$8.95

AUSTRALIA Nature

AUTUMN 2000

ROCK RINGTAILS

MAGPIE GEESE

SEX BUTTERFLY STYLE

BUFFALO BREAM

THE ORIGIN OF LIFE ON EARTH

Free Butterfly Poster

ISSN 1324-2598 01
9 771324 259009

AUSTRALIAN MUSEUM

Davidson's Arnhemland Safaris.

Northern Australia's most exciting Aboriginal wildlife and fishing experience.

- *Winner of the prestigious South Pacific/Australasian Guide of the Year - 1995*
- *Winner of the Northern Territory Brolga Award for Tourism excellence - 1994, 1996, 1997 & 1998*
- *Winner of the 1997 Australian Tourism Award*

Mt Borradaile - Tours to suit any budget

Mt Borradaile Arnhemland Adventures are an exciting and unique experience. Designed to suit your particular interest be it exploring, rock art, Aboriginal bush tucker and culture, wildlife, photography, barramundi fishing, bird watching or just soaking up the atmosphere.

Davidson's Arnhemland Safaris offers visitors to Australia's Top End an adventure they will never forget in one of the world's most beautiful wilderness areas.

Davidson's Arnhemland Safaris operates 12 months of the year.

Contact: Max & Phillippa Davidson PO Box 41905 Casuarina NT 0811
Phone: (08) 8927 5240 Fax: (08) 8945 0919
email: dassafaris@onaustralia.com.au

Up Front

For our first issue of the 21st century we thought we should tackle something really big. Like one of those questions that's been around for just about as long as humans have gazed up at the sky and wondered why. So, here it is, and it's for anyone who has ever asked where did we come from and how did such a miraculous thing like life get started on this planet? Because, although it is generally believed that life on Earth started several billion years ago in a type of primordial soup, it is not clear as to where the necessary organic molecules for this soup came from. Did they have a terrestrial origin or was something decidedly extraterrestrial involved? Jeremy Bailey, from the Anglo-Australian Observatory, thinks he knows the answer and believes he can prove it.

KATHIE ATKINSON

And now for something completely different . . . butterfly sex. It's hard to imagine that the sex lives of butterflies could be anything but a calm, fluttering experience, but in reality it's quite the reverse. The struggle to find a mate and compete with other males has driven certain butterflies to take desperate measures. The males of one species of butterfly hang around larval food plants in the hope of pouncing onto a newly hatched and unsuspecting female even before she has had time to stretch her wings. Others haunt hilltops waiting for virgin females to fly by. And then there are the males that hang around in vast numbers striving to out-manoeuvre one another and 'jostling' for territories, which is tricky when you're a butterfly. After reading this article you may not look at butterflies in the same way again.

How can such a cute possum with primate-like behaviour be such a mystery to science? It seems that, as with many of our small marsupials, Rock Ringtails are extremely hard to observe because of their isolated habitat and nocturnal habits. Anyone wishing to study these possums must run the gauntlet of tropical conditions and Australia's many deadly inhabitants including crocs, scorpions, snakes and spiders. Myfanwy Runcie, who's been studying the complex social behaviour of Rock Ringtails as part of her PhD and spent many hours dodging the lethal locals in order to observe these delightful little possums, says it's all been worth it.

In our other articles we investigate what's happening to Magpie Geese in Kakadu National Park, meet an industrious and vigilant 'fish farmer' on the shallow reef platforms off Rottnest Island, look at the world of parasitic plants, and, in Photoart, we have a feast for the bird fancier. Welcome to the new millennium.

—Jennifer Saunders

Nature AUSTRALIA

AUTUMN 2000 VOLUME 26 NUMBER 8

Published by the Australian Museum Trust
6 College Street,
Sydney, NSW 2010.
Phone: (02) 9320 6000
Fax: (02) 9320 6073
Web: http://www.aust mus.gov.au
Trust President: Malcolm Long
Museum Director: Michael Archer

MANAGING EDITOR
Jennifer Saunders, B.Sc.
email: jennys@amsg.austmus.gov.au

SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.
email: georgieh@bigpond.com

PHOTO & EDITORIAL RESEARCHER
Kate Lowe
email: klowe@amsg.austmus.gov.au

DESIGN AND PRODUCTION
Watch This! Design

PRINTING
Excel Printing

ADVERTISING
Robbie Muller
Phone: (02) 9320 6119
email: robbiem@amsg.austmus.gov.au

SUBSCRIPTIONS
Robbie Muller
Phone: (02) 9320 6119
Toll-free (1800) 028 558
Fax: (02) 9320 6073
email: robbiem@amsg.austmus.gov.au

Annual subscription (4 issues)
Within Australia $A33 Other countries $A45
Two-year subscription (8 issues)
Within Australia $A63 Other countries $A83
Three-year subscription (12 issues)
Within Australia $A89 Other countries $A116

New subscriptions can be made by credit card on the *NATURE AUSTRALIA* toll-free hotline (1800) 028 558 or use the form in this magazine. If it has been removed, send cheque, money order or credit card authorisation to the address above, made payable to the 'Australian Museum' in Australian currency.

Published 2000 ISSN–1324–2598

NATURE AUSTRALIA is proud winner of the 1987, '88, '89, '90 , '91, '92, '93 & '99 Whitley Awards for Best Periodical, and the 1988 & '90 Australian Heritage Awards.

Front Cover
The Rock Ringtail Possum (*Petropseudes dahli*) is restricted to the remote and rugged habitats of northern Australia. Photo by Pavel German.

CONTENTS

Articles

Regular Features

Columns

LETTERS

The forum for readers to air their views about their concerns, past articles and interesting personal events.

Bullfrog Bull?

The Nature Strips section, which presents fascinating pieces of biology from around the world, with the original sources cited (I wish everyone did this!), is always the part of *Nature Australia* I turn to first. But the "Blame Big Ears" story (Winter 1999), about the sense of hearing in the American bullfrog *Rana catesbeiana*, is a worry. What is unusual about *Rana catesbeiana* and some related species is that the eardrum of the male is as much as 50 per cent bigger than that of the female. The reported research was asking why. What turned out was that the male eardrum is not only big, but also has a highly unusual structure, because (uniquely among frogs, as far as we know) calling males radiate sound from their eardrums. There is no reason to believe that any of this is true of the African bullfrog *Pyxicephalus adspersus*, whose photo accompanied the story. Spectacular animal, great photo, but misleading in the context.

—Angus Martin
Biotica, Melbourne, Vic.

Flying Kite

The photo on page 32 of the Sea-Eagle article (*Nature Aust.* Spring 1999) is actually of an immature Brahminy Kite, not a young Sea-Eagle. The bird is too compact for a Sea-Eagle (head too large, bill and feet too small), and the tail is too long, although the very worn feathers (particularly the outermost) enhance its 'Sea-Eagle' shape. The dead giveaway is the plain chestnut, new inner primary feathers in the wings, as adult Brahminy Kites have.

I also feel I should point out that John Scanlon's "ravens" that he saw on the University of Queensland campus (Letters, Winter 1999) would have been Torresian Crows —the common corvid there as in most of eastern Queensland. (There are no ravens in Brisbane.)

—Stephen Debus
University of New England

Wingecarribee Affairs

We agree with Geoff Sainty that the damage to Wingecarribee Swamp is a disaster (*Nature Aust.* Winter 1999). However, Geoff's article gives a misleading impression of the role of various agencies in the saga. It is true that the significance of the Swamp was not widely recognised until relatively recently, but for more than a decade conservation groups have been fighting for its protection, and the NSW National Parks and Wildlife Service first identified the Swamp as a potential Nature Reserve as long ago as 1969. A holistic approach was also adopted when the site was listed on the Registers of the National Estate and National Trust in 1990 and 1992 respectively. This is a case where, despite strong and legitimate concerns of scientists, government departments and community groups about the values of Wingecarribee Swamp and the impacts of peat mining, the system of due process was inadequate.

At the Mining Warden's Inquiry into peat mining in 1997 (the longest and most expensive such Inquiry in NSW history), there was an unprecedented coalition of government departments and agencies opposed to the mining. The National Parks and Wildlife Service (as well as Sydney Water, Department of Land & Water Conservation, Environment Protection Authority, Royal Botanic Gardens, Heritage Council of NSW, Wingecarribee Shire Council, and others) presented extensive and comprehensive arguments, which certainly had a big-picture focus. It is unfair and incorrect to suggest that the Service "dillydallied on single rare-species issues" although, given the significance of the Swamp as a habitat for rare species and the legislative obligation to address threatened-species issues, it was proper that the threats to listed species be addressed. (Unlike Geoff we consider that the evidence favours *Lysimachia vulgaris* being indigenous and not an introduced weed, and that it is correctly categorised as endangered.)

There are many unanswered questions about events at Wingecarribee. For example, why in the face of a mountain of evidence did the Government fail to take immediate and appropriate action? Why was so much money wasted on the Mining Warden's Inquiry, which was a demonstrably and completely inappropriate forum to determine a major land-use and biodiversity conservation issue?

Peat mining, anywhere, is an ecologically unsustainable activity, destroying biodiversity and, globally, contributing significantly to the greenhouse effect. Importantly, there are viable alternatives readily available for all traditional uses of peat. Indeed some of these alternatives value-add to what would otherwise be regarded as waste products. Peat mining is therefore unnecessary. Australia has a very limited area of peatland—none of which should be mined. Governments need to recognise the habitat and ecosystem values of peat and refuse to allow any proposal for mining; they should also stop the import of peat from overseas. We all can play our part by refusing to purchase peat products, and instead using a range of substitutes. Our gardens won't suffer and the global peatlands will certainly benefit.

—Paul Adam (University of NSW), Phillip Kodela (Environmental Consultant, Summer Hill, NSW), David Tranter (Robertson Environment Protection Society) & Anne Reeves (National Parks Australia Council)

Anthropomorphism OK

I take issue with Dean Portelli's Letter (*Nature Aust.* Winter 1999). He objected to the anthropomorphic tone of Penny Olsen's Spring 1998 article about Peregrine Falcons, in which she said, for instance, that a female falcon can "judge what sort of a provider the male is and scale her reproductive effort accordingly". In popular scientific writing I see nothing wrong with such Richard Dawkins-style shorthand. What it may lack in precision it makes up for in impact and readability. Nor would I be as confident as Portelli that the birds' behaviour is "driven by instinct (not learned)". The

more we learn of the cognitive powers of animals, the more I wonder whether there is anything at all that is exclusively driven by instinct.

—Angus Martin
Biotica, Melbourne, Vic.

Floods and Platypuses

What happens to Platypuses during a flood? For five years now I have been observing Platypuses in a quiet reach of the Barron River in northern Queensland. Each February brings its fair share of rain, but last year it rained big time! On 11 February, Cyclone Rona struck the area and, within a few hours, the river became a turbulent mass of brown water trashing everything in its path. Assessing the after-effects two days later, I saw not a single Platypus where I would normally have seen three or four.

I knew that marked Platypuses in the Shoalhaven River in New South Wales had been recaptured after floods. Early naturalists had suggested the species could survive by holing up in refuges away from the river, such as in Rabbit burrows or under debris, but this event was different. I couldn't imagine how any could have escaped drowning in the murky swirling waters, or survived the inundation and destruction of the banks, where I had previously located their burrows. However, three days later I saw a Platypus swimming and feeding away from the interior current (see picture), and over the next few days several more were found foraging among the currents. How had they managed to shrug off Cyclone Rona?

Hopefully I will have the answer to this question sometime next year or the year after, as I have just started a radio-tracking study to follow some individuals during the high flows of the coming wet seasons. From my observations after Cyclone Rona, I predict that they will stay where they are, but exactly how, at this stage, I do not know.

—Alberto Vale
Wildscapes Safaris
Cairns, Qld

NATURE AUSTRALIA **welcomes letters for publication and requests that they be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in this issue will receive a copy of *The spirit in the gene* by Reg Morrsion. The winner this issue is Alberto Vale.**

How did this Platypus (right) survive the flood waters of the Barren River (below)?

PHOTOS COURTESY ALBERTO VALE/WILDSCAPES SAFARIS PHOTOGRAPHY

Nature Strips

COMPILED BY
GEORGINA HICKEY

Seafood Chain Reaction

From Alaska comes this cautionary tale of otters, Orcas, urchins and kelp, and the natural world's extraordinary interconnectedness.

The story began unfolding in the early 1990s when a research team led by James Estes of the US Geological Survey noticed a sudden and alarming decline in Sea Otter (*Enhydra lutris*) populations throughout western Alaska. By 1997, numbers in the area had plummeted to just 6,000, down dramatically from 53,000 in the 1970s. The ecological consequences spread like ripples from a stone tossed in water.

As the otters declined, their principal prey, sea urchins, prospered. And, as urchin populations boomed, their primary food, kelp, suffered. Large tracts of kelp beds were deforested and the impact on the diverse array of animals, from barnacles to Bald Eagles, that depend on this marine plant is a matter for further study. The researchers' first concern was to find the cause of all this.

Fur traders once hunted Sea Otters to near extinction but the species had been recovering well. The sudden decline was a puzzle. Estes and his team looked for and found no signs of disease or poisoning.

They then turned to a 1991 record, the first of its kind, of a Killer Whale or Orca (*Orcina orca*) in the area eating an otter. Ordinarily, Killer Whales ignore otters in favour of larger, kilojoule-laden seals and sea lions. But further reports confirmed a dietary shift in some of the local whales. The researchers estimated that a single Killer Whale can consume about 1,800 otters annually and that as few as four whales could have been responsible for the dramatic Sea Otter decline. They also believe that Killer Whales turned to otters as prey because seal and sea lion numbers have fallen due to the depletion of their normal food (due to overfishing, a change in the temperature regime, or both).

The lessons to be learned, the researchers warn, apply well beyond the waters of Alaska.

—K.McG.

Noisy Flowers

Flowers have evolved some ingenious adaptations to attract pollinators. Those visited by visual pollinators, such as butterflies, bees and birds, are usually brightly coloured, while those visited by highly olfactory pollinators such as flies have a distinct (and often unpleasant) odour. There are even flowers that mimic the females of their wasp pollinators, thus misleading amorous males into intimate

A sudden decline in Sea Otters led to a cascade of ecological disasters. But where did the otters go?

JEFF FOOTT/AUSCAPE

contact.

Many species of small bats also help pollinate plants. These nocturnal animals navigate in the dark largely by echolocation, directing clicks towards objects and listening for the reflected sound. It might be expected that flowers visited by these bats would have adaptations that make them easier to detect acoustically. And this is just what has been found for the Central American tropical vine *Mucuna holtonii*.

Dagmar and Otto von Helversen, both from the University of Erlangen in Germany, were intrigued by the function of a concave petal in the four-centimetre-long flower. They found that the petal, just under two centimetres across, opens up exactly when the flowers are ready to be pollinated, and that bats preferentially visited flowers with this petal fully open. However, when the researchers stuffed cottonwool into the concave centre of the petal, the bats largely overlooked the flowers, suggesting that the shape of the petal was important to detection.

Additional experiments in an acoustic laboratory revealed why. The petal concentrates and bounces back sound waves in the direction from which they came. When ripe for pollination, the flower raises this little reflecting dish that captures, amplifies and reflects the clicks emitted by foraging bats. Thus, it's a literal example of a loud floral design—the concave petal makes the flowers sound noisier to their acoustically oriented pollinators.

—Michael Lee
University of Queensland

Light Suckers

Environmental change drives evolution—fins became legs and hands turned into wings—but such cases of evolutionary transition are rarely witnessed. It was with some surprise, therefore, that Sönke Johnsen (Harbor Branch Oceanographic Institution) and colleagues caught a deep-sea finned octopus in the act of changing its suckers into light organs.

On a routine research expedition, 760 metres beneath the surface of the Atlantic Ocean, they snared several small *Stauroteuthis syrtensis* octopuses whose arms glowed blue-green in the dark. Closer inspection revealed that the light was being emitted from the octopus's suckers, which line up in a row on the inside of each arm. Although the suckers look much the same as in other octopuses, they have lost their ability to adhere, and instead produce chemicals like those found in fireflies. Additionally, the tendons behind the suckers have also been transformed into mirrors that reflect the twinkling lights.

Most of the light emitted from the bioluminescent suckers has a wavelength of 470 nanometres, which is close to that of maximum light transmission in the ocean. This would make them well suited for deep-sea communication. However, they may also act as lures. When the octopus spreads its arms in search of food, the

EDITH WIDDER/HARBOR BRANCH OCEANOGRAPHIC INSTITUTION, INC., FORT PIERCE, FLORIDA

The deep-sea finned octopus *Stauroteuthis syrtensis*: caught in the act from suck to glow.

BRIAN DOWNS/LOCHMAN TRANSPARENCIES

Goats raised by Sheep lust only for Sheep, and *vice versa*.

luminescent suckers may act like runway lights, directing small crustaceans to the mucous net near its mouth.

The researchers believe the move to the deep probably spurred the change. Shallow-water octopuses use a snatch-and-grab hunting technique, but the inky depths would require a different food-gathering strategy, hence the transition from suck to glow.

—R.S.

Obsessions with Maammaa

We often joke about how males marry females who look like their mothers. However, scientists have recently found that there may be more truth to nature's Oedipus Complex* than we think.

To determine how much influence mothers have on socialisation and sexual preferences, experiments with Sheep and Goats were carried out by Keith Kendrick (Babraham Institute in Cambridge, UK) and colleagues. In a reciprocal adoption program, Goats served as foster mothers to 21 newborn lambs, and Sheep mothered 18 baby Goats. As adopted babies grew up, the effects of 'nature' and 'nurture' could clearly be seen in their behavioural repertoire.

Young cross-fostered Goats had the same species-specific patterns of aggression, climbing, feeding and vocalisations as other Goats, but their playing and grooming behaviour resembled that of Sheep. And when the cross-fostered Goats reached maturity, they only wanted to socialise and have sex with Sheep. The researchers also showed that visual cues from the face were enough to elicit these preferences. The same happened for adopted Sheep, which remained fixated on Goats even after living exclusively with their own kind for three years. The researchers suggest that this strong maternal influence may function to prevent cross-species matings in nature.

Interestingly, this effect was more severe for males than females. The mothers' sexual imprinting affected sons for their entire lives, yet with daughters their sexual preferences could be reversed within one or two years. This indirectly supports Freud's belief that all men are secretly in love with their mothers, and gives us the scientific reasoning behind Oedipus' obsession with his mama.

—K.H.

**Oedipus Complex is the sexual desire of a son for his mother, named after a Greek legend in which Oedipus, King of Thebes, unwittingly married his mother Jocasta. On realising their biological relationship, Jocasta hanged herself and Oedipus tore out his eyes.*

What's Cooking?

Scientists agree that we humans evolved large brains, small guts, small teeth and relatively little size difference between the sexes. These distinctively human attributes are first noticeable in *Homo erectus*, around 1.8 million years ago. But why they evolved is more controversial. The traditional answer has been a switch to a hunting and meat-eating lifestyle, with the idea that the easier-to-digest meat reduced the need for large tooth and gut size, and fuelled the development of larger body size and brains, giving them a competitive edge over their australopithecine relatives. However, meat-eating may have started much earlier. Animal bones with cut marks have recently been found in the same 2.5-million-year-old deposits as the newly described australopithecine species, *Australopithecus garhi*. Tim White (University of California at Berkeley) and colleagues interpret this as the earliest evidence of butchering, which would indicate that meat-eating was not the dietary breakthrough that led to reduction in tooth size and enlarged brains, which don't appear in the fossil record until much later.

Richard Wrangham and colleagues, from Harvard

University, have now proposed a different trigger for the changes: cooking. And what do they propose *Homo erectus* was cooking? Plants—most likely plants with underground storage organs (tubers) like yams—which would have been available in high densities even in periods of climatic stress.

Cooking greatly improves the taste, digestibility and calorific value of food. And, according to Wrangham's team, the addition of cooked tubers to the early human diet would have provided a far more consistent supply of energy than the addition of meat. But to cook, you need fire. When did humans first start to use fire? Several renowned scientists say no cooking fires older than about 200,000 years are clearly identifiable. However Ralph Rowlett (Missouri University), among others, argues that fireplaces at Koobi Fora, in Africa, which are at least 1.6 million years old, were "undoubtedly" made by humans. In principle, therefore, *Homo erectus* had the means to cook, even though no direct evidence of cooking has been found.

Those females who increased the number of matings between pregnancies would have been able to 'keep' their man and also their cooked tubers.

Cooking may also explain why *Homo erectus* and subsequent humans exhibit little size difference between the sexes and why human females are almost always sexually receptive (which is unique among primates). The researchers propose the 'theft hypothesis'. The increased energetic value of cooked food, and the fact that it has to be accumulated in a processing area, would have made it a covetable and stealable resource, especially by dominant or larger individuals (generally males). Smaller females may have had to arrange bonds with males to protect them from other males scrounging a meal. Those females who increased the number of matings between pregnancies would have been able to 'keep' their man and also their cooked tubers. Without the pressure to impress other females for sex, there would have been less inter-male rivalry and thus a subsequent reduction in the selection for large size in males. Meanwhile, females, with all those extra calories, continued to increase in size (to better produce or nourish children), resulting in reduced sexual size dimorphism. The early threat of male theft would also have led to cooking becoming a female activity, which is still the general rule among modern human societies.

The most attractive part of Wrangham *et al.*'s cooking and theft theory is that it is a recipe for new debate and insights. Archaeologists can search for ancient starchy residues, assess the evidence for human-lit fires, and test the arguments against other theories of human behaviour and evolution.

—Richard Fullagar
University of Wollongong

Skin-breathing Mammals

'Breathing' through the skin is common in many animals, including worms and frogs. But until recent research led by Jacopo Mor-

GREG CALVERT

Julia Creek Dunnarts start life breathing through their skin.

tola (McGill University, Canada) it was not a trait associated with mammals.

'Breathing' involves oxygen diffusing into the bloodstream and carbon dioxide passing out. In mammals this occurs in the thin, moist lining of the lungs. There are good reasons why mammal skin isn't normally a major respiratory organ. It's usually too thick. And the surface area of skin is rarely large enough for the high volumes of gas exchange required to service the rapid mammalian metabolism. The latter problem is overcome in lungs by multiple folds (alveoli) that significantly increase the surface area.

In newborn Julia Creek Dunnarts (*Sminthopsis douglasi*), however, the muscles that work the lungs are weak and inactive. Like all marsupials, dunnarts are severely underdeveloped at birth and must mature in their mother's protective pouch. Weighing 15 milligrams and with a length of just four millimetres, Julia Creek Dunnarts are one of the smallest newborn mammals known. Fully formed but motionless lungs can be clearly seen through their transparent skin.

Working with a captive colony of Julia Creek Dunnarts at Melbourne's La Trobe University, Mortola and colleagues measured oxygen uptake in newborns up to three weeks old. At one day old, absorption through the lungs was negligible compared with that through the skin, but by the time they reached 100 milligrams in weight (when they were about eight days old), gaseous exchange through the lungs started to exceed that through the skin. The researchers conclude that, during the critical first few days of life, before the lungs are properly formed, this endangered dunnart relies on skin-breathing to stay alive. They also suspect that skin-breathing may be important in other very small newborn marsupials.

—K.McG.

Vampires or Rabies?

The lustful blood-sucking horror stories of vampires have struck fear in the hearts of people for centuries. But Juan Gómez-Alonso, a Spanish neurologist with the Xeral Hospital in Vigo, believes that vampire legends were made up to explain the bizarre behaviour of rabid men.

Stories of vampirism first became common in eastern Europe in the 18th century at a time when a major outbreak of rabies was sweeping through the Balkans. After researching historical literature on vampires and medical accounts of rabies cases, Gómez-Alonso is convinced that the similarities of their symptoms are too uncanny to be coincidence.

A man infected with rabies will suffer fever, hallucinations and disturbed sleep as the virus begins to attack the nervous system. The victim then becomes violent and agitated. Muscle spasms in the face and neck prevent him from swallowing and he might vomit blood. He becomes intolerant of overstimulation—strong odours, bright lights or mirrors may trigger spasms. Violent impulses may lead him to attack and bite people, giving him the look of a savage beast. He may also become hypersexual and maintain a painful erection for several

days. Even nowadays, a few extreme cases of this 'furious' rabies occur.

Wolves, Dogs and bats also suffer furious rabies and develop bizarre behaviour, and they frequently transmit rabies to humans, which may explain why these animals are associated with the vampire legend. Furthermore, the rabies theory accounts for the belief that being bitten by a vampire turns you into one.

Gómez-Alonso believes the vampire myth grew out of an actual event in history and humans have embellished these sorry cases with superstitious hysteria. Just think, if the real-life Draculas had been given rabies shots instead of stakes through the heart, the vampire legend as we know it may never have arisen.

—K.H.

Life on a Diet of Cold Jelly

Leatherback Turtles (*Dermochelys coriacea*) not only have the distinction of being one of the heaviest living reptiles (over 900 kilograms), they are also the most geographically widespread, found from the Arctic through the tropics to New Zealand.

Much of the energy gained from feeding is used in just heating up the prey before digestion.

Traditionally classed as 'cold-blooded', the ability of these jellyfish-eating leviathans to survive in such a range of temperatures has caused debate over whether they are actually endothermic (that is, create their own internal body heat), or whether it is simply a matter of their large size, good insulation and control of peripheral blood circulation that allows them to maintain a high core temperature.

This theory of 'gigantothermy' (essentially endothermy without the enhanced metabolic rate) was proposed after a study on the metabolic rates of Costa Rican Leatherbacks (see *Nature Aust.* Autumn 1992). But new research by John Davenport (while at the University Marine Biological Station in Scotland) has shown that this model underestimates the cost of life for an animal with a gelatinous diet in cold water, and that much of the energy gained from feeding is used in just heating up the prey before digestion.

