.
CIRCULATION MANAGER
Cathy McGahey
ART DIRECTION
Run Run Run Design Pty Ltd
EDITORIAL ASSISTANT
Jennifer Saunders
TYPESETTING
Excel Imaging Pty Ltd
PRINTING
Dai Nippon Printing Co., Tokyo, Japan
ADVERTISING
Wendy Symonds
Lisa Rawlinson
(02) 339 8234
SUBSCRIPTIONS
Annual subscription (4 issues)
Within Australia $A30
Other Countries $A42
Two-year subscription (8 issues)
Within Australia $A58
Other countries $A78
New subscriptions can be made by credit card on the ANH toll-free hotline 008-028558 or use the form in the back of the magazine. If it has been removed, send cheque or money order to the address above, made payable to the 'Australian Museum'.
Subscribers from other countries please note that money must be paid in Australian currency.

The Editor welcomes articles or photographs in any field of Australian natural history.

Published 1990
ISSN-0004-9840

Australian Natural History is audited by the Audit Bureau of Circulations.

Front Cover
High-speed still photography has enabled scientists to understand more clearly the mechanisms of flight in insects (see article on p. 368). Butterflies are used to demonstrate the concept of 'fluid' wings. Photos by John Brackenbury.

A PALER SHADE OF GREEN

BY FIONA DOIG
EDITOR

FAST-TAILING IN THE WAKE OF THE ENvironmental movement is the green consumer: a curious conservationist of the pale green variety. These people are not necessarily active environmentalists; they have supported the environmental movement in an extremely powerful way—with cold cash. They are leading marketing trends by making, what they believe to be, environmentally friendly decisions. Their dollars and cents are picketing large corporations. The message is loud and clear: we want environmentally sound products.

Such behaviour has not gone unnoticed and the war is on between chain stores as they battle to become voted 'the most environmentally friendly' by the purchasing public. Colourful logos (usually green) emblazon a variety of products. Labels scream out 'friendly to the environment'. But are they?

Major marketing campaigns have been foisted onto the public to buy envirofriendly recycled paper, unbleached toilet paper, washing powder etc. While some manufacturers' claims may be genuine, others are not. Some companies sponsor environmental concerns to boost their 'green' image but continue to produce the same environmentally unfriendly products. How does the uninformed consumer make a choice? Recently I spent 15 minutes looking at washing powders, attempting to decipher the labels to work out which ones contained phosphates. No information was included on the packaging.

This worries me. We are told it is our individual responsibility to choose environmentally friendly products, so a concerned consumer is faced with an ethical problem: whose message do I trust? And if a product is detrimental to the environment, why is it up to an individual to make that choice when clearly others don't?

Our choice to buy envirofriendly products isn't even as well protected as the environment we choose to help. What legislation exists to cover unqualified manufacturers' claims and advertising hype? And assuming the information given is false, how does one prove it? There are no real solid rules for this game: a new game that everyone wants to play but one that is fast becoming a free-for-all. When are legal criteria going to be attached to including words like 'biodegradable' and 'envirofriendly' in packaging and advertising? What about the word 'safe'? At the present stage, the green consumer industry is heading in the direction of the health food industry: an expensive mimic of the original product that might be sugar free but appeases our appetites with a glucose and carob substitute, then tells us it is 'good' for us. Being told unbleached disposable nappies are more environmentally sound than bleached avoids the issue of whether we should be using them at all.

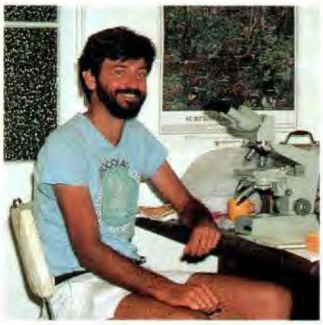
Clearly independent controls need to be placed on such messages—the establishment of some kind of body through which environmental claims can be ascertained and dangerous products banned or controlled. New labelling systems *are* springing up—like the Green Spot label in Victoria—and some chain department stores are creating their own. We will end up with chaos if care is not taken: a string of different systems that will confuse the consumer and ultimately just add to the hype without being of any benefit to the environment.

Firstly, it is essential that strong, well-researched legislation is created regarding product labelling. Secondly, all toxic and dangerous products should at the very least carry warnings, if not be banned outright. Thirdly, a single, coherent, simple international system of labelling or coding products needs to be adopted and administered by an international body. I say international because most of the environmental problems we now face are global and must be approached at that level. Such signs can be instantly recognised by anyone making a purchase. I see a great opportunity here for Australia to lead the way in inventing and initiating such a system. All too often we wait for another country to take the initiative and then copy its format.

Even if such legislation were implemented, we must be wary of the belief that the environment will be safe simply by shopping carefully. We cannot rely purely on purchasing choice when consumerism itself—green or any other colour—is a major cause of the problem in the first place. Making more conservative choices with regard to our resources does little to alleviate the major environmental problems we face today—overpopulation, atmospheric pollution and the alarming rate of species loss. Indeed, the question begs: why are products that contribute to these problems available at all?

IN THIS ISSUE

BY GEORGINA HICKEY
SCIENTIFIC EDITOR



Our cover story this issue discusses flight in insects. Special photographic techniques, designed by John Brackenbury, have revealed that insect wings do not act like fixed aerofoils as previously supposed but are like 'moving curtains'. An understanding of the fluid nature of the wing accounts for the enormous power generated during each stroke cycle. Butterflies, apart from being aesthetically pleasing photographic subjects, illustrate the point well.

Still on the topic of insects, Graham Pyke (pictured) looks at the controversy between beekeepers and scientists. Do Honeybees have an adverse effect on our native animals, and what's to be done if they do?

From the air we are taken on a rollercoaster ride by John Paxton to the darkest depths of the sea. Here we find an amazing bunch of creatures that have developed special means by which they cope with the pressures of the deep. In particular, we learn about a group of strange little fishes with a big name—the whalefishes.

Other articles discuss the restoration of a rainforest near Wingham in north-western New South Wales, and the unfortunate chain of events that occurred around Christmas time 100 years ago on a small island in the Indian Ocean. Robyn Williams homes in on Professor R.H. Brown, the astronomist and author of *The Wisdom of Science*; Mike Archer takes a tough look at our fragile necks; our evolutionary enlighteners discuss the nature of diversity and the issues of structuralism *versus* functionalism; and Laura Mumaw has the Last Word on the use of marine mammals in the military. Other bits and pieces include the huge and endangered crayfish found in Tasmania, that grizzly phenomenon of so-called 'spontaneous human combustion', and the butcherbirds' habit of impaling prey.

Articles

INSECTS IN FLIGHT: THE ULTIMATE SAILING MACHINES
Weight for weight, flying insects generate more power than any other moving animal. Special photographic techniques have shown that this is because their wings, rather than acting like fixed aerofoils, are highly flexible, deformable, elastic structures that can store energy during one phase of the stroke cycle and release it as useful work during another.
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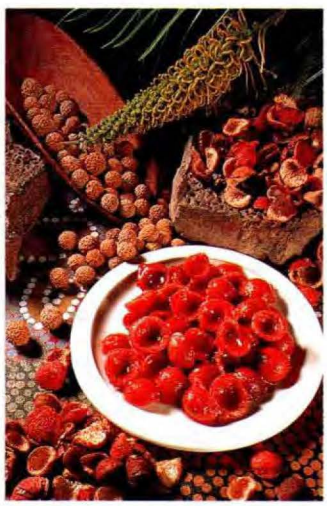

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LETTERS

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

Absolute Population Containment

In response to the Editorial "Onus on us" (ANH vol. 23, no. 2, 1989), I believe that population control or, more correctly, absolute population containment is the problem we must first solve. It is, for instance, a mistake to believe that the people of a country such as Africa are destined to always be virtually a 'hunter-gatherer' society. If this planet can be brought back into a balanced state, without doubt, as quickly as possible, such people will want to share Western superior living standards and conditions. Again, it is far too late to try lifting educational and general living standards with a view, amongst other things, to achieving a slowing down of family growth. Life on this Earth would be long gone before a result could be achieved.

—Fred James
Tabourie Lake, NSW

Pulling up the Ladder

The title of the article "A Vaccine for the Plague" (ANH vol. 23, no. 2, 1989), which implicitly equates human beings with vermin, is a worry. But much more worrying is the naivity of some of its content. For instance: "It is clear that we [Australia] must stop growing. This is a relatively easy matter for us: by simply stopping immigration we would fall to a level of zero population growth. The decision to stop immigration is an inevitable one. We must take it now if we hope to mitigate the coming disaster . . ."

This raises moral questions: are we 'Australians' so superior that we can just say 'Pull up the ladder, I'm aboard'? (Survival of the insulist.)

It raises practical questions: will the countless millions of overcrowded starving people in the rest of the world not affect us as we sit here in our island paradise?

But the question I want to focus on here is the question of growth. "We must stop growing", the authors write, and then discuss population growth without any reference to economic growth. (Oh sure, there are a few paragraphs on what they see as the connection between economy and ecology—the gist of which is that the looming ecological disaster will destabilise the price mechanism in the market economy, that is, will have adverse effects on profits.)

I would have thought that the writers, a rainforest researcher and a biophysicist, would have been more attuned to the potential for complexity between interacting systems than their simplistic treatise seems to indicate. They have missed completely the nexus of poverty, having children, Third World debt, economic 'growthmania'.

Economic growth has to be curbed. The idea of economic growth as the goal has to be abandoned. And that means that the entrepreneurial, industrial, consumerist system (the same system that brings us very enjoyable glossy natural history magazines) has to change.

—Paul Fitzgerald
Petersham, NSW

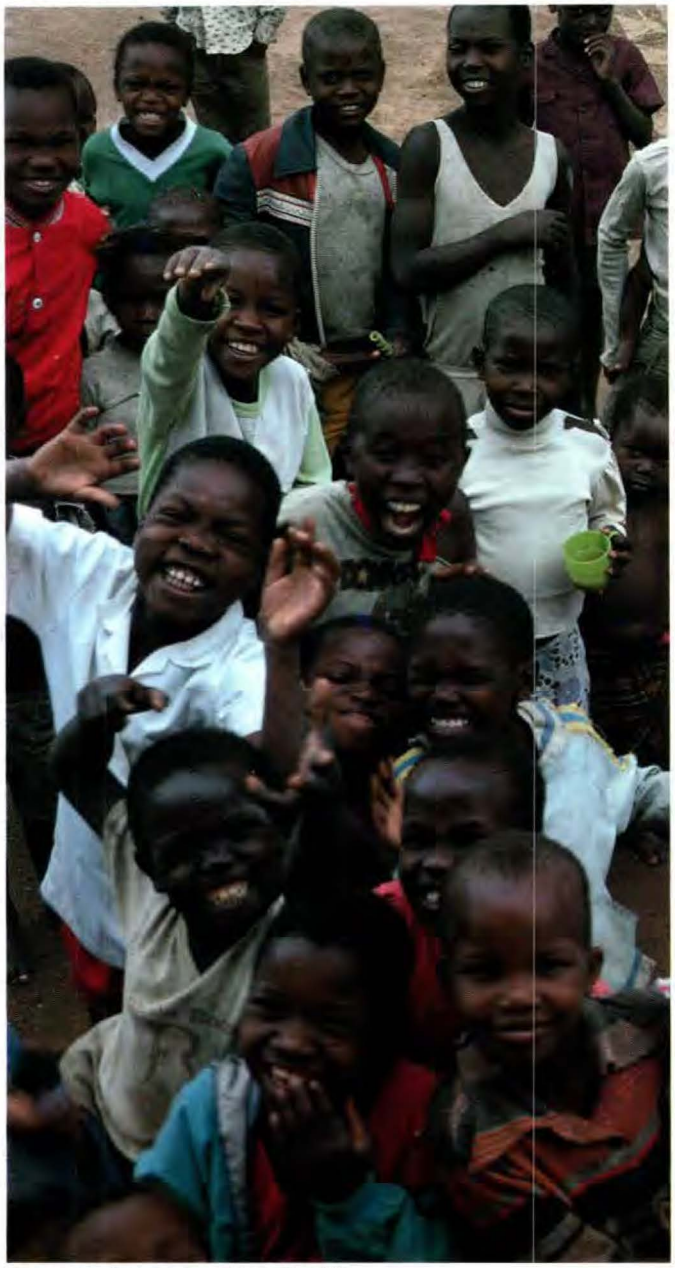
More People, not Less!

I very much appreciated ANH vol. 23, no. 2 (1989)—all except the Editorial, which proffered, yet again, a repetition of the theory of the Reverend Dr Malthus of former ages, the not so reverend Dr Ehrlich of the present time (whom the Australian Museum presumably has again brought to Australia), the Club of Rome, Zero Population Growth etc. We need more, not fewer, of the best species of all—*Homo sapiens*, the only species whose members can reason, learn, communicate, appreciate beauty, and study and preserve this wonderful and beautiful world and the wonderful and beautiful things in it.

Seventy years ago we were running out of coal; now we cannot get enough buyers. A little later we had only ten years' supply in known oil reserves; now we have ozone holes and the Greenhouse Effect etc. But do not worry—the world will still go on.

Scientists today produce more and more food from less and less land, so much so that even in South Africa (with cheap labour resources) submarginal land can no longer be farmed economically and in Australia, such as on the south coast, more land is going back under timber than is being cleared! This has been the case for quite a number of years. All over the world people are depopulating the countryside and heading into cities! Here in Australia, we are importing the 'meek' to inherit our good Earth while we abort our own children!

—G.H. Beswick
Sydney, NSW



FIONA DOIG

Do we need more people on Earth?

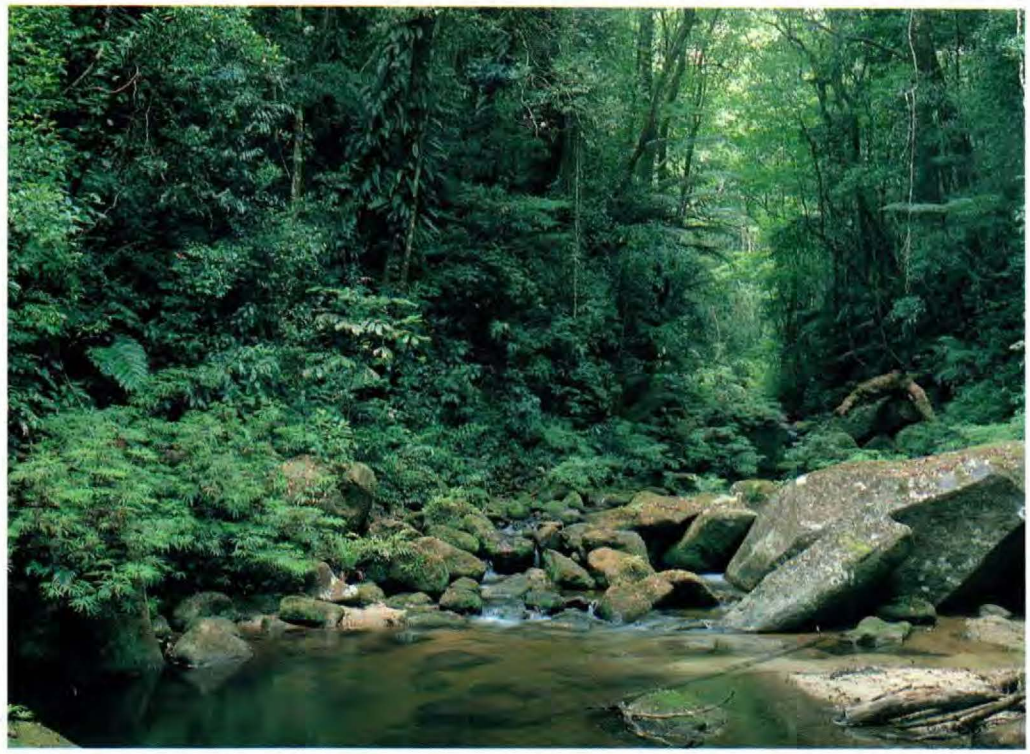
Doctrine of the Pontiff

Congratulations on the articles on the prospective collapse of the environment of our planet (ANH vol. 23, nos 1 & 2, 1989). The messages of these articles should be studied by a much wider audience than the subscribers to ANH, including young people still at school or college.

Incidentally, this is the first occasion, so far as my experience goes, when a responsible journal has pointed to the enormous damage and distress caused by the doctrine of the Pontiff that birth control is sinful.

I suggest that you owe it to the Australian public to make these facts more widely known and understood.

—Peter K. Chance
Langwarrin, Vic



MICHAEL TRENERRY

Should we harvest rainforests?

Rainforest Economics

Although I heartily agree with Tim Flannery and Telford Conlon's attempt to stir up some thought about the world's current ecological predicament, their ideas concerning rainforests and wilderness (ANH vol. 22, no. 2, 1989) wear a little thin. Their suggestion that rainforests should be opened for sustainable forestry practices is highly dubious. Do we really understand what the ecological consequences will be? I would be very surprised if we have reached that level of understanding of our rainforests! The diversity of rainforests is a feature that may suffer as a result of forestry practices, perhaps leading to a reduction in the real 'economic potential' of rainforests—that is, as gene banks for pharmaceutical drugs and food plants, not to mention the destruction due to logging for roads and the invasion of feral pests such as Cane Toads or Lantana.

Even if a lack of biodiversity were not the case, the inherent value of rainforests and all natural habitats as wilderness areas cannot be so easily assessed. There are so few areas left nowadays where human influence has been kept to a minimum and, if those areas that remain are kept for future generations, then their real value (selfish, isn't it?) may be as an important educational resource to us all. If we are really interested in sustainable resources, perhaps we should think more carefully about utilising land already damaged or, better still, find a solution to the vast amount of resources that are utilised by the developed world. In practice this may be no more difficult than developing a means of sustainably harvesting rainforests or, for that matter, any other habitat that has not yet suffered from human exploitation. I feel that wilderness areas are of immense value and should not be exploited in any way. Once they are disturbed their wilderness qualities are gone forever.

—Bradley Law
University of Sydney, NSW

Congratulations

Congratulations on your new ANH. Excellent. Copy very well produced as usual. All articles informative.

—Allen Chapman
East Woonona, NSW

Roxburgh Wrong

Rachel Roxburgh in her letter printed in the Autumn 1989 issue of ANH (vol. 22, no. 12) claims that our south-east forests are being destroyed. On behalf of the authority responsible for management of these forests, I assure you this is not the case.

Conservation, in the spirit of our National Conservation Strategy, is the responsible management of our natural resources to achieve the greatest sustainable benefit for the present and future generations. Conservation, therefore, embodies both preservation and utilisation, and the need for a balance between them. This balance, I consider, is now substantially in place in the Eden Region where more than 40 per cent of the publicly owned forests (some 140,000 hectares) has been excluded from logging and a further eight per cent is subject to special constraints to protect particular environmental values.

The protection to fauna, flora and other values provided by these large areas is complemented by an equivalent area of the State Forest subject to harvesting for timber production under normal prescriptions for multiple-purpose management, which includes provision for the long-term conservation of flora, wildlife and other values. To preserve all remaining natural areas in an undisturbed condition would be to derive less than optimal benefits from them now and in the future.

Management strategies for the areas to be harvested at Eden, as elsewhere, are planned in great detail to ensure that the forest is continually renewed by vigorous regeneration, for planned growth and harvesting to produce sustainable supplies of wood to established industries, particularly the sawlog industry.

Sustained yield strategies are in place throughout the State and levels of production will be within five per cent of long-term sustainable levels within five years. And you may not realise that already nearly half of the annual timber harvest from State Forests comes form trees regenerated under Forestry Commission management.

It is most surprising that someone who claims to be familiar with the Eden area and its forest operations should not have read the 1988 Eden EIS following the 1987–88 Jurasius case or kept in touch with the ongoing flora and fauna surveys outlined in it and subsequently undertaken.

Multiple-purpose management and utilisation of these State Forests as currently practised has proved to be economically and environmentally sound and sustainable. Its continuation is demonstrably in the best interest of the people of New South Wales in their present and future generations, and incorporates all reasonable safeguards for the protection of the environment.

—J.F. Yarwood
Forestry Commission of NSW

Catering for the Public at Hamelin Pool

I would like to respond to F. Taylor's concerns on visitor access and public education for the stromatolites at Hamelin Pool (ANH vol. 23, no. 1, 1989). An area between low water mark and 40 metres above high water mark in Hamelin Pool has recently been gazetted as a Marine Nature Reserve (Reserve No. 30885), with the remainder of the marine area to be included in the reserve in the near future. The purpose of the Reserve is to preserve these unique sedimentary deposits and to provide protection for the flora and fauna of the area. The Nature Reserve will not be 'closed off' but will restrict activities that may be detrimental to the Hamelin Pool environment. Activities that will continue include scientific research and passive recreation.

The public stromatolite viewing area mentioned by F. Taylor certainly was a poor example of stromatolite formations and did little to educate the public on their significance. Recently, sign-posting to the site has been removed and interested groups directed to a more suitable location.

At present, plans are being developed for a public area near the old Hamelin Pool Telegraph Station. Facilities are being designed that will allow visitors to view the spectacular domed structures at close range without walking on, and thus causing damage to, the fragile stromatolites. In addition, the Telegraph Station is being renovated to become a museum in which one room will be dedicated to providing information on stromatolites.

Hopefully, current planning for Hamelin Pool will provide the adequate protection the area requires, whilst allowing access to the majority of interest groups.

—Syd Shea
Executive Director
Dept Conservation and Land Management

JIM FRAZIER/MANTIS WILDLIFE

Meat ants feeding on lerp insects.

Lerps not Scales

Some errors in the photo caption "Meat ants feeding on scale insects" in Q & A (ANH vol. 23, no. 2, 1989) should be corrected. The insects on which the meat ants are stated to be feeding are not scale insects. Scale insects are placed in the superfamily Coccoidea, consisting of nine families. Insects associated with the ants in the photo are psyllids or lerp insects, superfamily Psylloidea, family Psyllidae, genus *Glycaspis*.

The white circular objects on the leaf are lerps, which cover the feeding nymphs of a *Glycaspis* species. *Glycaspis* derives from the Greek words *glycos* = sweet and *aspis* = shield.

For the more than 30 years since this genus has been studied, ants have not been observed to attack or feed on these nymphs under normal conditions. In the photo, it is noted that possibly one nymph near the centre is not covered by its lerp, and the ants nearest to it seem quite unconcerned by its presence. Note that in the photo the ants' heads are generally located at the edge of a lerp.

Many ant species can be found, sometimes in large numbers, ingesting the sweet honeydew (a surplus nymphal body excretion in excess of that required for lerp building), which at times flows from beneath the lerps onto the surrounding leaf surface. Honeydew at times supports the growth of a fungus called 'sooty mould', often seen on leaves bearing a copious exudation of honeydew from psyllids and scale insects.

On one occasion only, on a reserve just north of the township of Hillston (NSW) during 1967, it was observed that a number of mounds of the meat ant *Iridomyrmex* sp. were littered and white with lerps transported from surrounding eucalypts heavily infested with *Glycaspis* species. There was no observable forceful removal of lerps covering nymphs, nor any evidence that lerps might be food for the ants, even though lerps are sweet to the taste and were or are a sweet delicacy for Aborigines.

Assumptions evident in the photo caption are the curse of 'popular' journalism, and care needs to be exercised in the presentation of scientific material such as is given in ANH. I am still a 'satisfied customer' and trust that the above remarks are of some interest and might correct any wrong impression among readers.

—K.M. Moore
Yeppoon, Qld

Populate and Perish

A decade or so ago my (remunerated) employment required me to go to Trangie on the Macquarie River to chair a meeting of land-holders and colleagues. This jaunt entailed rising from a warm bed, in the dark, at about 5 am (never a favoured pastime) and had me in an F27 aircraft over Sydney's western suburbs as the sun rose. The landscape, slowly unrolling under my jaundiced eye, caused me to wonder what was familiar about the pattern of cul-de-sacs and crescents of the more recent urban development. It soon came to me that, when a eutrophic swamp is being colonised by Cane Grass, Cumbungi and Bullrush, the same sort of concentric patterns may be seen from the air. There are many swamps dotted about this country where nutrients have encouraged the growth of vegetation, to the point where the swamp is choked and dead.

Further musing led to the realisation that to culture a microbe on an agar plate is to see it develop similar patterns. And, on a parallel path, it occurred to me that, when a proliferating microbe invades an animal host, the host's days are numbered. From this point it was but a short step to the realisation that *Homo sapiens* (contrary to the tenets of my nominally Christian upbringing) is nothing more than a macro-microbe and that the species is doing no more to its host than the other microbes and weeds do to their habitats.

How flattering, then, to find in ANH (vol. 23, no. 1, 1989) that no less a person than Dr Tim Flannery had developed precisely the same view. And how chilling the thesis to which he led so adeptly, demonstrating conclusively with the microcosm of Easter Island where, in fairly short order, the whole of the Earth's population will find itself. And now, in ANH vol. 23, no. 2 (1989) Dr Flannery and his colleague Dr Conlon have taken us to the edge of the abyss and let us look into its infinite and intolerably unpleasant depths.

The 'conservationist' fringe dwellers of our society have come to irritate me as they chant their pointless incantations and promote their useless nostrums because they seek merely to fiddle with the symptoms of the disease—the destruction of resources in

timber and soil, and the fouling of air, water and land with toxic wastes. When these people, the anti-nuclear lobby and others with similar myopic views begin to bend their efforts toward population reduction, they will deserve every support—and they will need it.

But how much chance is there of the population explosion being reversed to implode? Precious little, it seems. The comment in Fiona Doig's Editorial (ANH vol. 23, no. 2, 1989) demonstrates that her African hosts are on the brink of the Easter Island situation but still espouse large families; the Chinese, with demonstrably the most authoritarian regime on Earth, tried to limit population growth but didn't get very far; for the Hindu masses, everything is ordained by the Gods so there is no point in struggle—take your feet off the ground and go down with the tide; the caption to the illustration of Pope John Paul II in Flannery and Conlon's article says all that needs to be said about the Vatican's insupportable position; Pol Pot does have a rather messy but only temporary solution; and a trip to Egypt in a couple of months may give me some insight into where Islam stands.

With my (Biblical) warranty running out next year, perhaps 10 or 15 years remain to me. Resources should hold up long enough to see me out. On the other hand, my three children with an average of 41 years can logically except to be around for 35 to 40 years, but their prospects for a confortable old age look pretty dim. And, for my six grandchildren (average age ten years), well...

Flannery and Conlon's concluding advocacy seems to me to be weak, only fiddling with the symptoms. But if the main thrust of their thesis (population reduction) could be made required reading for all decision-makers worldwide; if the television, radio and print media spent as much time and effort on promoting population reduction as they currently do publicising the antics of the myopic fringe groups; if the fringe groups could look through the symptoms, discern the disease and set about seeking its cure; if the Save the Children Fund, Community Aid Abroad and similar organisations adopted rational population reduction platforms; if religious doctrines advocating population growth could see the folly of their attitudes, then there might be just a glimmer of hope.

But it seems to me that, with the best will in the world (to be read literally), at least two generations—say 50 years—would be needed to fix such an attitudinal change in the habits of the population and then another 25 to 50 years for any impact to be seen. And by then the damage will be irreversible.

This brings to mind childhood recollections of an organisation called the Millions Club, which advocated immigration to this country with catchcries like "millions for Australia" and "populate or perish". How wrong was this group when we can now see that the litany should be "populate *and* perish"!

Even if, as seems to be the case, *Homo sapiens* really have insufficient collective wisdom to limit its numbers by biological process or medical intervention, and if the human immuno-deficiency virus does not do the job for it, the species does currently have the technology to solve the population explosion problem, once and for all. One can only hope that, in the struggle for access to fast-dwindling resources, the nuclear solution is not invoked. Such a solution would have the unsought effect of accelerating the demise of so many other species. On the other hand, might it not be a good thing if the planet were to be sterilised for a few million years and for the evolutionary process to be given the chance to arrive at a dominant species that is wiser and less destructive than we are?

Yours, in admiration of an excellently written and thought-provoking journal, sincerely.

—W.J. Youll
Narrabee, NSW

Watch Out!

I am impressed with the standard of production of ANH these days. Dick Smith had better watch out!

—Michael Brooker
CSIRO, Division of Wildlife and Ecology, ACT

QUIPS, QUOTES & CURIOS

COMPILED BY GEORGINA HICKEY
SCIENTIFIC EDITOR

Spontaneous Human Combustion

The room is hot, the floor slippery, condensation trickles down the closed and blackened windows. There is a strange glow caused by an orange–red deposit on the light globe. Metal objects are too hot to touch, the plastic television casing and face on the clock have melted. A pile of newspapers rests on a comfortable sofa. Nearby is an electric fire, but it is not switched on, and in front of this is a hole in the floor, across which lies the remains of a burnt body. The torso, head and arms have been totally consumed by fire and reduced to a powdery ash. Only the lower limbs from the knee down remain, with shoes, socks and lower trousers untouched by fire. So ended the life of Alfred Ashton.

Verdict? Spontaneous human combustion? Similar cases to this have been reported worldwide, particularly in Victorian England, but in no way are they restricted to the past. The latest case, described above, was reported on a cold morning in January 1988 in Southhampton, England. BBC Television researched the mysterious phenomenon for its QED program entitled "A case of spontaneous human combustion", which went to air in 1989. Much of the following information has been gleaned from a video of the program, kindly lent to me by the Producer of the show, Teresa Hunt.

In all cases it appears as if the body has been burnt from within, without seriously damaging the rest of the room. Various causes for spontaneous human combustion (SHC) have been suggested. At one time alcohol was thought to increase the combustibility of the body and thus the risk of SHC. Indeed, one of the key characters in Charles Dickens' *Bleak House*—"an eccentric individual of intemperate habits. . .named Krook"—was conveniently eliminated by attributing his death to spontaneous combustion.

TOPHAM PICTURE SOURCE

The remains of Dr Bentley, presumed dead by spontaneous human combustion in his home in 1966.

But can a body really burst into flames? Spontaneous combustion can and does occur in nature. In the case of haystacks, bacteria grow in moist conditions, producing heat through fermentation and the flammable gases methane and hydrogen. If a dewdrop or piece of glass acts like a lens, concentrating sunlight to a point source, it could conceivably ignite the gases, causing the haystack to burst into flames (Joseph Duflou and John Garrow, pers. comm.). Could the same type of bacteria account for SHC?

Well, no it can't. In a haystack there is an unlimited amount of material for bacteria to digest. In living tissue, thanks to the body's built-in defence mechanisms, bacteria are simply unable to build up to great enough concentrations to produce the heat required for spontaneous combustion. And, even if the methane and hydrogen that is produced could be ignited, it would not burn inside the body because oxygen is required. As Professor John Garrow from St Bartholomew's Hospital Medical College in London states "the total amount of heat produced by the action of bacteria in the human body is small. It wouldn't even boil a kettle, let alone a body."

So what other possible explanations are there? Could chemicals such as phosphorous, found naturally in the body, ignite the methane in the gut? Although phosphorous dramatically bursts into flames in the presence of oxygen, phosphorous in the human body is only found in the harmless form of phosphate. Yet phosphate *is* implicated in the natural phenomenon called 'will of the wisp'. In this situation, bacteria in the bottom of a pond or lake will change phosphates into phosphorous hydrides, which ignite any methane present to produce flames on the surface of the pond. Perhaps a similar sequence of events could occur in the human body? No. In the human body there is simply not enough upper gut contents capable of this form of fermentation and so the conditions will never arise. If they could arise, spontaneous combustion of animals such as cows with large rumens should be common. And, as Garrow points out, "as far as we know, cows don't spontaneously combust".

If biological and chemical explanations can't account for SHC, what about physical phenomena? The peculiar phenomenon of ball lightning has been implicated by some people to be the cause of SHC. Ball lightning lasts between 30 seconds and one minute. It moves at the same speed and height above the conducting surface. If the lightning is intercepted and trapped, it explodes, and occasionally it has been seen to be trapped inside a room and to slightly singe the surface of what it touches. One theory holds that if ball lightning touches something, it produces microwaves in that body so that the body burns from the inside out. However, Professor Roger Jennison from the University of Kent explains that the energy will simply try to escape into space; it will not hang around inside the body long enough to cook it slowly.

What, then, about murder? Perhaps the people concerned were murdered, moved, then burnt? But no motives of murder have been found in any of the cases studied. Suicide? Bodies soaked in petrol and then lit have been known to burn without damaging the rest of the room. But no matches or other suitable ignition source have ever been found at the scene. Accident? We're getting warmer.

Examination by forensic scientists has shown that all the cases of so-called SHC have been nothing more than a tragic accident. In each case, a viable ignition source is present near the body (such as the electric fire in the case of Alfred Ashton). The victim may have had a heart attack and fallen onto or near the ignition source, the clothes

catching alight and then the body burning like a candle from above and downwards.

In a candle, a wick is surrounded by wax. As the wick burns, the wax melts and the liquid is drawn onto the wick, which burns continuously. The human body acts like an inside-out candle: the external clothing is the wick, and the body, which consists of a large amount of fat, the wax. If the clothing is ignited, the fat melts and is drawn onto the clothing, which then continues to burn. There is a lot of water associated with fat and the human body but, because sufficient heat is liberated in the burning of the fat itself, it dries the water off ahead of the burning zone.

