SUMMER 1994-95

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Australia's Leading Nature Magazine

ANH

Males Dress for SEX

Giant SHARKS

BLUEBOTTLES Dangerous Stingers

DINING WITH THE DEVIL

FREE DEVIL POSTER

ISSN 0004-9840

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Dear Daryl,
I've only got 7 days to take in the Top End. Can you point me in the right direction?

DAY 1. Pants off, shorts on, welcome to tropical Darwin. First things first, lunch. Cruise down to the wharf and make two major discoveries. Darwin has a big, beautiful harbour. The plate of fresh fish and chips goes nicely with the nautical view. You are so moved, you can't move.

DAY 2. Do town tour. Hand feed giant schools of fish at Aquascene. Admire palm collection in Botanic Garden; examine Aboriginal art collection in The Museum and Art Gallery of the Northern Territory; watch sunset from harbour cruise, followed by corroboree and dinner. Enough for one day?

DAY 3. A day in the park. The Territory Wildlife Park. A 400 hectare, award-winning wildlife sanctuary. Here you can explore the enormous range of local wildlife - animals, birds and fish close up. Having worked up a big appetite, you can explore the enormous range of restaurants back in Darwin.

DAY 4. Off to Kakadu National Park, home to countless animals, birds and reptiles - including some giant saltwater crocodiles. There's one that's two storeys high. It's an hotel. Call into the Visitor Centre and see the audio/visual to plan your attack.

DAY 5. Up really early. Take a dawn boat tour on Yellow Waters. Watching countless numbers of birds as you silently cruise with the crocs is the experience of a lifetime. Follow breakfast with a scenic flight over the flood-plain, up and over the escarpment and into Arnhemland.

DAY 6. Aboriginal art lessons at Nourlangie Rock and Ubirr galleries given free by Park Rangers. These ancient rock paintings reflect the daily life and tucker of the Aboriginal people - like catching barramundi. Later on, you can tuck into a local barra for dinner.

DAY 7. Up early. Fly to Katherine to explore the spectacular gorge. Take leisurely cruise or if you're a 'hands-on' type, paddle a canoe. Fish jump. Birds sing. Silence reigns. Time up! Sorry, back to Darwin, back to home thinking what a 'Top' week it's been.

Name _____

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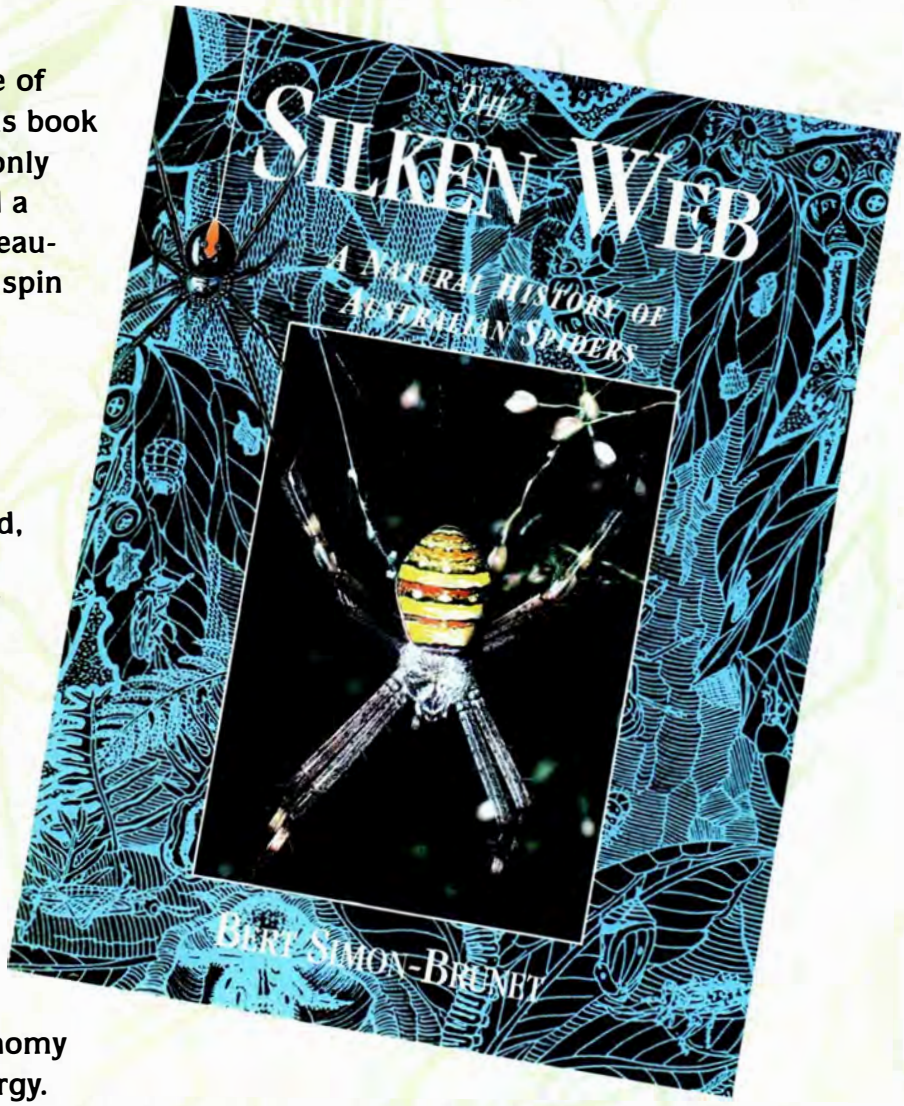
This is only a guide to get you going. You'll find there are endless variations when you read the N.T. Information Pack. To receive your copy please phone 1 800 621 336 or send the completed coupon to Northern Territory Holiday Centre, PO Box 2532, Alice Springs NT 0871. Hope you enjoy holidaying there as much as I do.