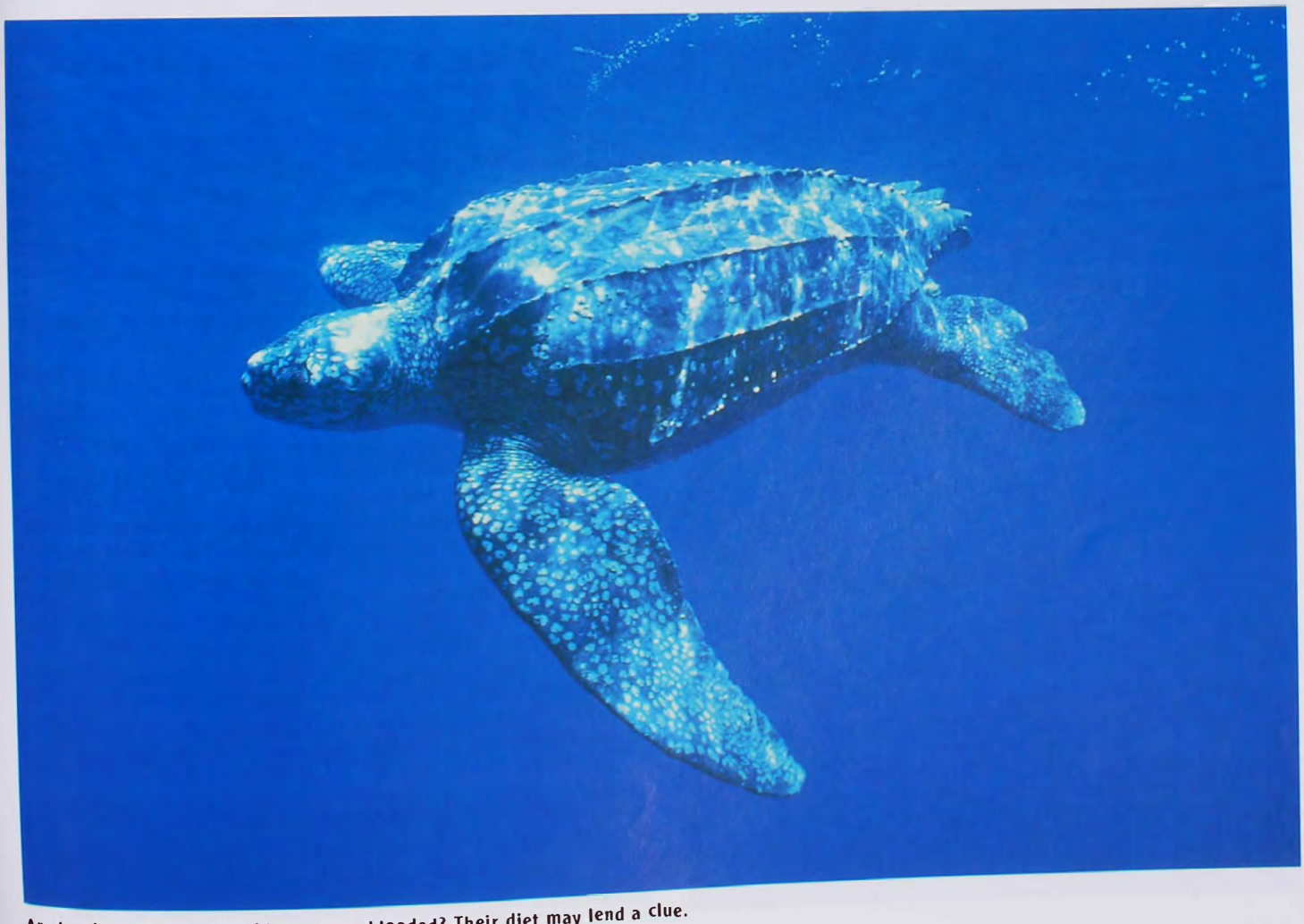
Because of the jellyfish's low nutritional value, Leatherbacks have to eat at least 50 per cent of their body mass per day. Davenport's calculations showed that, if a 400-kilogram turtle eats 200 kilograms of jellyfish, where the difference between jellyfish temperature and core body temperature is 20° C or more, the combination of heating costs and resting metabolic rate will exceed the minimum active metabolic rate recorded in tropical water.

This means that cold-water Leatherbacks must have a much higher routine metabolic rate than their tropical counterparts, and that size and insulation alone are insufficient to maintain such a high core body temperature. Based on these results, Davenport believes that at least sometimes Leatherbacks must be active endotherms.

—R.S.

Pollution's True Colours

Birds lend credence to the adage "you are what you eat". Flamingos, for example, get their rosy glow



DOUG PERRINE/AUSCAPE

Are Leatherback Turtles cold- or warm-blooded? Their diet may lend a clue.

D. BROMHALL/GENESIS FILMS/OSF/AUSCAPE

Without green caterpillars, the yellow plumage of Great Tits fades.

from eating the red crustaceans that bloom in their native waterways. (Zoo birds living away from their homelands have their colour 'topped up' by dietary supplements to keep them in the pink, as it were.) Similarly, the Great Tit (*Parus major*) gets its yellow colouration from the carotenoids present in one of its favoured foods—green caterpillars.

A recent study in Finland has shown for the first time that another environmental factor, air pollution, can indirectly affect a bird's feather colour and even its survival.

Tapio Eeva and colleagues from the University of Turku found that Great Tit chicks living near a copper smelter were paler yellow and weighed less than those living farther away. They also found a significantly lower density of green caterpillars, the closer they got to the site. The researchers believe that air pollutants from the smelter were killing the green caterpillars, which led to the reduced weight and paler colouration in chicks living nearby.

Previous studies with other bird species have shown that females prefer males with brighter plumage. Plumage colour may also affect male–male social dominance or even camouflage. Larger birds will tend to dominate even as early as two weeks after fledging, so the fact that paler birds were also smaller may doubly affect their survival.

—A.T.

New Look for Long-necked Dinos

Reconstructions of long-necked sauropod dinosaurs often depict them as gentle giants, grazing peacefully in the canopies of tall trees. But new research indicates that some of them wouldn't have been able to lift their necks that high even if they tried.

Faced with the weight and fragility of fossilised specimens which make physical reconstruction difficult, Kent Stevens, a computer scientist from the University of Oregon, and Michael Parrish, a biologist from Northern Illinois University, turned to computer modelling to simulate the neck postures of *Apatosaurus* and *Diplodocus*.

By modelling the biomechanics controlling mobility of the cervical (neck) vertebrae, they found that the most relaxed, neutral position for the animals' necks would have been almost horizontal, with their heads held close to the ground. In this position, they would have been able to browse the abundant soft ferns, cycads, horsetails and algae, a much more likely scenario given that the canopy vegetation of the time consisted only of low-nutritious conifers and ginkgoes.

The necks were also less flexible than previously thought. According to the computer models, *Diplodocus* could barely lift its head above its shoulders, while *Apatosaurus* was more limber, being able to move its head up and down and side to side. So why were their necks so long for such little apparent return? The researchers suggest that long necks would have been ideal for reaching into rivers or lakes to munch on aquatic vegetation, allowing the heavy body to remain on firm ground, a theory supported by the snorkel-like positioning of the nostrils.

—R.S.

Killer Willies

Californian scientists have witnessed what is probably the most dramatic attack by Killer Whales (*Orcinus orca*) ever made on a large whale species.

Robert Pitman and Susan Chivers from the Southwest Fisheries Science Centre were studying Sperm Whales (*Physeter catodon*) off the Californian coast when they stumbled onto the battle arena early one morning. In recent years, films like "Free Willy" have given Killer Whales a benign and friendly

A Killer Whale (front) circles a pod of injured Sperm Whales. In this case Killer Whales bit off more than they could chew.

COURTESY ROBERT L. PITMAN

image. But what Pitman and Chivers witnessed was a ruthless and wasteful hunter in action.

They came upon a pod of nine Sperm Whales that had formed a circular rosette, with their heads to the centre and tails outermost. Surrounding them was a large slick such as is frequently seen during whale kills when oil from blubber seeps to the surface.

The reason for the rosette soon became obvious. Three or four female Killer Whales, some with young, were circling the Sperm Whales. They took turns at charging the Sperm Whales and tearing off mouthfuls of flesh. One badly injured Sperm Whale was pulled away from the rosette and attacked. In a heroic act, two of its companions broke from the rosette to bring it back to the safety of the circle. After three hours of this, with several more Killer Whales joining the fray, the scientists believe that most if not all of the Sperm Whales were mortally wounded. Then, out of the blue, a bull Killer Whale came in for the *coup de grâce* and, just as quickly, disappeared with the rest of the pod, dragging a dead Sperm Whale with him.

What amazed the scientists most was that the Sperm Whales made no attempt to escape. Sperm Whales are able to dive to great depths, and the size and strength of their tails can inflict a killer blow. From their observations of this wasteful attack (the Killer Whales killed far more than they could eat), and noting that 80,000 Killer Whales live in the waters off Antarctica during summer, Pitman and Chivers suggest that Killer Whales could be playing a far greater role in shaping the life histories of large whales than previously thought.

—A.T

COURTESY KENNETH E. BARNETT

Good vibrations. Veiled Chameleons may buzz one another messages through branches.

Reptile Buzz Words

Using a form of primitive morse code, insects are known to tap out secret messages to nearby members of the same species, spreading words of warning or songs of seduction without alerting their presence to predators. It seems, though, that insects aren't the only ones to 'beat around the bush'; reptiles do it too.

While handling a Veiled Chameleon (*Chamaeleo calyptratus*), Kenneth Barnett (New York State Department of Environmental Conservation) and colleagues felt a buzzing sensation in the area in front of the animal's forelimbs.

Excited with the prospect of discovering the first case of vibratory signalling in a reptile, they recorded chameleons' reactions to various stimuli on a vibration-sensitive machine. Placing a male onto the branch of a leafy shrub, they found that when a receptive female was placed on the same branch, the male immediately changed colour and produced a series of vibrational signals, typically higher-pitched and shorter at the start, followed by one long, low-pitched signal. The short signals were accompanied by head tilting, while the long signal was coupled with vigorous shaking of the head. The female made no detectable response.

The researchers say that the chameleons' vibrations were unlikely to be auditory signals because they were only just audible to humans, and we hear better than chameleons at all frequencies. However, they were easily recorded by the vibration sensor, which was placed on the same branch as the animals.

Although there is no direct proof that the vibrations are communication signals, the fact that they are produced only when a female was present or in response to human touch suggests that the branches probably hum with chameleons' private chat sessions.

—R.S.

X Marks the Spot

Ötzi, the frozen mummy retrieved from the Alps in 1991, continues to teach us about life in Europe 5,200 years ago. The latest revelations come from tattoos on his body, which have been interpreted as the world's earliest evidence of needle acupuncture.

Tattoos are made by piercing the skin and applying pigment in the wound. Leopold Dorfer, Maximilian Moser (University of Graz, Austria) and colleagues recorded 15 groups of blue-tinted tattoos on Ötzi's back, knee, calf, foot and ankle, with no apparent ornamental significance. They had a simple linear geometric pattern (parallel sets of lines and crosses), and were on parts of the body that would not normally be displayed. (Others on the left wrist have been interpreted as traces left by a wrapping to protect his arm during archery.) When the researchers compared the locations of these tattoos with traditional Chinese acupuncture points, they found that most of the sites overlapped. Several tattoos, including an X-shaped tattoo on the left ankle, corresponded with acupuncture points used for the treatment of arthrosis of the lower spine, a disease from which Ötzi was known to suffer. Others, including a cross on Ötzi's inside right knee, corresponded with points used to treat abdominal disorders. Indeed, Ötzi had numerous intestinal parasites, and his colon was a quarter full of charcoal (a common cure for diarrhoea still used today).

Assuming no coincidence and that the tattoos were indeed used as acupuncture points, this pre-dates Chinese acupuncture records by 2,200 years and could indicate either independent invention of the treatment method or early cultural exchange between Europe and East Asia. It could also mean that tattoos had their origin in body maps and medicine, rather than body art. Having diagnosed the illness, a prehistoric doctor could have marked the acupuncture spots for future reference, as a permanent medical record for himself, other carers or even his patient. Could Ötzi have done it to himself? Konrad Spindler (University of Innsbruck, Austria) noted that among Ötzi's tools was a bone awl with a needle-sharp point, which he believes would have been ideal for the task. However, if Ötzi was using acupuncture, why did

COURTESY LEOPOLD DORFER

A cross-shaped tattoo on Ötzi's inside right knee. Could this have marked the acupuncture points used for treatment of his abdominal disorders?

the practice drop out of Western medicine for nearly 5,000 years?

—Richard Fullagar
University of Wollongong

Hoverflies Dress for the Occasion

Birds recognise the bold black-and-yellow patterns of bees and wasps as warning signals: don't eat me, otherwise you may regret it. Many hoverfly species have copied the look and it works just as effectively for them, even though they don't have harmful stings.

It turns out, however, that the patterning on the pretenders isn't just a straightforward case of mimicry.

Cliff Marriott and Graham Holloway, from the University of Reading, UK, noticed that the colouration in some hoverfly species varied considerably between individuals. In the common British species *Episyrphus balteatus*, for example, the variations followed a seasonal pattern. Those caught by the researchers in summer were paler (with more yellow markings than black), while those caught in colder months were darker. Because paler colours reflect more sunlight, they are better for keeping an animal cool. Darker shades absorb more radiant energy, providing greater warmth in the cold.

The researchers decided to test whether temperature during pupal development was the environmental cue behind colour-pattern variations in these hoverflies. Temperature can affect the length of time an insect spends as a pupa. The colder it is, the longer the pupal period, and *vice versa*. Indeed the researchers found that hoverflies raised under colder conditions, and therefore having a longer pupal period, emerged darker (in their winter colours) than hoverflies raised under warmer temperatures.

With colouration that not only deters predators but can also be adapted to suit climatic conditions, these hoverflies are certainly 'smart dressers'.

—K.McG.

Why Do Birds Fly in Vs?

Flocks of geese and other large gregarious birds often fly in conspicuous V-shaped formations. A century of debate has produced two major theories to explain these precisely aligned flight patterns. The 'orientation' theory suggests that birds are keeping a constant angle

© ANDREW HENLEY/LARUS

Climate-control colours: black-and-yellow hoverflies step up the black for winter and the yellow for summer.

HELLIO-VAN INGEN/AUSCAPE

V-shaped flight formation in the European Crane (*Grus grus*). The function of the V depends on the size of the birds.

between themselves and the bird in front to enhance communication and maintain orientation during flight. The 'aerodynamic' theory suggests that birds save energy by positioning themselves to take advantage of lift-generating vortices produced by the wing tips of the bird in front. Now new research on Europe's largest native goose has found that both of these theories may be true.

John Speakman and Debbie Banks from the University of Aberdeen photographed 25 flight formations of the Greylag Goose (*Anser anser*) from below, and measured the lateral (sideways distance) and longitudinal (distance behind) displacements of each bird in relation to the bird in front. They found that birds were not adjusting their positions to maintain a constant angle to other birds. However, when the flight positions of birds in formations were compared with optimum flight positions based on an aerodynamic model, Speakman and Banks found that on average the birds were flying very close to positions that would maximise energy savings. They calculate that, by flying in Vs, Greylag Geese could reduce their total flight costs by up to nine per cent.

These results contrast with the behaviour of the Pink-footed Goose (*Anser brachyrhynchus*), a smaller species that uses less energy in flight. These geese adopt and maintain flight positions that favour the orientation hypothesis. It appears that body size, and thus flight costs, may be a critical factor determining the function of V formations in gregarious birds.

—S.R.

Stowaway Lizards on the XPT

Polynesia was the last part of the world to be colonised by humans. On that, most anthropologists agree. But the pattern in which the islands of this eastern Pacific region were settled has long been a more

What was the pattern of human settlement in the Pacific islands? The answer may lie in *Lipinia noctua*'s genes.

contentious issue.

One of the two main theories argues that people from South-East Asia spread rapidly through the Pacific from west to east, as if on an 'express train to Polynesia'. En route, these colonists had very little genetic exchange with the Melanesian populations of the western Pacific. The alternative 'entangled-bank' model describes a more gradual pattern over a long period of time, with colonists spreading slowly and sporadically from resident Melanesian groups.

According to Christopher Austin from the South Australian Museum, the true colonisation pattern is reflected in the genes of a small reptile, *Lipinia noctua*, which has one of the broadest distributions of any lizard species.

Lipinia noctua occurs right across the Pacific, from the Papuan region in the west to Hawaii, Easter and Pitcairn Islands in the east. Its physical features vary little across its range. This and the immense ocean barriers that punctuate the lizard's distribution suggest it has been spread by humans. And so, Austin speculated, *L. noctua*'s pattern of colonisation in the eastern and central Pacific should mirror that of humans.

To retrace the lizard's spread, he turned to the record contained within its genes—more specifically its mitochondrial DNA. Austin analysed this material from 15 different *L. noctua* island populations across the Pacific. He found only two very minor genetic differences within all central and eastern Pacific populations, indicating this lizard probably took the 'express train' to Polynesia. Austin suggests that, as humans moved rapidly into the central Pacific, a few stowaway lizards, or even a single pregnant female lizard, may have gone with them.

—K.McG.

Vicious Circles

Sometimes the most fearsome monsters of the deep are not always as large as we would expect. One of the most gruesome marine predators is the innocuous-looking Cookie-cutter Shark (*Isistius brasiliensis*), measuring a tiny 40 centimetres in length. This slow-swimming, school-forming shark takes its name from its grisly feeding habit, which involves extracting cookie-shaped chunks of flesh from prey such as tunas, dolphins and the Swordfish. The shark latches on by protruding its jaw and forming a vacuum with suctional lips and retracted tongue. Once the shark is locked on, it rotates around the point of attachment to carve out the plug of flesh, using the thrashing motion of its victim to help it manoeuvre and suck the flesh free.

Yet how do these slow-swimming sharks get in suction range of their speedy prey? According to recent work by Edith Widder at the Harbor Branch Oceanographic Institution, USA, the Cookie-cutter Shark is an ambush predator that uses the ingenious trick of counter-illumination.

The shark's underside has a phosphorescent glow that breaks up its silhouette against the bright surface light. The only part that isn't luminous is a black strip under its throat, which from below looks like a smaller fish. As many predators hunt by scanning the waters above for the silhouettes of fish, the Cookie-cutter Shark is able to entice its victims by offering itself as prey . . . only to turn predator at the last moment.

The fact that Cookie-cutter Sharks swim in schools only enhances the power of the allure. Forming schools would also prevent counterattack from much larger predators, for, as Widder puts it, the damage inflicted by a school of these sharks "would make their company as appealing as a swarm of wasps".

—K.H.

Birds Sleep with One Eye Open

It is said that mothers of young children sleep with one eye open. But birds do it

The Cookie-cutter Shark's non-luminescent 'dog collar' lures large prey such as tunas within striking range. It then latches on and sucks out circular plugs of flesh (right).

PHOTOS: I. HUTTON

COURTESY INDIANA STATE UNIVERSITY

This sleeping Mallard Duck is keeping an eye out for predators.

too, quite literally. Not only do they keep one eye open, but the opposite hemisphere of the brain stays awake while the other half sleeps. Research on Mallard Ducks (*Anas platyrhynchos*) has shown, for the first time, that birds adopt this sleep pattern when the risk of predation is high, but sleep normally (with two eyes shut and both hemispheres of the brain asleep) when the risks are low.

Niels Rattenborg and colleagues from Indiana State University videotaped four groups of four ducks while asleep in a row. They found that the ducks at either end of the row (where they are more exposed to predators) slept with one eye open, while those in the middle slept with two eyes shut. What's more, the birds at the ends kept the outermost eye open, the eye on their most vulnerable side.

Electrical recordings of the brain confirmed that the hemisphere opposite to the open eye remained awake (although in a 'sleepier' state than when the bird had both eyes open), but that the reaction time to simulated predatory attacks was still very quick.

Aquatic mammals are the only other animals known to exhibit this 'unihemispheric slow-wave' sleep pattern, which allows them to sleep while surfacing to breathe.

—G.H.

QUICK QUIZ

1. What is a petroglyph?
2. Which side do most humans and great apes cradle their babies?
3. What is the name given to miniscule organisms that are measured in terms of millionths of a millimetre (or 10^{-9} of a metre)?
4. Which three seas wash northern Australia's shores?
5. What were scientists hoping to find evidence for when they sent the Lunar Prospector on a collision course with the Moon in July 1999?
6. Who is the author of *The selfish gene* (1976), *The blind watchmaker* (1986) and *Unweaving the rainbow* (1998)?
7. To the nearest billion, how many people inhabit the Earth?
8. On average, how long do adult mosquitoes live: two days, two weeks or two months?
9. What do pedologists study?
10. From which plants are the painkillers morphine and codeine derived?

(Answers in Q&A)

Hot and Horny

The weird and wonderful appendages of ceratopsian dinosaurs have certainly captured our modern imagination: the dorsal plates of *Stegosaurus*, the sails of *Edaphosaurus* and the neck frills of *Triceratops*. Yet what was the function of these bizarre structures? Traditionally they are thought to have been used as protective armour or in sexual displays. But a recent study on *Triceratops* suggests they may have kept these large beasts from overheating.

A team of American researchers led by Reese Barrick from the North Carolina State University has reconstructed the thermal physiology of *Triceratops* by studying a fossil skeleton. Within the bone phosphate the composition of oxygen isotopes records body-temperature variations. By sampling powder extracted with a dentist's drill from different depths and areas along the dinosaur skeleton, a temperature map was constructed.

Results show that *Triceratops* had a high and uniform heat flow through the frill, maintaining temperatures at 0–4° C below the body core. This would have allowed excess heat to be dissipated so the animal could maintain a stable temperature. The horns show more variability in temperature, suggesting they may have been supplemental systems important in stabilising brain temperatures during periods of extreme heat or cold. Both structures are highly vascular so that blood flow to the external surfaces could have been regulated to control temperature, in a similar way to the ears of elephants.

In reality, the horns and frills of *Triceratops* probably had multiple functions, so ascribing them a role in heat exchange would not necessarily compromise their use in love and war.

—K.H.

Further Reading

Asfaw, B., White, T., Lovejoy, O., Latimer, B., Simpson, S. & Suwa, G., 1999. *Australopithecus garhi*: a new species of early hominid from Ethiopia. *Science* 284: 629–635.

Austin, C.C., 1999. Lizards took express train to Polynesia. *Nature* 397: 113–114.

Barnett, K.E., Cocroft, R.B. & Fleishman, L.J., 1999. Possible communica-

tion by substrate vibration in a chameleon. *Copeia* 1999(1): 225–228.

Barrick, R.E., Stoskopf, M.K., Marcot, J.D., Russell, D.A. & Showers, W.J., 1998. The thermoregulatory functions of the *Triceratops* frill and horns: heat flow measured with oxygen isotopes. *J. Vert. Paleont.* 18(4): 746–750.

Davenport, J., 1998. Sustaining endothermy on a diet of cold jelly: energetics of the Leatherback Turtle *Dermochelys coriacea*. *Brit. Herpetol. Soc. Bull.* 62: 4–8.

de Heinzelin, J., Clark, J.D., White, T., Hart, W., Renne, P., WoldeGabriel, G., Beyene, Y. & Vrba, E., 1999. Environment and behaviour of 2.5-million-year-old Bouri hominids. *Science* 284: 625–629.

Dorfer, L., Moser M., Spindler, K., Bahr, F., Egarter-Vigl, E. & Dohr, G., 1998. 5200-year-old acupuncture in central Europe? *Science* 282: 242–243.

Eeva, T., Lehikoinen, E. & Rönkä, M., 1998. Air pollution fades the plumage of the Great Tit. *Func. Ecol.* 12: 607–612.

Estes, J.A., Tinker, M.T., Williams, T.M. & Doak, D.F., 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. *Science* 282: 473–476.

Gómez-Alonso, J., 1998. Rabies: a possible explanation for the vampire legend. *Neurology* 51: 856–859.

Johnsen, S., Balser, E.J. & Widder, E.A., 1998. Light-emitting suckers in an octopus. *Nature* 398: 113.

Kendrick, K.M., Hinton, M.R., Atkins, K., Haupt, M.A., Skinner, J.D., 1998. Mothers determine sexual preferences. *Nature* 395: 229–230.

Marriott, C.G. & Holloway, G.J., 1998. Colour pattern plasticity in the hoverfly, *Episyrphus balteatus*: the critical immature stage and reaction norm on developmental temperature. *J. Insect Physiol.* 44(2): 113–119.

Mortola, J.P., Frappell, P.B. & Woolley, P.A., 1999. Breathing through skin in a newborn mammal. *Nature* 397: 660.

Moser, M., Dorfer, L., Spindler, K., Bahr, F., Egarter-Vigl, E., Dohr, G. & Kenner, T., 1999. Are Ötzi's tattoos acupuncture? Skin markings on the Tyrolean Iceman may have been treatment for his ills. *Discovering Archaeol.* 1(1): 16–17.

Pitman, R.L. & Chivers, S.J., 1998. Terror in black and white. *Nat. Hist.* 12/98–1/99: 26–29.

Rattenborg, N.C., Lima, S.L. & Amlaner, C.J., 1999. Half-awake to the risk of predation. *Nature* 397: 397–398.

Rowlett, R.M., 1999. Fire use. *Science* 284: 741.

Speakman, J.R. & Banks, D., 1998. The function of flight formations in Greylag Geese *Anser anser*; energy saving or orientation? *Ibis* 140: 280–287.

Spindler, K., 1994. *The man in the ice: the preserved body of a Neolithic man reveals the secrets of the Stone Age.* Translated by E. Osers. Weidenfeld & Nicholson Publishers: London.

Stevens, K.A. & Parrish, J.M., 1999. Neck posture and feeding habits of two Jurassic sauropod dinosaurs. *Science* 284: 798–800.

von Helversen, D. & von Helversen, O., 1999. Acoustic guide in bat-pollinated flower. *Nature* 398: 759–760.

Wrangham, R.W., Jones, J.H., Laden, G., Pilbeam, D. & Conklin-Brittain, N., 1999. The raw and the stolen: cooking and the ecology of human origins. *Current Anthropol.* 40(5): 567–594.

Widder, E.A., 1998. A predatory use of counterillumination by the squaloid shark, *Isistius brasiliensis*. *Environ. Biol. Fishes* 53: 267–273.

Karina Holden, Karen McGhee, Stephen Richards, Rachel Sullivan and Abbie Thomas are regular contributors to Nature Strips.

FRANÇOIS GOHIER/AUSCAPE

What did *Triceratops* use its frill and horns for?

Deep down, the Peewee is a puddler, always happiest fussing around water, whether it's a garden sprinkler or a great outback dam.

PEEWEE POTTERINGS

BY STEVE VAN DYCK

THE SOIL MY PARENTS BUILT THEIR first home on was more suited to brick ovens than petunias. Under the house stumps was a 32-perch block of kaolin that could have relieved the dyspeptic worries of the world. Every weekend they broke their backs digging, dunging and dolomiting its borders until in the glorious end a few pigfaces managed a flower or two before their roots gagged and rotted in the clay pack.

To young wattlers-and-daubers though, the foundations were as good as gold. Two days after a heavy downpour, the run-off from half our suburb would come, like a tsunami, through our backyard, under the house and down the front driveway, where we could engineer aqueducts and zigzagged spillways that took many a seafaring ant in an upturned mandarin-skin boat down the rapids to Davy Jones' Locker.

Coming home plastered and mud-pied is not a condition restricted to children and pigs. Peewees (or Magpie-larks) shared our mud-puddling days to the full, their fondness for all things alluvial and their dapper penguin suit endearing them to just about everyone . . . except perhaps those who resented being woken at 5 o'clock on Sunday morning with the repetitious 'tink-tink-tink' of a Peewee cockfighting with the bedroom window or the car's hub caps.

Peewees (*Grallina cyanoleuca*), so named for their shrill tin-whistle calls of 'pee-wee pee-wee', are definitely the salt-and-pepper of the suburbs and usually a good sign of water in the outback. At home in every park, and a welcome visitor in most backyards, they score an almost perfect nine-out-of-ten for presentation and style (the territorial reflection syndrome is a bit of a bummer). They don't habitually pick holes in fruit or human heads, nor do they scratch up the garden. In fact, Peewees seem so devoid of bad habits that their buoyant presence and insect-eating ways are generally taken for granted. How often can the arrival of a shovel-dodging Peewee turn a lonely gardening job into a satisfying exchange of grubs for quiet company?

Deep down, the Peewee is a puddler, always happiest fussing around water, whether it's a garden sprinkler or a great outback dam. Here it busies itself picking up insects, worms, spiders and snails, but here it also falls for its most deep-seated weakness . . . mud,

Peewees love insects, mud and small freshwater snails.

DAVE WATTS/NATURE FOCUS

because next to being an ace puddler, the Peewee is a master pisé-builder using techniques perfected long before Australian settlers started wattle-and-daubing their houses.

Sound pisé needs straw—in the case of a human nest about one bale for every 400 bricks; in the case of a Peewee nest considerably less. The straw helps to bind the mud and clay, and assists in even drying. By packing wet mud and clay around a horizontal branch, then forcing coarse grass down onto it, a strong reinforced foundation is laid on which the bird later builds the walls. When it is finished, a Peewee's nest is a masterpiece of rammed-earth technology. And after enough feathers and soft grasses have been laid on the bottom, the structure is ready to take three or four spotty eggs that make up the jewels in this muddy crown.

When vacated, these used raku porridge bowls, vulcanised to an exposed gum or jacaranda limb, became irresistible as potential additions to our boyhood nest collections. Their wheel-thrown symmetry and primordial ceramic texture made them impossible for me to walk under with a clear conscience.