But how can the bones be burnt to ash when high temperatures of 1,300°C are needed in a crematorium, and why are the lower limbs left behind? The major fuel (fat) is located around the centre of the body (the torso). This is the area, once the fat is rendered out, that will be exposed to most of the flames. Because the limbs contain much less fuel, the fire is likely to go out before it reaches the extremities. In a closed room, local high temperatures will be produced by means of the 'wick effect', which gives rise to sustained, severe smouldering of the bones themselves, accounting for the sort of damage attributed to SHC.

But there are still some questions remaining. Why, for instance, are only certain objects in the room damaged by fire? To answer this question we need to understand the actual mechanism of fire. Fire is not a haphazard process. It involves well-established stages, each involving well-known physical and chemical processes. In an outdoor fire, fire grows by a process of flame contact, but indoors a different mechanism takes over. When the first item inside a room is ignited, heat and smoke rise to the upper part of the room and form a layer under the ceiling. As the fire progresses this layer gets hotter, deeper and thicker and eventually the layer descends until it starts to touch certain objects (such as the TV).

Using a computer model, Stan Ames from the Fire Research Station in London is able to determine what sort of fire produces the type of damage associated with death previously attributed to SHC. Certain critical parameters (such as the melting point of the TV casing, the height of the ceiling, the volume of space in the room, and the fact that the doors and windows were closed) are entered and the model tells us that, just after four minutes, the oxygen level will be reduced from the normal 21 per cent to 16 per cent. Oxygen at 16 per cent has the effect of suppressing burning, with the fire being reduced to low smouldering.

So there we have it. Some sort of ignition causes the clothes to catch on fire. This burns the body and, as the heat dries the body, condensation forms on the windows. Once the body dries, the fat melts and orange fatty deposits build up on the upper-level surfaces, such as the light globe, giving the room a warm glow. Because the fat doesn't burn cleanly, black soot sticks to the walls and doors. And, if the body is not discovered for a while, the 'wick effect' will give way to a slow, smouldering fire and the temperature in the room will rise, heating metal objects such as door knobs. As the hot gas layer produced by the smouldering fire descends, plastic objects such as clock faces and TV casings will melt. Because newspapers and sofas burn at much higher temperatures, they will appear untouched by the hot gas. The smouldering will continue until the body fat or the oxygen in the room runs out.

In Alfred Ashton's case, he would have fallen on or near the electric fire, caught on fire from the radiated heat, slowly smouldered and eventually burnt the floor and cable, which explains why the electric fire was off that morning. The burning body had cut off the power to the original source of ignition.

Science can provide a perfectly rational explanation for all of these deaths. Spontaneous human combustion does not exist. —**G.H.**

Biosphere II

Currently under construction in the foothills of the Santa Catalina Mountains north of Tuscon, Arizona, is the most ambitious endeavour to date in the creation of a complex ecological facility capable of extended operation and life support. The project is called Biosphere II, as opposed to the Earth's biosphere (= Biosphere I), and is designed for a life of 100 years. An initial two-year closure experiment with eight human crew members ('Biospherians') is scheduled for the end of September 1990.

The term 'biosphere', coined a century ago by the Austrian naturalist Edward Suess, refers to the envelope of life on the surface of the Earth. The Russian geochemist Vladimir Vernadsky first advanced a deeper scientific understanding of the biosphere as an immensely powerful force acting on the planet, helping to shape and maintain its properties. This concept was independently developed by James Lovelock and Lynn Margulis who developed in the 1970s the Gaia Hypothesis,

SPACE BIOSPHERE VENTURES

Biosphere II under construction in Arizona. A two-year closure experiment with eight humans is scheduled for September 1990.

which advanced our knowledge of life as an active agent in the creation of hospitable conditions on Earth (see ANH vol. 23, no. 1, 1989). Now, the advent of biospheric laboratories, such as Biosphere II, and other closed ecological systems research offer new tools of investigation into the developing science of biospherics—the study of the properties of the biosphere.

Biosphere II is essentially isolated from the existing biosphere. An airtight glass and metal structure prevents any atmospheric exchange, and a stainless steel lining covering the floor and underground sides prevents any exchange through the ground. Together with two expandable chambers or 'lungs' connected to the structure, which prevent the glass or seals from breaking due to changes in internal pressure, the total area of Biosphere II is 1.25 hectares with a volume of 200,000 cubic metres. Like the biosphere of planet Earth, Biosphere II will be a stable, complex, evolving, materially closed, life-closed, energetically and informationally open system containing five wilderness biomes or ecosystem areas (rainforest, savanna, marsh, marine and desert), plus human habitat and intensive agricultural biomes. The biomes are all tropical because of the Arizona location and climate, and will be controlled to different temperature regimes and dominated by characteristic vegetation and soil types as are the natural biomes of the Earth.

The tropical rainforest structure is approximately 27 metres tall. From the mountain in the centre of the rainforest a stream flows down a waterfall, across the forest floor and into the adjoining savanna biome. The stream then flows along a tropical savanna plain located at the top of rock cliffs and down into the marsh biome, which includes a freshwater area that grades up in salinity to a saltwater marsh, and then into the ocean (marine biome). The ocean is eight metres at its deepest point and includes a coral reef ecosystem and lagoon at one end. Wave action, required for the ecological maintenance of the coral reef, will be supplied mechanically. A thorn scrub forest completes the savanna biome and marks the ecotone (transition zone) between the savanna and desert biomes. Because of its proximity to the ocean, the desert biome is patterned after a coastal fog desert, such as the Vizcaino Desert in Baja California, and populated with species adapted to low rainfall but high humidity conditions.

The human habitat biome is a 25-metre-tall white domed building, analogous to an urban centre. It will include apartments for the eight resident researchers, laboratories, computer and communications facilities, workshops, libraries and recreation facilities. Adjacent to the human habitat is the intensive agriculture biome. Crops for food, fodder, beverages, fibre and other uses from a wide range of tropical and temperate plants will be grown on the broad terraces, behind which are areas for domestic animals (chickens, goats, pot-bellied pigs) and aquaculture. Since Biosphere II is materially closed, the intensive agriculture area will produce all of the food required for eight people, year round.

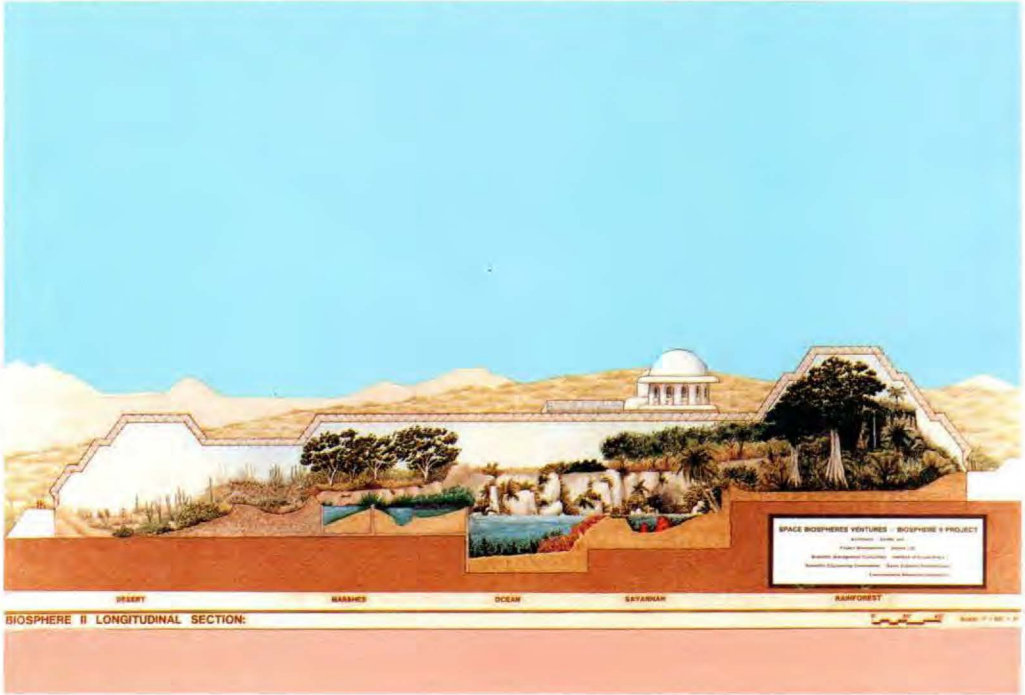
While species selection is not yet complete, it is anticipated that, excluding microbial species, there will be over 3,500 suitable species in Biosphere II. Besides domestic animals these will include birds, mammals, amphibians, frogs, reptiles, fish, crustaceans etc. At least 45 species of insect are being raised for pollination and detritus-recycling, and as important elements of the food web supporting higher animals. The microbes will be important, as they are in the global environment, for completing gas and nutrient cycles.

One of the project's goals is to create a prototype for the study of life systems for a space outpost. So far in the human exploration of space, life support systems for astronauts have been accomplished by almost purely physico-chemical means and by supply from Earth. When the provision of food, water and breathable atmosphere are consumed, the astronauts must return to Earth. Biosphere II's role in ecological studies and systems for space will be to provide the basis of a sustainable biologically recycling system. We will not be able to truly extend human life into space on a permanent and evolving basis until we can establish biospheric systems there.

Besides advancing the knowledge needed for space life support, Biosphere II will aid in understanding of the Earth's biosphere. Biosphere II will have over 2,000 computer sensors and it is anticipated that the monitoring, modelling and management of its ecological cycles will yield great insight into the operation of our Earth's biosphere. There is much scientific and popular interest in the functioning of the global biosphere, sparked mainly by current and potential threats to its health (overpopulation, pollution, greenhouse warming, ozone depletion, loss of tropical rainforest and species, desertification etc.). There is also an urgent need to find a way to harmonise human technological activities with the continued evolution of the biosphere. Technology must become a partner rather than opponent of the biosphere. Indeed, it is due to Space Age technology that we gained our first view of the biosphere as a totality on our Blue Planet. Space technology also gives us the ability to do much of the global studies and monitoring that are permitting a science of biospherics to develop. The creation, operation and studies of Biosphere II will offer a unique laboratory for the investigation of biospheric mechanisms as we learn the rules of our planetary 'cradle' and prepare to take biospheres with us into space.

—Mark Nelson
Institute of Ecotechnics, Lond.
Savannah Systems Pty Ltd,
Derby, WA

Biosphere II will contain five wilderness biomes, plus human habitat (white dome) and agricultural biomes. It is designed to increase our understanding of Biosphere I (= the Earth).



ALLEN MORGAN/SPACE BIOSPHERES VENTURES

One Dog: 500 Dead Kiwis

Many island animals are vulnerable to the introduction of exotic predators, but only rarely can scientists witness and record the devastation that often follows such events. One chilling incident is a recently published case (*Notornis* 35: 197–202; 1988) involving Brown Kiwis (*Apteryx australis*) living in the Waitangi State Forest—a commercial pine plantation near Kerikeri, on New Zealand's North Island.

The forest boasted the largest-known population of Brown Kiwis (between 800 and 1,000 individuals) when a team of biologists went there in mid-1987 to attach radio transmitters to some of the birds to follow their movements. Within six weeks, 13 of the 23 tagged birds were dead: with the help of the radio transmitters their bodies were found mauled (but not eaten) and buried. Another ten untagged carcasses were found by chance. Faeces, footprints and other evidence suggested strongly that a dog—and only one dog—was to blame, and

M.F. SOPER/ANT PHOTO LIBRARY ROGAN COLBOURNE

One dog was found to be responsible for the deaths of an estimated 500 Brown Kiwis in New Zealand's Waitangi State Forest. Inset: one of the victims.

that it was clearly having a marked impact on local kiwi numbers. The researchers noticed far fewer calls from the birds, and carcasses turned up in every part of the forest that was searched.

On 30 September 1987, a female German Shepherd was shot dead in the forest. It had a collar but was unregistered, and showed signs of having lived in the forest for some time. No more fresh deaths were recorded among the kiwis in the following final month of the study, and dog baits laid in the forest were not taken. The researchers concluded that the shot dog was solely responsible for the killings.

The team leader, Michael Taborsky from the Max Planck Institute for Behavioural Physiology in West Germany, notes that the kiwis were defenceless against the dog's attacks and were easily hunted—they are flightless, have a strong smell and a loud call. Taborsky calculates that the dog may have killed ten to 15 kiwis a night over the six weeks of its rampage— during which time the researchers just happened to be there—making a startling total of about 500 birds in all.

Kiwis are known to have low reproductive rates and Taborsky estimates it will be at least eight years, and perhaps as long as 20, before the Waitangi kiwi population recovers to its previous size.

The incident shows not only how destructive a single predator can be, but also how a prey species can be so easily exterminated without the predator itself dying out: the dog did not even eat the kiwis and, even if it had relied on them for food, could have switched to other prey items once all the kiwis had gone.

—**B.B.**

Frozen Turtles

If you've ever mistakenly put lettuce in a freezer, you'll be familiar with the structural damage caused by ice forming within a living cell: when the lettuce thaws, you're left with a limp green mess. Yet many organisms manage to survive at high altitudes and high latitudes, where sub-zero temperatures are routinely encountered.

Animals have developed a variety of strategies to get around the freezing problem. Some, such as high-latitude amphibians, snakes and turtles, avoid the problem altogether by overwintering in locally non-frozen burrows below the frostline, at the bottom of ponds or in communal huddles. Others, such as many Arctic and Antarctic fishes and insects, opt for a more specialised, biochemical form of protection, employing glycerol or special proteins as antifreezes that allow them to supercool without freezing. On the other hand, many terrestrial arthropods and intertidal invertebrates, plus four terrestrially hibernating frog species, can survive extracellular freezing to as low as −70° C, somehow overcoming the hazards of dehydration and anoxia.

Now the first reptile to adopt a biochemical solution to the freezing problem has been discovered (*Proc. Natl Acad. Sci. USA* 85: 8350–8354; 1988). The Canadian Painted Turtle (*Chrysemys picta marginata*) hatches in autumn and spends the winter in shallow soil, offering little insulation against frost. Kenneth Storey from Carleton University in Canada and colleagues measured the winter nest temperature of one batch of hatchlings and found that it repeatedly dropped below zero, to as low as −8° C, yet all the hatchlings emerged alive the following spring. When taken into the laboratory and cooled slowly, the turtles were found to freeze when the temperature got down to −3.3° C. When they were warmed and thawed, they showed every sign of good health. The turtles must therefore have frozen and thawed repeatedly in their nest. However, when they were again frozen in the laboratory to almost −11° C, they did not survive thawing.

The turtles used a veritable cocktail of glycerol, glucose and amino acids as antifreezes and to regulate their body chemistry once frozen. Another surprise was that, unlike other animals that survive sub-zero temperatures, the turtles were able to produce their cryoprotectants rapidly in response to cooling.

—B.B.

JANET STORY

Canadian Painted Turtles are the first reptiles that have been shown to withstand freezing.

BRIAN M. BARNES

ROBERT BOLES

Arctic Ground Squirrels are the first mammals to have been shown to supercool to sub-zero temperatures without freezing. The cupped hands are holding a torpid squirrel, in an abnormal upside-down position.

Mammals Join the Sub-zero Club

Hard on the heels of the first-known reptile to survive freezing has come news of the first mammal to routinely handle sub-zero body temperatures.

The Arctic Ground Squirrel (*Spermophilus parryii*) does not follow the usual response of other hibernating mammals to extreme cold. Rather than burn extra metabolic fuel to create just enough body heat to hold the animal's body temperature above zero, the abdominal temperatures of hibernating Artic Ground Squirrels were found to regularly fall below freezing. One squirrel measured by Brian Barnes of the Institute of Arctic Biology at Fairbanks, Alaska, reached a record low temperature for a hibernating mammal: −2.9° C (*Science* 244: 1593; 1989).

But the squirrels did not actually freeze; they managed to supercool themselves for up to three weeks at a time. Nor did they produce biological antifreezes of any known kind. Exactly how they performed the feat remains a mystery.

Barnes was able to shed light, however, on why the squirrels might opt for supercooling. Arctic winters are so long and so cold that maintaining body temperature above zero would entail a large outlay of metabolic fuel. Barnes calculates roughly that, by supercooling, the ground squirrels cut their fuel consumption by up to a factor of ten and stand a greatly improved chance of seeing the light of spring.

—B.B.

Bob Beale, senior writer for the Sydney Morning Herald, is a regular contributor to QQC.

Butcherly Behaviour

Among birds, the shrikes or 'butcherbirds' (family Laniidae) are renown for their habit of impaling prey on pointed objects. Many species are brightly coloured and all have a sharply hooked bill for killing prey. The majority are endemic to Africa, also occurring in the northern temperate and Arctic regions. The 'cuckoo-shrikes' of Australia, although sporting a shrike-like bill and a drab cuckoo-like plumage, are not related to either group. Some but not all species share the shrike habit of impaling prey.

Several hypotheses have been suggested to explain the shrikes' 'butcherly' behaviour: impaling prey may aid in the manipulation and dismemberment of prey; it may increase the size of the exploitable food items; or it may serve as a larder, to be used in times of food scarcity. Although shrikes do dismember their prey, often small insects that do not require immobilisation for butchering and even inedible items such as snail shells are impaled. And, although shrikes do use the cache of prey as a larder, the fact that it is exposed makes it subject to thievery by other animals (kleptoparasitism) and thus unlikely to be the main function of impalement.

So what other reasons can explain the butcherbirds' behaviour? Reuven Yosef, from the Jacob Blaustein Institute of Desert Research in Israel, and his colleague Berry Pinshow noticed that male Northern Shrikes (*Lanius excubitor*) in the central Negev, Israel, are permanent residents, while the females arrive in January to mate and then depart after the broods fledge. Yosef and Pinshow therefore hypothesised that the conspicuous caches of prey might play a role in mate attraction (*Auk* 106: 418–421; 1989). If this were the case, one would expect concentrations of impaled prey to be greatest at the onset of the breeding season, that males with richer caches would pair before those with poorer ones, and that males with bigger caches would produce more offspring.

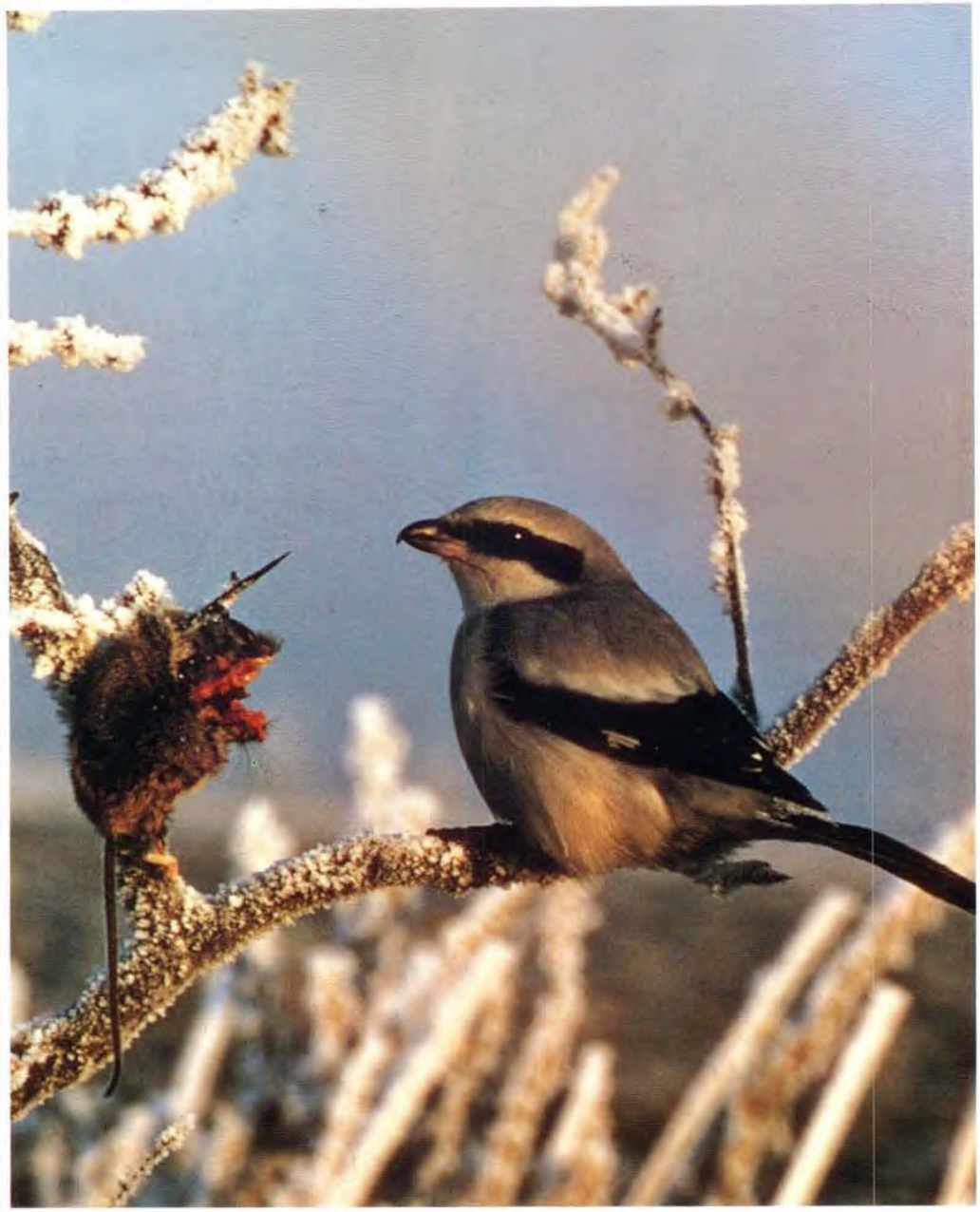
Twelve male Northern Shrikes were captured, colour-marked for individual recognition and released. Six of these served as controls, with their caches being counted weekly for a year; three had their caches regularly removed; and the caches of the other three were supplemented by increasing each by 25 per cent of the mean number of prey items in the control caches.

As predicted, the cache size of male Northern Shrikes was found to increase prior to the breeding season, peaking when nests were completed and eggs laid. Also, males with augmented caches paired with females about one month earlier than the controls; they fathered three broods each, compared to one or two broods fathered by the controls; and produced 87.5 per cent more eggs and fledged 60 per cent more young than did the control birds. Meanwhile the three males deprived of the caches remained unpaired, leaving the breeding area in mid-March.

It seems, therefore, that female Northern Shrikes do select males that have larger caches, the importance of the cache as a female-attracting device being emphasised by the fact that cache-deprived males failed to breed, and that the female's reproductive success increases when they pair with such males. Perhaps a large cache indicates to a female that its owner holds a territory abundant in resources, in which case reproductive success would be increased by virtue of the female being able to better feed herself and her offspring. Or perhaps a large cache indicates that the owner is more proficient at finding prey than other males in the area, and that males with larger caches generally have genes for higher viability, which would then be transferred to the offspring.

Female mate choice in other birds may be influenced by the size of a male's adornment (such as in birds of paradise) or by constructed decoration (as in bowerbirds). In shrikes, however, it is infuenced by the size of the male's cache and this may serve as a more direct measure of male or territory quality.

—G.H.



GUNTER ZIESLER/BRUCE COLEMAN LTD

A Northern Shrike with impaled prey. As far as females are concerned, the bigger, the better.

A two-headed polychaete worm discovered at Kurnell, New South Wales.

ANTHONY FARR

Two-headed Worm

Looking down a microscope and discovering a two-headed worm is something few people have experienced. In this respect you might say I have been privileged. A polychaete worm in the family Cirratulidae was part of a sample of live material taken from intertidal rock pools next to the sewerage outfall at Potter Point, Kurnell (New South Wales) in September 1989. This material was being collected to provide examples of live polychaetes for display in the Australian Museum's Discovery Room. The Potter Point area is an exceptionally rich marine habitat, apparently due to the high nutrient influx from sewerage discharge. Cirratulids prefer such areas as they feed on fine organic matter settling onto the bottom. Polychaeta is a class of the phylum Annelida (segmented worms) and is closely related to the Oligochaeta (earthworms) and the Hirudinea (leeches). Polychaetes are often quite bizarre in appearance but none recorded has been quite so odd as to have two heads side by side. Exactly how this animal came to have two perfectly formed and apparently functional heads is unknown but several possible explanations exist.

Some polychaetes have the capacity for asexual reproduction. This form of reproduction can involve the body subdividing and the missing parts regenerating to form a series of individuals joined head to tail like train carriages. The worm eventually breaks into fragments, each piece forming a new individual. So, during the process of asexual reproduction, polychaetes may be found with several heads, but normally one behind the other, not side by side.

Regeneration may also occur when a polychaete is damaged and loses part of its body. In this case the replaced segments start off smaller than the rest of the worm; only when all the segments are replaced do the new segments enlarge to match the old ones. In the polychaete family Syllidae it has been reported that regeneration of the tail involves the two sides forming separately and eventually fusing down the centre. It may be possible that the head of 'my' polychaete had been partially severed with regeneration of a new head and retention of the old.

However, the area from which this animal was collected brings to mind another troubling possibility—that of natural or artificially induced mutation. Many of our commonly used chemicals such as herbicides, fungicides and pesticides, as well as other manufactured chemicals, have been shown to cause mutations in marine organisms. The Lucas Heights Nuclear Reactor has a licence to discharge waste through this outfall and the area is surrounded by an oil refinery and several chemical plants. Unfortunately, however, nobody seems to know exactly what is being discharged through this outfall—legally or illegally. The discharge may be creating fascinating scientific phenomena, but these phenomena are at the base of a food chain that may eventually lead to chemical contamination of the food on our tables.

The most amazing thing is not that a two-headed worm has occurred but that it has been able to survive with two heads. Given the pollutants in our waterways, the odds are that such a mutation had to occur and be discovered sooner or later. Many other marine animals from similarly polluted areas may also be exhibiting strange mutations but at present little is known of what occurs in these habitats. The continental shelf waters, and especially the shallow coastal waters, are the oceans' most productive areas and are the areas most directly and drastically affected by human actions. Knowledge of these areas is minimal and our research is only scratching the surface in helping us understand and manage this vital natural resource.

—Rob Paterson
Australian Museum

MYSTERY PHOTOGRAPH

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

"Several references to Caley's bird collection posed a number of intriguing questions and opened the way to a journey of discovery."

CALEY'S BIRDS: A LITTLE KNOWN THING

BY JOAN WEBB
UNIVERSITY OF TECHNOLOGY, SYDNEY

GEORGE CALEY IS BEST KNOWN today among students of natural history for his exploits in exploration—he almost crossed the Blue Mountains in 1804—and for his extensive plant collections, now housed in the British Museum (Natural History) and other herbaria of Europe. Born in 1770 the son of a Manchester horse-dealer, Caley was a self-taught naturalist who, after making representation to Sir Joseph Banks in 1795, was sent out to New South Wales in 1800 as a botanical collector, in Banks' employ.

However, several references to Caley's bird collection posed a number of intriguing questions and opened the way to a journey of discovery. In a letter to the botanist Robert Brown in April 1813, Caley wrote that he had nearly 700 bird skins when he left New South Wales in 1810, although possibly this amounted to only 150 different species. What was the fate of these Australian bird specimens? And what was the background to a statement made by a Mr W.H. Mullens in *Museums Journal* (1918, vol. 17, pp. 132–137) that Caley (trained by Banks in the Botanic Gardens of London) was a zoologist sent out to Australia by the Linnean Society to collect birds?

After his return to England in 1810, Caley settled in his native Manchester, faced with the formidable task of cleaning his thousands of plant specimens damaged by mould and insects, and preparing his bird and other animal skins. Letters tell of his disenchantment with the weather and the people ("I am no longer an Englishman"), hours bent over his work table, and a lack of money that led to his decision to exhibit and sell his specimens. He set about preparing his skins, also much damaged by insects. His treatment was to put them in the oven, which "bids fair to be the best resource to fly to". He at first employed a stuffer but later found this too expensive and took to the task himself. By January 1814 he had stuffed about 200 specimens, still however in a half-finished state and "spoiling for want of being secured in cases".

The exhibition was held in Manchester in February 1815, and Caley admitted it was not a great success in terms of private sales, even though his personal opinion was that in the bird line even London exhibitions could not compare with his.

In 1817 the Linnean Society President, Sir James Edward Smith, announced at the meeting of 25 May that "an extensive and valuable collection of Quadrupeds, Birds and Reptiles, made by Mr. George Caley in New South Wales has been purchased by subscription...". So this is how Caley's birds came to be part of the Linnean Society's private natural history collection, which was kept in the Society's rooms in Gerrard Street, London, and herein lies the basis for the misconception that the Caley collection had been specifically made for the Linnean Society.

Today in the British Museum (Natural History)'s Sub-department of Ornithology at Tring, Hertfordshire, there is also a valuable collection of type specimens of Australian birds collected by George Caley in the years 1800–1810. However, it is indicative of the misconceptions concerning Caley that the Curator at Tring, Mr Peter Colston, expressed surprise in 1988 (pers. comm.) that the specimens were as old as 180 years, and had not been collected about 1860 as he had supposed. How did it come to be that George Caley is credited with a number of type specimens now in the British Museum and that they were obtained in the 1860s?

While the Caley bird specimens were in the possession of the Linnean Society, they were named and described by N.A. Vigors and T. Horsfield who, in the introduction to the 1827 publication, acknowledged that they were "indebted for much of this valuable information to Mr. Caley, who collected the greater part of the New Holland birds belonging to the Society, and who kindly allowed us to make use of his original notes...". In 1863 the Linnean Society decided to dispose of their natural history collection due to lack of space, and donated a large section to the British Museum. Seventy-two birds went to the British Museum (Natural History) and it was this transfer date of 1863 that led to the erroneous supposition at Tring that the specimens were circa 1860.

Discussions with Peter Colston in May 1989 confirmed that the 72 skins presented by the Linnean Society to the British Museum are all intact type specimens with 16 labelled as having been collected by Robert Brown and the other 56 being attributable to George Caley. One may well ask, are type specimens valuable? What is a type specimen?

The type of any organism (such as plant, animal, bacterium) is the specimen on which the description associated with

This Azure Kingfisher is part of the Caley Collection housed at the Liverpool Museum.

PHOTOS: NATIONAL MUSEUMS AND GALLERIES ON MERSEYSIDE

the original publication of its name is based. From that point of view, it is important not only for historical reasons (forming part of a country's archives), but it provides a fixed point for reference and allows our scientific nomenclature to be stabilised. Among George Caley's type specimens are many of our most common birds, including the Fan-tailed Cuckoo (*Cacomantis pyrrhophanus*), Sacred Kingfisher (*Halcyon sancta*), Yellow Thornbill (*Acanthiza nana*), Australian Raven (*Corvus coronoides*), Brown Falcon (*Falco berigora*) and Nankeen Kestrel (*Falco cenchroides*).

A rare specimen collected by Caley was the Red Goshawk, still in good condition in the Ornithology Sub-department at Tring. Vigors and Horsfield named it *Haliaetus calei*, and the label on the specimen says "Type of *H. cayleyi*, *Erythrotriorchis radiatus* (Latham)." At the end of the description there is a tribute in Latin to George Caley, translated "This species, which among many others we owe to his labours, is named after Mister George, an erudite traveller, a most wise observer...".

Further research by the author in May 1989 led to the discovery of six Caley bird specimens in the Liverpool Museum, Merseyside (England). The trail started with a short reference in a letter between Caley and Robert Brown in September 1812 to a certain Lord Stanley of Knowsley who was interested in acquiring some of Caley's birds. A letter sent to the present Lord Stanley, the Earl of Derby, on 24 April 1989 brought a reply three days later: "I can assure you we no longer have any bird skins. The only possible place where they might be would be in the Liverpool Museum. When the Zoo was given up here in 1851 a lot of things did go to the Museum."

A letter to the Liverpool Museum brought a reply from Miss Clem Fisher, Curator of Birds and Mammals, stating that the Museum did receive 20 birds as part of the Caley collection through Lord Derby, but only six can be located now. These are two specimens of the Pallid Cuckoo (*Cuculus pallidus*), two specimens of the Nankeen Night Heron (*Nycticorax caledonicus*), and one specimen each of the Maned Duck (*Chenonetta jubata*) and Azure Kingfisher (*Alcyone azurea*). Miss Fisher enclosed a photocopy of the relevant page in Lord Derby's original register, where he wrote "obtained July 19, 1813, from Mr. Geo. Caley who brought the skins from N.S.W.".

The Earl of Derby, apart from his minor part in the Caley story, is perhaps best known among Australian ornithologists for his part in the production of Latham's *Supplement to the general synopsis of birds* (1801); this work was based upon three volumes of paintings of Australian birds lent to Latham by the Earl of Derby, who acquired them from the wealthy amateur naturalist A.B. Lambert on the latter's death.