But they were usually high up and hard to get at. I remember buying two impossibly long pieces of dowel, contriving some ridiculously over-complicated nail-and-string device to connect the two and, with an accomplice equipped with an old black raincoat, skulking around for our chance at such a prize. While I hoisted the joined dowels through an arc like a straining marlin rod, my mate positioned himself directly below the nest and held out the raincoat to form a cradling hammock. Eventually I'd start prodding the bottom of the bowl with the far end of the dowel. Sometimes it would go straight through the nest under the pressures of the job's urgency and the lack of sensitivity transmitted through two kilograms of nails in the middle of six metres of uncontrollably buckling wood. Not invariably, after dislodging the nest, it would plummet into the raincoat. However a number were lost 'to science' when their flight path was crossed by a lower branch, or they were thrown off coarse by a departing flick from the prodding dowel. I can still see the explosion when the catcher misjudged a tail-spinning mortar that hit him on the shoulder to send the two of us rolling around the ground choking on feathers and dirt and gut-stitching laughter.

The nests are so durable they might outlive their builders, and many other kinds of birds (woodswallows, pigeons, cuckoo-shrikes) are quick to jump in the cup and call it their own as soon as the PWs have PO'd. One cuckoo in particular, the Common Koel (*Eudynamys scolopacea*), can't even wait that long, and slips its look-alike egg in the back door just after the Peewees have begun to lay. (Koels aren't all that fussy . . . one has been recorded laying its egg in a domestic fowl's nest inside a chicken coop!) This little cuckoo time-bomb hatches out at roughly the same time as the Peewees but, between two and three days old, the enterprising Koel chick engages in a bit of spring cleaning and tosses all the other nestlings (Peewees) overboard. These squirming impedimenta might, after all, get between it and the tucker bound for its great squawking gob.

Some Peewee pairs can be hoodwinked by the same pair of Koels three times in the same season and the Peewees never twig to the sting. I often wonder, after seeing the dedication of such cuckoo-feeding 'parents' (not just Peewees), what motivates the venom that those same devoted birds so furiously vent on adult cuckoos when they appear on their patch every spring. Probably it is just a response to the intrusive nature of cuckoos snooping around their nests and more than likely has absolutely nothing to do with any appreciation of the impending dupe.

The Peewee deserves a special pat on the back. It has cracked the code to living anywhere between the hearts of cities and deserts. On top of that, each year its humble mud bowl might churn out either a string of baby mudlarks, or some fantastic parasitic Koels; it might also provide serious takeaway for Kookaburras and goannas, a recyclable home for lazy squatters, or a collectable treasure for parasitic boys. Such is the versatility of the Peewee and its humble adobe abode. ■

PEEWEE OR MAGPIE-LARK

Grallina cyanoleuca

Classification
Family Dicruridae, subfamily Gralllininae (2 spp., one in Aust., both in PNG).

Identification
Size of an undernourished pigeon. Mostly black above and white below. Male with fine horizontal black bar through eye and black bib, female with broad vertical black bar through eye and white bib, juvenile with combination of both black bars but with white bib. Tail white-tipped; beak white, fine, sharp, black-tipped; legs grey-black; iris white. Length 280 mm. Head bobs forward (pigeon-like) when walking. Mid-range calls 'pee-wee', 'pee-o-wee'; high piercing 'tee-tee-tee'; low bubbling 'darl-it' when flying.

Distribution
Almost anywhere with mud. Throughout most cities and suburbs and in open woodlands, swamps to deserts of Aust., excluding central-west mainland and south-west Tas. (non-breeding in Tas.). Also in PNG, Timor, Lord Howe Is.

Food
Insects, their larvae and other invertebrates, including spiders, worms and molluscs. Treasured connoisseurs of the small freshwater snails that spread liver flukes.

Reproduction
Maintains home range of 8–10 ha. Breeds all months, but mostly Aug.–Dec. Nest is a hard mud/straw bowl, lined with soft material. Nests used for successive broods, even successive years if intact (1 nest in Qld Museum collection is 24 cm tall through topping-ups). Both sexes incubate 3–5 pink, brown-blotched eggs (20 mm long) for 17 days. Young leave nest at 20 days old. Pairs capable of raising 4 clutches annually, but usually manage 2. New recruits and non-breeding birds form huge nomadic flocks.

Further Reading

Coates, B.J., 1990. *The birds of Papua New Guinea. Vol. 2.* Dove Publications: Brisbane.

Higgins, E., 1999. *Handbook of Australian, New Zealand and Antarctic birds. Vol. 4. Parrots to Dollarbird.* Oxford University Press: Victoria.

Ivison, P., 1996. Magpie-larks. Pp. 206–210 in *Finches, bowerbirds and other passerines*, ed. by R. Strahan. Angus and Robertson: Sydney.

Dr Steve Van Dyck is a Senior Curator of Vertebrates at the Queensland Museum where he has worked since 1975.

The first Australian specimen was found less than a 20-minute drive from Atherton.

TUBE-NOSED INSECTIVOROUS BAT

BY CHRIS CLAGUE

THE TUBE-NOSED INSECTIVOROUS Bat (*Murina florium*) is an unusual-looking bat, with snorkel-like nostrils at the end of a long snout. Its entire body and some of its flight membranes are covered in fine woolly hair, which varies in colour from grey to russet brown. It is small, weighing a mere seven grams, and its short, stubby wings, which span less than 270 millimetres, make it highly manoeuvrable in flight and enable it to hover.

The bat was first described in 1908 by Oldfield Thomas from a specimen obtained from the Isle of Flores in the southern Indonesian Archipelago. Over 70 years later, in 1981, a World Wildlife Fund survey team discovered the species in Australia. The first Australian specimen was found less than a 20-minute drive from Atherton, a regional centre on the Atherton Tablelands in Queensland's wet tropics. An effort to recapture the species resulted in just a handful of specimens from near the original discovery site, and gave rise to the idea that it was a rare and highly specialised bat, occurring only on the highest cloud-shrouded mountain tops of the wet tropics region. This image of one of Australia's rarest mammals was shattered in 1994 when biologists surveying bats in the Wet Tropics Heritage Area caught and handled more of these bats than anyone had in the past decade. What's more, these captures occurred over a wide range of altitudes and in several forest types. The species is now known to occur in areas of wet forest and rainforest from Flores in the west through to Papua New Guinea and south through Cape York to the Wet Tropics.

The apparent rarity of the Tube-nosed Insectivorous Bat was really a function of the methodology normally used to capture and detect bats. My observational data show that this bat spends a large amount of its nocturnal activity in the rainforest canopy, high above conventional ground-set traps and nets, and out of range of ground-based ultrasonic bat detectors. The first hint of this canopy-dwelling lifestyle came from tagging and radio-tracking studies conducted over the last six years. It was soon discovered that, by elevating a microphone into the canopy where the species is most active, the bat's ultrasonic echolocating calls could be recorded and identified. However, the greatest increase in records for the species has come from identification of its loud social flight call, which is audible even to ground-based observers.

If the bat is feeding on nectar deliberately and collecting pollen on the way, it would be Australia's only insectivorous species to pollinate plants.

Although the bat's nocturnal activities seem to be mainly limited to the canopy, its choice of daytime roosting sites is much more catholic. In Australia they have been recorded in old bird nests, fallen but suspended palm fronds, tree hollows, epiphytes and foliage, and in Indonesia they are known to use caves.

The Tube-nosed Insectivorous Bat is well represented within the Wet Tropics World Heritage Area, although several recognised hotspots occur outside this protected area. The main threat to the species is considered to be further fragmentation of its habitat, as it appears to avoid cleared areas. Clearing on private land, or the construction of service corridors through the World Heritage Area, to supply the rapidly increasing population of the Cairns district, may contribute to this fragmentation. Domestic and feral Cats also pose a significant threat to those bats that roost close to the ground within their reach.

Although no longer on the endangered list, the Tube-nosed Insectivorous Bat continues to intrigue. For example, we are still at a loss to explain the function of its snorkel-like nostrils. Its diet, too, is of interest to scientists. It consists mainly of gleaned insects and spiders, but a significant amount of pollen, from a discrete group of trees, is also ingested (as found by sampling its faeces). Either the bat consumes the pollen incidentally when it captures flower-visiting insects, or it could deliberately feed on nectar and ingest the pollen while grooming its woolly fur. Other features that point to a nectarivorous habit include its relatively long snout, a rather long, narrow tongue, and a greatly enlarged section of the brain (the olfactory bulb) that controls the bat's sense of smell. If the bat is feeding on nectar deliberately and collecting pollen on the way, it would be Australia's only microchiropteran (insectivorous) species to pollinate plants. The only other Old World 'microbat' known to pollinate plants is the Lesser Short-tailed Bat (*Mystacina tuberculata*) from New Zealand (see *Nature Aust.* Spring 1998). Even more intriguing, all of the pollen grains taken from the scats of the Tube-nosed Insectivorous Bat were from plant species of ancient Gondwanan origin, perhaps from a time when Australia and New Zealand were connected. Fossil evidence has established the presence of mystacinid bats in northern Australia (see *Nature Aust.* Spring 1998), bringing these two bats tantalisingly close in space and time. ■

Further Reading

Schulz, M. & Hannah, D., 1998. Relative abundance, diet and roost selection in the tube-nosed insect bat, *Murina florium* on the Atherton Tablelands, Australia. *Wildl. Res.* 25: 261–271.

Richards, G.C., Hall, L.S., Helman, P. & Churchill, S.K., 1982. First discovery of a species of the rare tube-nosed insectivorous bat (*Murina*) in Australia. *Aust. Mammal.* 5: 149–151.

Chris Clague is a PhD student at the Vision Touch and Hearing Research Centre, University of Queensland, whose current research is into the bat communities of tropical wet sclerophyll forests.

M. PROCIV

Australia is home to many parasitic plants, and they come in all shapes and sizes.

ATTACK OF THE SAPSUCKERS

BY TIM LOW

WHENEVER PARASITES come up in conversation most people think of leeches, ticks or intestinal worms, not trees, shrubs and vines, yet Australia is home to many parasitic plants, and they come in all shapes and sizes. Mistletoes (more than 80 species) are just the most obvious examples. There are others, such as *Pilostyles collina*, which live entirely within the stems of shrubs, becoming visible only when they push out their flowers and fruits through the bark of their host. There are vines such as dodders (*Cuscuta* species), with no permanent earthly connections, drawing all their sustenance from the plants they cling to. And there are plenty of herbs, shrubs and trees with parasitic roots that rob nutrients from the rootstocks of adjoining plants. All up, about one per cent of flowering plants are parasites, amounting to 3,000 species worldwide.

Most (80 per cent) of these plants are known as 'hemiparasites', which means they steal water and minerals but photosynthesise their own sugars. The others, the 'holoparasites', take everything they need from their hosts. Botanists have four categories in all, depending on where the plants attack their hosts: stem holoparasites, such as dodders and *Pilostyles*; stem hemiparasites, including most mistletoes and the devil's twines (*Cassytha* species); root holoparasites, such as the broomrapes (*Orobanche* species); and root hemiparasites.

The root hemiparasites interest me greatly because, like mistletoes, they are particularly common in Australia, especially in woodlands growing on infertile, sandy soils. They include such well-known trees as the Desert Quandong (*Santalum acuminatum*), the sandalwoods (*S. album, S. lanceolatum, S. spicatum*), native cherries (*Exocarpos* species) and the Western Australian Christmas Tree (*Nuytsia floribunda*). All of these plants send out roots that creep through the uppermost half metre of soil in search of unwitting hosts. They may form thousands of parasitic attachments to nearby plants via their special

PHOTOS: TIM LOW

Musing about the native cherry *Exocarpos cupressiformis* in 1819, colonial writer W.C. Wentworth explained "Nature . . . seems determined to have a bit of play. Accordingly, she makes cherries with the stone outside." Like many root hemiparasites, this tree is leafless but with photosynthetic stems.

absorbing organs called 'haustoria'. By evaporating large amounts of water from their leaves, they extract sap from their hosts. (Their leaves often feel cool because the high transpiration rates also causing cooling.) Unlike mistletoes, which are usually very selective in their choice of victim, root hemiparasites are largely indiscriminate, attacking trees, shrubs, herbs, grasses, rushes, other kinds of hemiparasites, even their own roots. Western Australian Christmas Trees will also attack underground electrical cables, causing short circuits. These parasites seldom kill their hosts, and their devious deeds remain concealed from public view. They are ordinary-looking plants that appear capable of fending for themselves, but which nonetheless die if deprived of hosts.

Australia's root and stem hemiparasites belong mainly in the order Santalales, a very ancient group and one that probably evolved from a single parasitic ancestor. Most of the mistletoes attack plant families with a very old fossil record (Casuarinaceae and Myrtaceae, for example), suggesting that the parasitic relationship goes back an incredibly long time, perhaps 100 million years or more. Within the largest mistletoe family (Loranthaceae) there are a few plants that are actually root (rather than stem) parasites. These are the Western Australian Christmas Tree, the shrub *Atkinsonia ligustrina* (confined to the Blue Mountains) and the South American *Gaiadendron*, and they are thought to be the most primitive plants in their family, implying that mistletoes evolved from shrubs with parasitic roots. The creeping mistletoes (*Muellerina* species) are unusual in forming multiple attachments to their hosts, a habit shared with root parasites, and they may represent an intermediate evolutionary stage.

Root parasites hold a significant place in Australian history. Fruits of the Native Currant (*Leptomeria acida*) contain vitamin C and they helped save the lives of scurvy-stricken convicts during the first years of Sydney's settlement. Aborigines ate the fruits of the Desert Quandong, and country people still gather them today to bake in pies. Fruits of native cherries were also eaten by Aborigines and settlers, and their unusual fruits, which have a fleshy stalk attached to a hard fruit and look like a cherry with its seed on the outside, were taken as proof—along with the Platypus—that Australia was a topsy-turvy land. More importantly, the fragrant wood of sandalwoods was exported to China for incense, a harvest that continues today. On the debit side, dodders, broomrapes and witchweeds (*Striga* species) are serious weeds of agriculture, threatening grain crops and vegetables.

Recently the Desert Quandong has become important in the restaurant trade as a bush tucker plant, and farmers trying to grow it have had to cater to its parasitic tastes. It grows well if Lucerne (*Medicago sativa*), clover (*Trifolium* species) or Kikuyu Grass (*Pennisetum clandestinum*) are planted as primary hosts, but will not develop into a tree unless woody victims are provided.

Next time you are strolling through the bush, spare a thought for all the parasitic plants growing around you. Note the mistletoes in the trees, the devil's twines trailing over the shrubs, then look around at all the root parasites—the native cherries, Native Currants, sandalwoods, and such like. You will soon see that parasitism is pervasive in the plant world, just as it is among animals. ■

The crimson fruits of the Desert Quandong attract Emus, which disperse the seeds far away, reducing the risk of the seedlings attacking the hosts of the parent tree.

Further Reading

Kuijt, J., 1969. *The biology of parasitic flowering plants.* University of California Press: Berkeley.

Press, M.C. & Graves, J.D., 1995. *Parasitic plants.* Chapman & Hall: London.

Tim Low is an environmental consultant and nature writer. His latest book is Feral future *(1999), published by Penguin.*

A property thought to be only associated with life has been found to be present in a meteorite that is older than life on Earth.

ORIGIN OF LIFE

BY JEREMY BAILEY

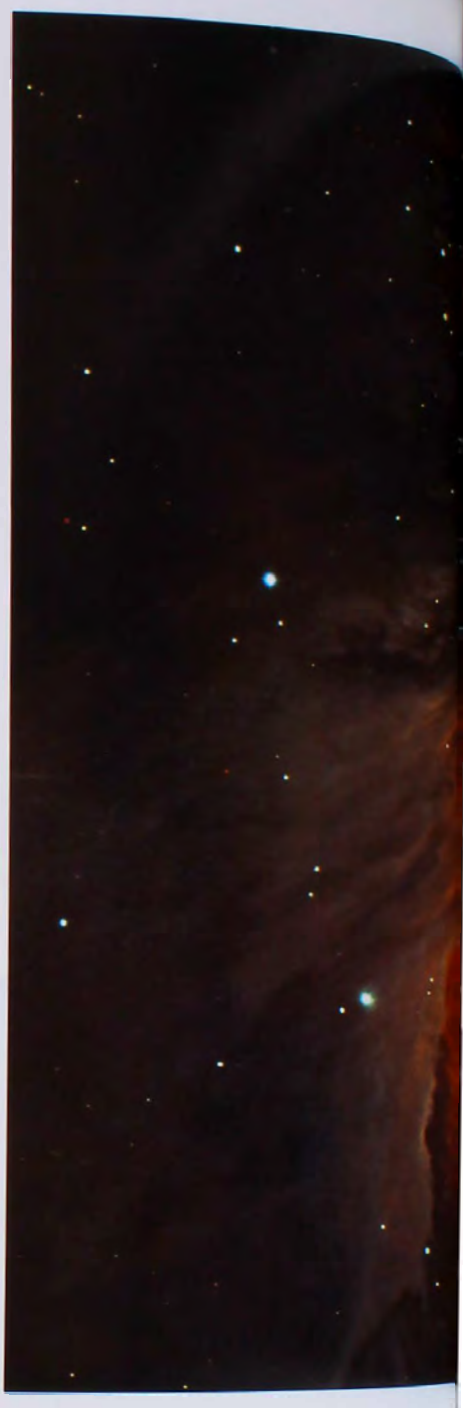
HOW DID LIFE ORIGINATE? Where did the bits and pieces necessary for life come from? Recent discoveries suggest that a key property of biological molecules may have come from outer space, thereby solving a problem that has puzzled scientists for more than a century.

Scientists believe that life began billions of years ago by complex, and as yet poorly understood, chemical processes in a mixture sometimes referred to as the primeval soup. The soup contained simple molecular building blocks out of which the substances needed by living cells might be constructed, but even these simple molecules had to come from somewhere.

In the 1950s a young American graduate student, Stanley Miller, came up with a recipe that seemed to do the trick. Miller's classic experiment used electric discharges in a flask to simulate a thunderstorm above a primeval ocean, in a mixture of gases (methane, ammonia and hydrogen) then thought to be the main constituents of Earth's early atmosphere. After running the experiment for a few days, Miller found that he had made a number of amino acids, the building blocks of proteins, and essential components of a primeval soup. It seemed that the first step on the road to life was understood. Or was it?

The success of Miller's experiment depended on his choice of gas mix for the early atmosphere. As the formation of Earth and its atmosphere has become better understood, it now seems likely that the early atmosphere would have been composed largely of carbon dioxide. In such an atmosphere a Miller-type experiment is much less successful, giving much reduced yields of amino acids. As these difficulties were showing up, evidence began to mount for another possible source of organic molecules.

In 1970 radio astronomers detected the presence of carbon monoxide in a region of space near the famous Orion nebula. This was the first hint of the existence of a previously unknown class of celestial object—giant molecular clouds. These are vast clouds of cold gas at temperatures as low as –263° C, and they provide the raw material from which new stars form.



Today over 100 different types of molecules have been detected in molecular clouds. Many of these are organic (carbon-based), including such familiar substances as acetic acid (the acid in vinegar), acetone (a common solvent) and ethanol (the alcohol in our alcoholic drinks). Most of the molecules are built from some or all of the four elements hydrogen, oxygen, carbon and nitrogen, the same four that are the most common in living organisms and the four that are needed to make amino acids.

If organic molecules were present in the cloud from which our solar system formed, could this material have found its way onto Earth? On 28 September 1969, pieces of a meteorite fell in and around the small town of Murchison in Victoria. Analysis of the meteorite

showed it to be an unusual type, rich in organic material, including a variety of amino acids. The Murchison meteorite may be one of the most primitive examples of solar-system material, preserving organic molecules that were present in the cloud from which the solar system formed.

Nowadays impacts of such meteorites

Above: The Great Nebula in Orion—a region of star formation on the edge of a giant molecular cloud. The formation of our own solar system, 4.5 billion years ago, probably occurred in a region like this. Right: A piece of the Murchison meteorite that fell in 1969. This meteorite has been found to contain a huge variety of organic compounds including many amino acids. Recent work has shown an excess of the left-handed form in some of these amino acids—a property previously thought to be only associated with life.

are rare, but in the first few hundred million years of the solar system, the Earth and other planets were subject to an intense bombardment as they swept up the debris left over from the formation of the solar system. Current evidence suggests that life on Earth was present at least 3.8 billion years ago, pushing its origin back into this heavy-bombardment period. Could this extraterrestrial bombardment, rather than terrestrial processes, have provided the organic material for the primeval soup?

There are so many uncertainties in our knowledge of the early solar system that it is hard to determine which mechanism—terrestrial or extraterrestrial—would have been dominant. Is there another way of determining whether extraterrestrial material played an important role in the origin of life? My colleagues and I think there is. We believe an extraterrestrial origin can explain an otherwise puzzling feature of biological molecules—why life's building blocks are left-handed.

ORGANIC MOLECULES IN LIVING organisms, including ourselves, have a remarkable property that distinguishes them from the molecules made in the laboratory. Many organic molecules have asymmetric structures that can exist in two distinct mirror-image forms. Make these molecules in the laboratory, and an equal mixture of left- and right-handed forms results. But living organisms use one form almost exclusively. The amino acids that make up proteins, for example, are always left-handed, while the sugars in DNA and RNA are always right-handed. What caused one particular handedness (or chirality) to develop has puzzled scientists for more than a century.

One possibility is that early evolution somehow selectively enhanced one form of handedness. However RNA (ribonucleic acid), which is scientists' best guess for a replicating molecule that could have been used as the earliest genes, can only be made to replicate in experiments that use molecules all of one handedness. Thus it seems that life's handedness must have been set before evolutionary selection could have operated.

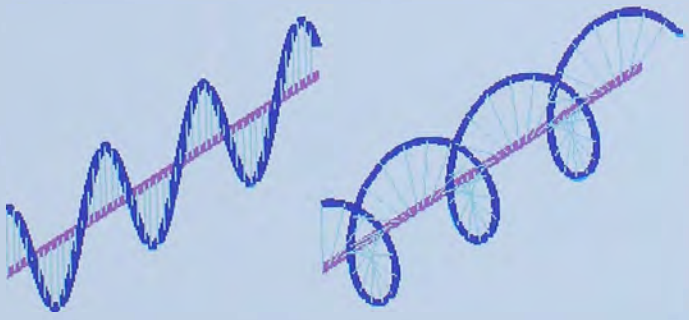
Terrestrial processes, such as Miller's simulated thunderstorms, provide no preferred handedness and would have led to a primeval soup with equal quantities of left- and right-handed molecules. But recent work on the Murchison meteorite has shown that it contains

If this model turns out to be correct, it may change our ideas on the chances of finding life elsewhere in the universe.

an excess of the left-handed form in some of its amino acids. Moreover this left-handed bias is found in amino acids otherwise unknown on Earth, ruling out the possibility of contamination by terrestrial biological material. The meteorite is as old as Earth (about 4.5 billion years). Remarkably, therefore, a property thought to be only associated with life has been found to be present in a meteorite that is older than life on Earth.

The Murchison results strongly suggest that the left-handed bias seen in amino acids today was already present, to some degree, in molecules in the cloud of gas and dust from which the solar system formed. If so, how did this come to be? We believe we have found a possible answer in our observations of the Orion nebula.

There is one process that is able to generate a significant excess of one-handedness in molecules such as amino acids, and has been demonstrated in numerous experiments. The action of circularly polarised light, a form of light in which the electric field direction traces a corkscrew path through space, can preferentially destroy molecules of one handedness, leaving an excess of the other.



Electric field direction oscillations of linearly and circularly polarised light.

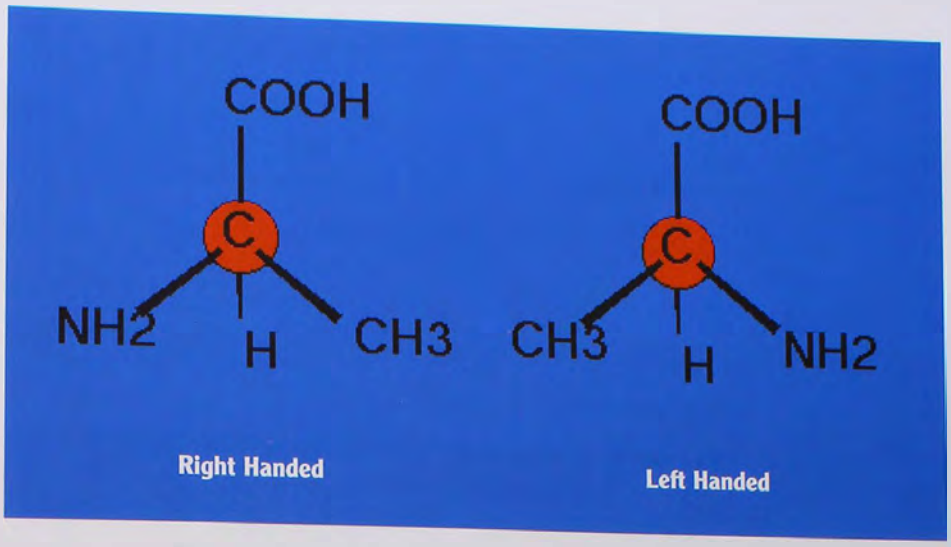
POLARISED LIGHT

Light is an electromagnetic wave consisting of oscillating electric and magnetic fields. When the electric fields are randomly oriented, that is pointing in all different directions, the light is said to be unpolarised. Many light sources such as the Sun and most artificial lights produce unpolarised light.

Light is said to be polarised if the electric field direction oscillates up and down along a fixed line (linear polarisation) or if the field rotates continuously (circular polarisation). A familiar example of linearly polarised light is the light from the daylight sky which becomes polarised as a result of scattering off atmospheric particles. Polarising filters, such as those used in polaroid sunglasses, filter out linearly polarised light and will cause the sky to darken if rotated to the appropriate angle. These filters will not block light coming directly from the Sun because this light is unpolarised.

Circularly polarised light is rarely encountered in natural situations. Depending on the direction of rotation (either clockwise or anticlockwise), circular polarisation can be either left- or right-handed.

Right- and left-handed amino acids (in this case alanine) have molecular structures that are mirror images of each other. Living organisms use only the left-handed version. The problem of why life should exhibit a preference for one-handedness has puzzled scientists for more than a century.



Our observations with the Anglo-Australian Telescope at Siding Spring have detected strongly circularly polarised light from a region of star formation in the Orion nebula, a region probably similar to that in which our own solar system formed. The circular polarisation is produced when light from infant stars scatters off interstellar dust grains. If the same process was operating at the birth of our solar system, the circularly polarised light might have resulted in an excess of left-handed molecules in the cloud from which our solar system formed. Comets and meteorites could then have seeded the Earth with a preferred handedness that would have tilted the scales for life to adopt left-handed amino acids.

If this model turns out to be correct, it may change our ideas on the chances of finding life elsewhere in the universe. It has usually been thought that Earth's suitability for life was determined by factors such as being at the correct distance from the Sun, and having plenty of liquid water. These new ideas suggest that we may have to look back even further to the environment in which our solar system formed. A strong dose of circularly polarised light at this stage may be the crucial factor that makes life possible. ■

Further Reading

Bailey, J., Chrysostomou, A., Hough, J.H., Gledhill, T., McCall, A., Clark, S., Menard, F. & Tamura, M., 1998. Circular polarization in star formation regions: implications for biomolecular homochirality. *Science* 281: 672–674.

Blitz, L., 1982. Giant molecular cloud complexes. *Sci. Amer.* 246(4): 72–80.

Davies, P., 1998. *The fifth miracle.* Penguin Books: Ringwood, Victoria.

Delsemme, A., 1998. *Our cosmic origins.* Cambridge University Press: Cambridge, UK.

Dr Jeremy Bailey is an astronomer at the Anglo-Australian Observatory in Sydney. His research interests include the application of polarisation measurements to a wide range of astronomical problems.

ANGLO-AUSTRALIAN OBSERVATORY

The central region of the Orion nebula. Inside this glowing cloud new stars are forming out of gas that is known to contain organic molecules.

Armed with radio-tracking equipment and litres of insect repellent, I set out to find out what I could about the lifestyle and behaviour of this most mysterious possum.

ADVENTURES AT POSSUM ROCK

BY MYFANWY RUNCIE

WHO EVER HEARD OF A POSSUM THAT LIVES IN rock crevices instead of trees or urban roof tops? Four years ago I hadn't either. Then I read about a secretive, rock-dwelling possum that was restricted to remote and rugged habitats of northern Australia. This was the Rock Ringtail or Rock-haunting Possum (*Petropseudes dahli*) and virtually nothing was known about it . . . which is why I decided to study it as part of my doctoral thesis. Armed with binoculars, head torch, radio-tracking equipment and litres of insect repellent, I set out to Kakadu National Park in the Northern Territory to find out what I could about the lifestyle and behaviour of this

PAVEL GERMAN

This juvenile Rock Ringtail will soon develop an orange smudge on the chest area. These smudges are produced from the sternal glands and are used in scent-marking.

most mysterious possum.

My first challenge was to catch some possums. After many fruitless trapping nights (they seem to shun traps), I found the most reliable method of catching them was by hand. This involved up to an hour of patient stalking, followed by an adrenalin-pumped 50-metre chase over fallen logs. My aim was to grab them before they reached their rocky haven. A final flying leap usually resulted in a successful capture. I would then carry the now-placid fur ball back to the base camp and fit it out with a radio-collar. With the help of these collars I began to discover just how odd these possums really are.

By day, Rock Ringtails sleep deep within rock tors. Their preference for rock dens is unusual for a possum. Scaly-tailed Possums (*Wyulda squamicaudata*) and Mountain Pygmy-possums (*Burramys parvus*) are the only other rock-dwelling possum species. Even more unusual is their social behaviour. In most marsupials, the young have intimate relationships with their mother, but not usually their father. Rock Ringtails are different. Young ones receive care from both parents. My detailed nocturnal observations of Rock Ringtails revealed that they are extremely social animals and live in groups consisting of a long-term female–male pair and up to two different-aged young. The males appear to remain faithful to their partner, which suggests that these possums have a monogamous mating system. Such a mating system is rare among mammals.

Young Rock Ringtails start life knowing just their mothers. Like all marsupials their early days are spent in the pouch, warm and safe with milk on tap. As they grow older, they are allowed outside to perch on a tree branch. This can be a dangerous time for a tiny creature with little sense of balance. Occasionally, a rotund family member can threaten the safety of a teetering tot by trying to squeeze impatiently past it on a narrow branch. This is the only time that a female Rock Ringtail is aggressive towards other possums. The mother will swipe the offender with an open paw, growl, and quickly hoist the little one onto her back. Only after this stage, when the young possums are larger and less vulnerable to falling, will they begin their relationship with their father. Like most young mammals, young 'puppy-fat' possums tend to burst with energy, bounding from mum to dad and up the rocks and down again, not quite realising that their overzealous actions may have them tumbling through space, possibly to a nasty end.

Sometimes when a youngster between two and five months old approaches one of its parents, it is embraced in a big bear hug. This behaviour has not been reported in marsupials before, but a similar form of embrace has been documented in primates. There are a variety of possible explanations for the role of these embraces. They could inform parents of maturation of the offspring, or offer reassurance to the young. Fathers embrace their young for long periods even though they cannot provide milk, and it is the young that actively solicit bear hugs from the dad, suggesting some sort of reassurance is required by the young. Both sexes groom their young. Physical contact with parents becomes increasingly important in a young Rock Ringtail's life until it leaves the family group at about seven months of age. Physical contact is then received

ROCK RINGTAIL POSSUM

Petropseudes dahli

Classification
Order Diprotodonta, family Pseudocheiridae.

Identification
Stocky build with short legs, small head, tiny ears and round muscular body. Main fur colour ginger to grey, underbelly cream, pale cream 'patch' over each eye. Dark dorsal stripe runs from nose to tail base. Tail, with its thick furred base, tapers to a thin section with no fur on underside. Adults weigh around 2 kg.

Distribution and Habitat
Endemic to rock outcrops of northern Australia, from the Kimberley Region in WA to the Top End and Gulf of Carpentaria in NT, and across to Lawn Hill in Qld.

Behaviour
Social groups of 2 to 10. Emerge from rock dens an hour after dusk to forage in nearby trees (less than 10 m away). Able to climb up and down sheer rock faces. Travel in cohesive groups with young positioned between adults. If disturbed they rush to the safety of the rocks. If only moderately disturbed, they repeatedly smack the tree trunk or branch with their tail, which makes a loud noise and can shake the tree. They may also give a low growl. Leaves mainly eaten but also some fruit and occasional flowers. Pungent rust-coloured scent deposited on rocks, trees or termite mounds within the most heavily used areas of their home range.

Reproduction
Social monogamy defines the mating system of one studied population. Extremely high degree of paternal care. Only 1 offspring produced in a breeding season, which occurs twice a year, but up to 2 offspring of different ages can remain in a family group at a time. Breeding is asynchronous. Young mature and disperse within around 7 months of birth.

I. MORRIS/NATURE FOCUS

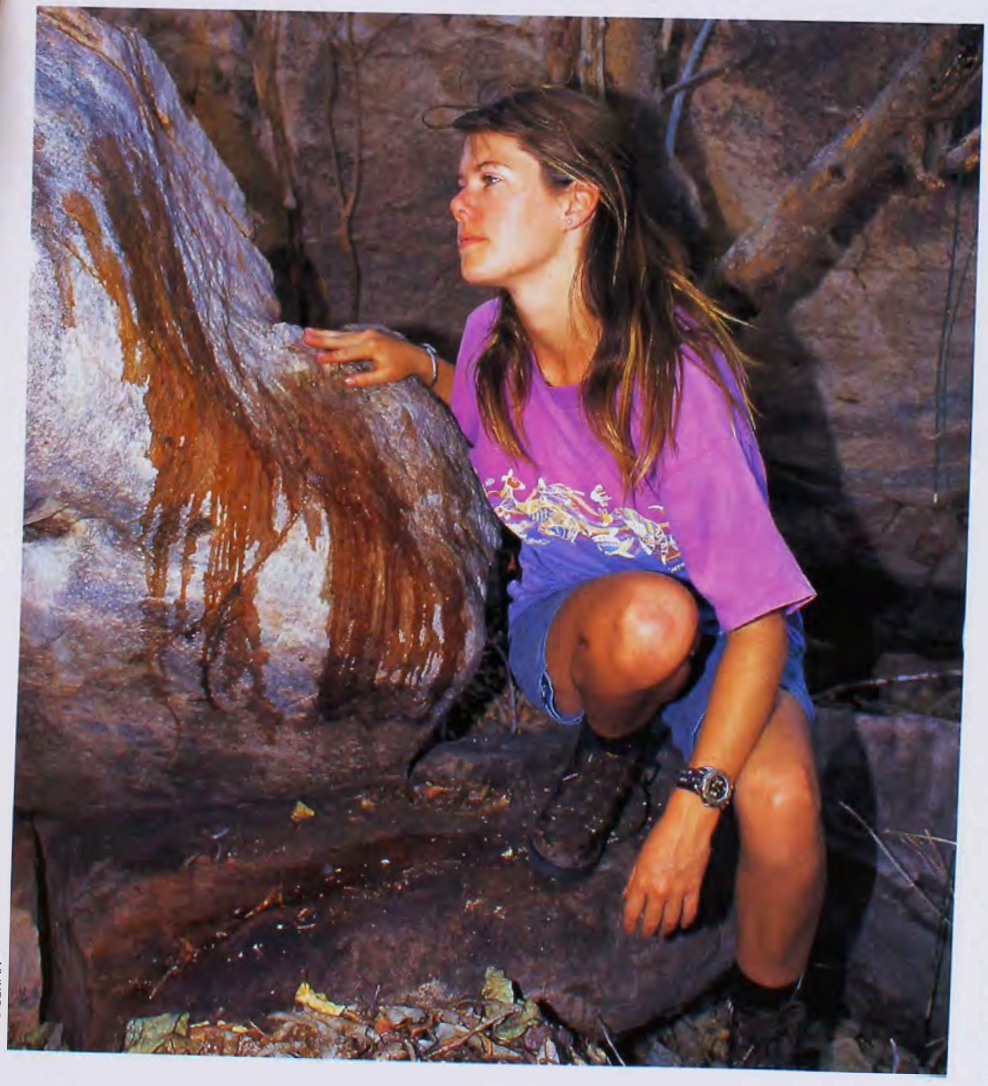
ELIZABETH TASKER/WILDLIFE IMAGES

Above: Rock Ringtail Possums live in family groups and like to sit in close contact with one another. Right: The Scaly-tailed Possum is the only other tropical rock-dwelling possum but, unlike the Rock Ringtail Possum, it lives a more solitary lifestyle. The distinctive scaly tail can be seen on this juvenile.

by and given to their new adult mate. Paired possums don't embrace but do groom each other and often sit with their flanks in contact while on a branch or rock ledge.

As young possums grow larger and move outside the confines of the pouch, they often hitch a ride on their mother's back, clutching her fur in their big paws. Juveniles even use their mother's back as an occasional bridge to gain access to faraway branches or another tree. Typically, the mother grasps the branch in

MYFANWY RUNCIE



PAVEL GERMAN

Above: Prime Rock Ringtail Possum habitat. Possums dine in a range of trees growing within a short sprint from the safety of the rocks. Left: The author inspects a rock, heavily scent-marked by Rock Ringtail Possums.

her forepaws and clings onto the other branch with her powerful prehensile tail and hind paws. Frozen in this position, she waits for the juvenile possum to race across her back and into the next tree. This behaviour has not been recorded for any other possum species.

Throughout their nightly activities, Rock Ringtails seldom stray more than a few metres from the nearest member of their family group. During trips between trees or along the rocks, the parents take turns in leading the group, but the juvenile is always sandwiched in the middle for protection. The leading possum waits for the others to catch up at certain places along the route, but occasionally the others lose sight of the leader. If this happens, the leader makes loud vocalisations until the rest of the group moves in the right direction.

Rock Ringtails also vocalise when predators pose a threat. This warning call consists of a low rumbling sound. Depending on the level of threat perceived, the call may be barely audible or extremely loud. Loud calls can be heard over a distance of 40 metres. Sometimes calling possums beat their tails lightly against tree branches, but when

extremely agitated they thrash the tail so vigorously that the entire tree shakes. I observed a similar behaviour in another northern rock-dweller, the Short-eared Rock-wallaby (*Petrogale brachyotis*). When aroused by a potential predator (usually me stumbling about in the night), this rock-wallaby would often hop to a nearby rock and start slamming both its long, flat hind paws onto the rock, making a loud thudding sound in the process. Other macropods living in other habitats are also known to thump the ground or 'footdrum'. Such behaviours may serve as warning calls for other individuals in the vicinity. They also inform me that I'm walking far too noisily and that my cover has been blown.

Many animals, particularly birds, position themselves at a high point where they can scan the landscape for tell-tale signs of predators. Some group-living birds and a few mammals assign one animal for sentinel duty while the others eat. Rock Ringtails have also adopted this watchful behaviour. Prime spots for sentinel duty are high ledges jutting out from the main rock. Branches near the bottom of trees are also favoured sites because there is little foliage to block the view. During possum-feeding sessions, one adult will remain alert and stationary while the others feed. Partners will then swap roles.

Throughout their nightly activities, Rock Ringtails seldom stray more than a few metres from the nearest member of their family group.

Some of the carnivores that Rock Ringtails must watch out for are Dingoes, owls, quolls, feral Cats and Dogs, and Australia's largest snake, the Oenpelli Rock Python (*Morelia oenpelliensis*). I too became wary of some of these and other nocturnal animals, and did my best not to upset them. In the past Aboriginal people caught Rock Ringtails for food and used their soft pelts as loin cloths. In Kakadu National Park, Rock Ringtails feature in Aboriginal mythology and painted rock art. Today, however, few Aborigines have seen these possums. Jacob Nayingal of Oenpelli in Arnhem Land told me how he once had a young Rock Ringtail as a hunting companion. The little possum travelled around on his head and clung to his hair, just as it would to its mother's fur. Even when Jacob ran quickly, it never fell off. He said with affection, "It made a good pet, but it ate everything it could lay its paws on, even my yams and water lily stems".

Rock Ringtails feed mainly on leaves of a large variety of trees, including acacias, eucalypts and the Cooktown Ironwood tree (*Erythrophleum chlorostachys*), which is toxic to stock. The possums also favour fruits with a high level of vitamin C, such as *Terminalia carpentariae* plums. These are one food item that they can't seem to get enough of and, quite unusual for these possums, they often make quite a racket in their haste to gobble them down.

One feeding observation had me quite puzzled. While sitting in the bush with my mosquito net draped over me, I saw one of the possum groups acting strangely. They were in one of their favourite eucalypt food trees but, instead of feeding in the top of the canopy on the usual menu of leaves, one by one the possums came down to crouch on the thick sloping trunk. All three took turns crouching and licking the grey surface of the trunk. This went on for 15 minutes. In the morning, when I returned to

MYFANWY RUNCIE

A Rock Ringtail family on its nightly journey down the rocks to forage in the trees below.

JONATHAN WEBB

The author fits a radio-collar to a Rock Ringtail Possum.

have a close look at the trunk, I found that the possums had been licking the smooth outer surface of a termite nest. This behaviour has never before been observed in a marsupial, but over the years I regularly saw them doing it. Why they do it is a mystery. Perhaps the nest is a source of minerals or substances that settle their stomachs. This is not as far-fetched as it sounds; some Aborigines occasionally consume handfuls of termite mounds to cure indigestion.

Another unusual activity not seen in any other possum species is the scent-marking of rocks. The tropical rock-dwelling Scaly-tailed Possum does not exploit rocks for marking. Other possums, such as the Common Brushtail Possum (*Trichosurus vulpecula*), do scent-mark but as they spend their time mainly in trees, it is only trees that they mark. Rock Ringtails possess a sternal (chest) and caudal (tail) gland, which they regularly use to mark trees, rocks and termite mounds within their home range. Rocks make a particularly good substrate for marking because their porous nature soaks up the scent and retains potent smells for a long time. A favourite location for marking is under rock overhangs, which provides protection from the sun and rain. To scent-mark, both sexes crouch or sit on their bottom and rub the gland located near the base of their tail onto the substrate. Sometimes, immature young possums mimic these behaviours. Sweet-smelling exudate is released from the adults' glands. Deposits of this rusty-coloured, sticky exudate accumulate with many marking episodes and the pungent odour permeates the air, especially just after rain. Interestingly, Aborigines appreciated the aroma and, in the past, rubbed the exudate through their hair and over their bodies after a successful possum hunt. Scent-marking most likely helps these nocturnal possums find and remember their way around the complex three-dimensional jumbles of rock faces, ledges and chasms. In addition, scent-marking may help to signal a territory, and may help prevent rival groups from stealing food or taking over dens.

Scent-marking helps these possums find their way around the complex three-dimensional jumbles of rock faces, ledges and chasms.

Scent-marking of rocks has also evolved in the unrelated African rock hyraxes (*Procavia* spp.) whose closest relatives are the elephants. Not only do both types of animal mark rocks, but they also possess morphological adaptations for the rocky environment in which they live. These include small out-of-the-way ears, highly developed paw pads with specialised grip to reduce slippage on rock surfaces, reduced claws, and a short muscular body. Collectively, these features enable them to climb up and down vertical rock faces with ease. These two small mammals have evolved independently on separate continents to become successful rock specialists with very similar characteristics, and are a good example of convergent evolution. Uncannily, the rock possums and hyraxes have similar facial markings (a cream patch of fur above each eye).

Rock Ringtails are true rock specialists and can climb among steep tors effortlessly. The major structural fea-

tures they require in their tropical environment are deep rock crevices for protection from predators and the elements of heat, rain and fire. They also need food trees growing nearby. My observations in Kakadu showed most possums foraged within ten metres of their rock den. Clearly, possums that travel farther from the rocks are more likely to be eaten by patrolling Dingoes and will expend more energy running the greater distances.

OTHER MAMMALS OF NORTHERN Australia that share the rocks with the Rock Ringtails include rock-wallabies, Northern Quolls (*Dasyurus hallucatus*), antechinuses and numerous rodent species. In the Kimberley Region of Western Australia, Rock Ringtails and Scaly-tailed Possums are sympatric (that is, they have overlapping distributions), and compete for dens and food trees. In northern Australia, rock outcrops form important mesic (moist) pockets of land within the dry tropical savanna. Major threats to the rocky environment are the destruction of trees and reduction of plant diversity growing among the rocks. Recent research suggests this could result from the diminishing number of birds that transport new and diverse seeds from the shrinking tracts of dry rainforest growing farther afield, into the rocky habitat. Fire also threatens the diversity of trees growing among the rocks, as does grazing of stock and land clearance. An increase in feral Cat and Dog numbers, and new diseases could also threaten the rock-dwelling fauna. At this stage, no-one knows how much of a threat any of these factors are. We need basic information about the natural history of all these fascinating animals. Without this we have no firm platform on which to direct future management plans.

As a young scientist interested in ethology, I am very lucky to have chosen such a fascinating and complex study animal. The antics of these possums have kept me entertained for many nights, more than making up for the hot, mosquito-ridden environment we shared. On the way, I experienced close encounters with death adders, crocodiles, wild Dogs and scorpions, which all added some spice to my fieldwork. Having spied on numerous family groups, I can now vouch that this possum is an extremely social animal, with an unusually high degree of paternal care, an extensive communication system and highly developed anti-predator behaviours. The unexpected level of complexity of these attributes makes me excited about the rest of our native fauna out there, whose possibly amazing behaviours are also just waiting to be discovered. ■

Further Reading

Clutton-Brock, T.H., 1991. Parental care in birds and mammals. Pp. 132–279 in *The evolution of parental care*, ed. by J.R. Krebs and T.H. Clutton-Brock. Princeton University Press: Princeton, New Jersey.

Mares, M.A. & Lacher, T.E., 1987. Ecological, morphological, and behavioural convergence in rock-dwelling mammals. *Current Mammal.* 1: 307–348.

Runcie, M.J., 1999. Movements, dens and feeding behaviour of the tropical Scaly-tailed possum (*Wyulda squamicaudata*). *Wildl. Res.* 26: 367–373.

Runcie, M.J., 1999. *Behaviour and ecology of tropical saxicolous possums* (Petropseudes dahli *and* Wyulda squamicaudata). PhD thesis: Northern Territory University, Darwin.

Dr Myfanwy Runcie studied Rock Ringtail Possums as part of her doctoral studies at Northern Territory University.

Special thanks go to Big Bill Neidjie and Jonathon Neidjie for allowing access to their backyard. Thanks also to Jacob Nayingal, the Rangers of the East Alligator district of Kakadu National Park and Professor Greg Hill.

S. SWANSON/NATURE FOCUS

Equipped with a strong muscular body, Rock Ringtail Possums can quickly climb up and down steep rock faces.

Hilltops are used as beacons exclusively for the purpose of meeting mates . . . the true butterfly equivalents of the 'desperate and dateless' singles bar.

SEX BUTTERFLY STYLE

BY DARRELL J. KEMP

PAUL ZBOROWSKI

Males of some species, like this Cruiser, patrol almost incessantly throughout the rainforest in search of a female.

ONE THING SHARED BY MOST animals on this planet is the need to have sex. It is perhaps not surprising then that the politics of sex tend to follow some fairly uniform ground rules. Usually it is the females that are coy and choosy, while the males are flashy, philanderous and competitive. Furthermore, sexually willing females within a population are almost always considerably outnumbered by reproductively active males. If one male can dominate or outsmart his rivals in the mating game, then his reproductive success is boosted entirely at the expense of his male colleagues. As a consequence, male sexual strategies are characterised by intense competition between the males.

Butterfly mating systems are a fine example of this familiar regime. In many species, females mate only once or just a few times, but are capable of storing the sperm to fertilise their lifetime supply of eggs. Once mated, a female is effectively divorced from the mating pool for a varying length of time, whereas her partner will proceed to front up shortly afterwards to resume his search for mating opportunities. Butterfly populations are therefore dominated by sexually receptive males and already-mated, sexually unreceptive females. This poses quite a grim scenario for individual males . . . not only are they searching for something akin to a 'needle in a haystack', but they are conducting this search alongside a score of equally enthusiastic rivals. The contestants in this game are driven to succeed at all costs by the ultimate evolutionary prize—the opportunity to perpetuate their genes throughout future generations.

IN THE BUTTERFLY WORLD, MOST OF A male's sexual success hinges upon his ability to actually find a mate. This is no trivial task, since the overall environment is large compared to the sensory capabilities of a male butterfly. Males are primarily visual searchers, but in most respects, their eyesight is considerably worse than our own (see *Nature Aust.* Winter 1997). Although we cannot say precisely how a male butterfly sees his environment, we do know that, compared to us, a butterfly's vision is coarse-grained and short-sighted, but more sensitive to aspects of movement and colour (including ultraviolet). Considering the available searching hardware, how then does a male butterfly go about finding a mate?

Obviously, not all places in the environment are equally likely to furnish a swathe of available females. Just as the resources used by butterflies (things like flowers, larval host plants and roosting sites) are often clumped, unmated female butterflies tend to accumulate in certain places. This is where the ever-resourceful mate-locating male butterfly can take advantage and narrow his search, provided the female distribution is relatively predictable. In many cases, this distribution is indeed predictable, and males of these species focus their efforts almost exclusively in highly specific areas known to invertebrate biologists as 'encounter sites'.

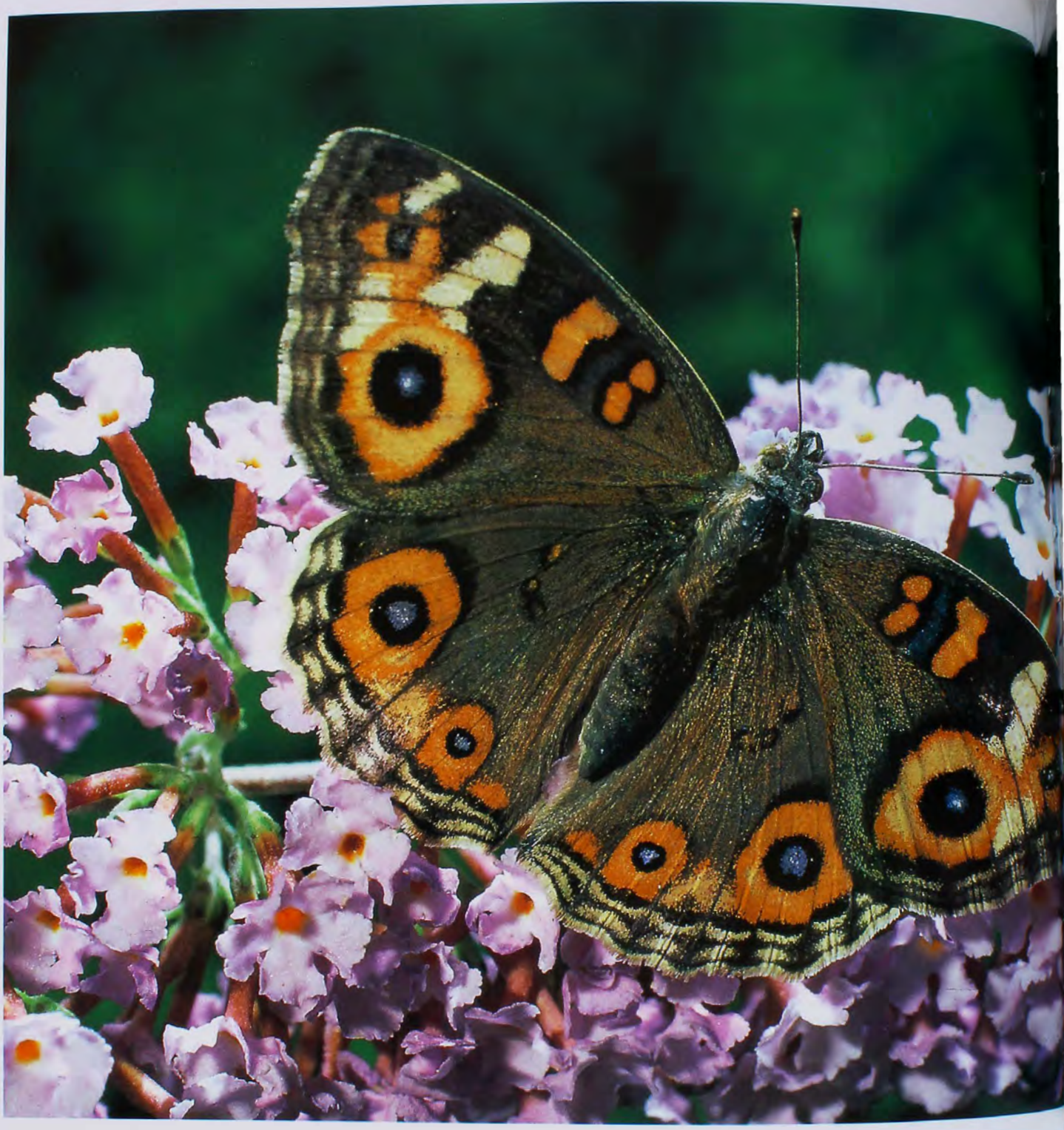
Since most female butterflies mate shortly after emergence from their pupae, a male could do well to stake out the places where females will be emerging. However, the success of this approach depends on whether a male is able to predict the location of emergence sites. This is precisely the theory championed most prominently by Ronald Rutowski from Arizona State University. In species whose larvae use a relatively large, discrete food plant and pupate on this plant rather than wandering off, males do indeed stake these sites out and wait for the adults to emerge. For example, larvae of the Common Imperial Blue (*Jalmenus evagoras*) feed on various species of *Acacia* in groups of 20 or more, and pupate together on the branches of this plant. Since half of these pupae will produce females in the ensuing weeks, these plants provide the optimum focus for males to search. Indeed, it is not uncommon for these *Acacia* shrubs to be ablaze with dozens of male Common Imperial Blues, all buzzing around in expectation of a veritable smorgasbord of mating opportunities come emergence time. Consequently, emerging females of this species may be pounced upon and mated very quickly . . . sometimes literally 'knocked off their feet' before their wings have had a chance to fully expand!

For many other species, males must wait longer to consummate their relationships with newly emerged females.

Male Common Imperial Blues stake out sites where females will emerge from their pupal sacs. They mate with them very quickly, sometimes even before the females' wings have had a chance to fully expand.

DARRELL J. KEMP

A mating pair of Common Imperial Blues. The female of this pair had just emerged from her pupal case, when she was pounced upon and mated within seconds. The pupal cases, to the left of the mating pair, are being tended by small black *Iridomyrmex* ants.



KATHIE ATKINSON

Larvae of the Meadow Argus (*Junonia villida*), for instance, feed on small herb-like food plants such as *Plantago*. Since each *Plantago* plant can only support one or two larvae, individual caterpillars often wander around from plant to plant, and are capable of travelling surprising distances. Clearly, in this species, pupae will never be reliably aggregated as they are in the Common Imperial Blue. The best option for searching males of species like the Meadow Argus is to focus their activities on the next reliable port of call for recently emerged virgin females.