George Caley deserves a place among the colony's earliest ornithologists; he did not publish his findings, like Surgeon-General John White or John William Lewin, but his extensive field notes and accurate observations on the birds he saw and collected contributed in no small way to the dissemination of knowledge of Australian birds through the classic Vigors and Horsfield paper; Caley, described by Robert Brown as "an acute and indefatigable botanist", deserves no less a tribute for his work as an ornithologist, a man who truly "cultivated nature in her secret place". ■

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Ms Joan Webb is Lecturer in Science Education at the University of Technology, Sydney, Kuringgai Campus. She has published several papers on George Caley and is currently engaged on a Ph.D. thesis relating to George Caley's contribution to Australian natural history.

A Maned Duck from the Liverpool Museum's Caley Collection.

"The fishing regulations for freshwater crayfish are in urgent need of alteration, and increased policing of the rules is needed."

TASMANIAN GIANT FRESHWATER LOBSTER

BY PREMEK HAMR
ZOOLOGY DEPARTMENT, UNIVERSITY OF TASMANIA

AUSTRALIA'S FRESHWATER CRAYFISH fauna is diverse and includes some of the largest and most colourful crayfishes in the world. In Tasmania we are fortunate to find the largest known crayfish and freshwater invertebrate in the world. *Astacopsis gouldi*, the Giant Freshwater Crayfish or 'Lobster' as it is called in northern Tasmania, can attain a weight of more than four kilograms and a total length of over half a metre. The species is found only in Tasmania and is restricted to the north of the State where it can be found in streams, rivers and reservoirs draining into Bass Strait as well as in the Arthur River system in the extreme north-west. This spectacular animal was first described by F.G.S. Gould in 1870 but has been studied little since.

Astacopsis gouldi prefers cool water, well shaded by stream-side vegetation. It can be found in deep pools sheltering under submerged rocks and logs as well as in shallower swift-running sections. The natural diet of *A. gouldi* consists of semi-decayed wood, aquatic insects, leaves and detritus but it also has a voracious appetite for animal flesh. This together with its large size makes fishing for this crayfish a popular pastime. The resulting recreational fishery is controlled by the Inland Fisheries Commission under Tasmanian Fisheries legislation. The regulations state that the minimum legal size is 130 millimetres carapace (body) length, that females carrying eggs must never be taken, and that a maximum of 12 crayfish may be taken by any one person in one day. The fishing season begins in early August and ends in late April. The use of nets and traps is prohibited but baited lines and landing nets may be used.

In 1969 a reserve, in which no fishing at all is allowed, was declared for the species at Caroline Creek, north-western Tasmania. The reserve is an easily accessible three-kilometre portion of the lower reaches of the creek. A recent survey by Dr Horwitz of the University of Tasmania and myself showed that old fishing lines can be found throughout the reserve and that a few crayfish are actually present in the creek. More importantly, none of the animals caught during this survey was of legal size. Overfishing and poor management over the years appear to have contributed to the decline of the population in the reserve, which should thus not be regarded as an efficient conservation measure.

The Giant Freshwater Crayfish is the largest known crayfish and freshwater invertebrate in the world.

Recently there has been concern from scientists and fishermen over the status of the species. This situation has led to a 'vulnerable' listing in the IUCN Invertebrate Red Data Book. Dr Forteath from the Tasmanian State Institute of Technology studied the aquaculture potential of *A. gouldi* and concluded that it is "not a suitable animal for intensive farming" due to slow growth rates and intolerance of elevated temperature. He also pointed out that females carrying broods of young are particularly vulnerable during the fishing season and he suggested the species is declining.

Over the past four years I have been studying the biology of *A. gouldi* as part of my Ph.D. dissertation. The results show that the giant crayfish grows very slowly, reaches maturity at a late age and the largest specimens may be as old as 30 years. Furthermore the females reproduce only every second year. My study has also shown that fishing is widespread and contributes to an overall decline of large, reproductively mature individuals. Easily accessible sites are most affected by overfishing with the proportion of reproductive individuals in catches dropping to as low as five per cent of the total (in less accessible populations the proportion may be as high as 50 per cent). Local fishermen claim that increased poaching of egg-bearing females and animals below the size limit is the cause. However, the number of convictions made under the regulations does not reflect this view. In the last five years there have been only two crayfish-related convictions compared to over 400 for fish-related offences.

In view of the above findings it is evident that the fishing regulations for freshwater crayfish are in urgent need of alteration, and increased policing of the rules is needed. My research has shown that it is difficult to catch 12 legal-sized animals per day even in the densest populations. Such a large catch can damage, if not decimate, the reproductive portion of populations, especially in small creeks and heavily fished, accessible areas. The present reserve at Caroline Creek is clearly inadequate due to the poor state of its population. A new reserve should be gazetted in a more appropriate location and strictly policed.

Freshwater crayfishes have been an important part of Australian and Tasmanian history; they were well known to Aborigines and the early European explorers who appreciated them not only as a popular food source but also as animals of considerable scientific interest. That the systematic depletion of existing populations of the Giant Freshwater Lobster should continue to occur is an indictment of the current, neglectful management strategies. It would be a tragedy to allow this unique Tasmanian to join the growing ranks of Australian species on the path to extinction. ■

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Mr Premek Hamr is a Ph.D. student at the University of Tasmania. His research interests centre on decapod biology and evolution. He has been studying freshwater crayfish life history and ecology in Australia and Canada for the past eight years.

PREMEK HAMR

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"Lotus seeds are said to be extraordinarily long-lived, sometimes germinating after more than 100 years."

THE ASIAN CONNECTION

BY TIM LOW
NATURE WRITER

MAGPIE GEESE AND JABIRU STRUTting through the sedges of Kakadu's wetlands are one of the endearing images of wild Australia. What few people realise is that the sedge at their feet is a well-known Asian vegetable—the Water Chestnut (*Eleocharis dulcis*). Deep in the mud beneath the plants lie small starchy tubers with a crisp sweet taste (*dulcis* means sweet). In Chinese restaurants in Australia these tubers, imported from Asia in cans, are served in stir-fry dishes. The sedge is cultivated throughout South-East Asia in manure-rich, flooded paddocks. Since 1988 the Queensland Department of Primary Industries has been cultivating Water Chestnuts experimentally near Brisbane, and a number of Queensland farmers have expressed interest. There is one small chestnut farm at Caboolture supplying the Brisbane markets.

The Water Chestnut is one of many edible plants native to both Australia and Asia. Better known in Australia as Tall Spike Rush or Bulkuru, it was an important vegetable of northern Aborigines who also used the stems for weaving dilly bags. Local Australian plants have much smaller tubers than their cultivated counterparts. The tubers are a staple of Magpie Geese, and more recently of feral pigs, which during the dry season shovel vast areas of mud in their food quest, wreaking environmental havoc.

Around the edges of Kakadu's lagoons, twining amongst the Water Chestnuts, there grows an aquatic creeper closely related to sweet potato (although it does not sprout tubers). This is Kang Kong or Water Spinach (*Ipomoea aquatica*), another popular Asian vegetable. In South-East Asia this plant is widely cultivated in ponds and even in the most polluted of inner-city canals, where it forms thick mats of lush foliage. The young leaves and shoots are sold in bundles in markets as a soup vegetable. Rich in vitamin C, they yield up to 100 milligrams of ascorbic acid per 100 grams, twice that of oranges. Aborigines did not eat many kinds of wild leaves and apparently made no use of Kang Kong.

Kang Kong is closely related to the garden morning glories (*Ipomoea* species) and its flowers look much the same.

Tall Spike Rush or Water Chestnut grows in seasonal swamps where the climate is monsoonal. During the dry season its foliage, consisting of hollow tubular stems, dies away and the plant survives as underground tubers awaiting the next Wet Season.

PHOTOS: TIM LOW

Yet another Asian vegetable is found in Kakadu's lagoons—the famous Sacred Lotus (*Nelumbo nucifera*). A popular motif in Hindu and Buddhist art, its spectacular pink flowers are often seen sprouting in ponds adjacent to temples in India, Indochina and Japan. Almost every part of this plant can be used as food. In South-East Asia the seeds are eaten boiled, roasted or raw; the young rhizomes are cooked or pickled; young leaves and leaf stalks are eaten; and in Indochina even the flower stamens have been used to flavour tea. As well, the enormous leaves are used as wrappers and in Thailand dainty cigarettes have been rolled in the petals.

The lotus was a popular food of Aborigines. The seeds were picked from the big flat pods and nibbled raw or roasted. The inner leaf stalks and the roasted rhizomes were also eaten.

Like the Water Chestnut and Kang Kong, the lotus is considered a native plant in Australia but its distribution is patchy. Widely separated colonies lie scattered across northern and eastern Australia as far south as the Darling Downs. The lotus was more common in the past when Australia was wetter. The southernmost colony, at Nangram Lagoon near Chinchilla, recently died out. I am hopeful that it will someday reappear, for lotus seeds are said to be extraordinarily long-lived, sometimes germinating after more than 100 years.

Other Asian vegetables found wild in Australia include the Round Yam (*Dioscorea bulbifera*), Taro (*Colocasia esculenta*), Cunjevoi (*Alocasia macrorrhizos*), Mung Bean (*Vigna radiata*) and Wild Melon (*Cucumis melo*). Wild Rice growing in the Gulf of Carpentaria was once thought to be a native variety of the rice of commerce (*Oryza sativa*) but is now considered a native species (*O. meridionalis*).

It is likely that early Chinese immigrants to northern Australia harvested Kang Kong and other vegetables. On a trip to Darwin in June 1989 I saw an old Chinese woman in the centre of town collecting young Banyan Fig (*Ficus virens*) leaves "to cook with chicken", and was told by a Thai woman that "waterlily" stalks were harvested from lagoons to the south. I contacted a Chinese community leader who said that in times past a number of wild plants were gathered as foods and medicines. He offered to arrange a meeting with knowledgeable elderly people, but the Tiananmen Square massacre intervened. He was called away to Canberra to see the Prime Minister and the meeting never eventuated. ■

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

The enormous flower of the Sacred Lotus, measuring up to a quarter of a metre across, is a favourite of nature photographers. The seed pods produced after the petals fall away are sold by florists for floral arrangements.

"Hanbury Brown was the original 'boffin', that beamish backroom boy who fiddles away with wires and glass and comes up with clever gadgetry."

THE ORIGINAL BOFFIN

BY ROBYN WILLIAMS
ABC RADIO SCIENCE SHOW

HIS FAREWELL PARTY WAS ATTENDED by the Minister for Science Barry Jones, the Chancellor of Sydney University Sir Herman Black and scores of other academic luminaries. He said goodbye in typical fashion: some jokes, several graceful tributes and the explanation that he'd come to Australia for just a short time, to set up an observatory, but the chap who was to run it deserted so Hanbury Brown had to stay. Months became decades. All the while the professorial visage that could seem stern in repose was brimming with little grins and twinkles. Robert Hanbury Brown AC, FRS, FAA is irrepressibly pixilated.

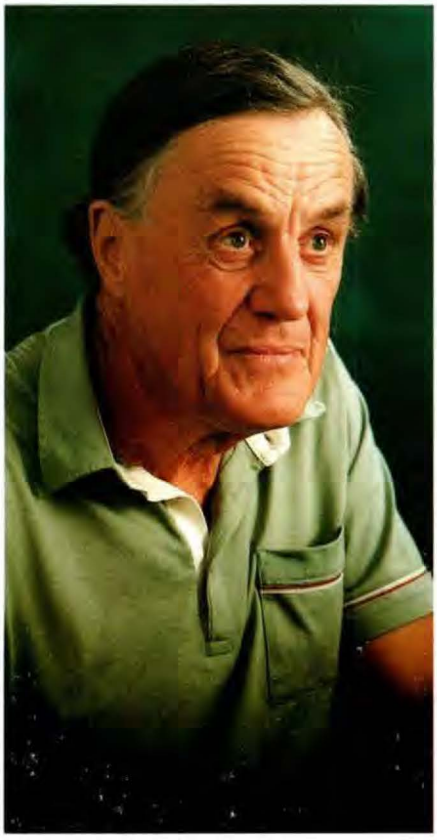
He was very sad to go, but back to England it had to be for a bit of writing in the cottage in Hampshire, some visits to India, which he knows well, and some astronomy. He'll return to Jodrell Bank, near Manchester, where he once helped his relation Sir Bernard Lovell set up the giant radio telescope. And, no doubt, he'll see some of his old colleagues from radar days during the war (although many of them are now in Australia, having helped establish our own peerless astronomical effort in the 1950s and '60s).

In fact, Hanbury Brown was the original 'boffin', having been dubbed such by someone as typifying that beamish backroom boy who fiddles away with wires and glass and comes up with clever gadgetry. But that's exactly what Hanbury is not; it's precisely what he deplores in the popular image of the scientist.

"A dapper little man but with shiny elbows
And short keen sight, he lived by measuring things
And died like a recurring decimal
Run off the page, refusing to be curtailed."

The disparaging lines by Louis Macniece are taken even further by Wordsworth:

"Sweet is the love which Nature brings;
Our meddling intellect
Mis-shapes the beauteous forms of things:
We murder to dissect."



Professor Robert Hanbury Brown.

In his splendid book *The Wisdom of Science* (Cambridge University Press, 1986), Hanbury quotes both Macniece and Wordsworth and then refers to William Blake: "May God us keep from single vision and Newton's sleep." He comments: "But in practice people don't look at the world only one way and most scientists whom I know have certainly not lost their appreciation of the 'beauteous form of things' any more than musicians lose their appreciation of music because they dissect it into notes and rules of harmony. To be able to see a rainbow both as a beautiful sight and as an example of optical dispersion, or to be able to read the score of a symphony while listening to it, is more likely to enrich than to 'murder' our appreciation of its 'beauteous form'."

So Hanbury Brown insists that science is the handmaiden of enlightenment, that it has contributed more than any other human activity to an aesthetic enjoyment of the world around us. We are enriched more by understanding than by mystery. He goes so far as to say that this approach will even enhance spiritual wisdom: "It may be that, for the critical mind, science is an easier road to God than theology!" Elsewhere he writes: "...furthermore I shall argue that we must make use of science to enlighten our religious beliefs."

I once asked Hanbury whether he's a Christian and he didn't know how to answer me. He's more interested in the way modern science shows how subtly nature is organised and how it invites us to ask how it came to be.

Yet, he also quotes the scientist Stephen Weinberg: "The more the Universe seems comprehensible the more it seems pointless." Hanbury counters this view by referring to Sir Arthur Eddington's quaint story of "the ichthyologist who explored the life of the ocean with a net which had a two-inch mesh. He came to the conclusion that all fish are longer than two inches!" Science is certainly precise in its enquiry. Without a proper focus, you cannot reach a valid conclusion about that small aspect of nature (such as fish) that you are studying. However, one must then take the investigation to a higher level (such as asking how the fish are linked to other living things and how their particular biosphere remains stable). "The belief that science is concerned only with facts and has nothing to say about values is misleading and harmful", he says.

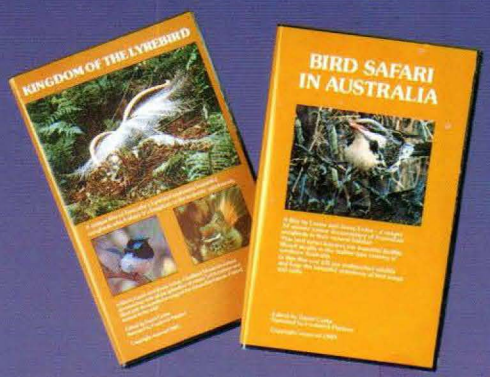
That's why he wrote *The Wisdom of Science*. Having been Professor of Astronomy at the University of Sydney for so many years, and having served a spell as Vice-president of the Australian Academy of Science (he turned down the chance to be President) and as President of the International Astronomical Union, Hanbury Brown has turned at last to musing about the place of science in our culture. And not before time. He is worried about the anti-intellectual tenor of our age.

Perhaps these two thoughts sum up his present view. "Our civilisation is often referred to as 'scientific', but that is only true of our gadgets and not of our ideas." And "As I see it, one of the greatest dangers to any society is that it should become too credulous."

I do believe we have lost one of our scientific treasures. Let's hope he comes back often. ■

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

AUSTRALIAN SONGBIRDS



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"The most fascinating thing about insect wings is not the way in which they conform to the conventional laws of aerodynamics, but the manifold ways in which they defy them."

INSECTS IN FLIGHT:

THE ULTIMATE SAILING MACHINES

TEXT AND PHOTOGRAPHY
BY JOHN BRACKENBURY
DEPARTMENT OF VETERINARY ANATOMY
UNIVERSITY OF CAMBRIDGE

RECENT YEARS HAVE SEEN A REVOLution in our understanding of insect flight. This has been due in part to the development of extremely sensitive instrumentation, which has made it possible to monitor almost instantaneously the energy consumed by

A Small Skipper (*Thymelicus sylvestris*) at the very beginning of upstroke. Note the bending of the wing tips under air pressure.

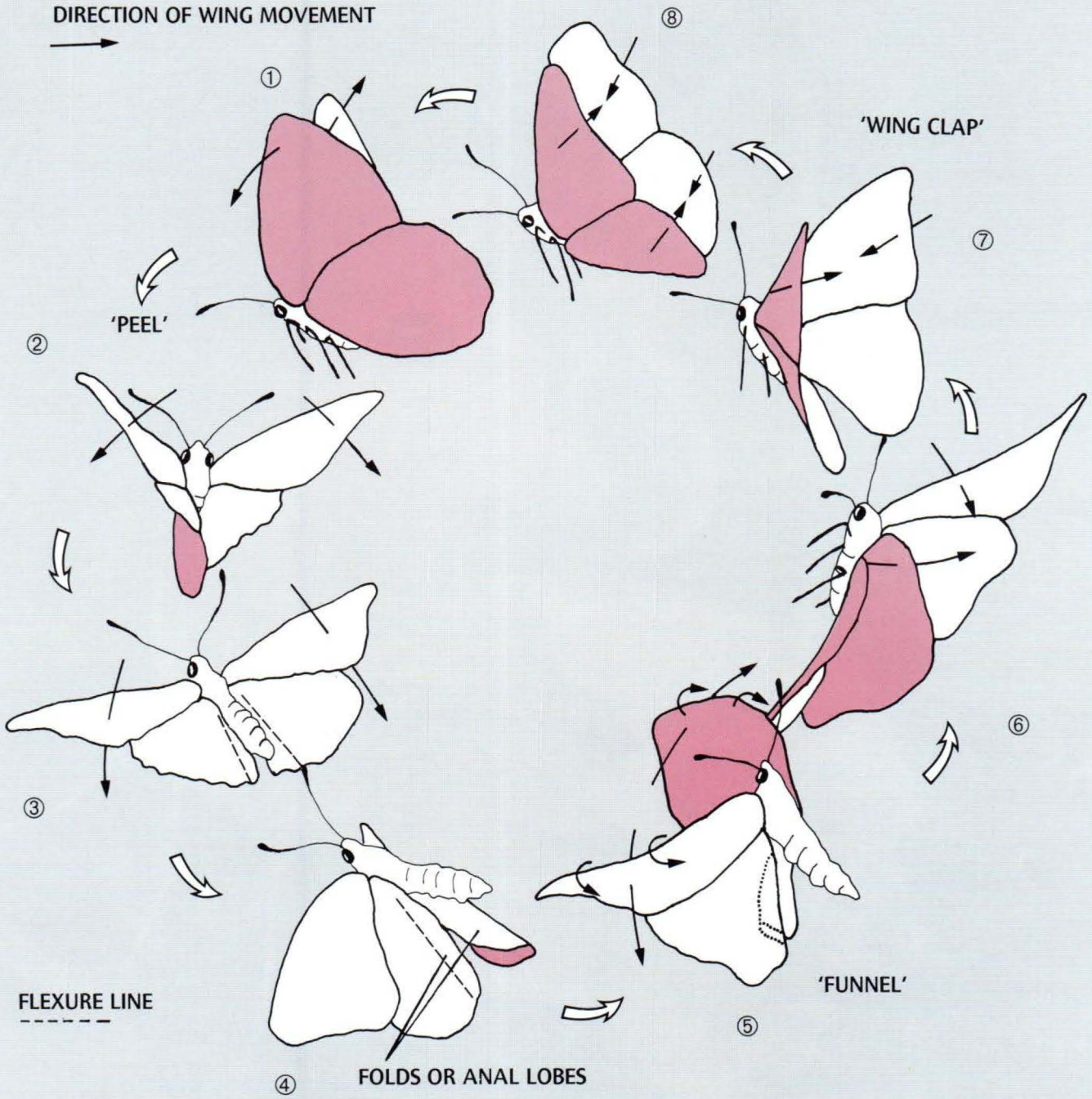
The forewings of this Marbled White (*Melanargia galathea*) are just beginning to peel after being 'clapped' in the mid-line at the end of the upstroke. (See number 1 in stroke cycle diagram.)

insects as they are flying in the laboratory. One thing has become very clear: weight for weight, flying insects generate more power than any other moving animal, by at least an order of magnitude. In the energy stakes elite human sprinters, thoroughbred racehorses, and antelopes honed to a peak of efficiency on the African plains, all lie well below the Housefly, the Honeybee and the humble Cockchafer. Even birds prove to be unexceptional: contrary to popular belief, the rate at which flying birds consume energy is no greater, on a weight for weight basis, than in a greyhound or any other good mammalian runner. The fact is, birds and mammals both have the same kind of muscle and it just cannot match the capabilities of insect flight muscle. Much debate is now underway about the nature of the biological machinery that allows insects to generate metabolic energy at such phenomenal rates. But part of the debate has also been a reappraisal of the mechanical processes involved in flight.

The main problem with earlier theories of flight mechanics in insects was that they modelled the wing on a fixed aerofoil. This is the classic technique that had been used to successfully analyse soaring and gliding flight in birds. As long as the wings remain stationary, or movethrough only small angles, it is fair to treat the bird as if it were an aircraft. Once certain physical quantities such as the aspect ratio (the ratio of the length of the wing to its width), angle of attack (angle of the wing relative to the direction of the wind) and speed of movement of the wing—all fairly straightforward measurements to make—were known, it was relatively easy to apply standard aerodynamic formulae to derive estimates of the mechanical power output of the wings. One of the first insects to receive this analytical treatment was a desert locust studied by Drs Martin Jensen and Torkel Weis-Fogh of the University of Aarhuus in Denmark. The locust proved very amenable to the theory since its wings performed a quite simple stroke and underwent comparatively little change in shape during the stroke cycle. The values predicted for the lift coefficient (which relates the upward force produced on the wing to the velocity of the air past the wing), for example, bore good comparison with the actual values measured in flying locusts mounted on delicately balanced force transducers.

Difficulties arose, however, when attempts were made to extend the same methods to other insects. A catalogue of unruly species emerged. Perhaps the most celebrated case concerned the tiny parasitic wasp *Encarsia*, which was observed by Weis-Fogh to rise into the air from rest before its wings actually began to perform a stroke. Dragonflies were found to have wings that sculled through the air then paused, but most of the lift was generated during the pauses. And it was possible to theoretically conclude that the Honeybee could not fly because its wings were not big or fast enough. The wings of every insect examined in flight showed wide variations in their angle of attack throughout the stroke cycle.

These, and many other observations of flying insects using stroboscopic lighting or high-speed cinematography, demonstrated beyond doubt that the real wing behaves no more like a fixed aerofoil than a ship's sail behaves like a wooden board. The analogy, in fact, is appropriate. Dr Robin Wootton of Exeter University, England, captured the idea perfectly in the title of a lecture delivered to an audience of beekeepers in 1987: "Insects: the ultimate sailing machines". Like sails, real wings are highly flexible, deformable structures that can 'bow to the wind'. They can bend elastically either at right angles to the long axis, parallel to it, or around it as in torsion, and all of these deformations have an important part to play at different points in the cycle of movement. Furthermore, because the wing is an elastic structure, it can store



STROKE CYCLE OF A BUTTERFLY

One complete stroke cycle, where 1–4 represent the downstroke and 5–8 the upstroke. The undersurfaces of the wings are shaded pink. 1. Beginning of the downstroke; the forewings are beginning to peel. 2. Both fore and hind wings are descending and the hind wings are peeling; note the large wedge-shaped space above the peeling wings. 3. Peeling of the wings complete. 4. End of the downstroke; the hind wings have folded along the flexure line and temporarily halted their motion. 5. Start of the upstroke; the leading edge of the forewing is rolling outwards in the direction of the arrows while the anal lobes come together to seal off the lower end of the funnel-like space enclosed by the wings. Note the strong bending of the leading edge of the forewing. 6. Continued upward movement of the wings; the funnel-like space has been destroyed. 7 & 8. As the wings ascend they develop a conical camber shown by their concave upper surfaces. As this conical space contracts due to the inward movement of the opposite pairs of wings, air is expelled from behind. After 8, the wings come together in the mid-line (clap), then begin to peel as in 1.

JESSE MASTROGIANIDIS

Peeling in the Wood Nymph (*Idea hypermnestra*) viewed from the rear. Note that the front cover shot illustrates the same point, viewed from the front.

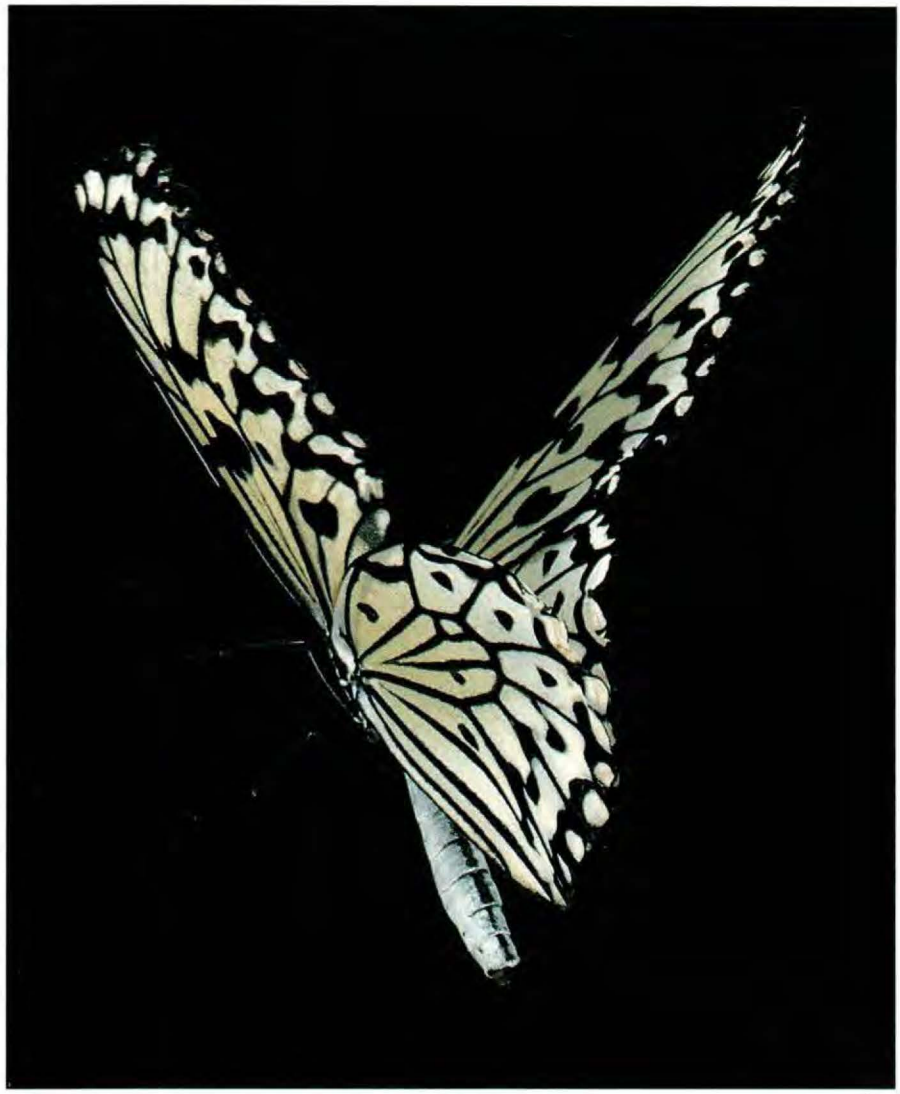
energy during one phase of the cycle then release it as useful mechanical work during another. In short, the most fascinating thing about insect wings is not the way in which they conform to the conventional laws of aerodynamics, but the manifold ways in which they defy them.

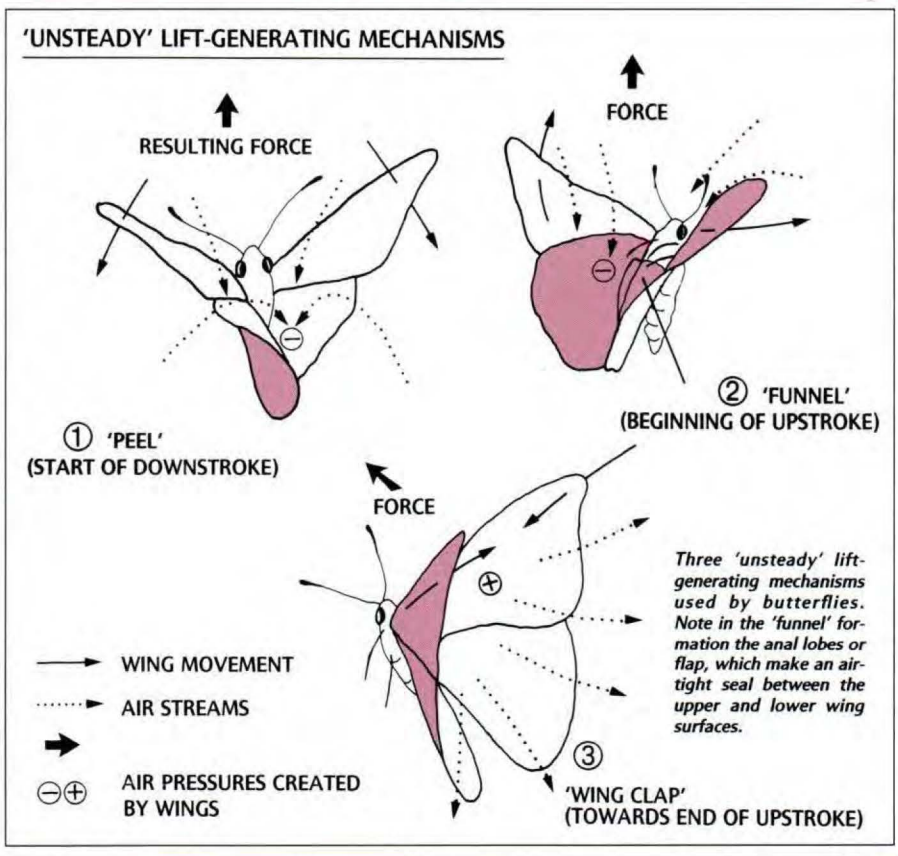
These discoveries have necessitated a major shift in the way we view the working wing: its plastic ability to deform under stress, far from being a design inadequacy, is the source of its strength. A 'floppy' wing can exploit novel mechanisms of lift generation that have no counterpart in fixed-wing design, and yet yield lift coefficients two or three times as high as those found in a rigid wing of the same dimensions.

No insects exemplify the concept of 'fluid' wings more than the butterflies. There is barely a moment in the wing cycle of these insects when the wings can be said to behave like simple aerofoils. When you examine pictures of butterflies in flight, you are struck by the 'moving curtain' appearance of the wings, yet these delicately rippling surfaces can generate enough force to accelerate a large specimen from rest to a height of two or three metres in a fraction of a second: a classic case of elegant, lightweight design linked with remarkable strength and resilience.

HIGH-SPEED STILL PHOTOGRAPHY offers the opportunity of studying these dynamic qualities of butterfly wings on a far higher scale of image resolution than is possible using high-speed cinematography. But the technical requirements are possibly even more daunting. The first indispensable requirement is a flash system capable of delivering sufficient light over a period of one ten- or twenty-thousandth of a second to provide proper exposure for a small subject on slow film (ASA rating 25, 50 or 64). This will stretch the capabilities of even the largest commercially available hammerhead flashguns. But they can do the trick, if you set the power ratio at 1/32, 1/64 or 1/128 of the nominal output in order to obtain the flash speed, and if you position the guns close enough to the subject to secure the necessary illumination. Much more powerful flash units are available from specialist manufacturers and these are capable of delivering a minor thunderbolt of light over as little as one forty-thousandth of a second, but they are costly and unwieldy. However, in some cases they may be the only choice. If you are interested in freezing the motion of the wings of a butterfly, which beat at

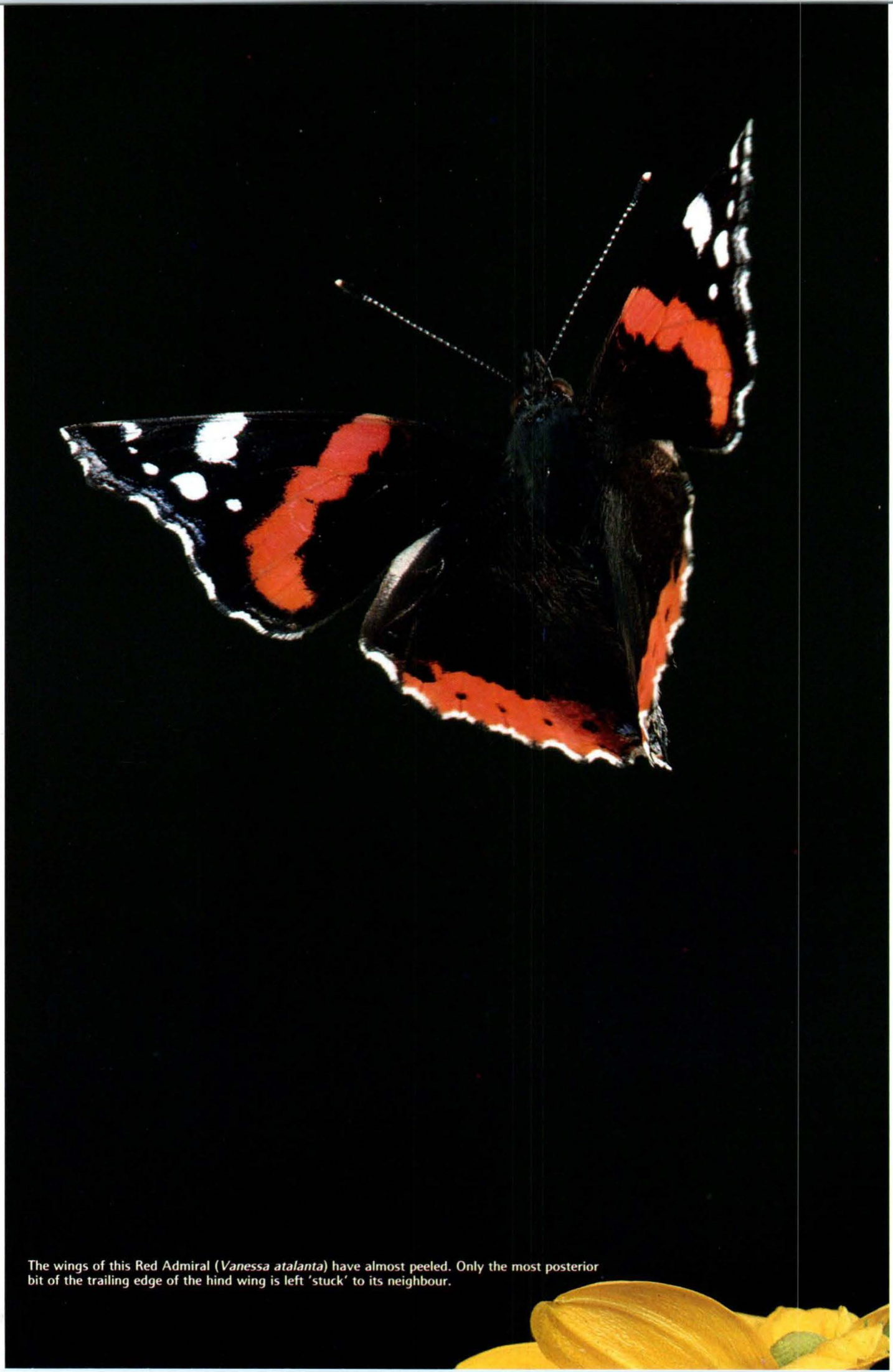
◀ The peel has spread to the Meadow Brown's (*Maniola jurtina*) hind wings. (See number 2 in stroke cycle diagram.)



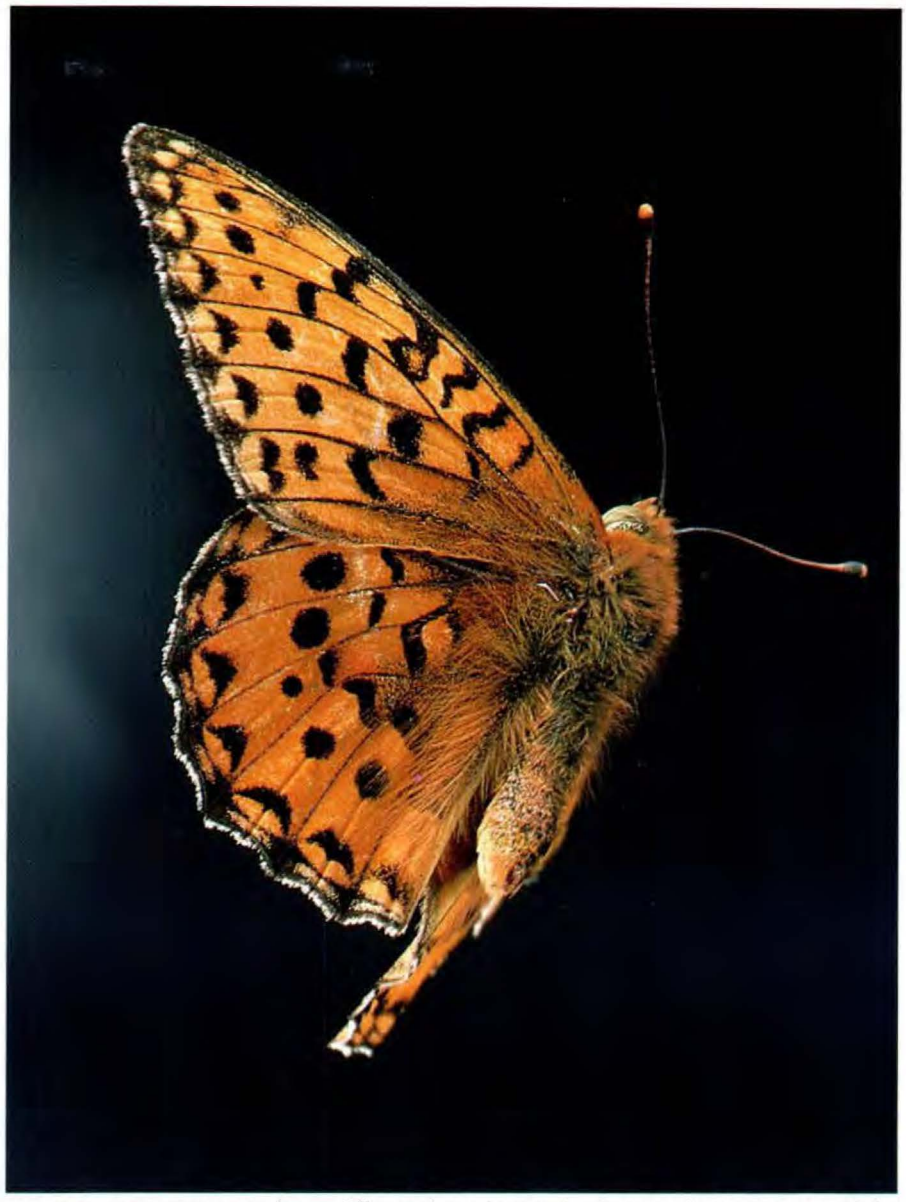


Three 'unsteady' lift-generating mechanisms used by butterflies. Note in the 'funnel' formation the anal lobes or flap, which make an air-tight seal between the upper and lower wing surfaces.

JESSE MASTROGIANIDIS



The wings of this Red Admiral (*Vanessa atalanta*) have almost peeled. Only the most posterior bit of the trailing edge of the hind wing is left 'stuck' to its neighbour.



A Dark Green Fritillary (*Mesoacidalia aglaja*) at the point of stroke reversal (downstroke to upstroke). Note the 'hinge' or flexure line along which the hind wing is folded. (See number 4 of stroke cycle diagram.)

less than ten times per second, then an exposure of one ten-thousandth of a second will be adequate. But in the case of a small fly, with wings buzzing at several hundred cycles per second, only the fastest flashguns will achieve satisfactory results.

Having sorted out the lighting, the next problem is to photograph the insect. After a few trials you will be persuaded beyond doubt that you need help—desperately. Imagine the scene: a butterfly performs an obliging run straight past you at a modest speed of 15 kilometres per hour. You are poised one or two metres away, eye pressed to the viewfinder, finger hovering over the shutter-release button. The head of the moving butterfly appears at the side of the viewfinder. (For the purposes of the argument you are also in a time warp and can actually 'see' the head of the butterfly; in practice the whole event is so rapid that you see nothing.) The signal travels from your eye to your brain, a second signal travels from your brain to your hand, the shutter-release button is depressed, clockwork is activated in the camera, and finally the shutter slides open. The time delay between first sighting the butterfly and the shutter flying open is, let us say, half a second. The flash discharges but the subject is now two metres out of the frame of the camera. Tragically, one learns, the speed of human response and the speed of the camera activation both conspire to make the enterprise impossible.

There is only one solution: the flying insect must photograph itself. This means designing an automatic shutter system that will be triggered within a hundredth of a second by the insect when it flies through the focal plane of the camera lens. The most practical method of achieving this result is to position a light or laser beam at an oblique angle to the camera axis so that it intersects the focal plane of the lens at a point in the middle of the field of view. The beam is detected by a sensor, which activates the shutter whenever the beam is broken. The biggest hurdle is yet to come: persuading the butterfly to fly through the beam at the right point. You will be aiming to achieve a reasonably large, well-focused image on the film, and this inevitably means that you will be working within tolerances of a few millimetres. There are various ways in which you can try to optimise the flight path of the insect, but success finally rests on understanding the behaviour of your particular insect and that demands almost limitless patience. In a group of, say, ten butterflies, all of the same species and identical appearance, eight may be found to be completely uncooperative, one may cooperate once in a while, and the last one may just save you from total despair! Do not embark on this kind of adventure expecting success rates of 50 or even 20 per cent. You will have to settle for five per cent, or else turn to photographing trotting tortoises!

THE WING BEAT CYCLE OF A BUTTERFLY can conveniently be described by beginning at the end of the upstroke. At this point, the wings lie vertically above the body axis in contact virtually over their entire area. Butterflies are perfect exponents of the so-called 'clap and fling' method of lift generation. This is the best-known of the 'unsteady' aerodynamic mechanisms practised by flying insects ('unsteady' because they do not conform to 'steady' aerodynamic conditions; that is, based on fixed aerofoils). Broadly speaking, during the clap and fling the wings are first clapped together, then rotated outwards from the base. The result is that the wings open out from in front like the pages of a book, before beginning their descent. Air is drawn into the wedge-shaped space between the wings and sets up a circulation around the leading edges. This circulation is the necessary condition for lift generation in any wing, fixed or vibrating, and the result is that the wings can begin producing force even before they have started to move down as a whole.

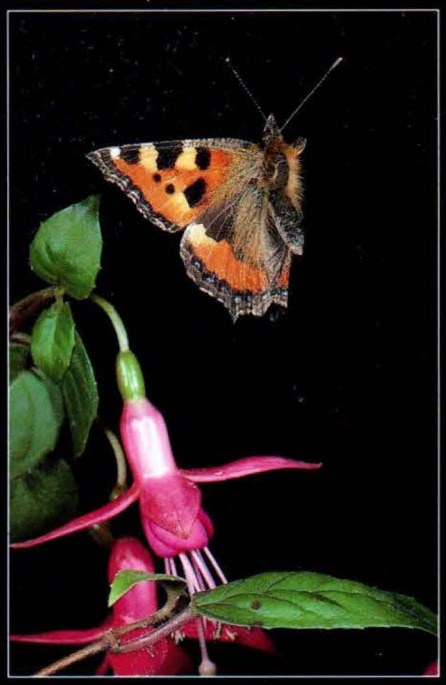
The production of a wedge-shaped space between the wings at the end of the upstroke is a way of bridging the potential dead spot in the stroke when the wings have just reversed their movement from up to down and have not yet achieved sufficient speed or translation to produce lift by conventional, 'steady' means. Unfortunately, as the wedge-shaped cavity enlarges there is a tendency for a bubble of air to break away from the wing surfaces, and this 'boundary layer separation' can impede lift generation. Butterflies have mastered this problem by steadily peeling the wings apart from the leading edge rather than abruptly opening the gap. This is one of the advantages of having a flexible wing.

The next trick shown by the butterfly in its flight cycle may be novel: at least no example of it has yet been described in

The tips of this Red Admiral's (*Vanessa atalanta*) forewings are approaching the mid-line towards the end of the upstroke. Note the pronounced 'reverse camber' on the wings. (See number 7 of stroke cycle diagram.)

other insects. The mechanism was described in an obscure Russian journal in 1981 and has almost completely escaped attention. Many of my own recent efforts have been directed towards identifying this same mechanism. At the completion of the downstroke the wings come together in the mid-line but do not touch, so that a gap remains between the tips of the opposite pairs. The wings now begin to move apart but the fore lead the hind wings in this movement. Next, the leading edges of the forewings begin to roll over so that their morphological ventral (lower) surfaces face forward. At the same time both the fore and hind wings flex gently in a ventral direction owing to the air pressure on their outer surfaces. The result is that during the early stages of the upstroke the wings form a tapering funnel-like surface, the mouth of which faces forward and is bounded by the leading edges of the forewings; the narrow nozzle of the funnel is formed by the posterior parts of the hind wings. The funnel is only short-lived since the wings continue to move outwards but, during the brief period of its existence, air is drawn into the front end of the funnel and the body experiences a suction force parallel to the axis of the funnel. If the axis is orientated vertically, as during take off, the suction force will boost the upward acceleration of the body and indeed the funnel may be the basis of the rapid 'vertical take-off' often seen in butterflies that have been alarmed. According to O. Bocharova-Messner and T. Aksyuk of the Soviet Academy of Sciences in Moscow, air may also be forced out of the narrow end of the funnel as a jet. These authors claim that this mechanism represents one of the first known instances of jet propulsion outside the marine environment (octopuses and squid, for instance, use it). This suggestion, however attractive, does not seem to withstand close scrutiny since the air pressure inside the funnel is negative, and not positive as it would need to be to produce a backwardly directed jet. It is more likely that the funnel represents a three-dimensional equivalent of the peel, although, because it is three-dimensional, it may be more efficient than the peel.

The most recent photographs I have obtained offer at least one more line of evidence in support of a positive role for the funnel. In those species that show funnel formation in the early stages of the upstroke, close examination of the hind wings reveals a region behind the first anal vein that does not move with the rest of the wing; rather it hugs the side and ventral surface of the abdomen throughout the stroke. A flexure line almost coincides with the anal vein, and the main part of the hind wing hinges up and down along this line. It seems at least possible that the main function of the expanded anal lobes of the hind wings is to form a flap-valve around the nozzle at the beginning of the upstroke, thereby sealing it against air leakage. Clearly more



A small Tortoise-shell (*Aglais urticae*) showing funnel formation of wings at the start of the upstroke. (See number 5 of stroke cycle diagram.)

The wings of this Dark Green Fritillary (*Mesacidalia aglaja*) have completely opened and the funnel has disappeared. Note the propeller-like twisting of the wings due to the backward rotation of the leading edge. (See number 6 of stroke cycle diagram.)

work needs to be done before the question about flight in insects can be resolved but the example of the butterfly illustrates how important it is to have minutely detailed information on what is happening to different parts of the wing surface during flight. This is where still photography is an invaluable tool and one has the feeling that the butterfly has many more secrets yet to disclose in the folds of its wings. ■

Suggested Reading

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Dr John Brackenbury is a zoologist and lecturer in the Sub-department of Veterinary Anatomy at the University of Cambridge, UK. His main research interests are in exercise physiology and animal locomotion.

BRUCE H. ROBISON

A flabby whalefish of the genus *Gyrinomimus* from off southern California. The huge mouth, large lateral line, dark colour and tiny eye, typical of cetomimid whalefishes, are all evident in this small 89-millimetre specimen.

"The low level of food seems to be one of the most important evolutionary forces in the harsh environment of the deep sea."

WHALEFISHES:

LITTLE FISH WITH BIG MOUTHS

BY JOHN PAXTON
FISH SECTION, AUSTRALIAN MUSEUM

THE 'DEEP SEA' CONJURES UP IMAGES of the most bizarre of animals: from long-necked sea-serpents to strange black fishes with huge mouths, tiny eyes and weird growths on the head and body. While the first is undocumented fantasy (perhaps based on the long arms of giant squid), the latter is real, based on two of the most common families of fishes in the bathypelagic zone (below 1,000 metres)—the whalefishes and anglerfishes.

In order to facilitate research, the world's oceans have been subdivided into layers. The epipelagic zone (or surface waters) comprises that part of the ocean

from zero to between 150 and 200 metres deep. It is the only area of the open oceans where marine plants occur and provides the source of food for all animal life below. Beneath this layer lies the deep sea, which has been further categorised into the mesopelagic, bathypelagic and abyssopelagic zones. The mesopelagic or twilight zone, from about 150–200 to about 1,000–1,200 metres, is the depth where downcoming sunlight is totally extinguished in clearest waters; the bathypelagic or true deep sea, from 1,000 to about 4,000 metres, is the zone of eternal darkness (except for occasional flashes of animal light or luminescence), relatively constant low temperature (2–6° C in the Tasman Sea, for example) and little food; and the abyssopelagic zone, deeper than 4,000 metres to the bottom (over 11,000 metres in some areas), is similar to the bathypelagic zone in its biophysical attributes. The distinction between bathy- and abyssopelagic is subjective and the latter zone probably arose from the human need to subdivide a volume of water that can be up to ten kilometres deep.

Together, the bathy- and abyssopelagic zones form the largest and most stable environment on Earth. There is no daily variation in light or temperature, and these and other features such as salinity and dissolved oxygen vary little even from month to month. Life in the deep sea is little affected by pressure, which increases one atmosphere (about one kilogram per square centimetre) every ten metres. The body cells of animals are filled with fluid, which is virtually incompressible. It is only when air spaces (such as lungs, sinuses or swimbladders) are present in the body that the effects of pressure are pronounced. While increased pressure may affect the rate of some chemical reactions, temperature has a much greater effect; biochemical reactions and the digestion of food are greatly slowed at temperatures near freezing.

Although there is about 100 times more aquatic living space below 200 metres than on the rest of the Earth combined, relatively few animals occupy this vast environment. Some 2,300 species of deep-sea fishes are known (ten per cent of the total fish species of the world), with less than 300 of these occurring in the bathy- and abyssopelagic zones. Here food is scarce, being derived from the photosynthesis of marine algae in the surface waters and being delivered in the form of 'rains' of dead animals, detritus and excreta from the zones above. Add to this scenario constant darkness and temperatures a few degrees above freezing, and it is then surprising that so many different kinds of animals have been able to survive at such great depths.

Bathypelagic fishes include a variety of eel families, including gulper eels and snipe eels, the crustheads or big scales, the fangtooths and the swallowers. The most dominant are the anglerfishes with ten families and some 100 species, and the single family of whalefishes (Cetomimidae) with nine genera and about 35 species. My study has centred on the biology and systematics of this last group of fishes, which is represented in all the oceans of the world.

The gulper eel *Saccopharynx lavenbergi* and snipe eel *Nemichthys scolopaceus* (inset) from off southern California. Both of these bathypelagic fishes have extraordinary mouths that enable them to exploit food items when they become available in the deep sea.

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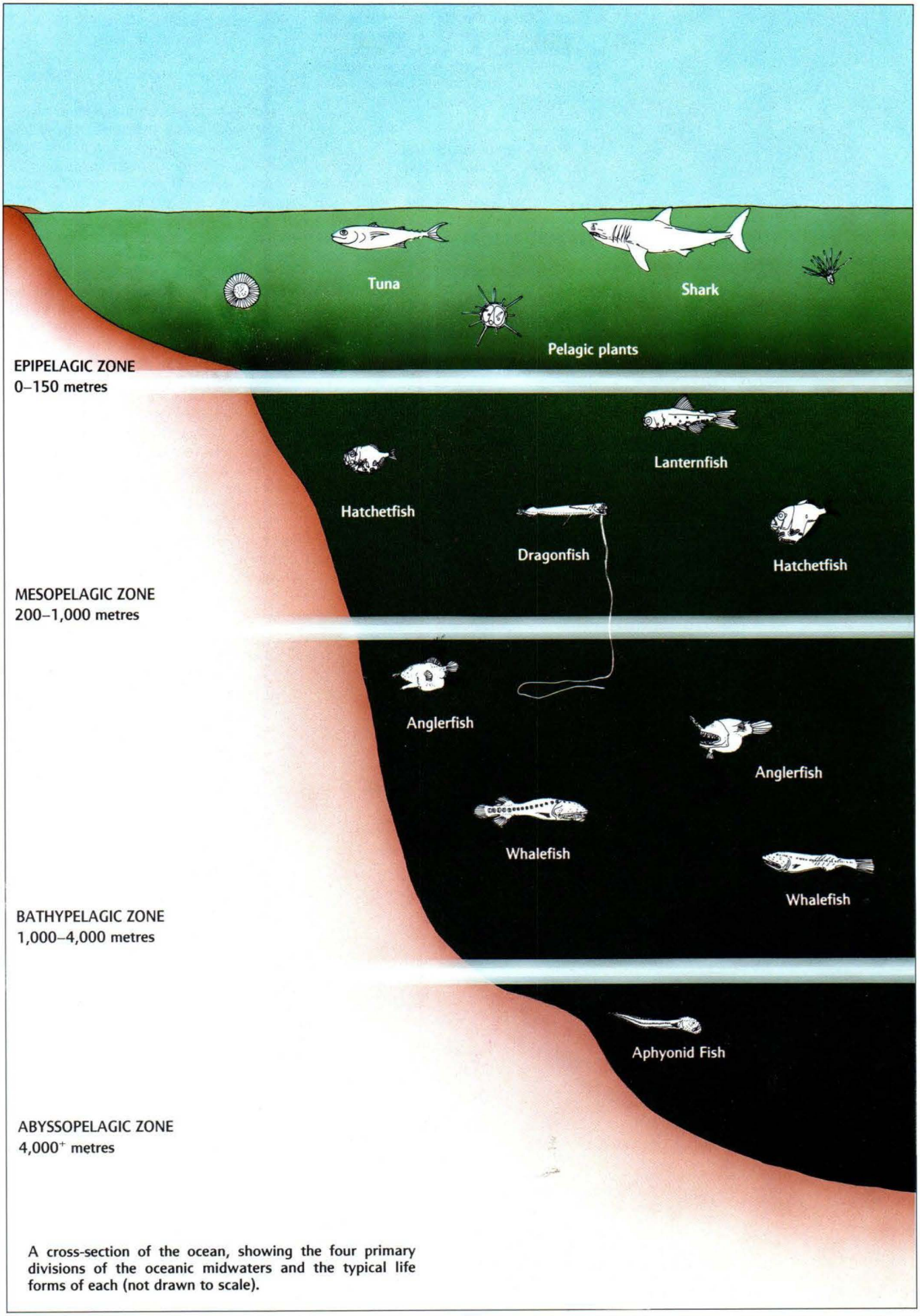
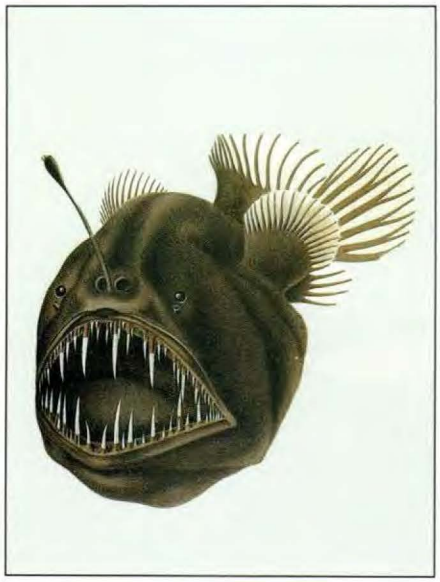
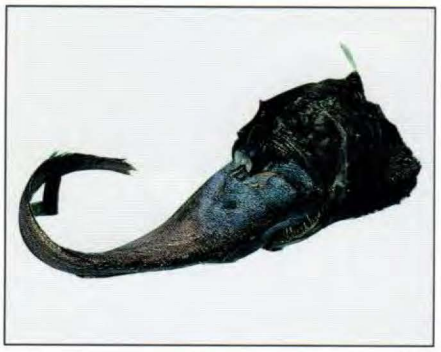


A cross-section of the ocean, showing the four primary divisions of the oceanic midwaters and the typical life forms of each (not drawn to scale).

IAN FAULKNER



The anglerfish *Melanocetus johnsoni* from the Indian Ocean. The illicium or fishing rod on the top of the head has a colony of luminous bacteria that produces light in the lure-like tip. The jaw teeth of anglerfishes are depressible inwards, but lock upright when prey attempt to escape. (From Brauer, 1906.)



The anglerfish *Diceratias bispinosus* with a partially swallowed rattail (*Ventrifossa johnboborum*). The specimens were found floating at the surface of the Bismarck Sea off New Ireland, presumably brought from the depths by the gases of bacterial decomposition. Although the meal was clearly too large for the anglerfish (the snout of the rattail is at the far right, the tail of the anglerfish above the centre of the body), the rattail could not be disgorged due to the locking upright teeth.

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WHALEFISHES ARE NAMED FOR THEIR shape, not their size, as the largest is only 40 centimetres long (most deep-sea fishes are even smaller, due to the lack of available food). Whalefishes have a large head, an enormous mouth, and fins placed far back on the body. The posterior placement of the fins allows a large space for the stomach; other characters such as lack of ribs, body scales and pelvic fins also allow for greater expansion of the stomach. The weakly developed pectoral girdle (the bony arch supporting the forelimbs or pectoral fins), with only a single attachment point from the skull rather than two as in most fishes, also allows expansion as food is swallowed. All of these features appear to be adaptations for consuming a single large meal, such as a large fish, when one becomes available. Unfortunately few examined whalefishes have had any stomach contents with which to test the hypothesis. Either the stomach contents are regurgitated in the net during capture (however there is no air-filled swimbladder to expand, which causes regurgitation during ascent in some fishes), or food is so scarce that bathypelagic fishes have empty stomachs most of the time. Surprisingly, those few whalefishes with identifiable food in the stomach were found to contain many small shrimp-like crustaceans. Thus the original supposition, that food would consist of large fishes (as is the case for anglerfishes and swallowers), appears wrong. Nevertheless, the combined features do allow for expansion of the stomach whenever food is available. The low level of food seems to be one of the most important evolutionary forces in the harsh environment of the deep sea.

Other striking features of whalefishes are the sense organs. Not surprisingly in continual darkness the eyes are small and less important sensory organs than those

The fangtooth *Anoplogaster cornuta* from off southern California.

BRUCE H. ROBISON

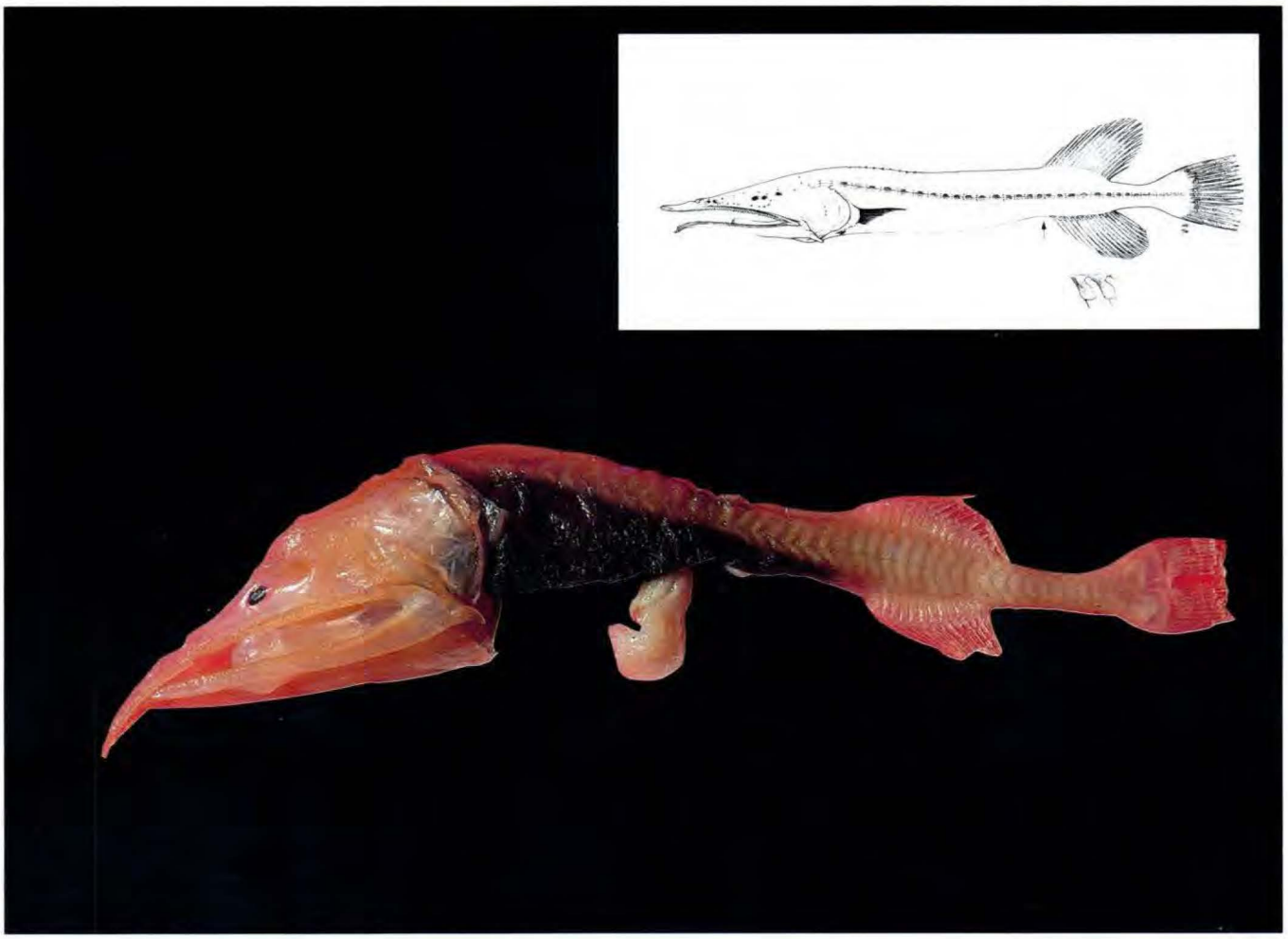
of fishes in the photic zone (where photosynthesis occurs). Whalefish eyes display allometric growth; that is, not growing at a constant rate with the rest of the body. With the exception of one species, the eyes of whalefishes never exceed two millimetres in diameter and lack a hard spherical lens typical of most fish eyes. The lens is presumably present in the larvae and smallest juveniles (no specimens less than 23 millimetres have been found), and degenerates after this stage; degenerated lenses have been found in a few of the smallest specimens. Thus whalefishes are unable to focus and, while the eye may be able to detect light, it cannot form images. Unexpectedly the nasal organs are also poorly developed, with one exception. With virtually nonfunctional eyes in a black environment, other sensory systems are likely to be well developed. The nasal organs, however, are small lumps of tissue that develop a few small lamellae (leaf-like structures) only in the largest specimens. Hearing also is apparently unimportant, for the otoliths or earstones are small and unsculptured.

It is the sense of pressure wave reception that has become pronounced in whalefishes. The lateral line system found in most fishes (and some aquatic amphibians) consists of neuromasts (receptor organs) with cilia (hair-like processes) that detect water movements; the neuromasts are either arranged in lateral line canals on the head and body or can be scattered (free neuromasts). Whalefishes have one of the widest and deepest of lateral line canal systems, as well as having a profusion of free neuromasts. The lateral line canal is set deeply in the skin, and the roof of the canal is pierced by large pores. In some species elaborate flaps of skin overhang the posterior pores, but their function is unknown. In most fishes the lateral line runs through small holes in specialised lateral line scales set in a row along the side of the body. In whalefishes the lateral line scales are set in the bottom of the lateral line canal, with a neuromast on top of each scale and the pores overlying the spaces between scales. This arrangement allows for more sensitive detection of water movement. It seems likely that the evolution of the specialised lateral line system of whalefishes has contributed to their success in the deep sea.

There are other features of whalefishes for which the function is unknown. The most striking is a distinctive tissue present around the anus of most species, at the bases of one or more fins in some species, and in a clump at the posterior end of the upper jaw in one undescribed species. Called cavernous tissue, it is white and occurs in small bundles that are often aligned in rows. One worker suggested it was luminous because of its similarity to tissue on the tail of a gulper eel that had been seen to give off light. However, microscopic sections of whalefish cavernous tissue indicate the similarities are only superficial. Unfortunately no whalefishes have been taken alive to conclusively test the hypothesis. Dr Dietrich Bürkel of the Hamburg Museum suggested the cavernous tissue might serve as a medium for the growth of bacteria, which in turn could serve as food for young whalefishes. This idea is based on the observation that the tissue is most pronounced in the smallest specimens. Clearly more research is needed.