These alternative encounter sites may contain resources (such as nectar plants that attract virgin females) or they may not. The latter sites are among the most puzzling for evolutionary biologists to explain. They usually centre upon some distinctive landmark, such as a forest clearing, vegetative corridor, rocky outcrop or hilltop. Hilltops are most often used by highly dispersed, low-density or rare species, such as many Australian skippers, swallowtails and blues, and are believed to offer a type of signposted meeting place for both sexes. This theory was put to the test some years ago by Per-Olof Wickman from the University of Stockholm, Sweden. Wickman and his colleagues released both mated and unmated females of the Wall Brown Butterfly (*Lasiommata megera*) at the base of a hill and then charted their movements. They found that the virgin, and not the mated, females showed a significant tendency to fly uphill, thereby supporting the hypothesis that hilltops are used as beacons exclusively for the purpose of meeting mates . . . the true butterfly equivalents of the 'desperate and dateless' singles bar.

Finding an appropriate encounter site is just the first step of a successful mate-location campaign. Once on site, a male must decide how to conduct his search. His options are to either fly around and actively search, or to remain stationary and attempt to ambush females as they fly past. What determines whether a male should perch or patrol around an encounter site? Since male butterflies

Nectar sources may be used as meeting places for the sexes, especially in widely dispersed butterflies like the Meadow Argus.

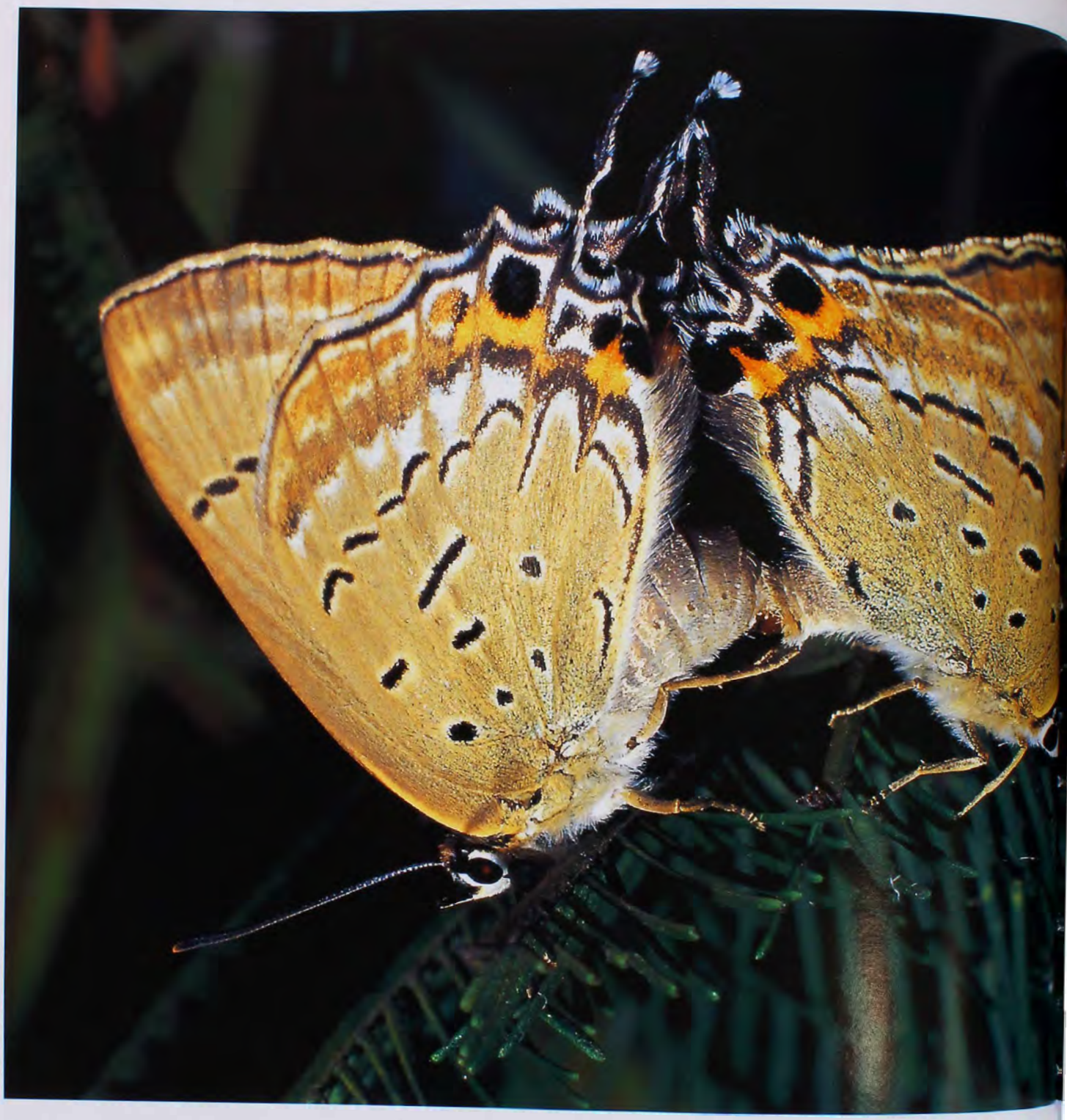
are visual searchers, one argument is that males should perch only if favourable vantage points are available within the encounter site. In other words, remaining stationary may be the optimum way to see a passing female only if there are good perching spots, such as near open clearings or along paths in the vegetation. Otherwise males are expected to move around to maximise their visual opportunities. Certainly, within butterflies, both behavioural strategies are amply represented. Males of the aptly named Cruiser (*Vindula arsinoe*) are classic patrollers, and move around almost incessantly throughout tropical rainforest areas in search of potential mates. At the other end of the spectrum, male Common Eggflies (*Hypolimnas bolina*) remain stationary in prime perching areas at their encounter sites, launching themselves at any moving object reminiscent of a mate. These males not only perch throughout the entire day, but they routinely return to occupy the same site on consecutive days, even perching on the same tree leaves for weeks on end.

Regardless of how individual males conduct their search, at the end of the day their reproductive success is always measured against that of their rivals. If one individual mates with several females, then several other males must miss out—such is the nature of the butterfly mating game. However, in butterflies and animals generally, the struggle between individual males often extends way beyond a simple 'scramble' for mates. Direct aggression among males forms an integral part of the mating systems of many animal groups (see *Nature Aust.* Winter 1996), and butterflies are no exception. However, butterfly fights are not physical struggles of strength, but rather contests involving stamina, willpower and bluffing. This behaviour is most often associated with the defence of a favoured perching site—the familiar strategy of territoriality.

TERRITORIALITY IN BUTTERFLIES MAKES A good deal of sense. Although it's a start, simply arriving at a favoured site does not guarantee mating success. A male can only fully reap the benefits of perching at a favourable site if he is the sole owner of that site. This point is demonstrated by the male Common Eggfly, along with other notables such as the Blue-banded Eggfly (*Hypolimnas alimena*) and Brown Soldier (*Junonia hedonia*). These species perch in forest clearings, along pathways, rainforest edges and vegetative corridors, and keep a lookout for females flying past. However, if two rivals perch at a single site, no longer is either male guaranteed to be the first to detect a visiting female. For this reason, jealous guarding of favoured sites has evolved as a crucial

When it comes to finding a mate, male Common Eggflies are ambush hunters—they perch at visual vantage points and launch themselves at any moving object reminiscent of a female.

DARRELL KEMP



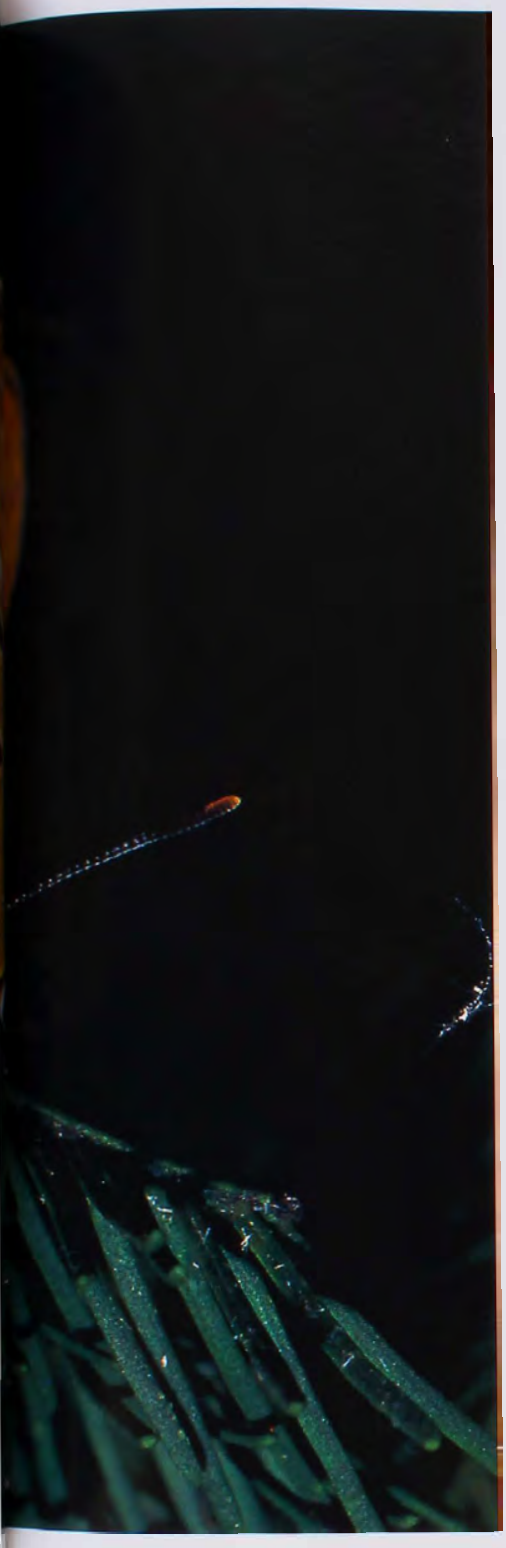
PETER MARSACK/LOCHMAN TRANSPARENCIES

The act of sex, butterfly style. Mating butterflies may remain coupled for an hour or more.

male tactic for many butterfly species.

It is generally accepted that territoriality has evolved in butterflies as an extension of perching in specific areas. However, even among the classic perchers, not all species can be rated as territorial. Under what circumstances should a male attempt to defend his perching site? To help answer this question, John Alcock and Kevin O'Neill, from Arizona State University, studied the mating behaviour of the Grey Hairstreak (*Strymon melinus*). Normally male Grey Hairstreaks stake out and guard sites along the tops of hills and ridges in central Arizona. However, under certain circumstances males cease to defend their sites, and even abandon perching altogether in favour of patrolling widely around the hilltop. When Alcock and O'Neill looked closely at this behavioural switch, they discovered that butterflies abandoned territoriality when the number of males at the hilltop reached a critical level. This makes sense because a male that spends all his available time expelling a steady stream of intruders seriously compromises his ability to spot a female. In this situation, a male is better off not trying to defend a site at all.

In male mating strategies throughout the butterfly world, the bottom line is diversity. Not only do males search in different areas of the environment, but they employ different behavioural tactics, sometimes involving aggression, sometimes not. Although scientists have



a good grip on the generalities of these systems, there are still many puzzling aspects. What factors, for example, lead to the evolution of species-specific meeting places such as hilltops? How do environmental aspects such as temperature and sunlight affect male behaviour? And how exactly does a territorial male butterfly fight off intruders? While studying the latter question, Nicholas Davies from Oxford University noted jokingly that a male butterfly with a machine gun would make the ultimate territory holder. But a male butterfly does not have a machine gun. In fact, male butterflies lack any weapons and essentially have no means of forcing the issue whatsoever. Their task of site defence is the equivalent of trying to evict an intruder from your house without so much as raising your voice! The good news is that scientists are learning more and more about this, and many other intriguing aspects of butterfly mating systems. For instance, it is now understood that 'warmer' male butterflies are more able to exert their dominance in the veritable scrap-fight for perching territories. Scientific advances like these are important, since they provide our most valuable insight into the wonderful world of sex, butterfly style. ■

Further Reading

Alcock, J. & O'Neill, K.M., 1986. Density-dependent mating tactics in the Grey Hairstreak, *Strymon melinus* (Lepidoptera: Lycaenidae). *J. Zool.* 209: 105–113.

Emlen, S.T. & Oring, L.W., 1977. Ecology, sexual selection, and the evolution of mating systems. *Science* 197: 215–223.

Rutowski, R.L., 1998. Mating strategies in butterflies. *Sci. Amer.* 279(1): 46–51.

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

Wickman, P.-O., 1988. Dynamics of mate-searching behaviour in a hilltopping butterfly, *Lasiommata megera* (L.): the effects of weather and male density. *Zool. J. Linn. Soc.* 93: 357–377.

Darrell Kemp is a PhD student in the Department of Zoology at James Cook University in Cairns, Queensland. His research interests include sexual selection and the evolution of insect mating strategies. Currently he is researching male mating tactics and the dynamics of territory defence in tropical butterflies.

DENNIS SARSON/LOCHMAN TRANSPARENCIES

Wanderer Butterflies (*Danaus plexippus*) at one of their primary food plants, the milkweed *Asclepias fruticosa*. Outcrops of this plant provide not only nectar, but reliable pick-up spots for males on the lookout for mates.

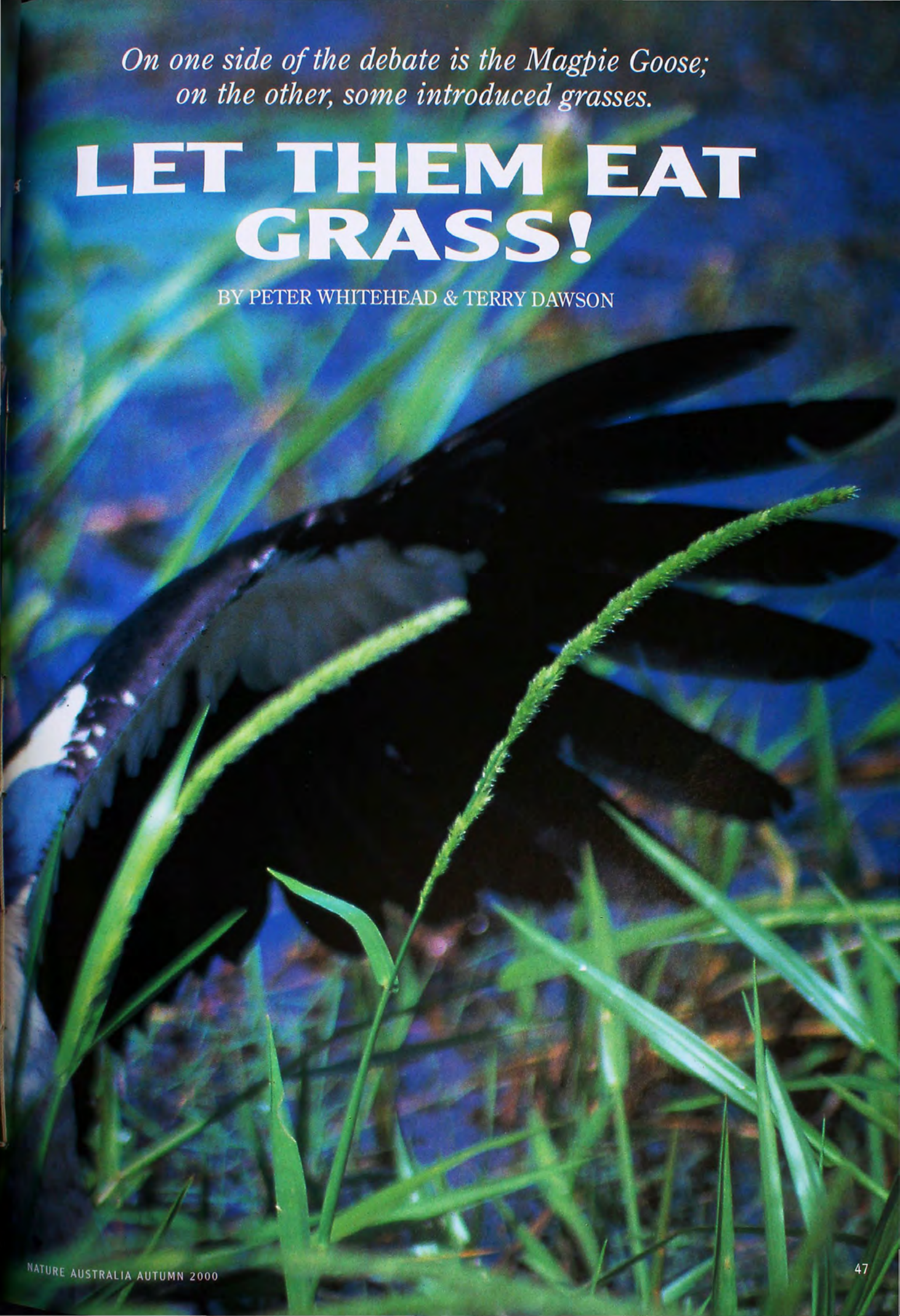
A young male Magpie Goose defending a nest in native sedge (*Eleocharis sphacelata*) and native grass (*Hymenachne acutigluma*) habitat. This bird was one of two males that defended this particular nest in which two females had laid a joint clutch of 12 eggs. This posture is typical of the displays used by some of the more aggressive males to deter or distract predators.

PETER WHITEHEAD

On one side of the debate is the Magpie Goose; on the other, some introduced grasses.

LET THEM EAT GRASS!

BY PETER WHITEHEAD & TERRY DAWSON



WHEN CONFRONTED WITH the news that French peasants were becoming restless because they could not get enough bread, the French Queen Marie Antoinette is said to have responded with the immortal line "Let them eat cake!".

Narrow and confused perspectives about the necessities of life are not confined to the 18th-century French aristocracy. When ecologists question land management practices that simplify habitats and so compromise food availability for native fauna, concerns are often rejected as alarmist. Sometimes the reasons given for disbelief reflect an appreciation of ecology similar to Marie Antoinette's grasp of the French economy: that the victims should, with initiative and sufficient effort, be able to identify and exploit other, tastier, options. The aristocratic view of wildlife ecology has recently had an airing in a debate about wetland management in Australia's Northern Territory. On one side of this debate is the Magpie Goose; on the other, some introduced grasses.

The Magpie Goose (*Anseranas semipalmata*) is a large waterbird (up to 3.5 kilograms) now mostly confined to Australia's tropics. It was once much more widespread, but changes in southern Australia's temperate wetlands to suit agriculture have caused its displacement from huge areas. Reintroductions have met with limited success, probably because wetland fragments remaining in southern Australia are incapable of sustaining large populations. Such a contraction in range has not been seen in any other Australian waterbird.

Despite its name, this bird is much more than just another goose, being the sole member of its own family, the Anseranatidae. Many features of its biology are unusual. For example, the Magpie Goose is the only waterbird to regularly form trios in which two females share the same nest and attentions of one, much larger, male. Also, the males have an extraordinarily elongated windpipe, probably a substantial handicap in terms of respiratory function, but which is used to produce loud, low-pitched honks that are used as honest signals of virility; honest because the calls can't be easily faked by lesser males unable to cope with the respiratory handicap.

Given the species' biological uniqueness and interest to science, its importance to tourism in northern Australia, significance in Aboriginal culture, and a history of eradication from much of the Australian continent, special attention to its conservation would appear to be a reasonable national goal. Indeed, both the Federal and Northern Territory Governments have put a great deal of effort and money into studies of its ecology, to promote competent management. Among the most important facts to emerge from these studies are demonstrations of dependence on two particular habitat types that play crucial

A Magpie Goose attending a nest with recently hatched young. Most eggs hatch within a day or two of each other and the parents then lead the young to rearing areas where there is more open water and lots of Wild Rice. Brood-rearing areas are at particular risk from exotic pasture grasses that displace native annuals like Wild Rice.

JEAN-PAUL FERRERO/AUSCAPE

ROGER BROWN/AUSCAPE

The typical Magpie Goose breeding group, a trio of one male (the larger bird with the larger bump on its head) and two females. Both females will lay their eggs in one nest, which the male vigorously defends against predators.

roles, first in the production of young and then in maintaining birds of all ages through the annual dry-season drought.

During breeding from March to June, Magpie Geese seek out patchy grass and sedgelands with large clumps of Australian Wild Rice (*Oryza meridionalis*), which produces seed consumed by both adult and juvenile birds. Families stay in these brood-rearing areas for up to ten weeks. The young grow extraordinarily rapidly, putting on more than 20 times their hatching weight (70 grams) in about seven weeks, when they weigh 1.4–2.0 kilograms and are beginning to fly. A human baby growing at the same rate would be bigger than its mother when less than two months old. Obviously such extraordinary growth needs to be supported by very abundant foods rich in energy and protein. Australian Wild Rice is one such food.

The young need to grow quickly so that in the mid dry season they can escape the drying rice-lands with their parents. They must be able to fly to different swamps, up to hundreds of kilometres away, that hold water longer and provide an even bigger bounty than the rice-lands. These ecologically 'greener pastures' are often muddy, nondescript-looking places. But their particular virtue is that they support large populations of an aquatic sedge, the Water Chestnut (*Eleocharis dulcis*), which produces starchy, high-energy bulbs in huge numbers. The density of the buried bulbs at one site near Darwin averaged five million per hectare. Flocks of hundreds of thousands of Magpie Geese churn through the mud until it is turned to sticky black slurry, each bird extracting and cramming its crop with hundreds of the bulbs each day.

From July until September, Magpie Geese grow fat on this bounty. But their gluttony is no mere indulgence. Many of the big sedge swamps like those in Kakadu National Park will be totally dry by October, and the dry-season drought may not break until late December. In the interim the birds crowd together on

Magpie Geese at a waterhole in the dry season. The birds depend on pools of open water like this to make it through the extended dry season. Vegetation overgrowing such sites can cause severe problems for waterbirds that need access to the open water and underlying soils to find food.

COLIN WILSON

the few remaining permanent water bodies. They need the fat and other nutrients accrued during the times of plenty to see them through this lean period. And if the dry-season drought is extended, they will also break down muscle to keep themselves going.

The really lean times do not end until reliable rains fall, most often in late November or December. Magpie Geese then graze around the fringes of the flood plain on fresh blades of grass, either newly germinated from seed or resprouted from perennial grass clumps. Grass blades at this time are not too fibrous and are high in soluble nitrogen and sugars, providing a useful source of energy and building blocks for protein to reconstruct run-down tissues. The birds pick the fresh blades greedily during this dry–wet transition, but then move back out onto the flood plains and switch again to seeds and bulbs once the wet season is really under way.

IN ADDITION TO EATING NATIVE GRASSES during the dry–wet transition, the birds may also graze on introduced species like Para Grass (*Brachiaria mutica*). For several decades this grass, originally from tropical Africa, has been cultivated as pasture for Cattle or Water Buffalo on Northern Territory flood plains. It occurs as sometimes large but

MAGPIE GOOSE

Anseranas semipalmata

Classification
Family Anseranatidae. The Magpie Goose is the sole member of this family. It is more closely allied with the South American screamers (Anhimidae) than the true geese and ducks (Anatidae)

Identification
Large waterbird with striking black-and-white adult plumage, with the white breast often stained by swamp sediments. Goslings predominantly dark grey with cinnamon head. Males up to 3.5 kg, females much smaller at 2.5 kg. Mature males develop a grossly elongated trachea (windpipe) and a large cranial bump. Females rarely show any tracheal elaboration and have much smaller cranial bumps. Magpie Geese differ from true geese in having much longer legs, weakly webbed feet (hence species name), elaborated trachea, strong hooked bill, and avoiding a post-breeding flightless period (primary feathers are moulted progressively). Loud, resonant honk, louder and lower-pitched in males.

Distribution and Habitat
Today most common on the seasonal flood-plain systems of Australia's northern tropics, southern New Guinea and Irian Jaya. High-density aggregations occur in the dry season on Water Chestnut swamps, especially in Kakadu National Park. Breeding concentrated in denser grass and sedge swamps adjacent to more open wetlands supporting high densities of Australian Wild Rice. Once common in temperate Australia but displaced from many areas by destruction of wetland habitats.

Behaviour
Highly gregarious, gathering in large flocks at favoured breeding and feeding areas. Breeding colonies may contain more than 10,000 nests built predominantly by trios of one male and two females. Family groups remain together throughout the year. Established groups move regularly between the same breeding colonies and dry-season feeding areas, which may be separated by several hundred km. Longer-distance movements may occur when local conditions deteriorate. Unusual in that the parents feed their young, passing items from bill to bill.

Breeding
Nest in the wet season (Feb. to Apr.) in large colonies in flooded grass and sedgelands. Clutches of up to 16 eggs (average 10) produced by trios including two females. Males participate in construction of nest, incubation of eggs and defence of nest. Laying extends over several days, and hatching occurs about 25 days after last egg laid. Family groups mostly leave nest 1–2 days after first egg hatches and move quickly to brood-rearing swamps up to 15 km from nest site. Young fledge and are able to fly when 8–10 weeks old.

Diet
Primarily herbivorous, consuming a range of aquatic plants and their parts. Varies seasonally with a strong dependence on abundant grass seeds during the wet and early dry seasons (Jan. to June), and bulbs of sedges and lilies during the mid dry season (July to Sept.). In the late dry season, when many swamps have dried up, food is often in short supply and includes residual seed and grass blades. Birds often unable to maintain weight at this time, regaining condition only after the first rains when newly germinated or resprouting grasses become available.

Status
Varies across States and Territories, the species being regarded as extinct in SA and Vic., vulnerable in NSW and presently secure in the northern Australian States and NT. Recent reviews indicate that reclassification as lower risk (near threatened) is justified primarily on the grounds of the huge range contraction.