A number of whalefishes have unique flaps, called anal lappets, that hang over the base of the anal fin. The lappets are supported by thin, internal scales and are either joined by skin to form one long flap or are separate, numbering 1–15. In one species there is a distinctive network of small vessels in the lappets, and in other species cavernous tissue is associated with the bases of the lappets. Again their

The Bird-snouted Whalefish (*Rhamphocetichthys savagei*) from the Gulf of California. Only four specimens of this species are known and details of life history, including food and use of its extraordinary mouth, remain a mystery. Inset: a drawing of the largest known specimen of the Bird-snouted Whalefish, 110 millimetres long from the Coral Sea, showing the curious anal lappets over the anal fin.



DIETRICH BÜRKEL

GREGORY MILLEN

SALLY E. READER

The diving vane and front of the net of an Isaacs-Kidd Midwater Trawl being set through the A-frame of HMAS *Cook*. This Royal Australian Navy research vessel has 10,000 metres of trawling cable, allowing mid-water fishing to depths of 3,300 metres.

function is unknown. In *Ditropichthys* paired ridges of thickened abdominal tissue run anteriorly from the cavernous tissue and anal lappets; in *Cetostoma* tiny ridges of thin skin cover the belly just in front of the cavernous tissue; in *Notiocetichthys*, a genus known from only two Antarctic specimens, a network of vessels runs diagonally through the lateral line; and in *Cetostoma* the membrane that joins the last ten rays (bony supports) of the anal fin is much more extensive than usual, so that the rays and membrane hang in curtain-like folds. None of these apparently unique whalefish features has a known function. While a number of speculations are possible, ranging from secondary respiration to the production and movement of pheromones, none fits all the data available. The capture of a living whalefish would help solve some of these mysteries.

IN THE COURSE OF OUR STUDIES, A SERIES of questions regarding the reproductive habits of cetomimid whalefishes were raised. The dissection of more than 300 specimens revealed that they were either females (with paired ovaries filled with tiny eggs) or so immature that the sex could not be determined. Gonads from eight of the larger specimens were sectioned and examined microscopically to test for the possibility of hermaphroditism, but no testes were found.

So, where had all the males gone? Either the males were not being sampled, perhaps because they live deeper or are simply too small; or the males were being sampled, but were not being recognised because they are so different from other whalefishes or are much smaller than females. Histological work, including the sectioning of smaller specimens, was clearly needed. We have now sectioned over 70 whalefishes and are excited at last to have found the males. They are tiny! The five males are 30–50 millimetres long, while the identifiable females range from 30 to 400 millimetres long. The testes, even when relatively mature, are also tiny, about five millimetres long by 0.5 millimetres wide. The males had previously been classified as immature juveniles of indeterminate sex, based on examination under the dissecting microscope.

Other questions have also arisen and are the basis of continuing research. For example, is there extreme sexual dimorphism in size (as in the deep-sea anglerfishes), or does sex reversal occur with the males becoming females as they continue to grow? More sectioning of the smallest specimens is required to see if any developing ovaries are found with male gonads.

The reproductive biology of the females is somewhat clearer, primarily because we have larger numbers to study. Surprisingly, two different patterns of lifestyle are apparent. In the commonest species of whalefish, *Cetostoma regani*, sexual maturity appears to be reached at about half the known maximum size (240 millimetres) and spawning appears to occur a number of times throughout life. Unfortunately we have no idea of the maximum age of any species of whalefish. With no body scales and tiny otoliths, finding annual growth rings is particularly difficult. In the second commonest species of whalefish, *Ditropichthys storeri*, female maturity is not reached until near maximum size (about 130 millimetres) and spawning appears to take place only once. Their entire life is probably spent building up the resources for a single spawning before death, a strategy that is known for other deep-sea fishes and understandable in the food-poor bathypelagic zone. Species of at least three genera—*Cetichthys*, *Ditropichthys* and *Gyrinomimus*—accumulate a considerable amount of flesh and fat as they become longer, but *Cetostoma* does not become more robust with age. Once again, more study and more specimens are required to determine which pattern occurs in the other genera of whalefishes (currently five of the nine genera are known from fewer than ten specimens each).

In addition to the unanswered questions regarding reproductive biology, many other whalefish mysteries remain. The functional significance of a number of unique cetomimid structures—cavernous tissue, anal lappets, skin ridges and subdermal vessels—may be answered only in the future when deep-sea fishes can be kept alive in experimental conditions. The whereabouts of larval cetomimids is a mystery. More than 600 juvenile and adult whalefishes have now been captured, yet the smallest specimen is 23 millimetres and fewer than ten per cent of the known specimens are smaller than 50 millimetres. The cetomimid larvae are either so different from the adults that they are not being recognised or, more likely, they live at adult depths beyond the limits of most plankton surveys. Other questions involve the relationships of the whalefishes. With a number of unique characters, these bizarre fishes do not show obvious relationships to other fish groups and their evolutionary position is uncertain. Current study of their skeleton, a relatively conservative part of anatomy that should not change as rapidly as other structures, will hopefully answer some of these questions. ■

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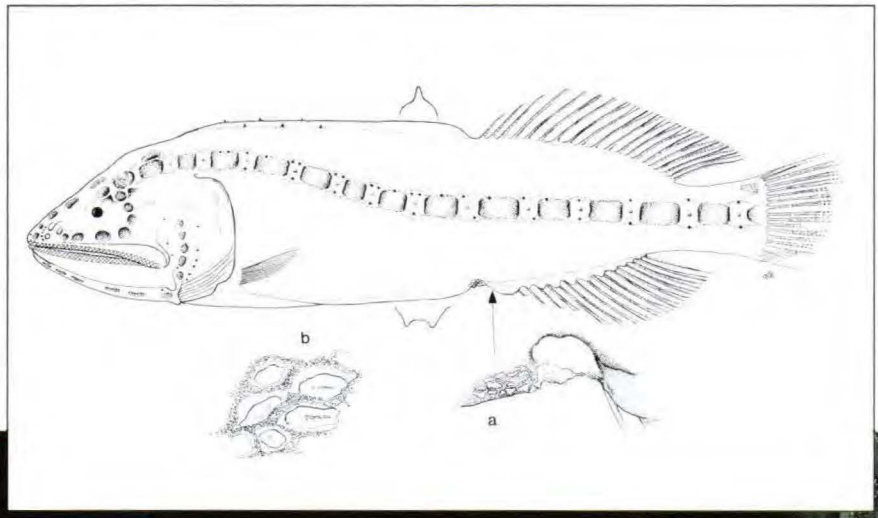
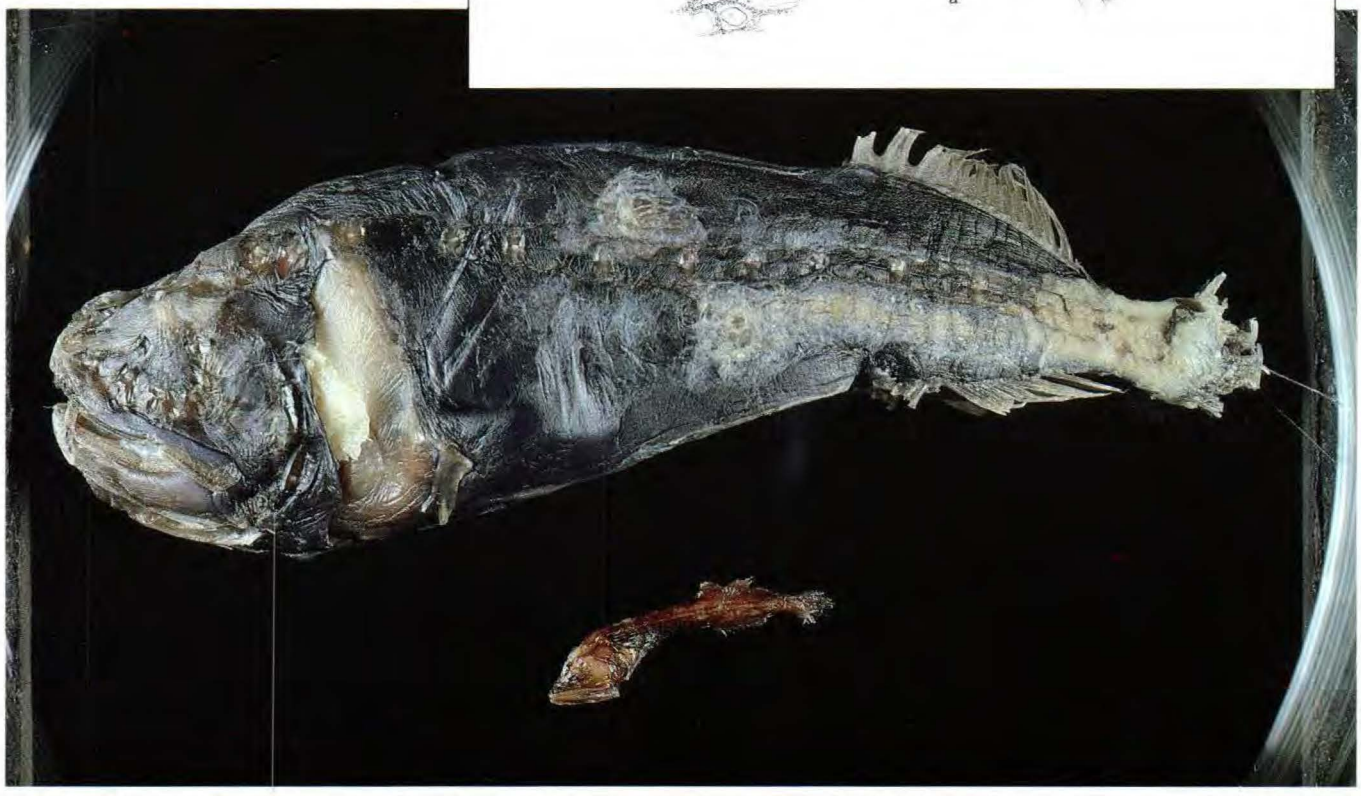
Dr John Paxton is a senior research scientist at the Australian Museum where he has been studying Australian and deep-sea fishes for the last 22 years.





DIETRICH BÜRKEL

ANTHONY FARR

Storer's Whalefish (*Ditropichthys storeri*): the larger specimen is a 137-millimetre female from off Madagascar, the smaller is a 33-millimetre male from off Japan. The extreme sexual dimorphism in size is apparently typical of all whalefishes, with none of the five known males exceeding 50 millimetres in length. Inset: another large specimen of Storer's Whalefish from the south Atlantic, showing the cavernous tissue in front of the anus (enlarged in 'a' and 'b') and the flap of anal lappets over the anal fin.

"Clearly there is prima facie *evidence that Honeybees have a deleterious effect on native plant and animal species. But what direct evidence is there one way or the other?"*

APIARISTS

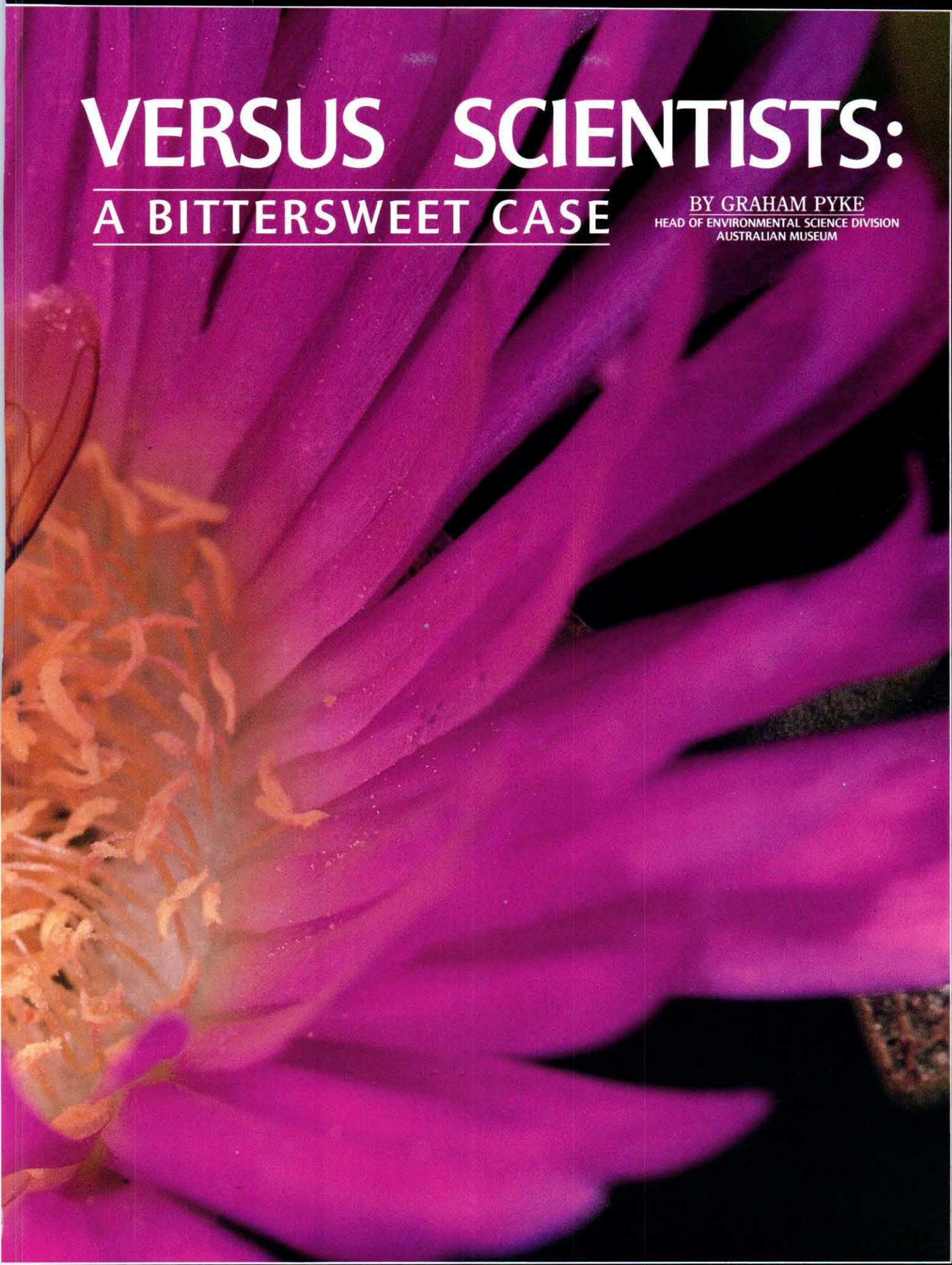
Honeybees consume a substantial proportion of available nectar and pollen from a number of plant species. They may reduce numbers of native animals by competing with them for these resources.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

VERSUS SCIENTISTS:

A BITTERSWEET CASE

BY GRAHAM PYKE
HEAD OF ENVIRONMENTAL SCIENCE DIVISION
AUSTRALIAN MUSEUM



HONEYBEES ARE PRESENTLY THE centre of controversy throughout Australia. On the one hand, a number of scientific studies have pointed to their deleterious effects on Australian native plants and animals; on the other, beekeepers who are seeking to maintain or increase their access to areas of natural vegetation deny any ill effects arising from their livelihood. In the middle are land managers who must make difficult decisions concerning the management of Honeybees in areas under their control. It is therefore timely to review the nature of this controversy and our knowledge concerning effects of Honeybees on native wildlife.

Honeybees were brought to Australia from Europe about 150 years ago to pollinate the settlers' crops and provide honey. However, they did not stay confined to their hives and today there are few places where feral populations do not occur. Shown here are combs of a feral colony in a rock crevice. Usually they nest in tree hollows.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Honeybees (*Apis mellifera*) have been in Australia for about 150 years. Native to Europe, Africa and Asia they were brought to Australia from Europe to provide honey and pollination of crops in the early days of settlement. In general, they performed these jobs extremely well, as they did elsewhere in the world, and there were soon beekeepers with their apiaries throughout the country.

Honeybees have not, however, remained confined to the beekeepers' hives. Instead they have escaped into the wild and there are now few areas where feral populations do not occur. Only in the higher regions of the Australian Alps where it is too cold and there is insufficient food in the winter, and in some desert areas where there is not enough water, are feral Honeybees absent.

Honeybees, be they from apiaries or feral colonies, utilise a wide variety of natural resources. They feed on nectar and pollen from hundreds of plant species, the pollen providing protein and the nectar providing energy. Some of the nectar is, of course, stored as honey. Feral Honeybees nest most often in tree hollows but they can also be unwelcome occupants in walls of buildings.

Honeybees share these resources with thousands of species of native animals. These include about 100 bird species, many mammals such as gliders, possums and flying foxes, and the 2,000 or so species of native bees. In addition many native species of flies, moths, butterflies, beetles and wasps use floral nectar and pollen as food resources. Tree hollows are also used as roosting or nesting sites by a large number of native animals, including birds such as parrots and cockatoos and mammals such as possums and gliders.

Because Honeybees overlap in resource use with so many native animal species, it is extremely likely that some of these native species are reduced in abundance by their presence. The population sizes of some native species will be determined by the availability of nectar, pollen or tree hollows. For such species, use of these resources by Honeybees means that there will be less available for the native species. In some cases Honeybees may even bring about the extinction of native animal species.

Honeybees are also likely to have an impact on Australian native flora. This could occur in a number of ways. Firstly, the removal of pollen from flowers by Honeybees may lead to a reduction in the amounts of pollen picked up on the bodies of the plants' native pollinators and consequently to a diminished pollination service provided by them. Secondly, the reduced availability of nectar and pollen may reduce the numbers of native pollinators visiting the plants, which could also

The Feather-tailed Glider (*Acrobates pygmaeus*) is one of many mammal species that rely on nectar for food.

W. TOLHURST

The population densities of other native insects, such as this moth (*Mythimna loreyimina*), may be reduced by the feeding activities of introduced Honeybees.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

lead to reduced pollination of the plants. On the other hand, the presence of Honeybees in addition to native pollinators could lead to pollination and resulting plant reproduction above natural levels. With either scenario, changes in plant abundance could occur. Thirdly, Honeybees may visit different numbers of flowers per plant or fly different distances between plants than native pollinators. The patterns of pollen movement between plants and hence the patterns of plant reproduction or the genetic composition of the seeds may therefore be different for Honeybees compared to native pollinators. This could also lead to changes in the abundances of some plant species. Finally, as a result of differences in foraging behaviour between Honeybees and native pollinators, the presence of Honeybees may affect the future course of plant evolution in Australia.

Honeybees pollinate many Australian plant species. We would not, however, expect them to do so as effectively as the native pollinators that have coevolved with our native plants for millions of years. As products of this evolution, we now see many plant traits that promote utilisation of their floral resources by native pollinators and many traits of native animals that enhance their effectiveness as plant pollinators. By comparison, the 150-year history of Honeybees in Australia is insufficient for any significant evolutionary changes.

Clearly there is *prima facie* evidence that Honeybees have a deleterious effect on native plant and animal species. But what direct evidence is there one way or the other?

IF HONEYBEES CONSUMED ONLY A SMALL fraction of available nectar and pollen, then it would be unlikely that they would have a major impact on native animals sharing the same resources. However, as studies by David Paton (University of Adelaide) have shown, this is not generally the case. Working in Flinders Chase National Park in South Australia, he found that for a number of plant species Honeybees usually consumed over 25 per cent of available nectar and pollen and often over 90 per cent. In the vicinity of the Grampians State Forest in Victoria he found that Honeybee consumption of total nectar production was low during winter but reached 50–70 per cent during summer. With these levels of nectar and pollen consumption, there is considerable potential for Honeybees to compete with native animals for these resources, thereby reducing the numbers of native species.

The best way to determine whether Honeybees are competing for resources with native animals is to experimentally manipulate the density of Honeybees in some areas and compare with areas in which no changes in Honeybee density occur. A few studies of this sort have now been done in Australia and they all indi-

Pollination by Honeybees has been shown to decrease the densities of native bees utilising the same resources. Shown here is a native solitary burrowing bee (*Neopasiphe mirabilis*) feeding on a native daisy.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

To determine whether Honeybees do compete for resources with native animals, Honeybees were airlifted into Nadgee Nature Reserve. This study showed that an increase in Honeybee density decreased the densities of native bees in the area.

cate competition between Honeybees and native animals. Liza Balzer (Australian Museum) and I reduced the density of Honeybees feeding on the tea-tree *Leptospermum squarosum* and found an increase in the density of native bees feeding on this plant. Evan Sugden, currently with the US Department of Agriculture, and I found similar results for *Hakea teretifolia* as did Paton for *Callistemon rugulosus.* Conversely, experimental increases in Honeybee density have been found to decrease animal densities. This was demonstrated for native bees in Kosciusko National Park by Balzer and myself, for native bees in Nadgee Nature Reserve by Sugden and myself, and for native birds (honeyeaters) near Goolwa, South Australia, by Paton.

A number of studies have also indicated that Honeybees have a negative effect on our native plants. Paton found that, as Honeybee density on *Callistemon rugulosus* increased, the percentage of flowers setting fruit decreased. Scott Mooney, in a study carried out in the Manly Dam Reserve in the northern suburbs of Sydney, found a higher fruit set in *Banksia ericifolia* when he decreased Honeybee density. I have found that in some years Honeybees remove so much pollen from Christmas Bells (*Blandfordia nobilis*) flowering in the Barren Ground Nature Reserve near Jamberoo, New South Wales, that the effectiveness of pollen transfer by honeyeaters, the native pollinators, is reduced and seed production consequently reduced. Paton found the same effect for Honeybees visiting *Correa reflexa.*

In summary, the available evidence does indicate that Honeybees have a deleterious effect on Australian native wildlife. It is therefore understandable that a land manager may decide not to allow beekeepers and their hives into particular areas of natural bushland. However, the above evidence, even if duplicated many times over, would not put an end to the controversy because it leaves a number of important questions unanswered.

So far the studies do not indicate whether any deleterious effects of Honeybees are due to Honeybees emanating from the beekeepers' hives or to feral Honeybee colonies. Beekeepers often argue that, because there are already so many feral Honeybees in the areas they wish to have access to, any additional effects of Honeybees in hives will be negligible. This may well be true in some cases but it is equally possible that the

GRAHAM PYKE

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

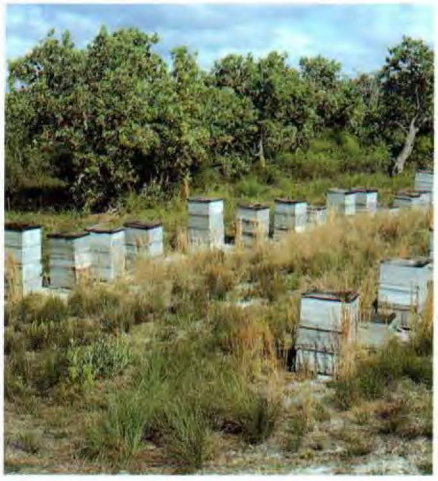
Feral Honeybees may compete with many native birds, such as these Galahs (*Cacatua roseicapilla*), for tree hollows in which they build their hives.

hives are the proverbial last straw as far as native wildlife is concerned.

Many beekeepers are migratory, moving their hives from one location to another in pursuit or anticipation of the best nectar flows. Therefore, they argue, because their hives are usually in places where there is a superabundance of nectar and pollen, the hives should not reduce food availability for native animals. This may be true in some situations. However, it seems most unlikely that coevolution of native plants and their pollinators would have resulted in nectar and pollen production vastly exceeding the animals' requirements. Instead we would expect, on an evolutionary time scale, that any feeding opportunities created by abundant food would be quickly utilised; in other words a reasonably close match between nectar and pollen production and their utilisation by native animals.

The relationship between the abundances of feral and hive Honeybees is also unclear at present. It is possible, as the beekeepers suggest, that the density of feral Honeybees stabilised a long time ago and that, even if all hives were eliminated, the feral Honeybee density would remain unchanged. Of course, it is also possible that the density of feral Honeybees in an area is maintained or enhanced by swarms emanating from beekeepers' hives. If this were the case, then cutting down the numbers of hives could lead to a reduction in the numbers of feral Honeybees. But as Honeybee colonies are often long-lived, the process would probably be slow.

So it is easy to understand why a conflict exists amongst beekeepers, land managers and scientists. The beekeepers are worried that their incomes will be restricted if they are denied access to some areas. Collectively, beekeepers contribute significantly to our economy through production of honey, much of which is exported, and through pollination of some of our crops (although here also the relative contributions of hive and feral Honeybees are unclear). Land managers, on the other hand, are expected to preserve the environmental values of the area they manage and, because scientific studies have so far indicated that Honeybees have a deleterious effect on native wildlife, rather than a neutral or positive one, they can only act on the side of caution.



GRAHAM PYKE

Beekeepers claim they regularly move their hives to areas where there is a superabundance of nectar and pollen, arguing that their bees should have little effect on native animals. However, it is unlikely that the coevolution of plants and their native pollinators would have led to a superabundance of nectar; rather, a close match would be expected.

KATHIE ATKINSON

Apiarists fear their incomes will be reduced if they are denied access to certain areas of native bushland. The conflict between beekeepers and scientists can only be resolved if there is total cooperation between both parties.

AS THE ABOVE SUMMARY OF AVAILABLE information indicates, there is a clear need for more research on Honeybees and their effects on native wildlife. Furthermore such research is in the long-term best interests of all concerned. Land managers would find it easier to decide how to manage Honeybees if more was known. With present information they are likely to act with caution and seek to reduce the numbers of Honeybee hives in their areas. And, for beekeepers to maintain or increase their access to natural vegetation, they will have to demonstrate that in particular situations the presence of their hives has little or no effect.

Thus there is much scope for collaborative research involving scientists, beekeepers and land managers. Sadly, however, such collaborative efforts are slow in coming and considerable antagonism persists. Beekeepers, for example, often accuse the scientists of bias or incompetence. They have also been unwilling to allow their bees to be part of experiments because they haven't wished to be seen as contributing to potentially damaging research. The scientists—however biased and incompetent they might be—have at least indicated an interest in collaborating with the beekeepers. The time is right for renewed efforts on everyone's part towards working together. ■

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Dr Graham Pyke's principal research interests are the ecology and behaviour of nectar-feeding animals and the pollination biology of the plants they visit.

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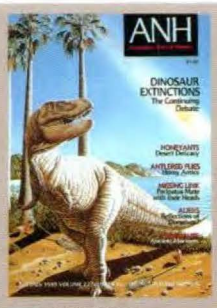

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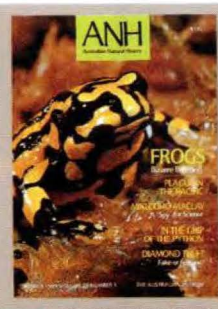

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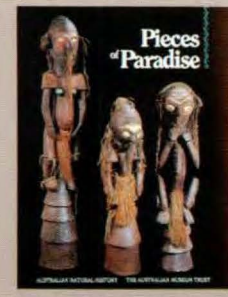

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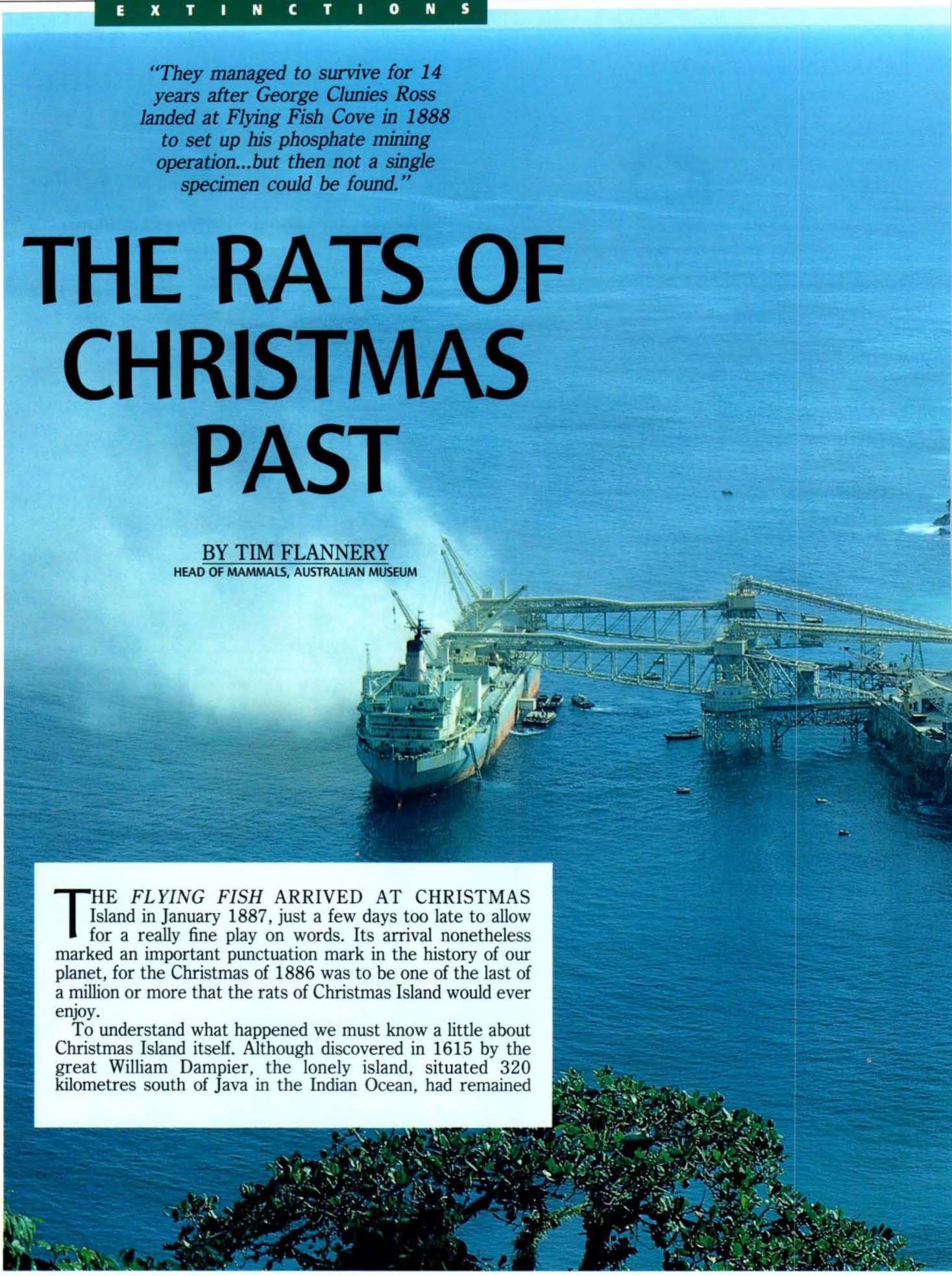
DEMYSTIFYING OUR NATURAL WORLD

"They managed to survive for 14 years after George Clunies Ross landed at Flying Fish Cove in 1888 to set up his phosphate mining operation...but then not a single specimen could be found."