PHOTOS: COLIN WILSON

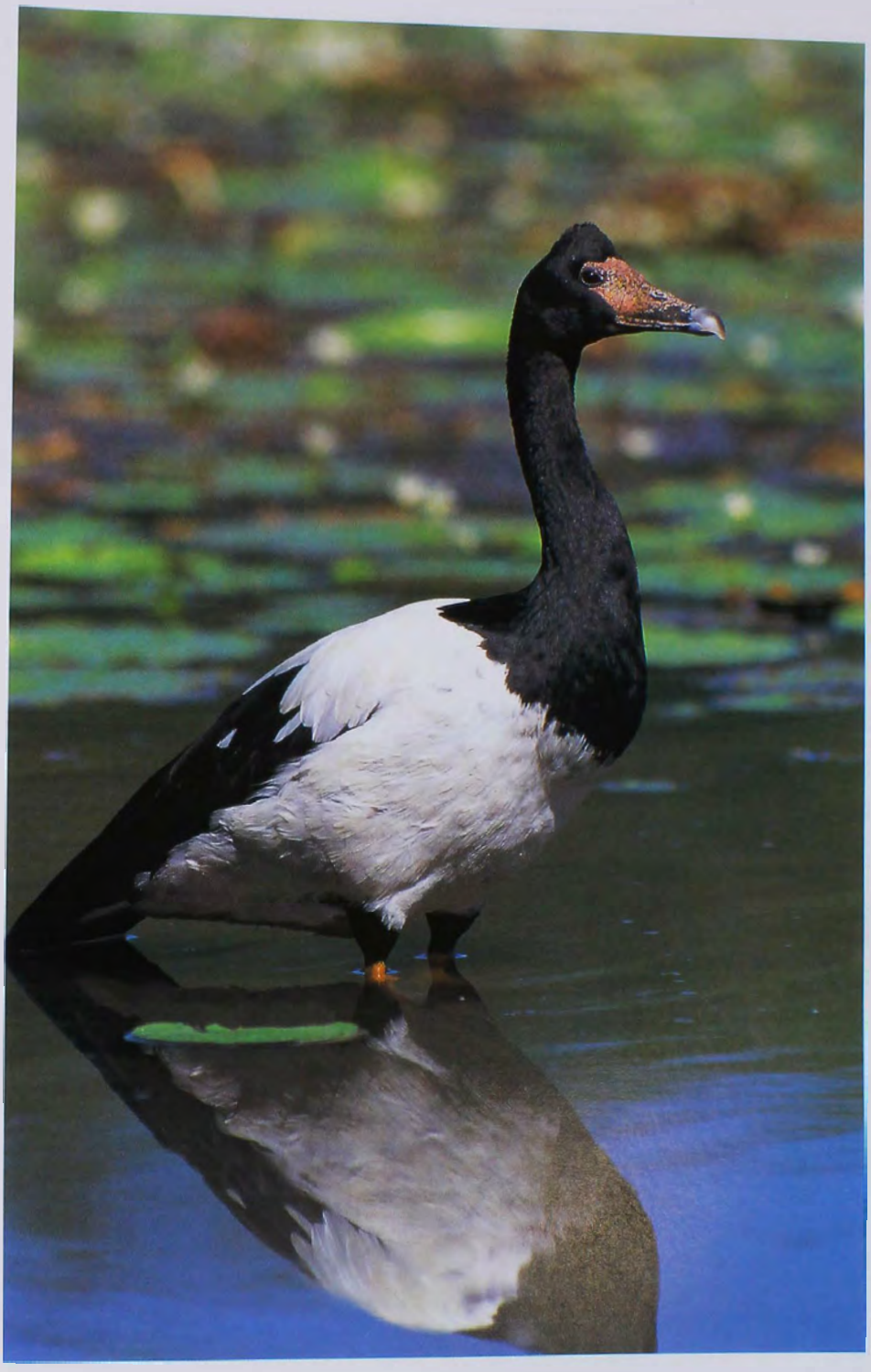
Top Left: Beatrice Lagoon is a typical shallow flood-plain lake near the Adelaide River in the Top End. This photograph was taken in 1986. The open water and sparse vegetation is typical of these water bodies in the absence of exotic pasture grasses. Bottom Left: The same location on Beatrice Lagoon in 1995 after Olive Hymenachne, an exotic pasture grass, had become firmly established.

mostly scattered infestations on several flood-plain systems, including the East and South Alligator River systems in Kakadu National Park.

Recently its use has been more strongly promoted. Para Grass is being introduced to new sites at an unprecedented rate, despite the fact that it is listed in catalogues of the world's and Australia's worst weeds. In a major survey of all the major wetland systems in the Top End of the Northern Territory, botanists found Para Grass in dense monocultures, from which all other plants were displaced. Infestations in Kakadu National Park have expanded greatly in recent years, and have even invaded the margins of rainforests abutting the flood plain. The infestations now carry fire into the forests, putting them at risk. What's more, a suite of new grasses is also being introduced to other wetlands. One of these, Olive Hymenachne (*Hymenachne amplexicaulis*), a deep-water grass from South America, has caused so many problems in the Sugarcane areas of Queensland that it has recently been formally recognised as a weed of national concern.

Perhaps the most frightening feature of Para Grass, from the perspective of a Magpie Goose, is that it appears to do particularly well in sites similar (in terms of water depth and salinity) to those normally favouring Australian Wild Rice and Water Chestnut. In tandem with the introductions, there are proposals to change the hydrology of the flood plains by ponding, to further favour exotics over natives. All these factors combine to present a bleak picture of the future of northern Australian wetlands, whether on pastoral lands or in reserves.

The desire of pastoral leaseholders to improve productivity is understandable. But to achieve this goal in ways that substantially damage the wildlife values of lands leased from the public seems reckless. Indeed, reckless is probably an unduly mild epithet for the approach adopted by Government pasture agronomists in introducing new species to northern Australia. A comprehensive CSIRO analysis of the fate of the hundreds of different plants introduced as forage showed that less than one per cent provided economic gain without causing weed problems, while 13 per cent became established as weeds of agriculture or caused other significant environmental problems.



A Magpie Goose reflects on what life would be like on a grass-only diet.

Those people unconcerned about the establishment of all-but-uncontrollable weeds justify their views in a number of ways. Some claim that the exotics are non-invasive. This notion is hard to swallow on simple logical grounds: why cultivate a grass that does not spread or compete successfully with native species? The argument becomes completely indigestible when presented side by side with the reasons given by some production authorities in Queensland when denying the need for action. They argue that it is too late, because the invasion of that State is complete; the exotics already occupy all of the wetland environments for which they are adapted.

But the single-mindedness does not stop at strained logic regarding the ecology of grasses. Because Magpie Geese have been seen to eat exotic grasses, it is sometimes argued that a wetland system dominated by introductions should actually be better for geese and other wildlife. One might think that even a little reflection would cause the proponents of such ideas some embarrassment, but they continue to be heard.

If a conservation argument is to be taken seriously when it conflicts with established practice, it seems to need much more than the backing of basic ecological theory or simple logic. Fortunately, some recently completed physiological studies have helped to reinforce

PETER WHITEHEAD

the obvious: that an animal with a simple digestive tract like the Magpie Goose is unlikely to be able to persist on a diet dominated by grasses. In these studies by ourselves and others, captive Magpie Geese were fed one of two diets: a fresh aquatic grass known to have higher nitrogen levels than Para Grass, and domestic rice complete with the husk. The birds thrived on the rice diet. They were able to digest some of the fibre present in both diets (and more fibre in the grass diet), but were unable to maintain either energy or nitrogen balance on the grass alone. The net effect was that birds eating grass began to metabolise their own tissues to provide the energy needed to keep them alive. Grass blades do not offer enough available nutrients to prevent them eventually starving to death, let alone allowing them to accrue the reserves needed to cope with the seasonal bottleneck of low food availability that occurs every year. Without access to high-energy plants with large seeds or bulbs, which are being displaced by perennial grasses, they will fail to breed and perish in the lushest of grasslands.

The inability of Magpie Geese to process much of the bulk in grass is far from surprising. Few vertebrate animals produce enzymes able to break down cellulose, a major constituent of all vascular plants, including grasses. To compensate, many large herbivores make use of populations of micro-organisms with the necessary chemical equipment. They harbour huge numbers of these little helpers in specialised chambers of the digestive tract. Carrying around these processing 'vats' and retaining masses of semi-digested food for the long periods required for chemical breakdown is best done by a large animal that spends most of its time on the ground. It doesn't take much imagination to see why animals relying on a light frame for efficient flight—to escape predators and travel long distances—can't waddle around with a huge gut stuffed with low-quality food.

Predominantly herbivorous birds like the Magpie Goose have taken a different evolutionary path. Rather than adapting to exploit local supplies of continuously available but poor-quality feed, they seek

A young male returning to a nest from which it had been displaced by an approaching airboat. The nest was in typical breeding habitat, dominated by the sedge *Eleocharis sphacelata* and patches of other native grasses in water about one metre deep.

out and quickly locate resource-rich patches in the landscape, where highly nutritious, readily processed forms of food are more easily gathered. Their strategy is neither better nor worse than the large ruminant animals; just different.

ACHIEVING CONSERVATION GOALS IS fundamentally about recognising the diversity of ecological strategies and resource needs of different plants and animals. Ecological sustainability is most threatened by actions that impose uniformity over large areas, so that the landscape no longer accommodates different needs. Invasive exotic plants with wide ecological tolerances, freed from constraints imposed by their coevolved consumers and diseases in their native range, combined with action to promote their expansion, are the most potent forces to threaten northern Australia's wetland diversity. The region has so far avoided many of the agricultural misadventures of the sort that governments and farmers are now attempting to redeem in temperate Australia at huge cost and with no guarantee of success. It would be nice to conclude that northern Australia's better situation is due to the unusually good sense of its recent settlers. However, the reality is that harsh climate, difficult terrain and poor soils have combined to resist all but the most determined.

Assiduous searches for 'better' plants to replace northern Australia's 'inferior' native species go on relentlessly. Given time and unlimited licence to gamble, by dipping globally into the very biological diversity that their actions threaten locally, agricultural scientists will undoubtedly come up with pasture plants to dominate any environment. Perhaps those who wish to replace northern Australia's ecosystems with the most productive pasture species the world has to offer are working to a vision inspired by huge herds of grazing animals on the African plains. If so, they follow in the footsteps of the acclimatisation societies of the 19th century who placed little or no value on the unique Australian biota, but sought to convert southern Australia into an image of Europe, and in many places succeeded.

But does the northern Australian and wider community really want important landscape rendered uniformly suitable for Cattle and not much else? Certainly those who value our wildlife for aesthetic, spiritual, subsistence or commercial purposes would hope for a very different future. That future should be based on a vision of better managing and using the Australian environment as it exists, not replacing it with an alien ecosystem designed to serve just one industry. ■

Further Reading

Humphries, S.E., Groves, R.H. & Mitchell, D.S., 1991. *Plant invasions of Australian ecosystems. A status review and management directions.* Endangered Species Program Report No. 58. Australian National Parks and Wildlife Service: Canberra.

Lonsdale, W.M., 1994. Inviting trouble: introduced pasture species in northern Australia. *Aust. J. Ecol.* 19: 345–354.

Whitehead, P.J., 1998. Boofheads with deep voices: sexual dimorphism in the Magpie Goose *Anseranas semipalmata*. *Wildfowl* 49: 75–91.

Whitehead, P.J., Freeland, W.J. & Tschirner, K., 1990. Early growth in the magpie goose *Anseranas semipalmata*: sex differences and influence of egg size. *Aust. J. Zool.* 38: 249–262.

Whitehead, P.J., Wilson, B.A. & Saalfeld, K., 1992. *Managing the Magpie Goose in the Northern Territory: approaches to conservation of mobile fauna in a patchy environment. Conservation and development issues in northern Australia.* North Australian Research Unit, Australian National University: Darwin.

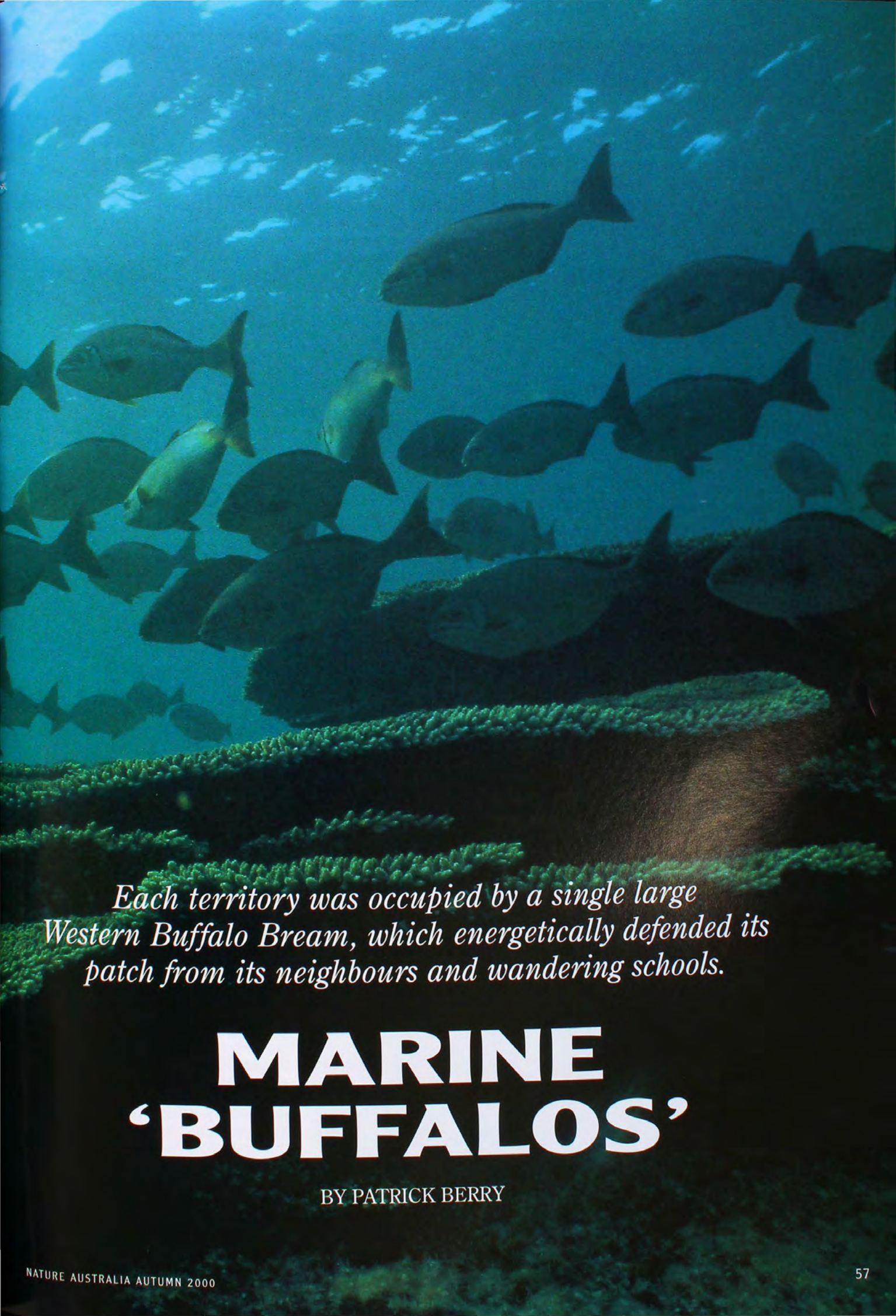
Peter Whitehead is a research fellow at the Northern Territory University with a particular interest in management of wetland faunas. Terry Dawson, Professor of Animal Physiology at the University of New South Wales, has carried out a number of studies of the digestive physiology of birds.

COLIN WILSON

A large area of dense Para Grass on a flood-plain edge in Kakadu National Park. The grass is so dense that it is able to support the weight of the quadcycle and rider. Such infestations accumulate enormous fuel loads, which contribute to the destruction of adjoining rainforests when wildfires occur or even when fuel-reduction burns are attempted.

EVA BOOGAARD/LOCHMAN TRANSPARENCIES

A school of Western Buffalo Bream at the Houtman Abrolhos. This herbivorous species is confined to the west coast of Australia between Cape Leeuwin in the south and Coral Bay in the north.



Each territory was occupied by a single large Western Buffalo Bream, which energetically defended its patch from its neighbours and wandering schools.

MARINE 'BUFFALOS'

BY PATRICK BERRY

"GOOD FENCES MAKE GOOD neighbours", the saying goes. That this is particularly true for farmers is demonstrated by some Western Australian fish farmers—not people who farm fish though, but fish that 'farm' algal turf! The fish is the Western Buffalo Bream (*Kyphosus cornelii*), a species that occurs only on the west coast of Australia from Cape Leeuwin to Coral Bay. It commonly attains a length of 40 centimetres and a weight of 1.5 kilograms, and occurs in large schools sometimes numbering hundreds of individuals in near-shore waters.

The Western Buffalo Bream shares its range with the more widely distributed Common Buffalo Bream or Silver Drummer (*Kyphosus sydneyanus*). Both species are herbivores and, like ruminants, digest their food using microbial fermentation. This gives them particularly smelly guts and makes them repugnant to fishermen. Despite their overlapping distributions these two herbivores do not compete for food. The Western Buffalo Bream feeds almost exclusively on red algal turf, while the Common Buffalo eats mainly brown algae such as kelp and *Sargassum*.

Both species are herbivores and, like ruminants, digest their food using microbial fermentation. This gives them particularly smelly guts and makes them repugnant to fishermen.

For years geologist Phillip Playford (Geological Survey of Western Australia) puzzled about the origins of numerous large, conspicuous geometric patterns of algae that cover the shallow sub-tidal reef platforms of Rottnest Island. These appear as a mosaic of irregular-shaped polygons (multi-sided figures), most measuring about six metres along the longest axis. The common borders that define them are composed of large brown seaweeds (*Sargassum* spp.), forming 'hedgerows' up to 20 centimetres high. Within each polygon is a dense covering of algal turf, dominated by red algae. Playford took intermittent photographs of the reef platforms between 1976 and 1988 and noticed that the *Sargassum* borders regrew each year in virtually the same positions (*Sargassum* plants are perennial and re-sprout each year from their holdfasts). But why didn't the *Sargassum* spread, as other perennial plants do? What kept it growing in such an orderly fashion?

Having satisfied himself that the polygon formation had no geological basis, he decided to enlist my help as a marine biologist. I first looked at the benthic organisms on the reef platforms at low tide, suspecting that large numbers of grazers such as hermit crabs or sea urchins must be responsible. Despite searching during the day and at night, I found no clues and was beginning to resign myself to failure. On my last visit to the reef platform before leaving the island I was dismayed to find that the tide was high. However, I decided to snorkel over it for one last look and there was my answer! Each polygon was occupied by a single large Western Buffalo Bream, which energetically defended its patch of algal turf from its neighbours and wandering schools of conspecifics.

This launched me into a detailed study of the territorial behaviour of the Western Buffalo Bream on Rottnest Island. My observations showed that both males and females occupy territories. Individuals 'own' and defend the same territory for prolonged periods; one marked fish held the same territory for over two-and-a-half years. If a fish was removed, it was replaced after much competition within the hour. Fish are forced to move on and

WESTERN BUFFALO BREAM

Kyphosus cornelii

Classification
Family Kyphosidae (drummers or buffalo bream).

Identification
Commonly attains a length of 40 cm and a weight of 1.5 kg. Lacks the black rear margin to the tail and moustache-like mark below the eye of the Common Buffalo Bream or Silver Drummer (*K. sydneyanus*).

Distribution and Habitat
Confined to the Australian west coast from Cape Leeuwin to Coral Bay. Common on shallow reefs.

Behaviour and Feeding
Occurs in schools sometimes numbering hundreds of individuals. Territorial; males and females defend and maintain large polygonal territories of red algal turf with distinct borders of brown seaweeds or seagrasses. Herbivorous; feeds almost exclusively on red algal turf.

Breeding
Breeding behaviour unknown; gonads active throughout year; probably releases eggs directly into water column where larvae develop and are passively dispersed. Recruitment of small juveniles into shallows of Rottnest Island coincides with arrival of the Leeuwin Current in autumn.

P. BERRY

P. PLAYFORD

Above: The yellow patches on the side of this Western Buffalo Bream are an infection that often sets into bites made by other fish. Right: Aerial photograph of polygonal fish territories on a shallow reef platform on Rottnest Island, Western Australia. Each territory is defined by a hedgerow of the brown seaweed, *Sargassum*, within which is closely cropped red algal turf. Each patch of turf is defended as a food resource by a single territory-holding fish.

off the shallow reef platforms according to tidal conditions, but occupy territories while they are covered by as little as 40 centimetres of water. In deeper water they occupy territories almost continuously. Territory-holders graze at leisure on their patch of algal turf, in between chasing off marauding schoolers and patrolling their territory borders, stopping occasionally to 'threaten' a neighbour. This 'threatening' behaviour involves raising fins and fin spines, and opening the mouth. Schoolers run the gauntlet of territory-holders, quickly

snatching a few bites of algal turf while one member, often a large fish, gets singled out and chased by the territory-holder. Passing Common Buffalo Bream, which are not territorial, are also driven away by territory-holders even though they only rarely feed on the *Sargassum* that forms the 'hedgerows'.

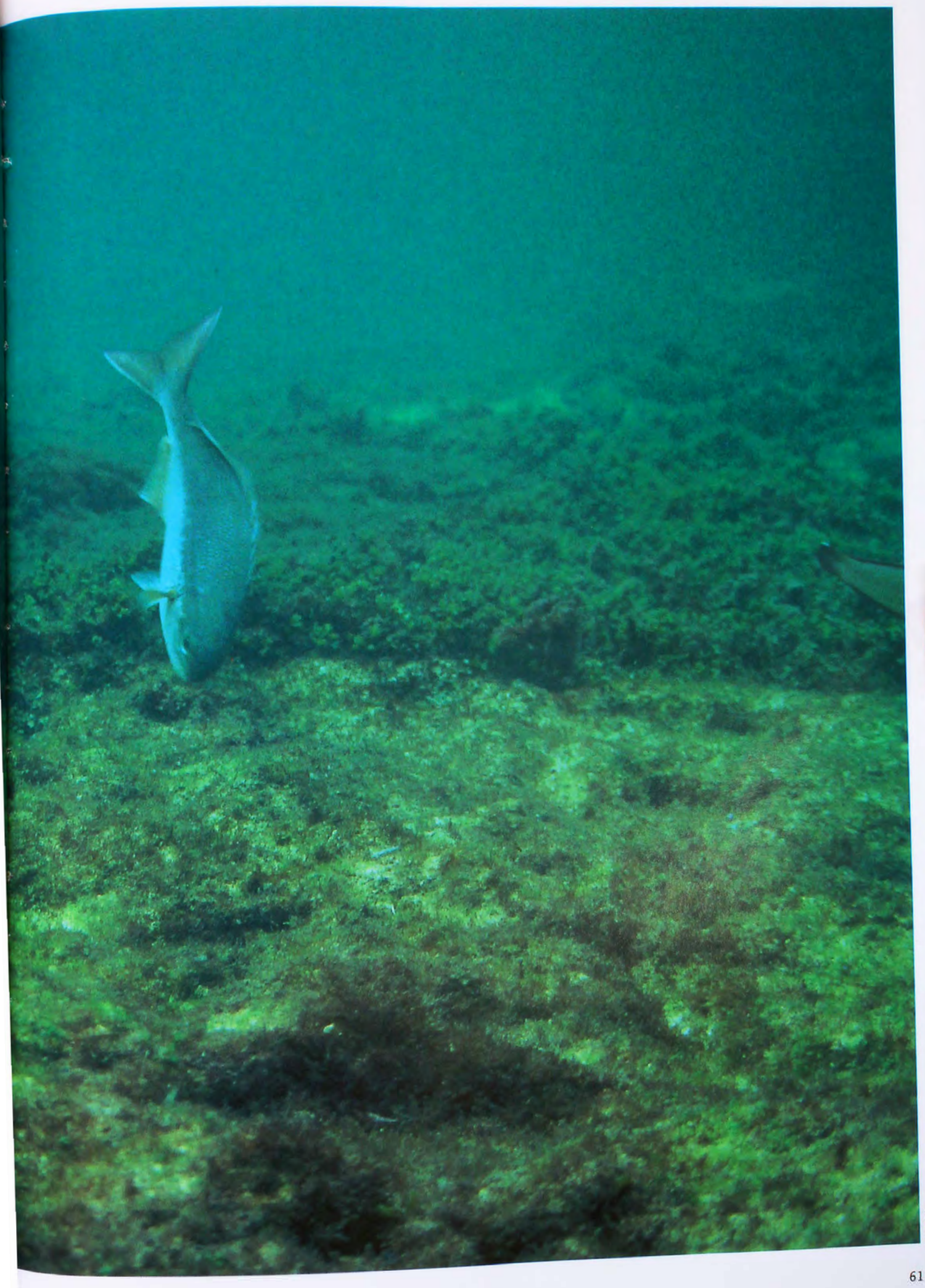
THESE OBSERVATIONS POSE SEVERAL questions. Why do the fish hold territories, why are the territories separated by *Sargassum* 'hedgerows', how are these maintained, and why are the territories polygonal in shape? The only other record of fish territories delineated by macroalgal 'hederows' is a brief description from Moorea, French Polynesia, for the unrelated Blue-lined Surgeonfish (*Acanthurus lineatus*).

There is no evidence that territoriality in Western Buffalo Bream is directly associated with breeding, as courtship behaviour has never been observed in any of the territory-holders. It seems more likely to be a mechanism to ensure adequate nutrition for what are probably the breeding fish in the population. By maintaining access to nutritious algal turf, these territorial individuals are assured of an ample food supply for development of their gonads (sexual organs), which were generally found to be in a 'ripe' or recently spawned state.

The fish are particularly vulnerable to aerial attack in the shallow water over inshore reef platforms and Ospreys have been seen catching them.

Western Buffalo Bream maintain their patch of red algal turf by nipping (and discarding) large seaweeds like *Sargassum* that would normally reduce light penetration and photosynthesis at the substrate level. The threatening behaviour between neighbours on either side of the shared territory borders probably inhibits 'weeding' in a narrow 'no-man's-land', thus allowing the *Sargassum* to

A Western Buffalo Bream crops red algal turf within its territory. Note the hedgerow of uncropped brown seaweed behind it that marks the boundary of its territory.



P. BERRY

P. BERRY

Two Western Buffalo Bream square off on either side of the hedgerow separating their territories.

grow in narrow 'hedgerows'.

Whether the *Sargassum* borders actually help the Western Buffalo Bream is unknown. They may provide some cover from predation by Ospreys (*Pandion haliaetus*). The fish are particularly vulnerable to aerial attack in the shallow water over inshore reef platforms and Ospreys have been seen catching them.

The polygonal shape of most of the shallow reef platform territories is probably a function of packing. Irregular pentagons and hexagons predominate, a hexagon (with six sides) being the shape that gives maximum interior area with minimal border length. This is likely to be the result of behavioural interactions between neighbours, as deeper sub-tidal territories with no shared borders are simply patches of red turf surrounded by brown algae or seagrass. Their shape is not polygonal and their boundaries often coincide with features of the reef. Significantly, the owners of these isolated territories only have to ward off schools of non-territorial fish, which invade from above.

Besides the intriguing behaviour of the Western Buffalo Bream, the ecological role of this species may prove to be significant. Its 'turf-farming' activities must benefit other animals that graze on algal turf or favour open habitat as opposed to the closed canopy of large brown seaweeds that predominate on many Western Australian near-shore reefs. In fact both species of buffalo bream are probably very important in the ecology of the shallow coastal waters off Western Australia. Together they undoubtedly constitute a very large biomass and an important link in the food chain as they convert living plant material to fine particulate matter in the copious faeces they produce. This, enriched by microbes, is known as detritus and is the food source for communities of filter-feeders such as sponges, bivalve molluscs and animal plankton. It is fortunate then that these gentle, marine 'buffalos' are currently not sought after by fishermen! ■

Further Reading

Berry, P.F. & Playford, P.E., 1992. Territoriality in subtropical kyphosid fish associated with macroalgal polygons on reef platforms at Rottnest Island, Western Australia. *J. Roy. Soc. W. Aust.* 75: 67–73.