THE RATS OF CHRISTMAS PAST

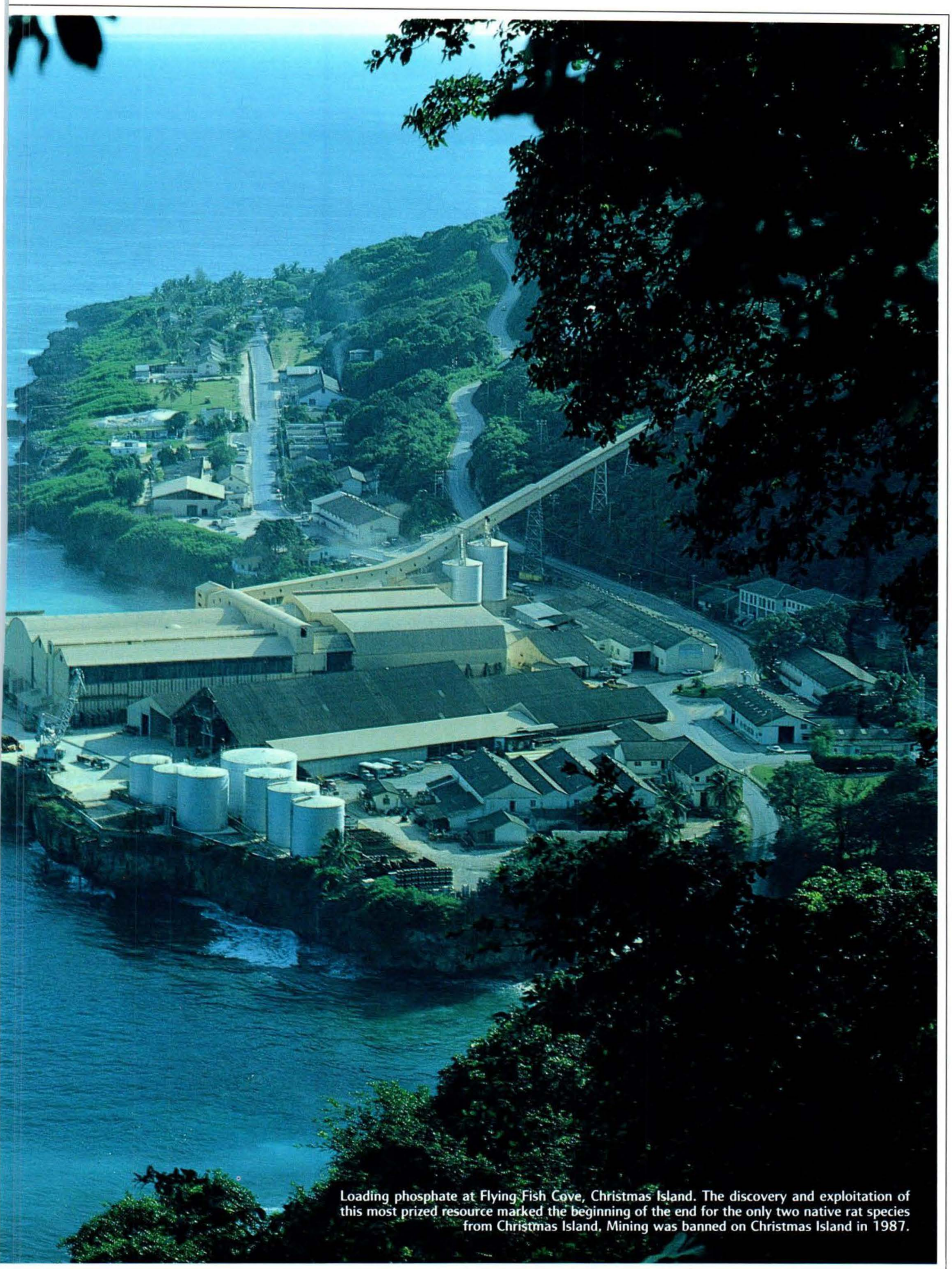
BY TIM FLANNERY
HEAD OF MAMMALS, AUSTRALIAN MUSEUM



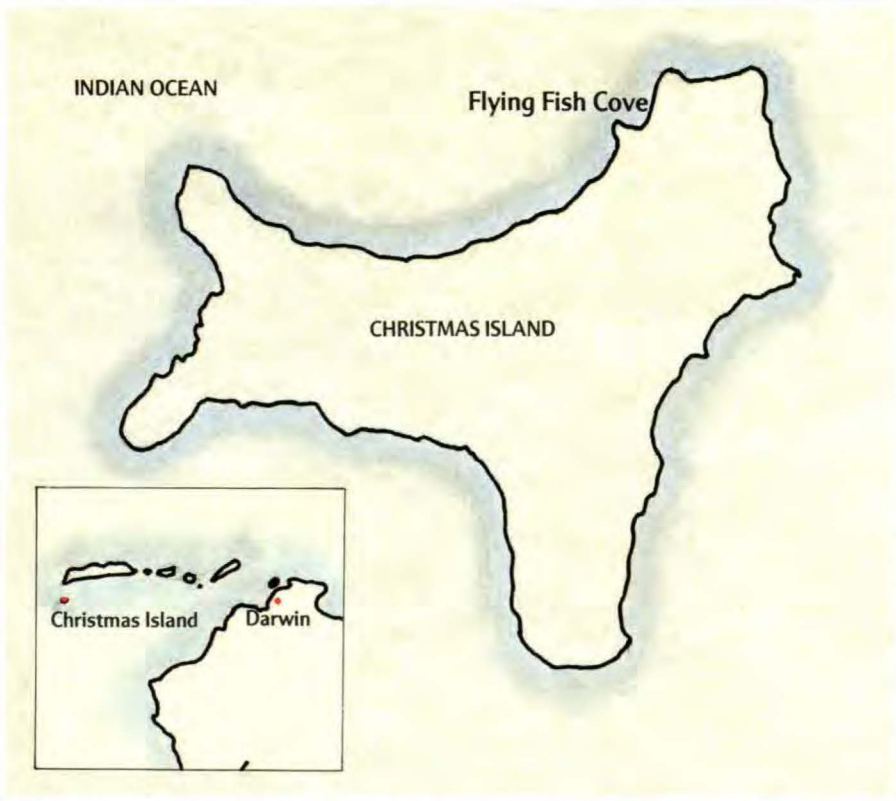
THE *FLYING FISH* ARRIVED AT CHRISTMAS Island in January 1887, just a few days too late to allow for a really fine play on words. Its arrival nonetheless marked an important punctuation mark in the history of our planet, for the Christmas of 1886 was to be one of the last of a million or more that the rats of Christmas Island would ever enjoy.

To understand what happened we must know a little about Christmas Island itself. Although discovered in 1615 by the great William Dampier, the lonely island, situated 320 kilometres south of Java in the Indian Ocean, had remained

HAROLD G. COGGER



Loading phosphate at Flying Fish Cove, Christmas Island. The discovery and exploitation of this most prized resource marked the beginning of the end for the only two native rat species from Christmas Island. Mining was banned on Christmas Island in 1987.



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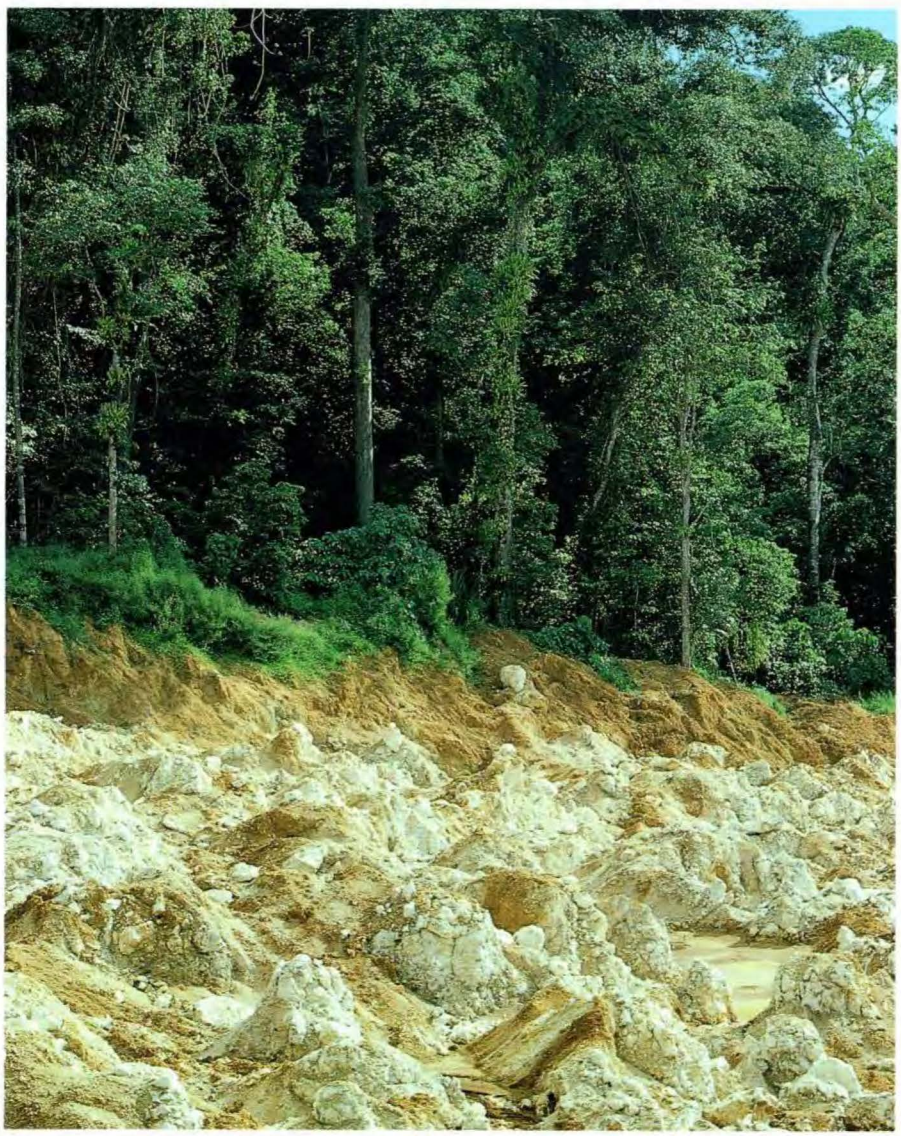


HAROLD G. COGGER

one of the few specks of habitable land (its area is 13,470 hectares) of the entire planet that had remained unpopulated by humans. As such it was a very special place. Even such remote islands as Henderson and Pitcairn in the eastern Pacific, although uninhabited when discovered by Europeans, had in the past been colonised by Polynesians who had eaten them out before moving on. Life had been evolving on Christmas Island for perhaps a million years. It had an impressive fauna that included two native species of *Rattus*, a shrew, a flying fox, ten species of reptiles (four endemic to the island), endemic and spectacular land crabs, and many, many birds. Indeed, it was these birds that were to ultimately bring about the end of its splendid isolation for, when the *Flying Fish* left Christmas Island, it carried with it not only the first example of one of the endemic rats to become known, but also a collection of rocks. The rocks, when analysed, proved to be phosphate—that highly valued fertiliser that is the result of thousands of years of accumulated bird droppings.

It is ironic that it was the very fact that humans had not occupied the island that allowed the birds to exist in the numbers required to create this prized resource. The phosphate deposits brought exploitation; exploitation in turn destruction. The story of one of these phosphate contributors, Abbott's Booby (*Papasula abbotti*), illustrates Christmas Island's significance. This highly distinctive seabird, placed in its own genus, is today known only from Christmas Island where it has become rare and endangered. It could be argued that the species is of little importance: it plays a small role in the ecology of a tiny island, and seems to have produced all of the useful phosphate that it will ever produce. However, it is now clear that such sentiments are borne of deep ignorance. Archaeological investigations by Dr Steadman of the New York Museum have shown that as little as 3,000 years ago Abbott's Booby had one of the widest distributions of any bird—from Assumption Island in the western Indian Ocean to the Marquesas Islands in the Pacific. Thus it played a role in the ecology of more than half of the globe's oceans! The archaeological remains from the Marquesas were apparently somewhat larger than those from elsewhere, so the wag who described them has named a new subspecies *Papasula abbotti costelloi*. Unfortunately, Abbott's Booby nests only in tall trees and has become extinct everywhere that humans have become established—except, for the time being, on recently settled Christmas Island. By the late 19th century it was still depositing phosphate on Christmas Island but

The rich phosphate deposits in a newly mined area on Christmas Island are the result of thousands of years of accumulated bird droppings. Phosphate is highly valued as a fertiliser.

Abbott's Booby was once a source of the rich phosphate deposits on Christmas Island.

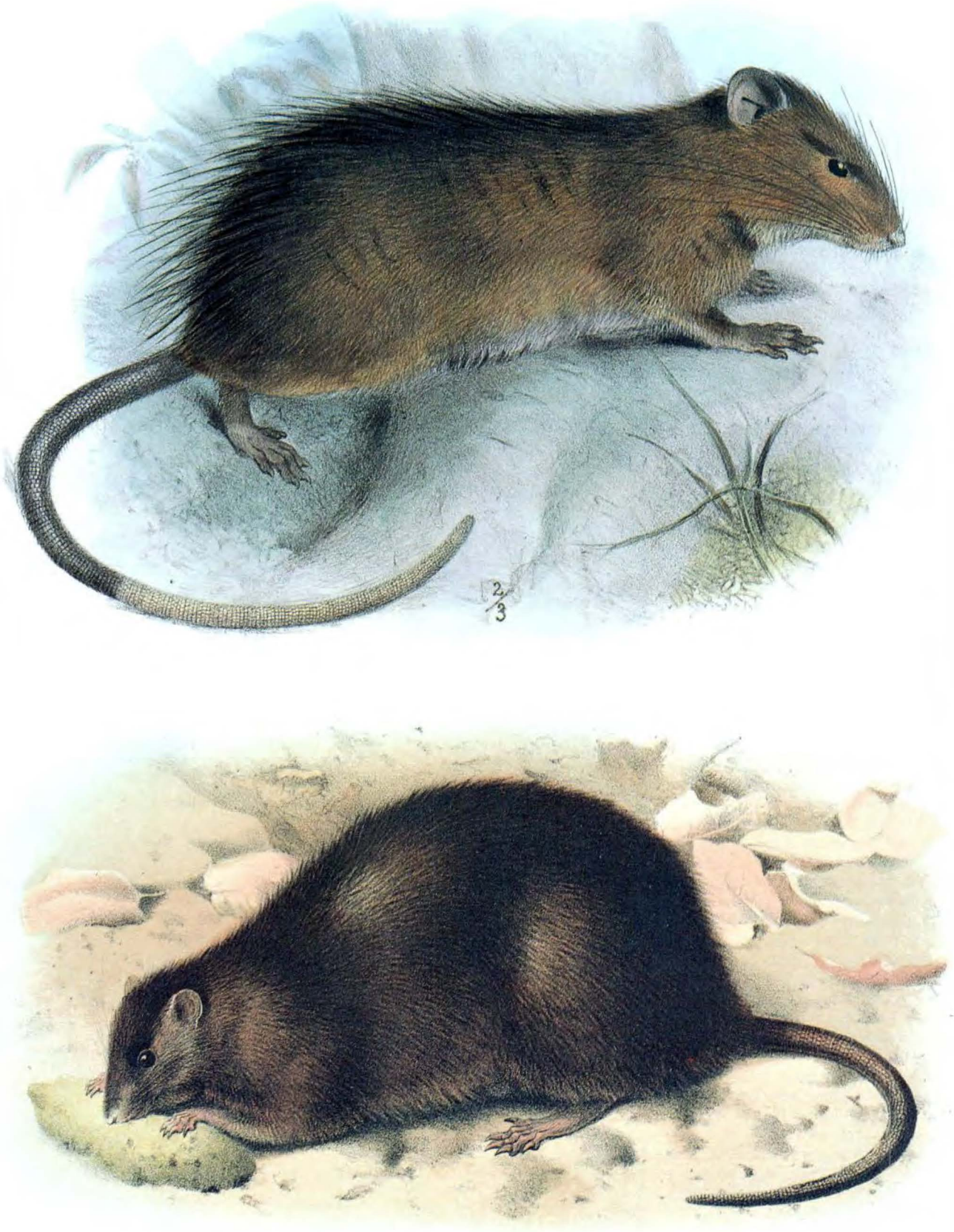
GRAHAM ROBERTSON/AUSCAPE INTERNATIONAL

was not even a vague memory elsewhere. Perhaps one day we will redress some of the wrongs we have done to our planetary home, and reintroduce Abbott's Booby to part of its former range—that is, if it survives for the next few decades on Christmas Island.

As for the flying fox (*Pteropus melanotus*), it also inhabits the islands of Indonesia and has survived the human invasion fairly well. The tiny shrew, however, remains largely mysterious. Although shrews have been caught on the island recently, it is unclear as to whether they represent the same species as that caught originally, or are another invader.

BUT WHAT OF THE RATS OF CHRISTMAS past? Well, they managed to survive for 14 years after George Clunies Ross landed at Flying Fish Cove in 1888 to set up his phosphate mining operation. There were two species: Maclear's Rat (*Rattus macleari*) named for Captain MaClear of the Flying Fish, and the Burrowing Rat (*Rattus nativitatis*) named for the birth date of an Iron Age Middle Eastern cult figure. Maclear's Rat was a beautiful creature, chestnut brown above with a partly white, long tail. Almost all that we know of it was recounted by Dr Andrews who visited the island in 1897. He is worth quoting: "In every part I visited it occurred in swarms. During the day nothing is to be seen of it, but soon after sunset numbers may be seen running in all directions, and the whole forest is filled with its peculiar querulous squeaking and the noise of frequent fights. These animals, like most of those found on the island, are almost completely devoid of fear, and in the bush if a lantern be held out they will approach to examine the new phenomenon. As may be imagined they are a great nuisance, entering the tents or shelters, running over the sleepers and upsetting everything in their search for food. They seem to eat anything, and destroy any boots or skins incautiously left within their reach. . .A number of dogs is kept to keep them in check, and near the settlement they are already certainly less numerous than elsewhere. In the daytime these rats live in holes among the roots of trees, in decayed logs, and shallow burrows."

The Christmas Island Burrowing Rat was an even stranger beast. It had a much shorter tail and was called 'Bulldog Rat' by the locals. It had a layer of subcutaneous fat up to two centimetres thick on the upper surface of the body, the function of which is still unclear. Andrews records this of it: "Though very numerous in places, especially on the hills, e.g. Phosphate Hill [it] is very much less common than [*Rattus*] *macleari*. They seem to live in small colonies in burrows, often among the roots of a tree, and occasionally several may be found living in the



Top: Maclear's Rat was once a common sight on Christmas Island. Bottom: the Burrowing Rat became extinct soon after humans invaded Christmas Island. It had a two-centimetre-thick layer of fat on its back, the function of which is still unknown.

long, hollow trunk of a fallen and half decayed sago palm. . .[It is a] much more sluggish animal than [*Rattus*] *macleari*, and unlike it, never climbs trees; and it is difficult to avoid the belief that the former species is being supplanted by the latter in spite of the abundance of food. . .When [it] is exposed to daylight, [it] seems to be in a half dazed condition." The interactions between these two largish rats and the island's abundant land crabs must have been fascinating. Perhaps changes to crab and other animal populations are still in train from the rats' abrupt extinction. Tragically, unlike Abbott's Booby, they can never be returned to their home.

As to precisely what became of the rats, their veritable Boswell the good Dr Andrews related after a visit in 1908: "In spite of a continual search, not a single specimen of either species could be found on the island." The resident medical officer told Andrews what had happened. In 1902 or 1903 many rats had been seen in broad daylight, crawling about on the paths, apparently in a dying condition. Additionally, it was recorded that by 1933 the Black Rat (*Rattus rattus*), the Pacific Rat (*Rattus exulans*) and the House Mouse (*Mus musculus*) were all present on Christmas Island. Andrews notes that, by 1908, at least the Black Rat was present but that it had not spread to the remoter parts of the island. Thus he blamed the extinctions upon an epidemic disease, possibly a trypanosome introduced with the Black Rats, against which the endemic species had no resistance. It seems unlikely, however, that a single disease was responsible for destroying two species. Perhaps a closer analogy can be drawn from events in Australia's past. The Black Rats that reached Christmas Island were doubtless from the slums and docksides of a great port such as Jayapura or Sydney. Such areas seem to produce the most disease-ridden populations of organisms anywhere, because they can contact other populations from all over the Earth, and because population densities of species such as rats and humans are high. Thus colonisers drawn from these areas can be fatal to long-isolated but closely related animal populations. Had the British, for example, set out at the start to exterminate Australia's Aborigines they could not have chosen a better tool than the scrofulous, syphilitic and smallpox-ridden criminal classes of London.

If a single disease was involved in either the case of the Aborigines or the Christmas Island rats, it would doubtless have had less impact as immunity would have had a chance to develop. In all likelihood a great plethora of microbe types descended on Flying Fish Cove with those Black Rats around the turn of the

One of the inhabitants of Christmas Island that managed to survive the human invasion is the flying fox *Pteropus melanotus*.

COURTESY ANPWS

Red Crabs are extremely abundant on Christmas Island. Perhaps, with the abrupt extinction of the island's native rats and consequent reduction in competition, the crabs had 'room to expand'.

DICK WHITFORD/NPIAW

Black Rats were to the native rats of Christmas Island what the scrofulous, syphilitic, smallpox-ridden classes of London were to the Australian Aborigines. Animals that live in high densities in the slums of port cities (be they rats or humans) have a greater chance of carrying various diseases and spreading them to similar populations in isolated areas.

century. Rats that became immune to one disease would have been stricken by another. Perhaps one day this issue can be resolved, for three specimens of Maclear's Rat are preserved entire in alcohol in the British Museum. However, this task would have been a lot easier if that medical officer had bottled a few of the freshly stricken rats in 1902.

Thus it was that the rats of Christmas past slipped quietly into oblivion. They are now remembered only from old accounts and a few specimens held in the British and Australian Museums. Christmas Island, a unique resource, is altered forever. Why a unique resource? Well, show me another island in our region with such diversity that is untouched by humans. They don't exist. Our very idea of a tropical island is one drastically modified by people. Wouldn't it be nice to have a control; an island really untouched by which to judge our impact? Christmas Island probably came closer than any other island in our region to being this, but we missed out by 100 years. If only the *Flying Fish* hadn't carried those rocks back to England, or if Abbott's Booby had politely pooped in the sea! ■

NATIONAL PARK STATUS

Christmas Island National Park was declared in 1980, 22 years after the Island became an Australian external territory. In 1986 the park was extended to include 18 per cent of the Island's land area. The Federal Government announced in 1987 that priority would be given to developing a strategy for preservation of the Island's rare fauna and flora, including a major extension of the national park. Subsequent clearing of rainforest was halted and a program attempting to re-establish rainforest habitat on former phosphate mining fields commenced.

In December 1989 the park was increased in size from 2,400 hectares to over 8,700 hectares, including a significant proportion of the surrounding reef. Now over 62 per cent of Christmas Island is national park and includes most of the remaining intact rainforest and virtually all of the breeding habitat of Abbott's Booby and the Christmas Island Frigatebird (*Fregata andrewsi*). The breeding habitats of other seabird species are also included, as well as important colonies of the fruit bat *Pteropus melanotus* and Blue Crab (*Cardisoma hirtipes*) plus a unique stand of mangrove trees growing in fresh water 40 metres above sea-level.

Although the park now incorporates much of the unique flora and fauna of the Island, areas of significant natural value still remain outside and proposals for extensions have been put to the Australian National Parks and Wildlife Service.

—Dr Peter Coyne
ANPWS, ACT

Suggested Reading

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Dr Tim Flannery is Head of the Mammal Section at the Australian Museum. He wrote this article while musing over the yuletide festivities of 1989.

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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COURTESY M.T. GIBSON

"Many residents viewed the dense mantle of vines and colourful flowers as part of the natural vegetation, and were unaware they were witnessing the strangulation of the forest."

WINGHAM • BRUSH

RESUSCITATION OF A RAINFOREST

BY JOHN STOCKARD & GLENN HOYE
SUPERVISOR, WINGHAM BRUSH REGENERATION TEAM
FREELANCE PHOTOGRAPHER

AUSTRALIA'S FIRST ATTEMPT TO REgenerate a remnant rainforest occurred not in Queensland, as one would expect, but in New South Wales at Wingham Brush. The events at the small town of Wingham have triggered the regeneration of a string of remnant rainforests in northern New South Wales, and the methods and techniques have spilled over the border into Queensland.

After the wholesale clearance of lowland subtropical rainforest last century, only remnants remained of this luxurious growth. Wingham Brush on the Manning River, 250 kilometres north of Sydney, is one of a series of remnants, all with similar management problems. Although less than ten hectares in area, it nonetheless represents about a tenth of the total floodplain rainforests remaining in New South Wales. Together with nearby Coocumbac Island Nature Reserve at Taree, it comprises the most southerly sample of its type and the species association is distinctive.

Due more to good fortune than intention, Wingham Brush survived because of its reservation for wharf development at the head of navigation on the Manning. Eventually dedicated for Preservation of Native Flora and Public Recreation in 1909 and 1916, management practices were non-directional and the small forest increasingly deteriorated through overuse and the invasion of exotic plants.

CATHY MCGAHEY

One of the enormous Moreton Bay Figs in Wingham Brush, taken about 1920.

R. DEER

JOHN STOCKARD

The ornamental Cat's Claw Creeper, introduced from South America, represents the first phase of weed invasion by smothering the trees of the canopy. Inset: close-up of the flowers and seed pod.

Timber, including huge quantities of Red Cedar (*Toona australis*), had been extracted from the Brush, large areas within the southern half were grassed, and cattle were grazed there with tenders called by local council. As one citizen wrote to the Wingham Chronicle in 1915: "We hear so much of the Wingham Brush that you would be led to believe it was being preserved for future generations to admire, but what do you find? The very people that are supposed to be keeping it, are killing it as fast as they can, by allowing the undergrowth to be devoured by hungry cattle."

Photographs taken during the early 1960s show heavy infestations of the yellow-flowered Cat's Claw Creeper (*Macfadyena unguis-cati*), an ornamental vine that either entered the Brush in garden refuse or was planted for beautification. Native to South America, Cat's Claw is a prolific seeder with long pods of winged seeds. An extensive root system that produces vegetative tubers every half metre, and an ability to grow in heavy shade, allowed this pest to spread readily. Flood deposition resulted in layers of interconnected tubers interwoven with the root systems of native plants, and the trunks of trees were often obscured with these vines. One keystone native, a Giant Stinging Tree (*Dendrocnide excelsa*), measuring 1.5 metres in circumference had 560 vines climbing on it, with the larger vines attaining diameters of 15 centimetres. The Cat's Claw completely enveloped the crowns of the native trees and, together with massive root competition, increasingly weakened their hosts. The resulting 'green poles' eventually toppled to the ground. Many residents viewed the dense mantle of vines and colourful flowers as part of the natural vegetation, and were unaware they were witnessing the strangulation of the forest.

Another South American native, Potato Vine (*Anredera cordifolia*), was also well established within the Brush by the 1960s with the primary centre of infestation being the southern half, which had been used for grazing. Originally grown as a purgative, it requires higher light levels than Cat's Claw and was particularly advantaged by gaps within the canopy. As Cat's Claw continued to destroy the canopy, Potato Vine penetrated deeper into the forest. The heavy weight of fleshy leaves and rampant growth rate accelerated weed invasion and tree mortality. As larger trees collapsed, the understorey was swamped by vines, resulting in an impenetrable thicket one to two metres high.

In openings, the vines themselves were eventually smothered by a 0.6–1.0-metre layer of luxuriant Wandering Jew (Tradescantia albiflora), also originally from South America. Natural seedling regeneration was totally impeded by this ground cover plant, representing the final stage of South American weed invasion.

WINGHAM BRUSH IS AN IMPORTANT MAternity site for Grey-headed Flying Foxes (*Pteropus poliocephalus*), which dominate the recorded history of the Brush. The local community considered the presence of the animals an affront to civic pride, and their annual arrival, which included heavily pregnant females, was regularly greeted with volleys of rifle fire.

Shoots to exterminate the bats span over 70 years. Casual shooting was halted in 1915, following complaints that birds as well as bats were being destroyed, that bullets were falling on nearby houses, and

JOHN STOCKARD

G. HOYE

Potato Vine, another native of South America, completes the smothering of the understorey after the destruction of the upper canopy by Cat's Claw Creeper. With growth rates exceeding a metre per week and a proliferation of vegetative tubers along its length, this vine has represented the greatest challenge for the regeneration team. Megan Booker frees a leafless sapling, which will display vigorous growth without the overwhelming competition from the blanket of Potato Vine. Inset shows aerial tubers (reproductive agents). These fall to the ground and grow vigorously under the right conditions.

a terrible stench was arising from the unburied bats. Subsequent bat shooting became more organised and involved the local council, Police Department and rifle clubs.

Bat antipathy reached its peak on 9 December 1961. A referendum calling for the destruction of the southern half of Wingham Brush was attached to the general election: "Having regard to the nuisance and health menace caused by flying fox, are you in favour of the removal of the Wingham Brush on the south side of Isabella Street?". Despite the biased wording, 75 per cent of residents voted against the referendum in the belief that the bats would only move across to the northern side of the Brush. Still this outcome did not deter opponents of the bats and, two months later, 9,000 rounds of ammunition were fired by experienced marksmen. Thirteen hundred carcasses were collected, mainly by school children, with the majority left dead and dying in the forest canopy.

However, the bats were as determined as the residents. After the destruction of the other nearby maternity sites at Mondrook, Brushy Mountain and Kimbriki, there was little suitable habitat remaining and so they had to return to Wingham Brush as a matter of survival. During the late 1960s, other deterrents including repellents, aircraft, flying fox distress calls, electronic devices, tear gas, burning sawdust heaps and sulphur fumes were considered in an attempt to eradicate the animals. In the end, the Wingham Council gave up and the persistence of the bats triumphed. As an alderman who supported the 1961 referendum stated in 1969, the only way to get rid of the flying foxes was to "knock down the

Just as the vines have smothered and killed the trees, the vines in turn are ultimately buried by a luxuriant carpet of Wandering Jew representing the final phase of this South American invasion.

G. HOYE

G. HOYE

Wingham Brush is an important maternity site for Grey-headed Flying Foxes. Unfortunately their annual arrival has not been welcomed by all members of the Wingham community.

Brush". But townsfolk were not prepared to knock down their local landmark.

THE NATIONAL HERBARIUM OF NEW South Wales recognised the threat to the Brush posed by exotic vines in the 1960s but attempts by the managing authorities to shade out the infestation by intensive plantings on the edges of the Brush were unsuccessful. By the late 1970s, as the older trees continued to collapse under the exotic blanket, it became obvious that the Brush was dying. This once impressive forest was becoming a thicket of exotic vines.

Following a highly critical report by the New South Wales National Parks and Wildlife Service (NPWS) in 1978, Wingham Council sought advice from the Forestry Commission, the NPWS and National Trust. The Wingham Brush Regeneration Team was formed in the spring of 1980, marking the first attempt to regenerate a rainforest anywhere in Australia.

The National Trust claimed success with weed control in remnants of Sydney bushland, using the slow and meticulous 'Bradley Method' of hand weeding the ground. This method was the cornerstone of the Trust's Bush Regeneration Program and so was proposed by the Trust for the regeneration of Wingham Brush. However, the Sydney bushland differed markedly from Wingham's rainforest, with its high levels of weed infestation and growth rates, and it soon became obvious that the manual removal of Cat's Claw Creeper was impossible. Joan Bradley, chemist and co-founder of the Bradley Method, introduced various herbicides for trial against Cat's Claw in November 1980 with the herbicide glyphosate (Roundup®) being ultimately chosen because of its toxicological profile, biodegradable characteristics and potency against Cat's Claw.

Although the team was under a five-year contract with the Trust to regenerate Wingham Brush using the Bradley Method, necessary adaptation and alterations occurred from the inception of the program. Continuous experimentation and evaluation by the local team led to the conclusion that the Bradley Method was simply not applicable to the rainforest environment, nor to the rampant weeds they were tackling. Adaptation continued and, as the Cat's Claw infestations were subdued, the team advanced to the devastated areas dominated by Potato Vine. Again the team's reliance on selective herbicide to control this pest, plus the emphasis on canopy as opposed to hand weeding the forest floor, placed

G. HOYE

From this single group of trees (right), 586 Cat's Claw Creeper vines were cut and treated with herbicide (top).

the team's efforts further outside the definition of the Bradley Method and caused increased friction with the Trust administrators. Although the team's approach was unanimously supported by expert opinion, these changes were unacceptable to the Trust. The disagreement led to the unfortunate "Battle of the Brush" in January 1984 and the sacking of the entire team. Amid considerable political pressure, the team continued to work as volunteers to keep the program going. Strong support from the local community throughout the dispute encouraged the team's persistence.

JOHN STOCKARD

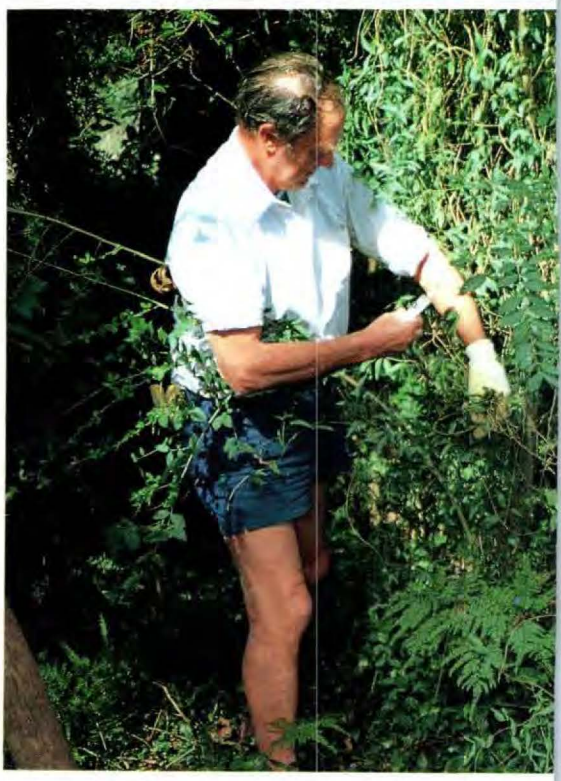
JOHN STOCKARD

G. HOYE

An area shown before and eight months after treatment illustrates the colonisation by Tobacco Bush, which provides cover for the establishment of native tree seedlings. The buttress roots of the fig tree were found to be rotting in many places from the dank conditions underneath the weed mat.

In 1984 the National Trust began to restructure the Trust's Bush regeneration program and introduced the National Herbarium into the program to assess the team's methods. The continuing internal political situation within the Trust, however, made reinstatement of the Wingham team difficult. The local team continued to work as unpaid volunteers for two years until February 1986 when the contract expired. The Wingham team was then reinstated by the Greater Taree City Council and the National Herbarium continued to monitor the program. In November 1989, the Herbarium's five-year study was completed, resulting in the first scientific assessment of a regeneration program in Australia.

THE RESTORATION PROGRAM RESEMBLED an archaeological excavation as the smothered native vegetation was carefully uncovered with knives, secateurs and brush-hooks. Rescue of the natives was a rewarding experience as each new mound was excitedly probed for hidden trees. As the luxuriant mantle of weeds withered and died, the Brush turned from



G. HOYE

green to brown, and it appeared to some residents that the team was killing the Brush. Yet displays and continual press releases helped explain the program and, as the native vegetation recovered, these fears were eased.

As the regeneration extended into the open areas originally used for grazing, Wild Tobacco (*Solanum mauritianum*) sprang up after the weeds were sprayed. Tobacco is widely persecuted as a weed by graziers and many people couldn't understand why the team encouraged this plant, a native of Asia. Wild Tobacco is short-lived (about five to seven years at Wingham), shade-intolerant and only able to invade gaps and clearings. As most rainforest seedlings are vulnerable to exposure, Wild Tobacco provides protection from frost, strong winds and sun. In addition, these trees are heavy fruiters and so attract bats and birds that also deposit native seeds from the surrounding forest in their droppings beneath the Wild Tobacco plants. Wild Tobacco is therefore considered a beneficial plant in the program to reestablish rainforest within the canopy gaps. The same applies to the native Giant Stinging Tree, which superficially resembles Wild Tobacco and which is, because of the nasty sting inflicted by young specimens, also largely persecuted. Red Cedar is another colonising species that requires high light levels, and trees grown from local seed source have been reintroduced into the Brush in open areas.

Notwithstanding years of inattention and mismanagement, the forest at Wingham Brush retains 70 indigenous tree species and at least 120 species of native rainforest plants. Ninety species of birds have been sighted, as well as 15 mammal species, many of which roost in

GLEN HOYE

After cutting the Cat's Claw Creeper, team members paint the basal sections with concentrated herbicide, which destroys the extensive root systems of the vines. The tops of the vines are left to wither and fall to the ground as the trees reform their crowns.

the hollows of the giant Moreton Bay Figs (*Ficus macrophylla*)—believed to be over a thousand years old and the largest examples of their genus in Australia. And as for the bats, after seven decades of attempted extermination, Wingham Brush remains a major maternity site for the recently protected Grey-headed Flying Fox. Primarily nectar feeders, they are important pollinators of the surrounding forests and are crucial seed distributors of rainforest plants. Their less congested habitat probably contributes to their increased tolerance by locals.

A course for students on the Brush and rainforest regeneration was implemented by the adjacent Wingham High School in 1987, and students have assisted the program with weed clearance, propagation and tree planting. To cater for the numerous school groups that visit the Brush, as well as continuing education classes and rainforest regeneration workshops, the Education Department has been asked to consider the establishment of a Field Study Centre at Wingham.

For the restoration work at Wingham Brush, the Greater Taree City Council received a special commendation in the Environment Section of the 1988 Australian Heritage Awards. The team's methods have now gained wide acceptance and have been endorsed by the National Trust, National Parks and Wildlife Service, and the National Herbarium. Several restoration programs, including all the Bicentennial rainforest restoration projects in New South Wales, have followed Wingham's lead. The word is out: management is in. ■

One of three types of possums occupying the Brush, the Mountain Brushtail Possum (*Trichosurus caninus*) feeds on various rainforest leaves and fruits.

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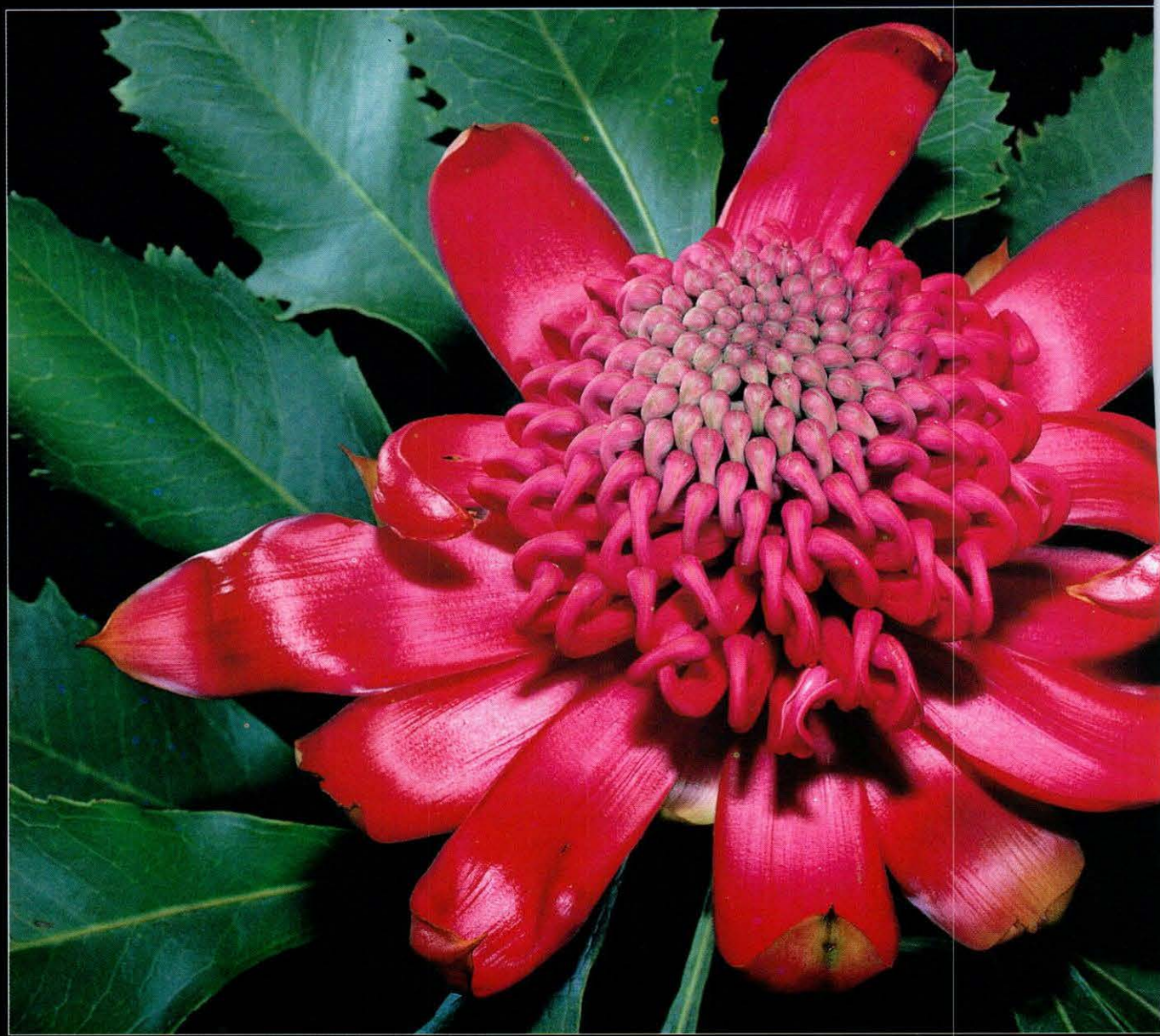
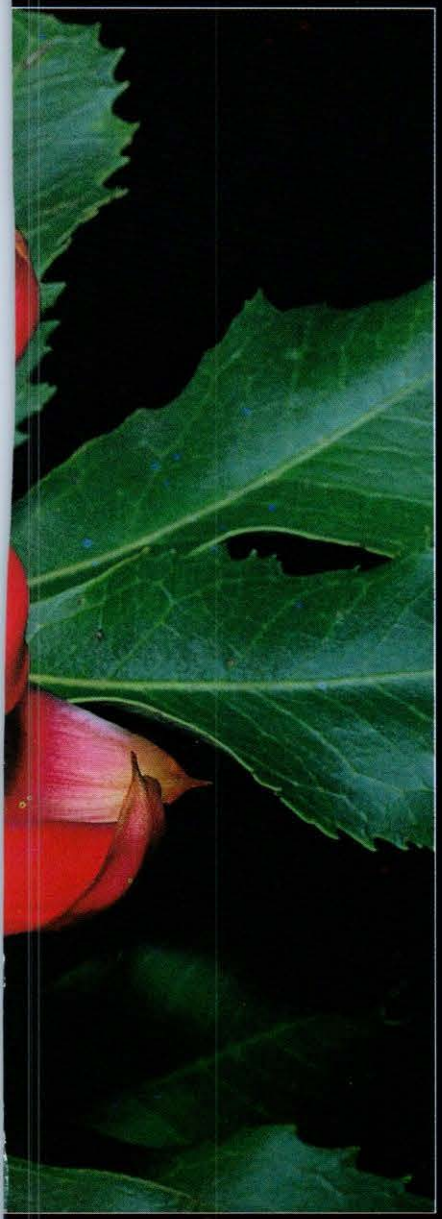
Dr John Stockard is Supervisor of the Wingham Brush Regeneration Team and has worked on the Brush since the inception of the Wingham Brush Program. Although a practising dentist, his interests include rainforest ecology and management of remnant vegetation communities. Mr Glenn Hoye is a mining engineer from the Hunter Valley whose interests cover natural history and photography. For the past decade he has studied the behaviour and ecology of Australian bats.



Waratah (*Telopea speciosissima*).

BUSH FLOWER PALETTE



Bottlebrush Orchid (*Dendrobium smillieae*).

BY PAVEL GERMAN
NATURE PHOTOGRAPHER

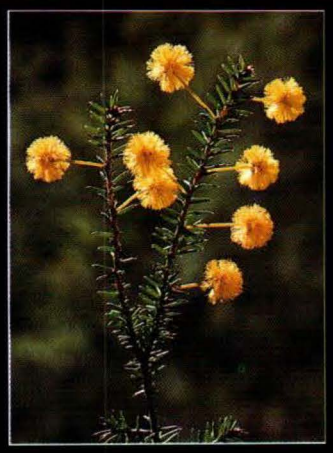
Spending countless hours in the bush photographing native animals, Pavel German finds he cannot ignore the beautiful native flowers. Their rich colour and amazing array of shapes and textures lure this colour and amazing array of shapes and textures.

BUSH FLOWER PALETTE

Willow-leaved Crowea (*Crowea saligna*).

Dotted Sun Orchid (*Thelymitra ixiodes*).

Mountain Devil (*Lambertia formosa*).



Juniper Wattle (*Acacia brownii*).

Western Australian Red Flowering Gum (*Eucalyptus ficifolia*).

Pink Waxflower (*Eriostemon australasius*).

"Bullet-shaped, three-eyed babies could be shot out of the birth canal with barely a maternal grunt and certainly no worries about cord strangulation."

PAIN IN THE NECK OF CREATION: THE PROVOCATIVELY FLAWED HUMAN

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

REMEMBER THE MIND-BOGGLING scene in the "Exorcist" where Linda Blair's possessed head whirls around on her neck like a top? Ten to one, your first thought (if you managed to recover from that plus her green vomit and baritone blasphemy) would have been the same as mine: "*that* is impossible", which is of course precisely why it seemed so spooky. We *know* what would happen to someone whose head did that, with or without a devil inside—as tissues stretched much too far, the head would unceremoniously fall off. Healthy mammal heads just don't *do* that.

While watching Linda's head do its unnatural thing, I found myself wondering *why* the rear half of our personal space must always be hidden from view. Why can't I see the shadowy monstrosity sneaking up behind me as I sit here late at night whacking away at my word processor? (Werewolves know about this inability and always sneak up directly behind you.) It doesn't seem fair. Surely many a bitten buttock would have been saved if we humans were constantly aware of a full 360° around our tasty bodies, ideally without having to continually snap our heads back and forth for the enhanced view.

Fair enough, spinning heads are out for good biological reasons. But given the advantage of wide-screen vision in keeping our eye fillets out of the clutches of carnivores, what other options might evolution have used to equip us with better hindsight? Wallowing wildly in biological possibilities, why not an eyeball turret mounted on the backs of our heads?

Just think what such a tiny shiny orb might have meant if the ancestor of all tetrapods had developed this observation port perhaps 370 million years ago. For starters, abominations like suit ties and starched collars might never have darkened the civilised world. Why? Because with a reduced need to rotate the head, fragile necks, around which ties get their irritating grip, might never have evolved.

Let's think about necks for a moment. Certainly, they're useful things on which to hang necklaces and watch Adam's apples bounce. And for many animals, besides providing a rotational device for front-mounted sensory systems, they assist other activities such as enabling Koalas to lick their backsides and Giraffes to browse six metres above the savanna floor. But they also have a distinct down side. Necklaces were originally worn to ward off evil intentions focused on what we quickly learned to be the body's most vulnerable region. Here vital internal structures such as the carotid arteries are closest to the body's surface. Carnivores, instinctually lunge for the neck knowing this to be the 'Achilles heel' of their prey. As any lion or homicidal maniac knows, necks are places where the larynx can be crushed to suffocate the victim. Here also the predator's long canines can most easily slice between vertebrae to severe the vulnerable spinal cord producing instant paralysis and a dinner that doesn't bite back. Necks are clearly a dangerously weak link in the body's chain of strength.

Even spectacularly sighted humans like Willie 'Popeye' Ingram lack the simple hindsight of a crab.

So why do we have them if not to rationalise the invention of the guillotine? Although rampant speculation, I suspect the primary, original biological *raison d'etre* for the vertebrate neck was an enhanced ability to gyrate the front-fixed senses without having to turn the whole body. A pair of laterally situated bulging eyes in aquatic vertebrates might have been adequate optical equipment where an about-face required a mere flick of a scaly tail.

It would be difficult to imagine that necks evolved in water because they would only have produced turbulence and a fragile region in the body. It is probably significant that whales, arguably the most successful terrestrial invaders of the oceans, have 'lost' their ancestral necks (their cervical vertebrae being fused into a lump) in the pursuit of a hydrodynamically streamlined shape. Although a few specialised invaders of the oceans, (turtles and plesiosaurs) retained necks, similar neck reduction or modification characterised sirenians, seals, ichthyosaurs and penguins, all of which descended from more 'necked' ancestors.

So when did our ancestors pass through the evolutionary 'bottleneck' that left us with the tie rack? Not long after fin evolved to foot about 370 million years ago. The earliest well-known tetrapods, such as the late Devonian *Ichthyostega*, lacked distinct necks, although slightly younger amphibians like the early Carboniferous *Proterogyrinus* had necks by 350 million years ago.

Attempts by the earliest beached tetrapods to make rapid neckless about-faces, perhaps necessary to avoid becoming someone else's dinner, would have had the local invertebrates clacking with laughter. Red-faced and sometimes dined-upon they *may* eventually have evolved necks because of selection pressure to keep a protective eye on their tail ends as well as to more efficiently spot edible laughing invertebrates.

On the other hand, if these first tetrapods had emerged from the primal waters with an observation port facing aft, would evolution have subsequently fitted them out with a neck? This is a reasonable question because there are many groups of invertebrates with panoramic vision and no necks. In fact, invertebrates in general demonstrate a dazzling array of observation turrets and eyes, a number of which are noted in John Downer's excellent book *Supersense*.

Many crustaceans put their dome-like eyeballs on erectile periscopes. Molluscs display every conceivable kind of optical paraphernalia from light-sensitive pigment spots on the mantle of clams to the infinitely flexible, hydraulically controlled

Adaptive advantage of hindsight: "Well, shucks! I've lost again. Talk about your alien luck!"

eyes of snails to the vast, highly efficient eyes of predatory squids, which also lack the blind spot that flaws the less efficient eyes of vertebrates. Swallowtail butterflies even have 'eyes' on their genitals so these vital organs can literally keep an 'eye' on what they're doing. Eyes, it would appear, can pop up in the most unlikely places.

Vertebrates too had alternative routes to hindsight up their genetic sleeves. Consider the albeit small parietal organ or so-called third eye found in most early amphibians, one of a pair of central, upwardly pointing light-sensitive organs (the other being the pineal body) developed between the normal more laterally positioned pair of eyes. In lizards, this medial eye sometimes develops a lens, cornea, retina and an optic nerve. Even humans have the haunting aberration known as 'spring fever' triggered by the light sensitivity of our pineal body parked just below the lid of our skull.

Hence it is possible to visualise a world in which a functional posterior eye became standard equipment for consequently neckless tetrapods. Today's beasts and behaviours would certainly have been very different. Human chests might merge gradually up into cone-shaped heads. Brains mightn't bulge like bloated blisters swaying on the ends of fragile stalks. Bullet shaped, three-eyed babies could be shot out of the birth canal with barely a maternal grunt and certainly no worries about cord strangulation. Words like 'gallows' wouldn't exist in our vocabulary because effective hanging involves the snapping of one of the most dangerously fragile bits of the body—the odontoid peg near the top of the neck, a seemingly trivial lump of bone that facilitates rotation of the head. When the neck 'breaks' during hanging, this peg snaps off the axis vertebra and drives into the nerve cord leading to instant paralysis of the muscles that enable us to breathe.

But, that's not the way things happened. Although neckless, hindsighted vertebrates may have been a viable alterative, we *have* fragile necks, are eternally suspicious of the space behind us, our bums are frequently bitten and lions easily strangle zebras. For better and worse, early tetrapods willed us necks and foresight only.

As an evolutionary biologist, I am not surprised that necks have negative as well as positive aspects. We, like all other living creatures, are opportunistically compiled bundles of biological compromise between genetic repertoire and the capricious demands of eternally changing environments. Necks were possibly the best solution that creatures of the late Devonian could devise to cope with selection pressures for panoramic vision. That this also introduced into the vertebrate pattern a dotted line across which future lethal factors might occasionally cut, was clearly not a deciding factor in the equation for evolutionary change.

In the same way, although evolution of erect posture sometime prior to four million years ago may have provided our australopithecine ancestors with enhanced abilities to carry food and avoid predation on Africa's savannas, it also saddled us with a barrel load of biological imperfections including bad backs, fragile fibulae, tortuous birth canals, sciatica, the need for anal support of the uterus and 'beer guts'.

Our pre-australopithecine ancestors were dominantly quadrupedal, in which position these problems would rarely have occurred. For example, abdominal muscles are well suited for sharing the load of the often copious guts of quadrupedal mammals, even those encouraged to remain unfit and fat in feed lots. But in our newly acquired upright posture, ample fat-bedecked guts have an irritating habit of stressing and ultimately overtaxing the lower half of this musculature, whereupon they readily drop out as the distinctly human 'beer gut'.

Similarly, whereas the vertebrae and vertebral discs of quadrupeds are well suited to resist strains suffered in a horizontal plane, in our new upright posture, particulary in tall individuals, ours frequently fail under the awful stresses of compression leading to sciatica, neckaches, or years of excruciating pain in the lower back.

God's perfect Creation or imperfect creature of compromise with miles of evolution to go before we 'sleep'? No prizes for guessing my conclusion. Even for those convinced of Edenic perfection, you must nevertheless allow that necks can be a right pain in Creation. ■

Suggested Reading

Downer, J., 1988. *Supersense: perception in the animal world.* BBC Books: London.

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

"A frog is a frog is a frog: there may be many species of them but they are obviously frogs, even when they are toads."

THE STRUCTURE OF LIFE

BY GLEN INGRAM & RALPH MOLNAR
VERTEBRATE ZOOLOGY, QUEENSLAND MUSEUM
VERTEBRATE FOSSILS, QUEENSLAND MUSEUM

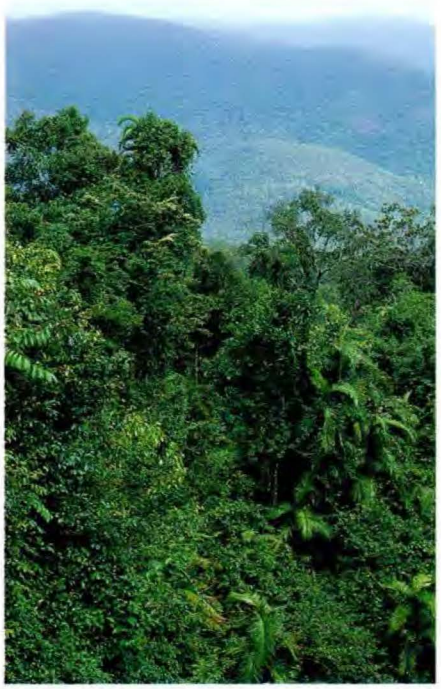
THE LAST HALF OF THE NINETEENTH century would have been a good time to be alive. The great tropical rainforests were just being explored by naturalists and these great ecosystems were giving up their secrets. It was a time of wonder when the writings and discoveries of such naturalists as Wallace, Bates and d'Alberti thrilled the public. Their narratives were enthralling, but what was most impressive was the richness and the diversity of life that was revealed—the sheer multitude of its forms.

These were the days when books on biology were best-sellers. Darwin didn't start the trend but his controversial books certainly maintained it. His most influential, *On the origin of species*, was not a travelogue. It did not describe the wondrous diversity of nature. Instead, it attempted to explain how this diversity originated. His explanation was natural selection. In modern times we have come to know much about natural selection, but what do we know about the diversity of nature? The answer is "very little".

In fact, there is reason to believe that we have not been too critical in examining just how diverse nature really is. It can even be argued that the claim of enormous diversity is a popular fantasy, that nature is not that diverse. This argument can be put as follows.

When one looks at the living world, what impresses is the lack of diversity. While there may be a multitude of entities, what is noticeable is their sameness. So much so, that most life is a variant on relatively few patterns or structures. For example, a frog is a frog is a frog: there may be many species of them but they are obviously frogs, even when they are toads. Similarly there may be millions of species of beetles but nonetheless they do not vary much from the typical beetle-like form. For example, you find beetles neither the size of a whale and living in the sea, nor with hydrogen chambers by which they can float in the air. Although there are a great many beetles (God loved them according to Darwin), all of them are recognisably beetles and there is no intergradation of beetles with other kinds of insects. Overall, nature is not very diverse.

The small number of living groups is striking. Lynn Margulis and Karlene Schwartz recognised 92 phyla in the living world. These were grouped into five kingdoms and arrayed as three great levels of life: the prokaryotes (bacteria, of the kingdom Monera), eukaryotic microorganisms and relatives (Protoctista) and the larger eukaryotic forms (Plantae, Animalia and Fungi). (Viruses are excluded: they are probably not living and are almost certainly more closely related to their hosts than they are to each other.) The small number of living groups is even more striking when one thinks about what could be. The permutations of the genes is enormous. The famous fruitfly, *Drosophila*, has about 5,000 genes. This gives $10^{16,000}$ permutations, which is much larger than the number of known organisms (about 10^6). Why then is this tremendous magnitude of diversity not expressed in the phenotype? Where is all this potential diversity?



FRITHFOTO

People often use the example of a tropical rainforest to illustrate how diverse nature can be. But is nature really all that diverse?

If we accept that life is limited in its diversity, then we should ask "why?". The traditional answer is "because of natural selection". That is, the environment acts on the field of variation, which has been generated by the genetic material, and selects the most useful of the traits. Thus an explanation is sought in extrinsic, environmental factors and these extrinsic factors act on limitless variation to produce limited diversity. In other words, the resultant forms are suited to their (limited) environments. But what if the possible variation on which the environment acts is in itself limited? What if the nature of living systems is such that relatively few forms are possible? And what if these forms are intrinsically determined?

This question of intrinsic and extrinsic determination of variation underlies two different ways of looking at evolution and at the living world: the first is called structuralism, the second functionalism. The difference between the two ways of thinking can best be illustrated through 'Martian eyes'. She passes by in her flying saucer just as you are photographing the view, after a morning of rock-climbing. Noting the photos that you obtain from your Polaroid, she readily deduces that the camera functions to provide images on paper. In your surprise at having a close encounter, however, you drop the camera, which bounces down the rock face and comes to rest in several pieces at the bottom. She wonders why cameras can make pictures but not survive a fall of a mere several metres. She is, after all, a functionalist and interprets the camera in terms of what it does. But you are a structuralist and realise that a plastic camera, even if it could survive the fall, could not maintain the rigidity necessary for the optics of picture-taking.

You see this in the biological world as well, especially if you are a connoisseur of the 1950s type of science fiction film. Giant ants, crabs and spiders populated some films. And yet there are no truly giant ants or spiders, none the size of a horse, pig, or even cat. But why not? Is no environment suitable for them? Or is it that vertebrates 'got there' first? Since insects live in a wide variety of environments—from the storm-swept shores of Antarctica to the hot springs of Wyoming—it seems hard to believe that the environments were unsuitable. And insects appeared in the Devonian before any completely terrestrial vertebrates had evolved, so really insects 'got there'

UNIVERSAL PICTURES

Giant spiders like the one in the sci-fi movie "Tarantula" (1955) do not exist in the real world because there are intrinsic, structural limitations to spider size. The width of this spider's legs, for example, would be insufficient to lift its hulking body from the ground.

first. Apparently there is some intrinsic—structural—limitation to insect size. Indeed there are several. Insects, and other land-dwelling arthropods, breathe through a suite of tubes, the tracheae. Oxygen reaches their tissues not by any active pumping, as in vertebrate lungs, but simply by diffusion. And since diffusion can supply oxygen only slowly and over short distances, any insects larger than a few centimetres would quickly succumb to oxygen starvation.

Furthermore, giant insects would have to be 'redesigned' to look more or less like vertebrates. The long, slender legs of many insects are sufficient to support their weight of a gram or less. But large animals bulking several kilograms must be supported by stouter limbs. The strength of a limb is proportional to its cross-section. A long, slender spider leg has a relatively minute cross-section, but quite adequate to support the also minute weight of the spider. However, the weight of an organism increases with its volume, and volumes increase more quickly with increasing size than do cross-sections. Mathematically speaking, size is proportional to length, while cross-section is proportional to the square of length, that is length multiplied by itself. And volume is proportional to the cube of length. If the length of an animal is doubled, the cross-section of its legs is quadrupled and its volume is increased by eight times. Thus doubling the size of an animal implies that its legs become effectively only one eighth their strength. To compensate, they must be quadrupled in cross-section. So rhinos have thick legs, while gazelles have slender ones—but not nearly as slender as those of a spider.

It is these inherent changes in anatomy to maintain function that demonstrate the intrinsic limits on the form of organisms. These limits are not set by the environment as such but by the laws of physics, although any organism that does not meet them will be culled by natural selection. However, natural selection does not itself set these limitations.

Such physical (and chemical) limitations are well known if not always obvious. A more important question is whether there are any inherent biological limitations. Some 40 years ago the science fiction writer Arthur C. Clarke recognised one. He pointed out that we can hardly expect an eye to be as good as a camera, given that an animal was constrained to use muscle and jelly as the building materials, rather than metal and glass. Drs Brooks and Wiley, who were the subject of the last issue's column, contend that thermodynamics poses another inherent biological limitation. In their view the structure of organisms is determined and limited by the constellation of their genes.

Changing these limits to variation transforms the structure of an organism and results in substantial evolutionary change. Such changes lie at the origins of the major groups of living things—the kingdoms and phyla. Phyla differ from one another by such alterations as having jointed limbs *versus* none, or being segmented *versus* unsegmented, or by having tube feet or notochords or nematocysts (stinging cells). These changes make up evolution on the grand scale—macroevolution. They occurred 91 times to create the 92 phyla, and all the further diversity in organisms that so impressed the Victorians, from those of rainforest to coral reefs, results from rather minor variations in these 92 themes. ■

Suggested Reading

Dwyer, P.D., 1984. Functionalism and structuralism: two programs for evolutionary biology. *Amer. Natur.* 124: 745–750.

Lauder, G.V., 1981. Form and function: structural analysis in evolutionary morphology. *Paleobiol.* 7: 430–442.

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

QUESTIONS & ANSWERS

COMPILED BY JENNIFER SAUNDERS
EDITORIAL ASSISTANT

Birds of a Leather

Q. I was looking something up in my Australian ornithological field guide the other day when I noticed that it included an Ostrich. It was given the subspecies *australis* but very little information was supplied. I thought there was only one species of Ostrich and it was African. Can you please explain if the Ostriches in Australia are indeed Australian, or, if not, how and when they got here? I'm curious.

—S. Reading
Fremantle, WA

A. There is a single species of Ostrich (*Struthio camelus*), and nowadays it occurs in a natural state only in Africa (previously it extended into Arabia until its extinction there in 1968). There are, however, several subspecies recognised in Africa—the southernmost one occurring from Zimbabwe–Botswana to northern South Africa being called *Struthio camelus australis*, meaning 'southern'. Birds from this population were brought to South Australia in 1870 for the plume trade (mainly for fashion); following World War I the industry failed and many birds were released. Today, small numbers of feral Ostriches remain in scattered localities in South Australia. So the Ostriches found in Australia are all introduced. It is interesting to note that Ostriches are again being farmed for fashion: this time for their attractive, soft leather rather than their feathers. This is practised on a broad commercial scale in South Africa. In Australia, Ostrich farming has only recently been reestablished, although it has its competitor: Emu farming.

—Walter Boles
Australian Museum

FIONA DOIG

Ostriches are native to Africa.

The Power of Power

Q. Okay, so I've improved my environmental fitness by recycling everything possible, being more aware of what I buy and walking to the shops rather than driving. Consequently I've saved money and become fitter, so I figure I'm onto a good thing. I now want to up the stakes a little, but what I want is some kind of formula or scale of priorities, rather like the labelling system Tim Flannery discussed in his article "Vaccine for the Plague" (ANH vol. 23, no. 2, 1989) to help me prioritise energy consumption in the home. I want to get a grip on what I should be doing less of (for example, is driving a car the worst thing I'm doing environmentally?), and what energy sources I should be replacing (for example, solar-power to replace gas or electricity?). This would aid me in making everyday decisions (like should I get a wood-fuel, gas or electric barbecue?).

—J. Dunne
Narrabeen, NSW

A. The Greenhouse Effect represents the greatest environmental threat. Thus, the logical course of action is to reduce personal and global consumption of fossil fuel and to support sustainable agricultural practices such as organic farming. Some changes are difficult when society is arranged otherwise, but personal reductions in fuel use can have an immediate and profound effect if enough people cooperate.

The family car and the fossil-fuelled electricity industry are our two biggest non-agricultural problem areas. Driving a small car saves you money, cuts Greenhouse emissions by half compared with V6s and V8s, and usually gets you there in about the same time. Using an old inefficient car is not good recycling—environmentally, it is much worse than discarding the old car and buying a new, efficient one. Using public transport is even more responsible and a bicycle is the best if you can accept the inconveniences. When electric cars arrive, sometime during this decade, use these.

In the home, there are many ways to cut down electricity consumption: use the new electronic ballast compact fluorescent lighting instead of incandescent bulbs in frequently used lamps; install solar water heating (preferably backed up by gas or wood-fuel); improve home insulation and weather-stripping; include house modifications to improve passive solar usage and lower air conditioning loads; use solar, wood-fuel or gas space heating in that order, also gas cookers (or solar when they finally arrive), and low-flow showerheads such as the Australian Delrana will help reduce consumption.

In Tasmania where hydro-electricity is used to produce power, electricity or solar power with electric backup *should* be used for the above domestic applications in place of gas or wood. Energy efficiency, however, should still be practised where cost-effective. Finally, recycling reduces industrial consumption considerably and should be practised wherever possible.

If you practice the above suggestions you will have reduced your personal Greenhouse contribution by between 40 and 80 per cent and saved money as well.

—David Mills
University of Sydney

Bereft of the Bends

Q. I've heard that seals can dive to incredible depths. If they have lungs like us, why don't they get the bends?

—J. Turner
Wollstonecraft, NSW

A. Recent research has shown that elephant seals are the deepest diving of all mammals including the large whales. Instruments attached to Northern Elephant Seals (*Mirounga angustirostris*) have 'gone off the paper' at over 1,000 metres and one particular animal dived to an estimated 1,200 metres! Southern Elephant Seals (*M. leonina*) have been accurately recorded diving to depths of 1,198 metres (see QQC in ANH vol. 23, no. 3, 1989). They do not have a continuous air supply like human divers and so take down a limited

supply of nitrogen (the gas that causes the bends). Seals do not rely primarily on oxygen stored in the lungs while diving; rather, most of the oxygen used during a dive is stored in the blood. The animals exhale before diving and, at about 40 metres, the lungs collapse and no further oxygen exchange occurs. Seals also possess a larger volume of blood to store the oxygen. In the case of elephant seals, this blood supply is about 2.5 times that of humans relative to weight.

—**Linda Gibson**
Australian Museum

Tucking into Bush Tucker

Q. I enjoy reading the Wild Foods column immensely and I was wondering where in the city I can try out, or purchase, some of these delicacies. Could you suggest some suppliers?

—**Paula Johnson**
Vaucluse, NSW

A. Apparently there is only one supplier of wild foods in Sydney: Bush Tucker Supply Pty Ltd, run by Vic Cherikoff (02 816-3381). There are also a number of distribution outlets for Bush Tucker Supply in other States. In Victoria, there is Robins Food Store (424 Toorak Road, Toorak, 03 241-9201); in Adelaide, Andrew Fielke can supply wild foods (08 337-8142). In Cairns, Ric Macleod distributes for Bush Tucker Supply (070 55-1475).

There are now many restaurants using bush foods in their menus. In Sydney, Rowntrees The Australian Restaurant (188 Pacific Highway, Hornsby, 02 476-5150), specialises in Australian cuisine. Barrenjoey House at Palm Beach (1108 Barrenjoey Road) also serves bush foods, as does Blueys Down Under, a theatre restaurant at Darling Harbour. Other restaurants that include bush foods on some of their menus are Le Kiosk at Shelley Beach near Manly, The Garrison Restaurant at the Rocks, Forgotten Valley Restaurant at Wiseman's Ferry and the Fig Tree at Byron Bay. Out of New South Wales, The Metropolitan Brasserie in Bendigo not only features bush foods in the restaurant but also choreographs an Australian cuisine promotion each year in Hong Kong. Most major international hotels (Sheraton, Hilton, Hyatt, Four Seasons, Bankstown International) use bush foods for particular menus, such as on Australia Day or for culinary competitions.