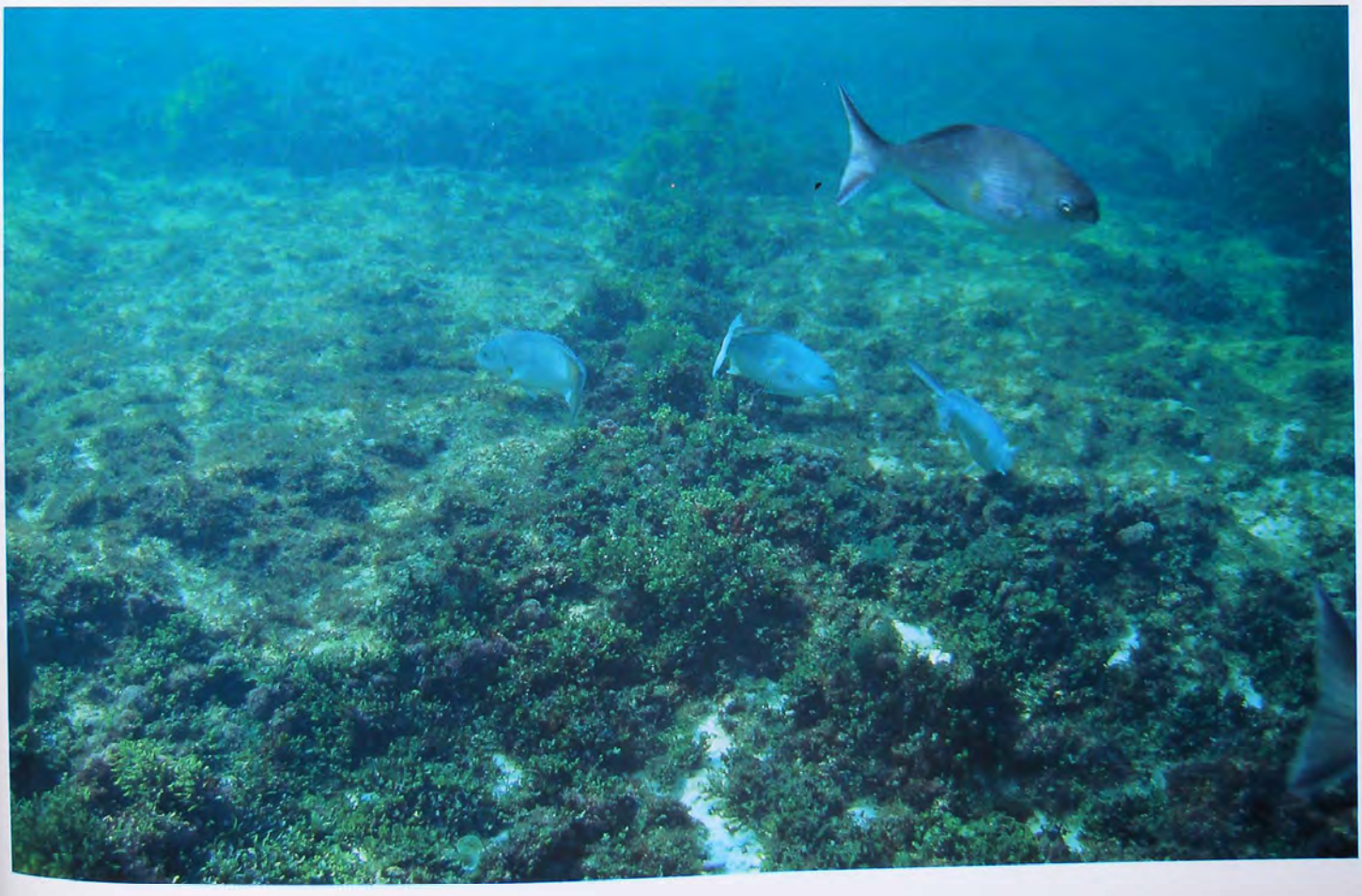
Playford, P.E., 1988. *Guidebook to the geology of Rottnest Island.* Geological Society of Australia, Western Australian Division, and the Geological Survey of Western Australia: Perth.

Rimmer, D.W. & Wiebe, W.J., 1987. Fermentative microbial digestion in herbivorous fishes. *J. Fish Biol.* 31: 229–236.

Robertson, D.R., 1989. The surgeonfish *Acanthurus lineatus* grows hedgerows of macroalgae. *Coral Reefs* 8: 8.

Dr Patrick Berry is Director of Natural Science at the Western Australian Museum. His research interests include reef ecology, and the biology of rock lobsters and bivalve molluscs.

Top Right: Two territory-holding Western Buffalo Bream, with their tails to the camera, are threatening each other on either side of the hedgerow. The fish behind the right-hand territory-holder is about to move in and sneak a bite of turf. Bottom Right: Moments later, the non-territorial fish (lower right) sneaks in to take a quick bite of turf and is about to be driven off by the territory-holder, which has just turned away from its altercation with its neighbour. The fish in the upper foreground is a passing non-territory-holder.



PHOTOS: P. BERRY

Major Mitchell's Cockatoo (*Cacatua leadbeateri*).

BIRD DAYS

BY JOHN COOPER

Hoary-headed Grebe (*Poliocephalus poliocephalus*).

Yellow-tufted Honeyeater (*Lichenostomus melanops*).

Eastern Rosella
(*Platycercus eximius*).

Whiskered Tern
(*Chlidonias hybridus*).

Rainbow Bee-eater (*Merops ornatus*).

Nankeen Kestrel (*Falco cenchroides*).

Intermediate Egret (*Ardea intermedia*).

From the moment the young Chuditch was placed in my hands as a beguiling ball of fluffy white spots, he stole my heart away.

MONSTROUS MOGGIES OR CHARMING CHDITCHES?

BY MICHAEL ARCHER

AUSTRALIA'S DASYURID marsupials, from Devils to dunnarts, have fascinated a long line of Australian mammalogists. When the same bug bit me, with a focus on their diversity and evolution, I was a research student in the University of Western Australia and keen to learn everything I could about these beasts. So when a colleague offered me a young Chuditch or Western Quoll (*Dasyurus geoffroii*) to rear, I leapt at the opportunity.

From the moment the young Chuditch was placed in my hands as a beguiling ball of fluffy white spots, he stole my heart away. He was simply, utterly beautiful. What followed was years of interaction, extraordinary observations about behaviour, and a life-long commitment to the idea that these creatures rather than Cats or Dogs, whether in flats or in houses with backyards, should be the animals Australians have as domestic companions. A recent survey was conducted by Meri Oakwood (Australian National University) and Paul Hopwood (University of Sydney) of people who had kept quolls. In terms of aesthetic appeal, odour, temperament, expense, and ease of feeding and housing, those people who had raised young quolls as companions found them at least as satisfying as, and often far more satisfying than, Cats.

My own chance to consider the suitability of Chuditches as companions, compared with Cats and Dogs, came while living in a flat in Perth. From 'kittenhood' to adulthood, the Chuditch was devastatingly charming, entertaining and attentive. He loved to be tickled on the tummy, to wrestle with my hand and play hide-and-seek around the furniture. He'd follow me around in the evening after I got home, hoping for the attention that was impossible not to lavish on him. He never yowled or howled, making only a 'Nark!' sound when he wanted attention or to startle the Cats. When stroked, he made a contented purring sound deep in his chest. His hours perfectly suited mine for, unlike a Dog, he slept soundly in the 'working' part of the day, coming to his peak periods of wakefulness in the early evening and early mornings when I was home and keen to interact.

These creatures rather than Cats or Dogs, whether in flats or in houses with backyards, should be the animals Australians have as domestic companions.

On balance, in terms of temperament, intelligence and responsiveness, he was more like a Dog than a Cat. However, he was far 'cleaner' than a Dog and more like a Cat in terms of ease of care. He always used his 'kitty litter' box for wees and poos. His tastes in food could best be described as opportunistic omnivory—just about anything, from honey to hamburgers, but with a distinct leaning towards meat and a liking for plump mice, which were dispatched instantly rather than played with in the manner of a Cat.

In contrast, the two adult Cats that shared the flat space with the Chuditch

COURTESY MICHAEL ARCHER

Michael Archer with his pet Chuditch—love at first sight!

spent relatively little time seeking human attention, unless they were hungry or cold. At night, they would watch the playful young Chuditch with the single-minded intensity of consummate predators. When the Chuditch attempted to play with them, they bit and kicked him until he raced for cover. But as he grew to become closer to their size, with reflexes much faster than theirs and a very long memory, he put kinks in their tails that sent them screeching to the ceiling. By the time they'd landed, he'd be safe in his retreat, probably laughing in Quollese, in the bottom drawer of the bedroom closet.

The whole experience wedded me to the welfare of Australian native animals in a way that no book or bush experience could ever do. Concerned as we all are about the future of so many of Australia's endangered native animals that are declining in the wild, it seems immoral to me that we can own and breed Cats by the cartload, despite the fact that they are a disaster to urban and suburban wildlife, yet would be fined if caught caring for a quoll. This lack of regular contact with native wildlife leads to a situation where most Australian children, when asked to name the first ten creatures that come to mind, include few if any native animals.

Ironically, marsupials that are illegal to keep in most States of Australia, such as Red-necked Wallabies (*Macropus rufogriseus*) and Sugar Gliders (*Petaurus breviceps*), are now bred in captivity beyond our shores and sold overseas as high-priced companions. Whole societies devoted to breeding and caring for Sugar Gliders, which are promoted as loving "pocket pets", have sprung up in the USA.

Australians, in contast, are encouraged to keep introduced Cats, despite their habit of spraying urine and anal gland smell around the house, caterwauling at night, shredding lounge suites, catching and plucking parrots in our backyards and exposing us to potential diseases such as toxoplasmosis, which can lead to the death of unborn children. Each year thousands of these Cats invade the shrinking bushlands of urban and suburban Australia to tear millions of native animals apart. While de-sexed Cats are probably OK for people who live in flats more than four stories up, Cats that can access the ground are a problem.

Surely it's time we explored alternative, more environmentally friendly schemes for companion animals. Suitable native animals, such as Eastern Quolls (*Dasyurus viverrinus*), Mitchell's Hopping Mice (*Notomys mitchelli*), Children's Pythons (*Liasis childreni*) and many others, could be bred in captivity by registered breeders who had been trained and licensed by National Parks. In turn, the breeders could make juveniles available to the public. Quolls, for example, could be provided as de-sexed, electronically tagged individuals—at a cost more or less equivalent to that of a high-priced moggie. A large chunk of the price could be dedicated to conservation programs focused on native populations in the wild. Included in the price would be manuals on care and handling, and a guaranteed pick-up service if, for any reason, the owners tired of their companions. If one happened to escape, the environmental damage would be negligible compared to that caused by an abandoned Cat or Dog. In the process, more people would learn to appreciate first-hand the magnificence of Australian animals, thereby increasing overall commitment to conserving them and the wild environments upon which they depend. No species ever adopted as a human companion has gone extinct; enormous numbers left to their own resources have.

The last undoubted mainland population of the Eastern Quoll vanished in the mid 1900s from the Sydney suburban area, having survived there for millions of years prior to European settlement. Traditional strategies for securing mainland populations of this species failed. The vulnerable Western Australian Chuditch had populations spread across all States except Tasmania when Europeans arrived, and now the Spotted-tailed Quoll (*Dasyurus maculatus*) is also regarded to be vulnerable. How could it hurt to trial companion breeding programs while continuing to care for threatened populations of the same species in the wild? This is not an 'either/or' thing; we can do both. If we don't explore multiple strategies for conservation of vulnerable species, particularly ones that increase human commitment through personal bonding, almost certainly the losses will continue. Isn't it just possible that the Thylacine (*Thylacinus cynocephalus*) would still be alive today if colonial Australians had kept it as a 'Native Dog'? ■

Further Reading

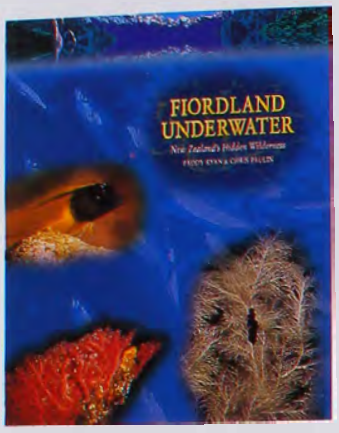
Hopwood, P., 1995. Too precious for pets? *Gazette* April 1995: 18–20.

Hopwood, P., 1996. Pet or perish? *Aust. Geog.* Oct.–Dec. 1996: 33.

Oakwood, M. & Hopwood, P., 2000. A survey of the attributes and requirements of quolls that may affect their suitability as household pets. *Aust. Zool.* (in press).

Michael Archer is the Director of the Australian Museum and Professor of Biological Science at the University of New South Wales. His major research interests are the fossil faunas of Riversleigh, north-western Queensland.

REVIEWS



Fiordland Underwater: New Zealand's Hidden Wilderness

By Paddy Ryan and Chris Paulin. Exisle Publishing, New Zealand, 1999, 192pp. $59.95rrp.

Fiordland underwater discusses the natural history of a fascinating region of New Zealand. Ryan and Paulin have compiled information about a wide variety of underwater organisms. Terrestrial animals, conservation, environmental management, human impact and research are also discussed. The text is richly embellished with superb photographs.

The authors state that "The major purpose of this book is to collate existing knowledge and present it in a manner which allows more people to make an informed input." They have achieved this aim.

They discuss the high rainfall of the region, which results in a layer of fresh surface water, overlying clear marine water. This layering cuts out much of the sunlight, resulting in light levels at ten metres being the equivalent of those at a depth of 70–100 metres offshore. This contributes to deepwater species often being observed in diveable depths in the fiords.

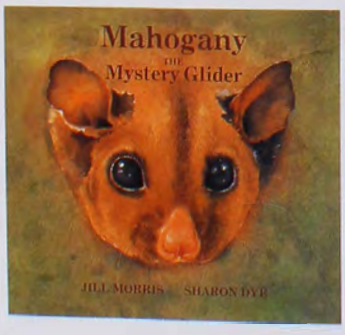
The book is full of fascinating snippets, including why sand flies thrive in Fiordland, why the Fiordland Crested Penguin chick might vomit on you, why Black Coral colonies 'enjoy' the company of snake stars, and why the endemic fish *Fiordichthys slartibartfasti* has such a strange name.

There are, however, some aspects of the book that are frustrating. Organisms are often discussed in the text with no reference to an image, which may be present many pages further on. The text often discusses abundant organisms that are not illustrated. An index to images would have been useful.

In some places the text could flow better, and readers need to be comfortable with the use of scientific names, which are used throughout. There are other minor problems such as the many references that are quoted, but not included in the reference list. I was also concerned with the maximum length of five metres given for the bottlenose dolphins of the fiords. According to several cetacean specialists contacted, this figure exceeds the upper size of this species by about half a metre.

Despite these shortcomings, the book gives an excellent overview of the natural history of the region. After reading it I can understand the authors' plea that the area be World Heritage listed.

—Mark McGrouther
Australian Museum



Mahogany the Mystery Glider

By Jill Morris and Sharon Dye. Greater Glider Productions, Qld, 1999, 32pp. $24.95rrp.

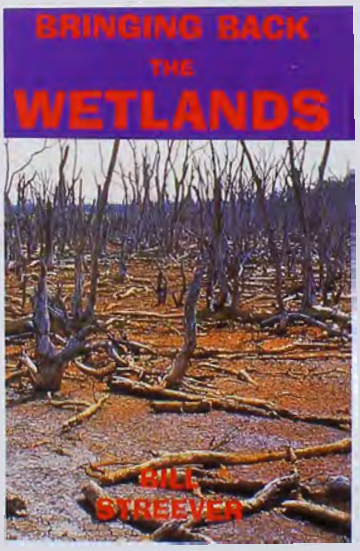
Mahogany the mystery glider is another winner for Greater Glider Productions. The combined talents of writer Jill Morris and illustrator Sharon Dye have produced a beautifully written and illustrated book for younger readers about a range of very cute Australian animals—the gliders.

The book covers a variety of topics associated with gliders, such as the Mahogany Glider's endangered status, the types of gliders and how gliders actually glide. Jill Morris' writing style ranges from reports of factual information to recounts, poetry and narrative. This clearly demonstrates to younger readers how different text types are appropriate in different situations.

Sharon Dye complements each topic with exquisite, detailed illustrations on paper stained with coffee, giving a beautiful, rich quality to the book.

If you like gliders, you are going to love this book! Treat yourself or buy it for a young friend.

—Cheryl Hook
Australian Museum



Bringing Back the Wetlands

By Bill Streever. Sanity & Associates Pty Ltd, NSW, 1999, 215pp. $19.95rrp.

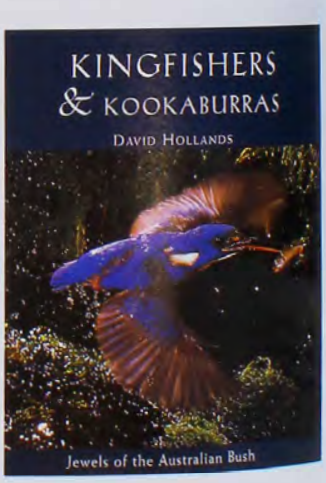
Preservation of wetlands is a global issue. Australia has already lost approximately 50 per cent of its wetlands. *Bringing back the wetlands* is an insightful and enjoyable read. It focuses on the rehabilitation work being undertaken at the Kooragang Island wetlands, near Newcastle, New South Wales.

Streever uses a narrative style to describe his work in the reclamation and management of wetlands. The narrative approach reads a little like Bill's essay on "what I did on my summer holidays", sitting slightly at odds with its scientific content. Throughout the book he displays his passion for wetlands and mixes scientific theory with observations of the Australian humour.

In examining wetland reclamation, Streever provides details of a large range of experiments undertaken across Kooragang Island. This provides a real insight into ecology in practice. In describing the fieldwork, a clear and logical reasoning for the protection and rehabilitation of wetlands is presented.

Each experiment is clearly described, with the aims, how each one is set up, problems and limitations inherent with each experiment and comparisons with results gained from the same experiment elsewhere in the world. Unfortunately, not all the results are recorded, so the reader is left unsure if all the time and money spent was worthwhile.

—David Bock
Australian Museum



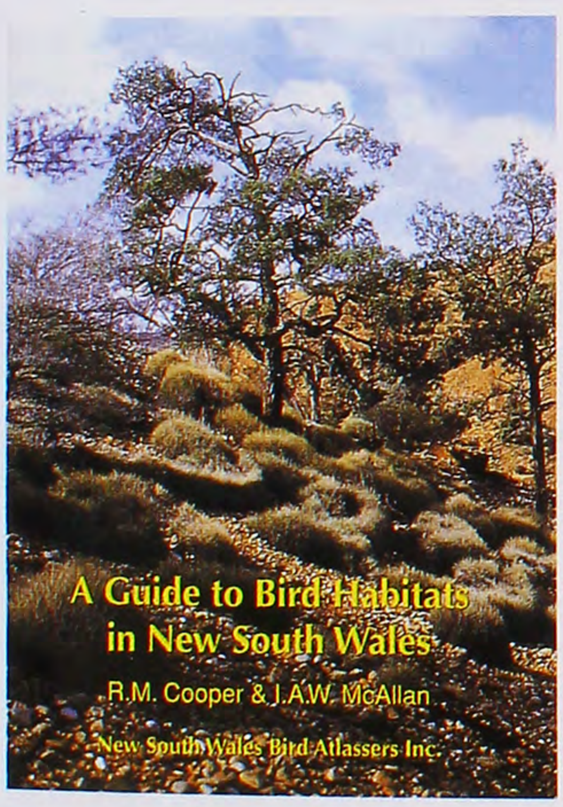
Kingfishers & Kookaburras: Jewels of the Australian Bush

By David Hollands. Reed New Holland, NSW, 1999. 132pp. $39.95rrp.

David Hollands follows up his successful books on birds of prey and night birds with this new offering on the ten species of kingfishers that occur in Australia. These

colourful members of the avifauna are aptly described by the book's subtitle—*Jewels of the Australian bush*. As in the earlier volumes, the format consists of Hollands' photographs accompanied by his text. This is a successful juxtaposition, for he is an accomplished photographer and an engaging writer. The main text comprises the writer's own observations on the birds and his experiences while obtaining the photographs. General information on the species is presented in a section at the rear of the book. Following the species' accounts, there is a chapter on the practical aspects of taking the pictures. Kingfishers present different problems from those encountered in compiling the previous books, but overall were tolerant subjects. Hollands' efforts were rewarded, as this book shows. It will appeal to anyone who likes birds in general and kingfishers in particular.

—Walter E. Boles
Australian Museum

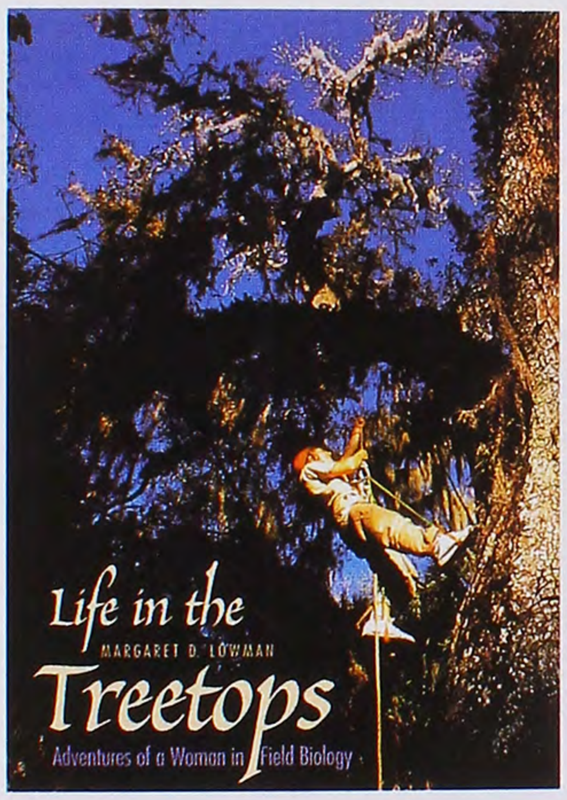


A Guide to Bird Habitats in New South Wales

By R.M. Cooper and I.A.W. McAllan. Available from the New South Wales Bird Atlassers Inc., 18 Lewis Dr, Medowie 2318 NSW, 1999, 155pp. $32.00rrp.

The New South Wales Bird Atlassers Inc. was set up in 1982 to monitor the distribution of birds in New South Wales and the ACT. In an effort to increase the utility of their database, the Atlassers hope to include information on where the birds occur, thereby discerning more accurately the relationships between distributions of different species with particular habitats. To standardise the way in which habitats are recorded, the Atlassers have produced this useful little book. The bulk of it consists of a written description of a habitat, illustrated with one or more colourful photographs. It encompasses a wide range of bird habitats, not all restricted to land, and extending to ocean waters. It also includes both human-altered environments, such as cultivated land, urban and parklands, aquatic habitats and native vegetation types. Each habitat account gives a list of typical bird species that can be found there. This book will have obvious benefits to Atlas participants, but a wide range of groups and individuals with environmental interests should also find it useful in their work.

—Walter E. Boles
Australian Museum



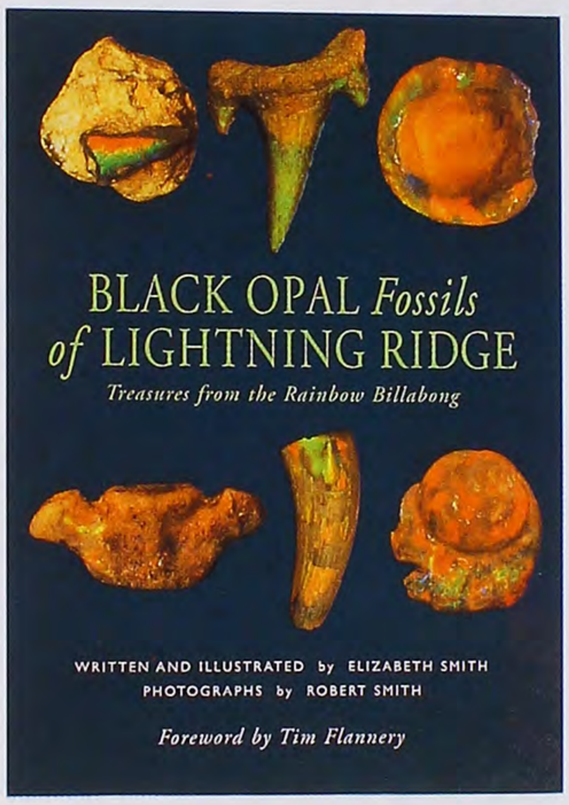
Life in the Treetops: Adventures of a Woman in Field Biology

By Margaret D. Lowman. Yale University Press, USA, 1999, 219pp. $27.50rrp.

Over the past 25 years, tropical rainforest canopies have become an ecological "new frontier". In the sun-soaked layer of leaves and branches high above the dark forest floor, biologists have discovered a unique world of undescribed species and complex interactions. In order to study in the canopy, an entire treetop technology has developed, ranging from basic rock-climbing gear to permanent canopy walkways, giant cranes, and even dirigible rafts.

Life in the treetops is the personal story of treetop biologist Margaret Lowman and her attempts to juggle family life with her rather unusual occupation. Lowman, who is now the Director of the Selby Botanical Gardens in Florida, began her canopy studies in Australia with work on herbivorous insects in the northern New South Wales rainforests. Since then she has conducted research in various canopy study sites around the world. The book comprises her anecdotes and adventures, related in a good-natured and humorous manner. Read along with such books as *The high frontier* by Mark Moffett, it provides a good summary of life in the treetops.

—Daniel Bickel
Australian Museum



Black Opal Fossils of Lightning Ridge: Treasures from the Rainbow Billabong

Text and illustrations by Elizabeth Smith, photography by Robert Smith. Simon & Schuster, NSW, 1999, 112pp. $45.00rrp.

I should declare my interests in this from the start. I am a palaeontologist. I know the Smiths and I have been to Lightning Ridge to look for opal fossils. However, I can still be objective.

In the case of this wonderful book by Elizabeth and Robert Smith, it is hard not to be impressed. The book is beautifully presented, well written and superbly photographed. With books such as this, it can be very easy to just look at the photographs

and ignore the text. I started doing this but was soon hooked by Elizabeth's written prose, which provides the right level of scientific information to satisfy people with some knowledge in the field and interested readers with no prior knowledge. This information is interspersed with wonderful stories about lucky finds, some that have got away and a range of the colourful characters at the Ridge. Once I started reading, I found it hard to stop. As well as a fluid writing style, Elizabeth is also a skilled illustrator. Her reconstructions, drawings and even pages from her field notes are first class.

The quality of Robert's photography was brought home to me when I saw some of the specimens recently. While the specimens certainly had some colour, they did not shine nearly as brightly as they do in the book. Robert has really brought out the colours in the specimens in ways that only a highly skilled photographer can do.

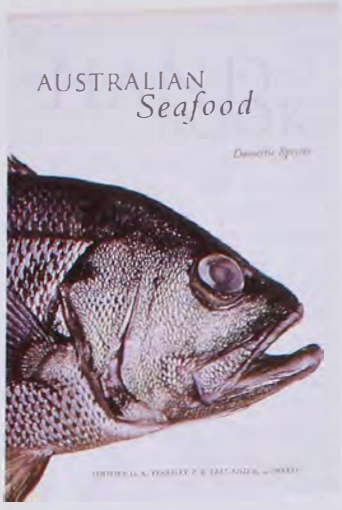
I can thoroughly recommend this book to anyone with an interest in natural history, fossils, opals or Australia's past. It would make a highly desirable birthday or Christmas present. It would also be a nice way of recognising all that Elizabeth and Robert have done over the years to educate opal miners into keeping these bits of our heritage from being lost forever and to ensure more specimens are kept for the future. The Smiths themselves have made a wonderful gesture and donated their collection to the Australian Museum. May they continue their good work so that in the near future we will be able to admire a larger second edition of this excellent book.

—Phil Creaser
Australian Museum

Australian Seafood Handbook: Domestic Species

Ed. by G.K. Yearsley, P.R. Last and R.D. Ward. CSIRO Marine Research, Tas., 1999, 461pp. $39.95rrp (standard edition), $75.00rrp (waterproof edition).

Over 600 species of Australian seafood are sold in



Australia for human consumption. In the past there has been considerable confusion over the marketing names of these species. Not only has the same species been marketed under different names from State to State, but in many cases, different names have been used between shops in the same town.

The Australian seafood handbook is a sensational publication that attempts to solve this dilemma. It is the culmination of five years of work by CSIRO scientists who are all experts in their fields.

The authors state that "the main aim of this handbook is to provide an affordable, easy-to-use identification guide to all major Australian domestic seafood species, including fish fillets, and to link each species with an approved marketing name". They have achieved these aims. Funding from the Fisheries Research and Development Corporation (FRDC) ensured affordability. The handbook comes in standard and waterproof editions, and both sell for very reasonable prices.

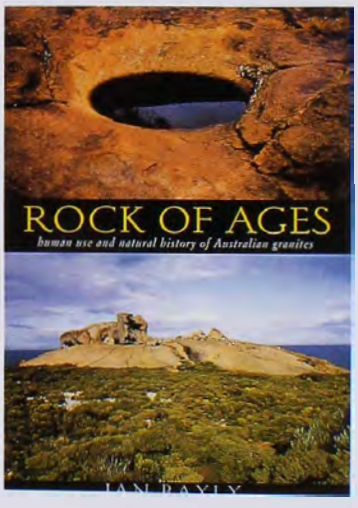
The book is easy to use, logically organised and accurately written. The bulk of the book deals with Australian domestic seafood species including fishes, crustaceans, molluscs and other invertebrates. Each account includes a colour photograph of the species, its fillet (for fishes), and a distribution map. Details are given on identification, size, comparisons with similar species, and information on the habitat and fishery. Importantly each species is listed under its approved marketing name.

The book also contains two other important pieces of research. The first is a description of the protein fingerprint for each species. This relatively simple technique can be used in most cases to identify seafood from a tissue sample. The second is an analysis of the oil content of the seafood. Research has shown that the oils in seafoods, such as the polyunsaturated fatty acids, are beneficial to human health.

My only concern is that some of the yellow numbers that are used to label the photographs are very hard to read. In the light of what has been achieved by the authors however, this is a tiny problem. In fact it is refreshing to review a book and have little but praise to offer.

The authors have made a huge contribution to the knowledge and understanding of domestic seafood species. This book will become an essential reference for anyone who deals with Australian seafood.

—Mark McGrouther
Australian Museum



Rock of Ages: Human Use and Natural History of Australian Granites

By Ian Bayly. University of Western Australia Press, WA, 1999, 132pp. $34.95rrp.

The title of the book excited me. The information on the back cover referred to ". . . the natural history of Australian granites" and I was certainly left with the impression that this was a comprehensive account of ". . . the history, biology, beauty and recreational potential of Australian granite landscapes".

Regrettably, this is one book that should not be judged by its cover. Much of the book is devoted to 'water-related' aspects of granite landscapes in south-western Western Australia. While this is examined in detail with interesting information and excellent photographs, most

Over 600 species of Australian seafood are sold in Australia for human consumption.

of the other aspects of Australian granite landscapes are barely represented. The introductory section on the geology of granites is very brief, and at the risk of being pedantic, it is annoying when maps don't match the text and when some basic things like the shape of the ACT are wrong.

With the focus being on south-western Western Australia, the eastern seaboard and indeed the rest of Australia get some photographs but not much else. I may have been expecting too much given my love of granite landscapes, both from a geological and recreational perspective. Australian granite terrain is considered to provide some of the best orienteering in the world.

Even the final chapter on conservation is very brief and superficial, considering the importance the author places on these landscapes. I had expected that mention may have been made of 'geodiversity' and 'geoconservation', especially as one of the references is a definitive work on geoconservation.

Granite landscapes do have a special place in our hearts, and the author clearly has a special affiliation with these areas in the south-west of Western Australia. It may have been better if the title of the book reflected this.

—Phil Creaser
Australian Museum

SOCIETY PAGE

Get involved! Across Australia there is a network of active societies, large and small, local and national, which exist to further the cause of the subject that you hold dear. Whether your special interest is conservation, birds, science, national parks, bushwalking or a particular group of animals, there's a society for you.

ANIMAL WELFARE

FAWNA
PO Box 218
Wauchope, NSW 2446
Ph: 0500 861 405
Web: www.communitech.org.au/cws/Fawna
Contact: Sue Emerton

Membership Fee: $20 single; $25 double; $30 family

Native Animal Trust Fund Inc.
PO Box 162
Raymond Terrace, NSW 2324
Ph: 0500 502 294
Contact: Annette Rees

Membership Fee: $15

Northern Rivers Wildlife Carers
PO Box 6439
South Lismore, NSW 2480
Ph: 0500 882 626
Contact: Leonie Armbruster

Membership fee: $15

Wildcare
PO Box 2379
Nerang Mail Centre, Qld 4211
Ph: (07) 5527 2444
Contact: Eleanor Hanger

Membership fee: $35 family; $25 single

Wildcare Inc.
PO Box 464
Palmerston, NT 0831
Ph: (08) 8988 6121
Contact: Mignon McHendrie

Membership fee: $20

WIRES - NSW
PO Box 260
Forestville, NSW 2087
Ph: (02) 8977 3333
Web: www.wires.webcentral.com.au
Contact: Sheridan Thomas

Membership fee: $20

Are you a Club Secretary?
NATURE AUSTRALIA's Associate Society Scheme is designed to help your club or society with free publicity, funds and member benefits. Call Robbie Muller on (02) 9320 6119 for more details.

BIRDS

NSW Field Ornithologists Club Inc.
PO Box Q277
QVB Post Shop, NSW 1230
Ph: (02) 9698 7263 or (02) 9436 1556 (after hours)
Contact: Penny Drake-Brockman

Membership fee: $30 adult; $15 juniors

South Australian Ornithological Association
100 Fifth Ave
Joslin, SA 5070
Ph: (08) 8303 4498
Contact: John Hatch

Membership fee: $30 single; $40 family; $24 concession

CONSERVATION

National Parks Association of Qld Inc.
PO Box 1040
Milton Centre, Qld 4064
Ph: (07) 3367 0878
Web: www.bit.net.au/~npaqld
Contact: George Haddock
Membership fee: $35 single; $50 household; $20 student

EDUCATION

CSIRO's Double Helix Science Club
PO Box 225
Dickson, ACT 2602
Ph: (02) 6276 6643
Web: www.csiro.au/helix
Contact: Lynn Pulford

Membership fee: $25

Dinosaur Club of Victoria
Monash Science Centre
Monash University
Clayton, Vic. 3168
Ph: (03) 9905 1370
Web: www.sci.monash.edu.au/msc
Contact: Prof. P. Vickers-Rich

Membership fee: $12

Science Teachers Association of NT
PO Box 41809
Casuarina, NT 0811
Ph: (08) 8945 4486
Contact: Anne Donnelly

Membership fee: $80

Science Teachers' Association of Victoria
PO Box 190
Richmond, Vic. 3121
Ph: (03) 9428 2633
Web: www.stav.vic.edu.au
Contact: Dianne Hayes

Membership fee: $100 secondary

ENVIRONMENTAL

Independent Landcare
PO Box 116
Port Sorell, Tas. 7307
Ph: 019 978 541
Contact: David J. Lane

Membership fee: $5

The Hut Environmental Community Association Inc.
PO Box 804
Kenmore, Qld 4069
Ph: (07) 3878 4581
Contact: Rachel Griffiths

Membership fee: $15

Australian Bush Heritage Fund
GPO Box 101
Hobart, Tas. 7001
Ph: (03) 6223 2670
Web: www.bushheritage.asn.au
Contact: Cameron Gardiner

Coast and Wetlands Society
PO Box A225
Sydney South, NSW 1235
Ph: (02) 9385 2076
Contact: Dr Paul Adam

Membership fee: $25 Ordinary; $10 student

INSECTS

Australian Entomological Society
c/- Dept of Zoology & Entomology
University of Qld, Qld 4072
Ph: (07) 3365 1564
Contact: Dr David Walter

Membership fee: $60 single; $80 family

Queensland Museum Association Inc.
Box 3300
South Brisbane, Qld 4101
Ph: (07) 3840 7632
Contact: Carol Middleton

Membership fee: $25 single; $30 family; $20 concession & country

MUSEUM

The Australian Museum Society
6 College St
Sydney NSW 2000
Ph: (02) 9320 6225
Contact: Michelle Ball

Membership: $55.00 single, $75.00 household, $40.00 student/pensioner

REPTILES & AMPHIBIANS

Cape York Herpetological Society
PO Box 848M
Manunda, Qld 4870
Ph: (07) 4054 7317
Contact: Michael Anthony

Membership fee: $25

WA Society of Amateur Herpetologists Inc.
9 Birch Place
Stoneville, WA 6081
Ph: (08) 9295 3007
Web: www.nettrek.com.au/~bush/index.html
Contact: Brian Bush

Membership fee: $20

WETLANDS

The Wetlands Centre
PO Box 292
Wallsend, NSW 2287
Ph: 049 516 466
Web: http://users.hunterlink.net.au/~maatb/core.htm
Contact: Clare Crockford

Membership fee: $30 single; $50 family

ZOO KEEPING

Australian Society of Zoo Keeping
Currumbin Sanctuary
28 Tomewin St
Currumbin, Qld 4223
Ph: (03) 5957 2800
Contact: Liz Romer

Membership fee: $45

Newsletter/Journal; Monthly meeting; Bi-monthly meeting; Annual meeting/Conference; Weekly meeting; Quarterly meeting; Field outings/Tours; Conservation/Working programs; Discounted Goods; Magazine; Social/Education activities; *Nature Australia* magazine; Seminars

The Guide.

WELCOME TO THE GUIDE, *Nature Australia*'s marketplace. Over 100,000 *Nature Australia* readers look to the guide for up-to-date information on travel destinations and equipment, wilderness tours; even 'bed and breakfasts'.

Our readers are a very special group – outdoor enthusiasts with a real interest in *Australian* nature. *Nature Australia* magazine is read in homes, libraries, universities and colleges—right across Australia and in over 30 countries worldwide. *Advertisers, you can reach these discerning readers for a surprisingly low cost with* The Guide.

Call Robbie Muller on (02) 9320 6119 for more information.

HEADLAND LOOKOUT COTTAGE
NORTH COAST NSW

UNWIND IN BROADWATER NATIONAL PARK, ONE OF THE OLDEST AND BEST-PRESERVED COASTAL HEATH AND GIANT SAND DUNE HABITATS IN NSW.

THE COTTAGE, SITUATED INSIDE THE PARK, IS COMFORTABLE, SELF-CONTAINED AND PRIVATE.

- RELAX ON THE VERANDAHS AND ENJOY THE PANORAMIC VIEWS OF THE OCEAN & HEATH MOSAIC
- WALK TO THE BEACH AND SALTY LAGOON
- WHALEWATCH FROM THE LOOKOUT WITH A VIEW THAT IS SIMPLY MAGNIFICENT

FOR MORE DETAILS PLEASE CONTACT
AH (02) 6643 4144
MOB: (0418) 498 400
PO BOX 1650
GRAFTON NSW 2460

Environmental Wildlife Tours
Far North Queensland

Venture into magnificent high altitude World Heritage areas with Cairns' original environmental tour company (est.1982) to observe rare local endemic birds and animals in their natural habitat.
Relaxed afternoon/evening tours combine rainforest walks with birdwatching, platypus search and nocturnal wildlife viewing. Small groups (maximum 8) departing Cairns 2pm daily.

Advanced accreditation.
Ecotourism Association of Australia.

DISCOUNTS AVAILABLE TO READERS OF NATURE AUSTRALIA

Wait-A-While Environmental Tours
Ph: (07) 4033-1153 Fax: (07) 4033-5999
Email: info@waitawhile.com
Web: www.waitawhile.com
PO Box 6647, Cairns 4870

ECO ADVANCED ACCREDITATION TOURISM

SHOC2000

The Southern Hemisphere Ornithological Congress, hosted by Birds Australia is the premier forum for avian researchers in 2000, to present and consider current and future issues.

The Congress will attract a cross-section of scientists, students, amateur and professional people from bird clubs, societies, educational, scientific and environment management backgrounds in Government and non-government organisations.

- Congress
- Guided Tours
- Exhibition
- Social Functions

For further information on the Southern Hemisphere Ornithological Congress please contact:

Secretariat
PO Box 4044
ST LUCIA SOUTH QLD 4067
Ph: 07 3870 8831 Fax: 07 3371 9514
Email: shoc2000@convqld.org.au

BIRDWATCHING & WILDLIFE TOURS
Broome & the Kimberley

Informative tours with an experienced and knowledgeable guide - **George Swann** - who knows this region, its birds and wildlife.

Take advantage of George's extensive local knowledge - small groups max 6

23rd August to 1st September 2000
Superb Tour of the Kimberley with the comfort and convenience of Homestead Accommodation - A great chance to meet the locals !

PLUS MORE EXCITING TOURS

Experience the spectacular Mitchell Plateau, Bungles, Gibb River Rd by 4WD safari, air, sea.

Contact us for details on all our 2000 tours

KIMBERLEY BIRDWATCHING
Wildlife & Natural History Tours

GEORGE SWANN
P O Box 220
Broome W.A.
6725
Ph/Tel: 08 9192 1246
Email:kimbird@tpg.com.au

NORTH WEST SAFARIS 2000

OUR 4WD EXPEDITIONS LET YOU EXPERIENCE.....

Kimberley, Mitchell Plateau, and Purnululu
29 April–26 May 2000 $3000

Rudall River & Karijini National Parks
3 June–30 June 2000 $3000

Rudall River & Karijini National Parks
8 July–4 Aug 2000 $3000

Canning Stock Route
12 Aug–8 Sept 2000 $3000

Little Sandy Desert
16 Sept–6 Oct 2000 $2300

Great Victoria Desert
14 Oct–3 Nov 2000 $2300

.....WITH THE PERSONAL TOUCH OF A SMALL FRIENDLY TOURING GROUP
All ex Alice Springs

WRITE TO NORTH WEST SAFARIS
P.O. BOX 211, EAST KEW, VIC. 3102
Phone (03) 9852 3398 Melbourne
(08) 8280 7149 Adelaide
0417 846 238 Mobile

OUTBACK QUEENSLAND

Strike out from Winton and discover Outback Queensland's best kept secrets . . .

- **Lark Quarry** Dinosaur Prints
- The geological wonders of the **Merton Escarpment**

DIAMANTINA OUTBACK TOURS

- Fully guided day tours
- Field guidance for charter groups
- Tag-a-long tours

Local knowledge, exclusive access to protected areas, along with comprehensive field interpretation ensures thorough understanding of this region's natural environment.

PO Box 335 Winton,
Outback Queensland, 4735
Freecall: 1800 625 828
Fax: (07) 465 71722

Q&A

Exploding Beetle

Q: *When I was at Tarrawanna Primary School, I encountered a smoke beetle in the playground. The insect emitted heat when touched, and raised smoke when poked with a twig! Can you tell me the correct name for this insect?*

—Brian Ward
Douglas Park, NSW

A: This sounds like Australia's only known species of bombardier beetle (*Pheropsophus verticalis*). This beetle is normally black with yellow or orange spots and, like other bombardier beetles, is famous for producing an explosion from its rear end, hence the smoke you saw. The beetle mixes two chemicals in its rectum that violently react, forcing out steam, noxious odours and considerable heat, often with a pop or fizzing noise. It's quite enough to deter predators like birds, and anyone handling the beetle will be left with nicotine-like stains on his or her hands.

—Martyn Robinson
Australian Museum

Human Hybrids

Q: *I was wondering if you could help our biology class solve an intriguing question. We are currently studying genetic diversity and recently the following question was asked: as a Horse and Donkey can produce a Mule, is it possible for a human and a Chimpanzee/monkey to create offspring? Perhaps in a test tube? Our science teacher did not provide a satisfying answer and I hoped that perhaps someone at the Museum will be able to.*

—Sally Heighway

A: Hybrids between different species (interspecific hybridisation) are often, but not always, sterile. Hybrids between races or subspecies (intraspecific hybridisation) are often vigorous and fertile. Interspecific hybridisation is more common among closely related and very similar species. Chimps and humans are not that closely related, despite the fact that they have large amounts of genetic similarity. They are classified in different genera for a start.

It might be possible in the laboratory to achieve human–Chimp syngamy (sperm enters egg) between a Chimp egg and a human sperm or *vice versa*. The question would then become how long would the fertilised egg or embryo survive? If after thousands of trials a hybrid animal was born, it would almost certainly be very feeble, short-lived and definitely sterile. This is called negative heterosis. When we look at the effect of hybridisation we describe the outcome as being either positive heterosis (hybrid vigour, fertility etc.) or negative heterosis (hybrid infertility, reduced fecundity, fitness, fertility and lifespan, sterility, inability to reach reproductive condition or age, prone to disease, maladapted in a natural habitat etc.).

The most obvious cause of negative heterosis is due to mismatched genes and chromosomes with poorly coordinated gene function. Genes evolve to work well in the normal genetic environment, not in a hybrid genetic environment. Chromosomes have to be in pretty good shape to sort themselves correctly into sperm cells or egg cells when they form. Genes are carried on chromosomes so, if the chromosomes are not being correctly assorted during the process of egg and sperm formation, the genes aren't being 'correctly' inherited. Interestingly, if you put partially sterile male and female hybrids together so that they can breed only among themselves, after several generations, natural selection starts weeding out the genetic cause of the negative heterosis and the population starts to become 'healthier'.

—Shane McEvey
Australian Museum

© ANDREW HENLEY/NATURE FOCUS

A female Chimpanzee with her young. Could a Chimp and a human interbreed?

Sticky Question

Q: *Why don't spiders stick to their webs?*

—Louis Kelly
Mosman, NSW

A: If you look at an orb web-weaver in its web, you'll notice that the body is held slightly clear of the web, especially when the spider is moving about. The spider has only minimal (but vital) body contact with its web via the claws and bristles at the tip of each leg. Compared to its prey, which crashes or blunders into the web, the spider has only a tiny portion of its surface area in contact with a very small amount of silk at any time. This is obviously an important factor when moving on a sticky web—the less contact the better.

Another important factor is that not all silk lines in a sticky web are sticky. For example, the central part of an orb web (where the spider sits) is made of dry silk, as

PAVEL GERMAN/NATURE FOCUS

Orb-weaving spiders have a number of tricks to keep them from being caught in their own web.

are the spokes supporting the sticky spiral line, which the spider can use when moving around its web. It's only when the spider makes a quick, direct charge across the sticky spiral to capture prey that it may cause some disruption to the web—but it never gets stuck.

Spiders also spend a lot of time grooming their legs. The spider draws the ends of its legs through its jaws to clean them of debris, which may include silk fragments. This is a very important maintenance activity that contributes to efficient function of the claws and bristles. As well as cleaning them, some secretions from the mouthparts may help make the leg tips less susceptible to sticking.

—Mike Gray
Australian Museum

Answers to Quiz in Nature Strips (page 18)

1. A rock carving
2. Left
3. Nanobes
4. Timor, Arafura and Coral
5. Water
6. Richard Dawkins
7. Six billion
8. Two weeks
9. Soil
10. Poppies

P I C T E A S E R

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *The Graham Pizzey & Frank Knight field guide to Australian birds* from the Australian Museum Shop. Summer's Pic Teaser was a harvestman (order Opiliones).

KAREN GOWLETT-HOLMES/NATURE FOCUS

The best fence in the world won't save your species if it's dying from the inside.

GENETIC TOOLS FOR CONSERVATION

BY DON A. DRISCOLL

AS IS TYPICAL OF MOST disciplines, whenever biologists pose an either/or position, the solution usually involves bits of both. This is certainly true of the dichotomy raised by Mark Elgar (*Nature Aust.* Spring 1998) when he suggested we must choose to either manage endangered species over the ecological short term or the evolutionary long term. Current research applications demonstrate that both can be addressed and, contrary to the impression readers may have formed from Elgar's article, genetic research has proven invaluable in doing so.

As Elgar pointed out, some species can survive, and even thrive, with low levels of genetic variation. However, there are examples where the opposite is true. In 1998, Ilik Saccheri and coworkers from the University of Helsinki demonstrated that low levels of genetic variation, and subsequent inbreeding depression, significantly increased the risk of extinction of wild Glanville Fritillary Butterfly (*Melitaea cinxia*) populations. In a laboratory study in 1997, Dara Newman (University of Montana) and Diana Pilson (University of Nebraska) compared inbred and outcrossed populations of the winter annual plant *Clarkia pulchella*. Three-quarters of the outcrossed populations survived for three generations, compared with less than a third for the inbred populations. Given this sort of evidence, managers would be foolhardy to ignore loss of genetic variation and possible inbreeding depression in the populations they manage. The best fence in the world won't save your species if it's dying from the inside.

In addition to problems of genetic variation within populations, studies of genetic variation between populations make major contributions to conservation. For example, reintroductions have the potential to alter natural evolutionary patterns, and can reduce the fitness of the introduced and/or remnant native populations. Because the genetic makeup of a species can vary throughout its geographic range, moving individuals from place to place can be a risky business. Andrew Young (CSIRO Plant Industry) and Brian Murray (University of Auckland) recently found that a reintroduced population of the endangered daisy *Rutidosis leptorrhynchoides* in Victoria was likely to suffer reduced fertility, possibly threatening its survival. A nearby natural population of the daisy with half the number of chromosomes had cross-pollinated with the introduced plants, resulting in plants with an intermediate number of chromosomes and about half the fertility level. The problem could have been avoided using knowledge of the species' genetic structure prior to translocation.

Population genetics is also useful for working out what to conserve. The more genetic probing that's undertaken, the more we realise that species described on the basis of morphological evidence can actually consist of several distinct species. Without genetic studies, cryptic biodiversity is overlooked. What might, for example, be thought of as a local population extinction of a widespread species may actually be the complete extinction of a distinct species. Take the Corroboree Frog (*Pseudophryne corroboree*). Prior to genetic studies by Wil Osborne (University of Canberra), only a single species was recognised, with a small, southern population apparently declining. We now know that the southern population is a genetically distinct species and warrants redoubled efforts to stem its decline.

Genetic studies can also provide short cuts for land managers and planners to maximise the representation of biodiversity in reserves. Imagine a wet forested landscape that, over aeons, is split in two as the climate dries, then is reconnected much later when rainfall increases. The whole set of wet-forest creatures may then have two distinct forms, each the product of genetic divergence while they were separated. By studying genetic patterns in a handful of species, managers can locate evolutionary splits and ensure that the different forms are represented in a reserve system.

The brief of conservation biologists is to work out how to conserve biodiversity, which includes maintaining the evolutionary potential of species. That is a massive undertaking, and will necessarily involve a wide range of approaches, using all of the available tools. Genetic tools have a proven record of facilitating responsible conservation management, and will remain essential components of good conservation into the future.■

Managers would be foolhardy to ignore loss of genetic variation and possible inbreeding depression in the populations they manage.

Further Reading

Newman, D. & Pilson, D., 1997. Increased probability of extinction due to decreased genetic effective population size: experimental populations of *Clarkia pulchella*. *Evolution* 51: 354–362.

Osborne, W.S. & Norman, J.A., 1991. Conservation genetics of corroboree frogs, *Pseudophryne corroboree* Moore (Anura: Myobatrachidae): population subdivision and genetic divergence. *Aust. J. Zool.* 39: 285–297.

Saccheri, I., Kuussaari, M., Kankare, M., Vikman, P., Fortelius, W. & Hanski, I., 1998. Inbreeding and extinction in a butterfly metapopulation. *Nature* 392: 491–494.

Young, A.G. & Murray, B.G., in press. Genetic bottlenecks and dysgenic gene flow into re-established populations of the grassland daisy *Rutidosis leptorrynchoides*. *Aust. J. Bot.*

Dr Don A. Driscoll is a Post-Doctoral Fellow with CSIRO Wildlife and Ecology, Canberra. His research interests include population genetics and metapopulation biology.

The Last Word is an opinion piece and does not necessarily reflect the views of the Australian Museum.

BACK ISSUES AND SUPPLEMENTS

23/6

23/7

24/1

24/2

24/6

24/10

25/1

25/2

25/3

25/4

25/5

25/6

25/7

25/8

25/9

25/11

26/1

26/2

26/3

26/4

26/5

26/6

26/7

SUPPLEMENT

S2
Tracks through Time

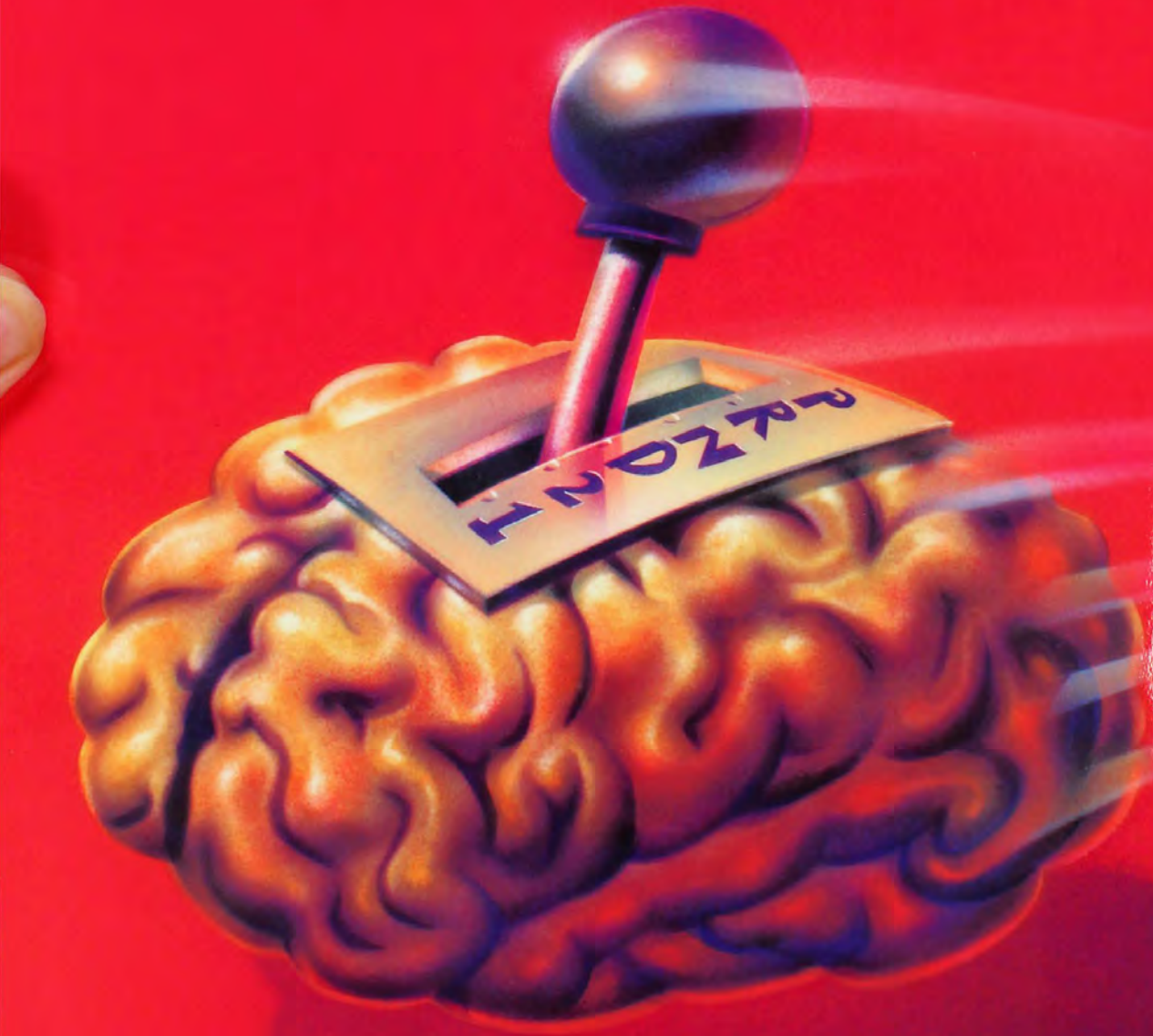
Nature Australia's

Library Box

Holds twelve issues of the magazine. Finished in durable, dark green PVC, it will ensure your copies remain in mint condition.

To order use the form opposite

Get your mind into gear



AUSTRALIAN MUSEUM
6 College Street Sydney
(02) 9320 6000 www.austmus.gov.au