Of course we take many of our usual wild foods a bit for granted: don't forget that our wonderful seafood is available around the country and that the Macadamia nut is native to Australia!

—**F.D.**

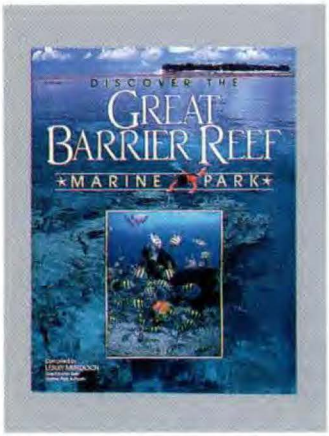
Questions for this column may be submitted to Jennifer Saunders, Australian Natural History, P.O. Box A285, Sydney South NSW 2000.

REG MORRISON/COURTESY TI TREE PRESS

Stewed Quandongs and other native delicacies can be tried in a number of restaurants serving bush foods.

REVIEWS

COMPILED BY JENNIFER SAUNDERS
EDITORIAL ASSISTANT



Discover the Great Barrier Reef Marine Park

Compiled by Lesley Murdoch, Bay Books, 1989, 96 pp. $9.95.

At first glance, this book is just another on the Great Barrier Reef. However, at second glance, the reader discovers much more than just good photos and easy-to-read, informative text. Compiled by Leslie Murdoch of the Great Barrier Reef Marine Park Authority (GBRMPA), this book tells us, in layman's terms, of the wonder of the reef, its constituents, its history and its future.

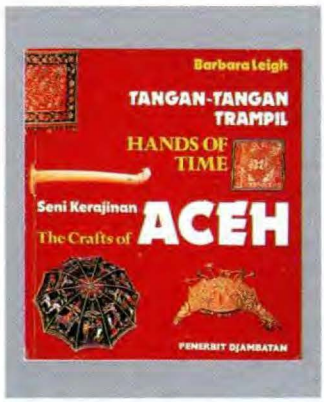
In the first chapter we are introduced to the Great Barrier Reef and briefly to the role of GBRMPA in maintaining a balance between the usage and conservation of the reef. We then discover how reefs are formed and the wide range of reefs and islands that are part of the Great Barrier Reef. The chapter titled "The reef community" looks at the corals and the algae—the building bricks and mortar of the reef. It discusses how the corals are established, how they feed and reproduce, and how members of the associated community interact with the coral and with one another. "All creatures great and small" looks at the main animal groups that inhabit the reef and includes a section on "Reef nasties", which not only identifies the animals dangerous to humans but also suggests ways to avoid or deal with injury.

We are then taken on a journey through the history of the reef from early Aboriginal explorers to the first European exploration and present-day expeditions. Early encounters with the reef often resulted in large numbers of wrecks that now, as discussed in the chapter titled "In days gone by", represent a priceless irreplaceable heritage. The book clearly outlines the law surrounding shipwrecks and removal of artefacts, and subtly suggests training courses associated with wreck survey for those who might be more interested in this area. "The reef and us" concentrates on those issues affecting the reef, from the human impact (tourism, recreational and commercial fishing, holidays) to the Crown of Thorns Starfish problem, and the role of research in learning more about the reef and assisting to maintain and preserve it for the future. The final chapter takes us to the aquarium recently established at Townsville and tells of the painstaking reconstruction, down to the most minute detail, necessary to duplicate the reef environment in artificial surrounds and thereby make the reef and the marine park more accessible to the public.

Discover the Great Barrier Reef Marine Park is blessed with short and concise but informative chapters that, together with the easy-to-read text, virtually guarantee to hold the reader's interest throughout. Supplemented by mostly excellent photos, simple and effective block diagrams, profiles and cross-sections, and animated habitat drawings, this book has something for everyone. Whether you are a diver, student, scientist, marine park enthusiast, photographer, holiday-maker, adventure seeker or an armchair biologist, I would be surprised if there isn't something in this book that wasn't new to you.

Priced at only $9.95, *Discover the Great Barrier Reef Marine Park* is well within everyone's budget. And after you have read the book, go discover the reef for yourself. You won't be disappointed.

—Jenny Gates
Australian Museum



Hands of Time: The Crafts of Aceh; Tangan-Tangan Trampil: Seni Kerajinan Aceh

By Barbara Leigh. Penerbit Djambatan, Jakarta, 1989, 181 pp. $21.95.

This book is a labour of love. The author, who accompanied her husband to Aceh, Sumatra, for two years in 1978, found herself drawn to the task of recording the ongoing indigenous crafts of this vigorously Islamic northernmost province of Indonesia. The result is a refreshingly personalised account, introducing the reader to individual Acehnese specialists in the crafts of embroidery, silk weaving, reed plaiting, jewellery, pottery, woodcarving and metal work.

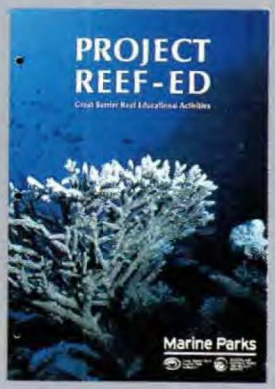
Not only are technical details described and amply illustrated with black and white photos and diagrams, but the total context of the items made—their social role, emotional value, and the religious and cultural concepts that they convey—is given. To quote from the author's personal note: "All crafts dealt with in this book are part of the people's existence. . .They are not created primarily for a tourist market, or as a romantic sideline, or as a tasteful optional extra. They have an intrinsic relationship to the cultural, political and religious life of the province."

The author repeatedly demonstrates her understanding of this cultural wellspring, and concludes with an intelligently wide-ranging discussion of the design elements characteristic of Acehnese work. Using footnotes she provides the reader with opportunities to follow up specialised ideas, and a detailed bibliography is included.

This is not merely a book for the specialist craftsperson or Indonesianist. A very readable introduction to the area, culture and history of Aceh, and the author's warm and direct approach to her topics, make this book accessible to the general reader. The provision of the bilingual text, in English and Indonesian, makes this book particularly useful for enterprising teachers of Asian Studies and Indonesian Language, who could use it as a source of 'case studies'. It also ensures that the results of her research will be shared with the people of Aceh and of Indonesia generally.

My only criticisms of the book are technical ones concerning the quality of the publication: the use of non-glossy paper, while keeping the book competitively priced, does not do justice to the photos, which lose in both contrast and definition. Also, the use of a two-column text, with the additional necessity of including bilingual captions and footnotes, occasionally leads to a distracting and confusing page layout. Photos are not always optimally adjacent to text and there are several typing errors that have slipped past the editing process. In a book of such valuable content, this is a pity. However, these drawbacks are not sufficiently serious to detract from the overall merit of the book, which breaks new ground in providing a detailed record of these craft traditions.

—Zoe Wakelin-King
Australian Museum



Project Reef-Ed: Great Barrier Reef Educational Activities

By A. Byrnes, P.T. King, J.A. Marsh, B. Moffatt, J.S. Oliver and A.L. O'Neill. Great Barrier Reef Marine Park Authority, Townsville, 1988, 400 pp. $19.95.

If you have ever had to devise, plan, organise, implement, conduct or survive a student excursion to *anywhere*, you will delight in this book. Your only regret will be that it was not written years ago.

Project Reef-Ed is a book for teachers and other educators to assist them in organising student excursions to the Great Barrier Reef. In its approach and layout it serves as a model for any student field excursion, not just those to the Reef.

The bulk of the book consists of 159 student activities presented from a multidisciplinary perspective. Although these are organised under two main headings, "The natural world" and "The human dimension", the book does not attempt to separate science from humanity. There is merely a shift of emphasis from the objective scientific approach to the more subjective human perspective. At all times the human participant is kept intrigued, alert and involved, and hopefully stimulated to creative achievement and scientific understanding.

The activities are well presented, with clear aims and requirements, and have all been tested in the field by students and teachers. Relevant information and references are provided where appropriate, as are field record sheets, useful diagrams, and suggestions for subsequent reading and activities. The activities are designed for years 10–12, but many are suitable for students both older and younger.

This is not merely a compilation of exercises. It is a cleverly constructed tool that can be used in a multitude of ways. The "Examples of reef activity programs" near the front illustrate just a few of the many ways in which activities can be selected and integrated to provide a cohesive plan, tailored to the group and its particular needs. Here is a wealth of ideas, from the most basic observational exercise (Activity 2: "Your first reef walk") to the challenges of managing conflicting land-use demands (Activity 143: "User roles and zoning game"), or composing reef-inspired music on reef-inspired instruments (Activity 118: "Reef orchestra").

Key words provided beside each activity highlight underlying concepts, skills and attitudes. These key words alert one to the real learning experience that the exercise seeks to achieve. Further support in this area is provided in the comprehensive rear section, which puts reef education in the context of environmental and science education, and details its relevance to current Queensland and New South Wales school syllabuses in science and geography.

Practical advice on safety, collecting, environmental protection and permits is given at the beginning of the book. In fact, the whole book is beautifully practical, not only in its presentation, but also in its construction. Holes for ring-binders are already drilled—it seems one is encouraged to tear this book apart. The student need then only carry the selected sections into the field.

The only pity is that the substantial list of "Amendments and additions", attached inside the back cover, could not have been incorporated into the text. Such is the cost of printing deadlines.

At a very affordable price, *Project Reef-Ed* is a book to be used and re-used. Do not leave it idle on your shelf.

—Sally Stephens
Australian Museum

Insect Delight: a Life's Journey

By John Evans. Brolga Press, Canberra, 1989, 212 pp. $16.50.

The history of the Australian Museum falls clearly into two periods: the first 125 years during which it was fumbling towards an identity; and the last 35 years in which it has taken its place among the great natural history museums of the world. The pivotal year was 1954, when John William Evans was appointed Director. An intensely private person, he let himself be known only to a few intimate friends but the veil is lifted, to a degree, in his autobiography, published in his 83rd year.

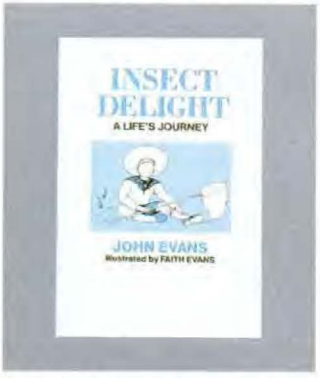
The only child of a professional soldier, he was born in India but sent back to England at the age of two-and-a-half to live with a series of real and surrogate 'aunts' until he was ready for the misery of boarding schools. Declining to follow the family profession of arms, he took an unimpressive degree in natural science from Cambridge and obtained a position in a shark-fishing company that was to have operated in Australian waters. He arrived in Sydney to find that the company had collapsed but family contacts led him into a very junior position in the new Council for Scientific and Industrial Research (CSIR, now CSIRO), which was the springboard to a traineeship in entomology. This involved something like a master–apprentice relationship with the famous R.J. Tillyard, then working in Wellington, New Zealand. After further training in England, he returned to the new CSIR Division of Entomology, where Tillyard was now Chief and, in the manner of a good apprentice, married one of his master's daughters, Faith (sister of Patience, Hope and Honor).

What had every appearance of a career for life lasted only five years. In 1935 he moved to Tasmania as Government Entomologist and subsequently Chief Biologist. Restless after seven years, as a frog in a small puddle, he applied for a position in the Imperial Institute of Entomology, London, and eventually settled into this in 1944.

Disappointed again, he moved to the Department of Agriculture as Chief Scientist in charge of infestation control and endured this for five years before coming back to Australia to take charge of the Australian Museum. Even here, in what was undoubtedly his most satisfying job, he lasted only 12 years, choosing to retire at the age of 60.

One cannot help feeling that the reasons given by Evans for his moves are somewhat superficial but he is either not given to deep introspection or, more likely, regards this as none of the reader's business. If there is any motivational pattern behind his peregrinations, it would seem that he had a tendency to take offence where it was not intended; an ambivalent attitude to success (seeking it but mistrusting the achievement); and a feeling (usually contradicted by events) that distant fields were greener. And one must wonder what personal needs were satisfied by obtaining *two* doctorates of science (Tasmania, 1939; Cambridge, 1949). What we are mostly given in his book is an insight into his enthusiasm for insects and into his most fortunate marriage.

Evans' researches as an economic entomologist were spread so widely that they failed to yield dramatic results: such successes usually require decades of work in a restricted field. His high repute as a scientist rests largely on his intensive study of leaf-hoppers,



most of which was performed in his own time. Both aspects of his work are enthusiastically described in his appropriately named book, delicately illustrated by his wife.

Of his marriage it must be said that it is hard to imagine John Evans without Faith. By the greatest of good fortune, this woman, with whom he fell in love at the age of 23, is his

COURTESY ANGIE TESTA

perfect complement—ebullient, outspoken, fiercely protective, a biologist in her own right, and a home-maker. This last capacity was frequently called upon and, if we can believe her husband, given uncomplainingly. It is hard to imagine any other museum director's wife engaging in domestic service to eke out the family income while settling into Sydney.

Such a complex life as John Evans' deserves a deeper analysis. I only wish that *Insect delight* had been two or three times longer.

—Ronald Strahan
Australian Museum

Big Banana Horticultural Theme Park

Pacific Highway, PO Box 1236, Coffs Harbour, NSW, 2450, ph. (066) 52 4355. Admission $9.90 (adults), $5.90 (children); 12-month pass $17.50 (adults), $9.00 (children).

When Alexander the Great came across a group of philosophers sitting under a banana palm in the year 333 BC, he decided that the fruit must impart wisdom so he gave it the name *Musa sapietium* meaning 'the inspiration of wise men'. Since then the banana has been put to a lot of uses but it has taken a very wise man of modern times to create the Big Banana Horticultural Theme Park, near Coffs Harbour.

The park is a showpiece offering a wide range of activities including an historical village, shell museum, hydroponics display, time tunnel, Dreamtime Cave, as well as a farmers' market and a fine restaurant, just to name a few. The *piecé de rèsistance* is a futuristic museum that includes a working tissue culture laboratory billed as a "tour of an alien orbital space laboratory...". A shuttle transports visitors right around the 17.5-hectare park. One can spend an hour or a whole day there.

The Big Banana, with its famous oversized sculpture at the entrance, has been around since 1963. The original owner, an American scientist called John Landi, had great plans of a Disney-style park but was never able to realise his dream. Over the last year Bob Johnson, the Principal of Horticultural World Ltd, has tirelessly watched over the reshaping of the park, which has involved a massive capital injection of $31 million. The results are stunning.

Upon arrival there is a short audiovisual shown in the theatrette giving the visitor an idea of the range of activities and purposes of the Big Banana. Part of the aim of the park is to make people think of what is happening in the world: how the world will be affected by today's actions and what has happened as a result of previous environmental mistakes.

Then, after the audiovisual and prior to boarding the shuttle, one comes to the Dreamtime Cave where a life-size figure of an Aboriginal tribesman tells the Dreamtime story, complete with lightning bolts and didgeridoo music. For this exhibit local Aboriginal input was sought to make it as authentic as possible.

While one can see most of the features by shuttle, and a running commentary on the park is played during the 40-minute journey, visitors can also stroll through the exhibits of farm machinery and the historic village.

Further along is the hydroponics glasshouse where plants grow using special nutrients and without soil. On the hillsides the shuttle passes the banana plantations and fruits before it enters the time tunnel and the Futureculture Centre where one is encouraged to leave the shuttle to view a museum with a difference. Issues are raised here to do with the environment and its future.

Examples include the thinning of the ozone layer and the careless misuse of pesticides. There are computerised models and interactive exhibits as well as many other displays. Plant reproduction is presented in the working tissue laboratory where identical clones are produced from tiny amounts of growing plant tissue. Technology for producing whole new generations of disease-free plant stock is explored, as well as probing questions about the safety of nuclear technology for producing fresh foods that resist decay. After this brief education the visitor reboards the shuttle and continues on to the restaurant where a variety of foods ranging from Mediterranean and Asian to seafood or just fruit and ice-cream can be purchased, not to mention the famous banana smoothies! A tour of the farmers' market where a wide variety of fresh fruits as well as nuts, juices and honey are on sale concludes the visit.

In addition to the exhibits mentioned above there is also an interesting recycling program. A worm farm breaks down organic materials from the park and restaurant, yielding a nutrient-rich compost to be used again. There are many facets to this park.

All in all one can spend a fascinating day exploring at the Big Banana, as well as learning about the environment. The only problem perhaps is that, once seen, it is not as interesting the second time round. There needs to be a little more variety. However, as the park is only new, I've no doubt this will happen. It is an excellent way for a family to spend a day, particularly during the school holidays.

—Angie Testa

Kingdom of the Lyrebird Bird Safari in Australia

Filmed and written by Paul Lazslo, sound recording by Jenny Lazslo. Paul Lazslo Productions, Melbourne, 54 minutes each, 1985 & 1989 respectively, $45.00 each.

There is much that appeals in these videos. The photography and sound recording are generally of a high standard, and there are many attractive shots, with some action sequences presenting bird behaviour of particular interest, some of it rarely captured on film. Each video has its major theme but extends its coverage to draw in a diversity of other interesting subjects.

The "Kingdom of the Lyrebird" serves as a good introduction to this special Australian bird. Starting in late spring, it presents a year in the life of the Superb Lyrebird (*Menura novaehollandiae*). Sequences of displaying males are, of course, obligatory—and these are well filmed—as are some fine bouts of mimicry showing the vocal abilities of this species to good effect. To these are added a range of other daily activities: feeding, bathing, preening, nesting and, of considerable interest, copulation—a rarely seen, much less filmed event. After completion of copulation, the male

immediately resumes dancing in front of the female but with the tail held in a posture different from that normally seen during display.

The title of "Bird Safari in Australia" suggests a broader coverage than is offered by the video. Filming took place in parts of drier southern Australia, mostly in mallee country (other than an abrupt interjection of coastal eastern Victoria at the end). The primary aim of the video is to show how birds and plants exist together, each aiding the other as the bird searches for nectar among the flowers, receiving food and in the process assisting in the pollination of the plant. There are many good sequences of nectar-feeding involving several species of honeyeaters, lorikeets and woodswallows at a variety of different plant species. The range of feeding methods, while not directly described in the narration, allows for interesting comparisons. There are also several sequences at a waterhole as the birds crowd and squabble for drinks. A very nice clip shows a female Rufous Songlark (*Cincloramphus mathewsi*), her beak full of food for her chicks, wading deep into the pool to soak her belly feathers before returning to the nest where the water will help keep the young cool during a heatwave. Other segments of note include sunning by a male Golden Whistler (*Pachycephala pectoralis*), an unusual display by a Striated Pardalote (*Pardalotus striatus*), pellet regurgitation by woodswallows and a section on regeneration after fire. Although incongruous with the habitat shown throughout the video, there is a concluding segment filmed in eastern Victoria that shows the extremely endangered Helmeted Honeyeater (*Meliphaga melanops cassidix*). While the bird does very little, this must be one of the few times this species has ever been filmed.

The scripts are the weakest part of the videos. There are several problems that, while not major, are nonetheless annoying and unnecessary. The presentation, particularly in "Bird Safari", too often meanders without a sufficiently well-specified direction. Some subjects seem overly long or repetitious. The occasional anthropomorphic phrase is grating ("The male [Golden Whistler] must be very proud of his bright plumage" in "Bird Safari"), as is the loose or unfortunately incorrect use of certain terms (the habitat shown in "Kingdom of the Lyrebird" is continually referred to as rainforest, yet it is mainly open sclerophyll forest with a scattered rainforest understorey). Unfortunately that horrible phrase 'birds and animals', usually restricted to signs in national park camping grounds, makes an unwanted appearance in "Kingdom of the Lyrebird". And a few statements are simply incorrect, such as the male lyrebird in "Kingdom of the Lyrebird" being said to shed his entire tail in summer. Except possibly in abnormal circumstances, such as attack by a predator, the tail feathers are lost and replaced gradually over a number of months.

"Bird Safari" has the tendency to interject short sermons on the need to protect the environment. While these sentiments are certainly laudable, they are somewhat disruptive to the flow of the narration and, by the third instance, become unnecessarily intrusive.

Both videos share the problem of occasionally failing to identify the subject on the screen. Several birds, flowers and kangaroos (referred to simply as such) occupy the screen for extended periods yet pass unnamed. This shortfall also extends to some of the prominent and well-recorded bird songs that dominate the sound track.

However both videos successfully achieve their goals of presenting the viewer to aspects of Australian birdlife; "Kingdom of the Lyrebird" is a simple but fairly thorough introduction to the life of one of the most intriguing of this country's unique birds; "Bird Safari" explains the interdependence of birds (and other animals) and flowering plants for survival. Unfortunately one wishes the entire presentation could have been tighter and more rigorously written and edited. Then these two pleasant videos could have been excellent ones.

—Walter Boles
Australian Museum

"Inhumane treatment of animals is not only ethically unacceptable in our society; it is counterproductive and wasteful by any management standards."

MARINE MAMMALS IN THE MILITARY

BY LAURA M. MUMAW
DIRECTOR, AUCKLAND ZOO

ALTHOUGH HARD TO BELIEVE, REPUtable publications such as *BBC Wildlife* and *Science* began telling of how dolphins had been dispatched to Cam Ranh Bay in Vietnam to protect a United States Naval base there. Then American newspapers reported on dolphins working for the United States Navy in the Persian Gulf during the Iran–Iraq war. And in 1988 the United States Army Corps of Engineers announced plans to construct dolphin pens at Bangor Naval Submarine Base (Puget Sound, Washington), apparently to house dolphins intended to 'guard' submarines based there.

The United States Navy has confirmed the existence of a marine mammal investigative research program whose findings, from studies of dolphin hydrodynamics, sonar capabilities etc., can be used in the design of underwater intelligence equipment and vehicles. A less publicised aspect of the program is the training of marine mammals (seals and dolphins) to search for and recover equipment lost under water. Little is known of the military use of marine mammals for surveillance work or what their trained response might be should they detect intruders. Navy spokesmen have flatly denied that marine mammals are trained to kill or to take any action that would endanger their own lives.

Should marine mammals be trained for military use? Let's take a look at several of the underlying issues currently being debated.

Some of the most vehement criticism of the United States Naval marine mammal program relates to alleged mistreatment of animals during training, neglect of animals, and movement of animals to inappropriate climates. There can be no justification for such offences. Humane techniques for training and husbandry of marine mammals have been developed over the last 40 years and a number of countries worldwide have legislated mandatory standards for the care of captive marine mammals. The most frequent causes of animal abuse in professional programs today relate to inexperience, ignorance and carelessness. Inhumane treatment of animals is not only ethically unacceptable in our society; it is counterproductive and wasteful by any management standards. Correction of any physical animal welfare problems in military programs should be straightforward and mandatory.

The ethical dilemma over use of animals in a military context, however, is not so easy to resolve. Animals have been used in human warfare for millennia, in action and behind the scenes. Camels, horses and elephants are notable examples of the former; message-bearing carrier pigeons and tracking and guard dogs of the latter. More recently the possible use of bacteria, viruses and smaller living particles in biological warfare has raised an ominous spectre that most of us feel is not only immoral but genocidal. For many people, war itself is, if not unacceptable, a solution of last resort. It is hard to accept the use of any animal in active battle or in a military situation where risks of death are high. However, defensive actions may be necessary in a military context and well-trained animals can be used successfully in them, providing it is for the mutual benefit of humans and the species. Most animals used historically for such military purposes (such as for guarding and bearing messages) have been domesticated species. The benefits to them would be the ongoing care and husbandry (including long-term survival of their species through breeding) provided by humans. The physical and psychological health of these animals is something that most people, down to the average pet owner, feel qualified to judge.

But what of the human use of marine mammals, animals that are not domesticated? Are we justified in taking them from the wild? What benefits could they derive from this association? In 1865 Francis Galton wrote an essay, still largely accepted, on the human use of animals and the nature of domestication. It stated that successful domestication had occurred only in species that shared six traits: they were "hardy", had an "inborn liking for man" (that is, were social animals that would accept a human as a leader), were "comfort loving" (that is, readily accepted domesticated conditions), "bred freely", were "easy to tend", and were "useful". It is remarkable how well today's most commonly kept marine mammals (California Sealion and Bottlenose Dolphin) fit these criteria. No doubt the alienness of the marine environment has heretofore kept these animals from being as intimately involved with the average human as, say, the dog has been. The dolphins of Monkey Mia in Western Australia show how easily our species interact at the interface of our environments.

Training of animal species that possess traits conducive to doing so is acceptable, provided priority goes to using animals bred in or already adapted to the captive environment and that the species benefits directly from the work. For those animals with populations in the wild such as marine mammals, benefits must go to the wild populations. If we train seals or dolphins to rescue drowning people, retrieve airline black boxes, detect man-made underwater objects, or guard our ships, we must use the information we gain from these animals to safeguard the fish stocks on which the species feed, keep their natural habitats livable, and protect them from driftnets and incidental killing.

The International Union for Conservation of Nature (IUCN) recognises that basic and applied research is critically needed on the biology of the world's species and encourages research that contributes to species survival. Where threatened species are concerned, IUCN recommends that, if research programs do not directly contribute to the conservation of a species, monetary or other substantial resources should be devoted to sustaining wild populations in their natural environment. We should expect nothing less from any military programs that use marine mammals, whether the species are immediately threatened or not. ■

Suggested Reading

Galton, F., 1865. The first steps towards the domestication of animals. *Trans. Ethnol. Soc. Lond. n.s.* 3: 122–138.

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Mulvaney, K., 1989. Dolphins learn that war is hell. *BBC Wildl.* March 1989: 191.

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Laura Mumaw is currently Director of the Auckland Zoo. She has had 13 years professional experience working in zoos and aquariums holding marine mammals and began her career with a Master's degree in Fisheries.

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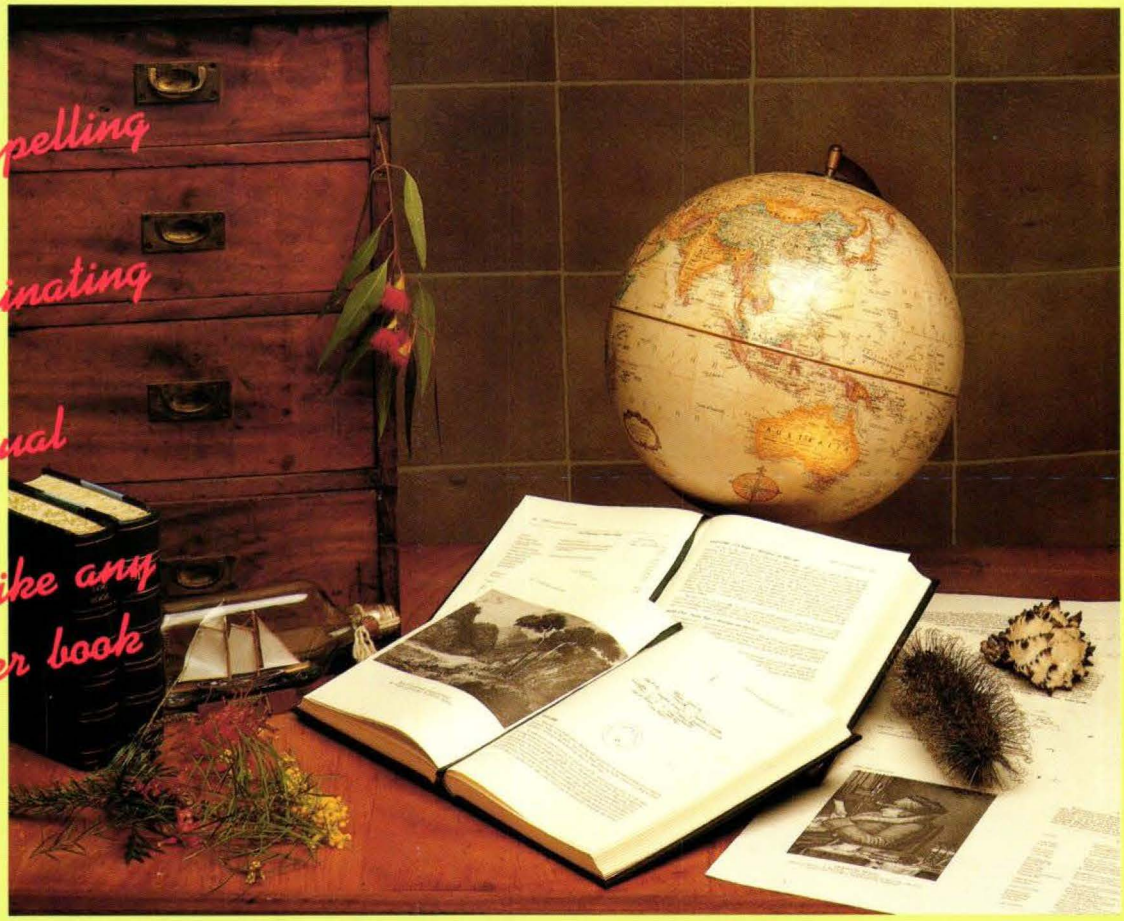

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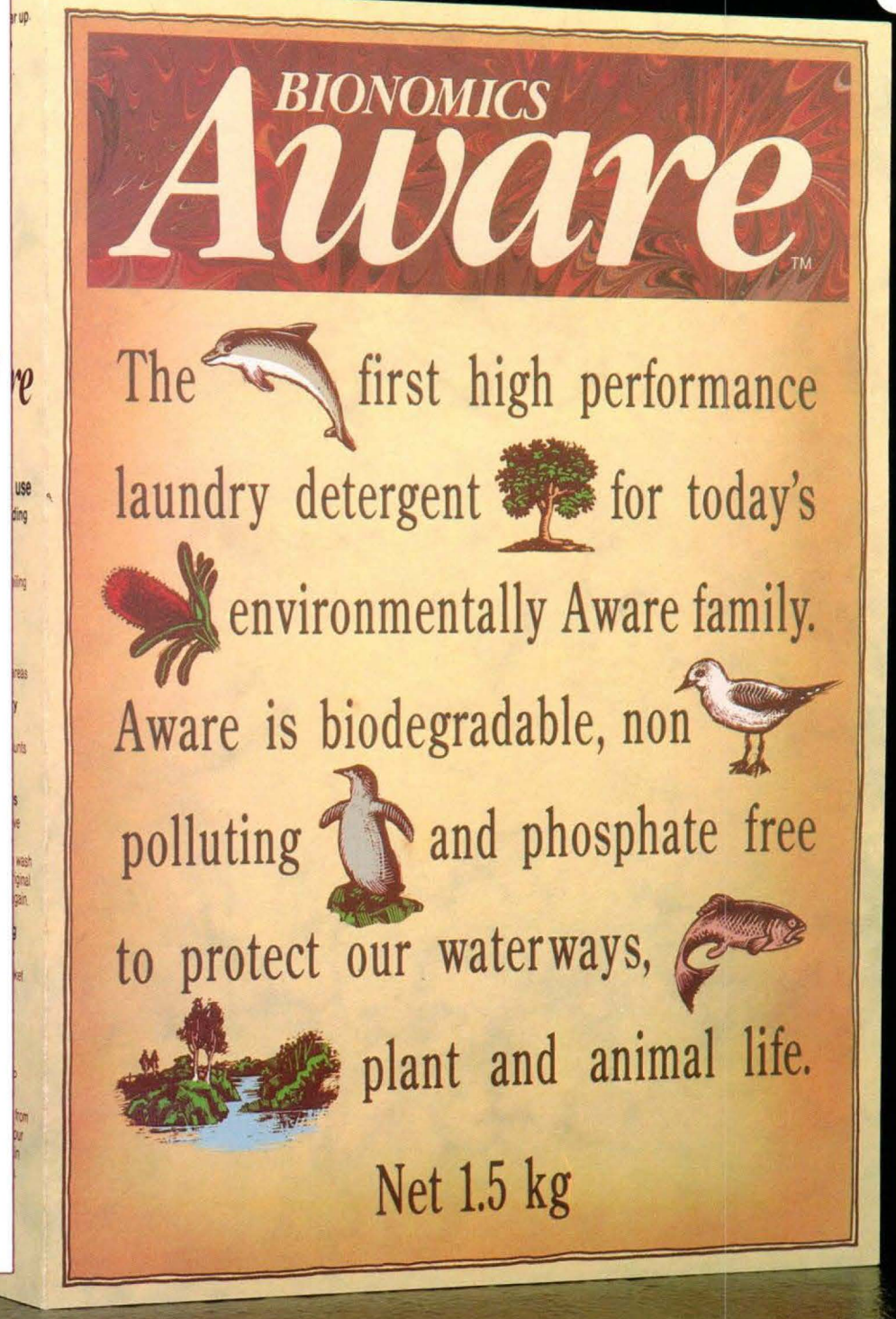

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