ANH

"You'll never never know, if you never never go."

MN&C/FCB NTT3773

A great adventure awaits the intrepid...



The world of spiders is one of mystery and intrigue. This book is a natural history of commonly found Australian spiders, and a fascinating account of how beautifully and effectively spiders spin their silken webs.

A spider's use of silk is the key to its development. There is distinct progression from the earliest home-bound, ground-dwelling spiders, the Mygalomorphs, which simply grabbed at passing prey, through to the acrobatic, wheel-web Master Weavers. How did spiders evolve snare making and learn to construct such remarkable pieces of engineering? Master Weavers, with their two-dimensional, masterfully designed webs, manifest amazing economy and efficiency of silk and energy.

A total of 220 colour photographs and 20 colour artworks illustrate the silken world of spiders and pay tribute to these often misunderstood creatures. The spider's silk is not only beautiful, but very functional. Without spiders, the world's insect population and, consequently, levels of famine and disease, would soar.

The Silken Web – A Natural History of Australian Spiders
by Bert Simon-Brunet
ISBN 0 7301 0401 X
RRP $39·95

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Up Front

When I was young, like many other children my age, one of my favourite television shows was the Bugs Bunny Show, and one of my favourite characters was the Tasmanian Devil. Since then, I have always been intrigued by these supposedly insatiable carnivores. For some time now I have been keen to locate someone to write an accurate piece on the curious animal behind the cartoon. When Linda Gibson, one of the Australian Museum's mammalogists, attended the 1993 mammal conference at the University of New South Wales I asked her to speak to any Devil researchers that may turn up, on our behalf. Menna Jones, an experienced Devil researcher from Tasmania, was there. She indicated she would love to write for ANH, but a prior commitment to an overseas publication meant she would unfortunately have to pass on the opportunity. It looked like the real Devil would have to stay hidden behind that crazy animation. But then almost a year later a letter arrived from Menna saying that she had been released from her obligations and would we still be interested in an article on her Devil research! Needless to say we accepted and the ten-page result is sure to surprise and fascinate you.

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

This may be the image we are most familiar with but it belies the true nature of the Devil.

CALVERT MARINE MUSEUM

A model in the making: 'Big Tooth' Shark.

Ever wondered what the ancestors of the Great White Shark might have been like, or why the males of some species go to elaborate lengths to satisfy the desires of some very choosy females? Well, it's all in this issue of ANH, along with tree frogs, bluebottles, the Golden Bandicoot and a rather different look at man-made landscapes.

—Jennifer Saunders

ANH

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Jennifer Saunders, B.Sc.
SCIENTIFIC EDITOR
Georgina Hickey, B.Sc.
PHOTO RESEARCHER
Kate Lowe
DESIGN AND PRODUCTION
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Mike Field
Phone: (02) 339 8331
ADVERTISING
Sari Järvenpää
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Front Cover
Emerging from its daytime shelter, a Tasmanian Devil (*Sarcophilus harrisii*) yawns, revealing the powerful jaw and strong teeth that enable it to be Tasmania's bush undertaker. Photo by John Cancalosi/Auscape International.

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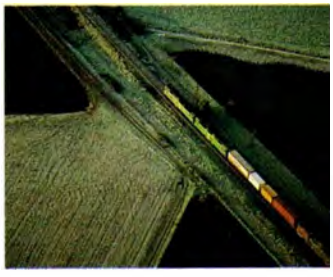


Columns

LETTERS

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

Timber Troubles

In the Winter 1994 issue of ANH, Nigel Wace wrote a Letter about timber on the Arthur River Beach (Tasmania) that bore evidence of being cut with a chainsaw. His hypothesis, based on this observation, was that the timber had floated down the river from logging operations upstream and had escaped the 'drift net' of industry. What he failed to observe was that the major forest industries in Tasmania must conform to the requirements of a Forest Practices Code that prohibits all logging activity within 40 metres of a major stream such as the Arthur River. On tributaries draining catchments of greater than 100 hectares, a 30-metre buffer strip is required; and on catchments of 50–100 hectares no logging is permitted within 20 metres of either bank of a permanent stream. It is therefore impossible that any significant quantity of timber could have fallen into the streams from operations carried out under these regulations, which are enforced by both the timber companies and the Forestry Commission. The Arthur River is not used for transport of timber, as Wace implies, and there is no facility to salvage material washed down by floods. How then did the logs come to bear "the unmistakable marks of chainsaws"? Perhaps (and this is *my* hypothesis) some of those scavengers who collect "high-quality pieces for craft work" use such implements.

As a professional forester with almost 15 years experience (yes, I have worked in the Arthur River catchment), I am dismayed when a quality journal such as ANH wastes ink and paper engaging in debate fuelled more by emotion and prejudice than by sensible scientific observation.

—Stephen Campbell
Launceston, Tas.

It is good to know that the Tasmanian Forest Practices Code prohibits logging near creeks. My "sensible scientific observation" was simply that many large forest trees are lying on Arthur Beach and that they bear the unmistakable marks of having been felled by modern one-man chainsaws, with "clean cuts through the massive trunks". A reasonable inference is that the trees were washed down the Arthur River from logging within its catchment, much of which is old growth forest that has been logged for many years. If the trees didn't come down the Arthur River, how else did they get to the Arthur Beach?

—Nigel Wace
Australian National University

Beyond the Last Word

I'm sure there are many subscribers to ANH who hope Dr Freudenberger's Last Word article "Beyond the Kangaroo" (ANH Winter 1994) is really his 'last word'. To claim that "shoot 'em or wear 'em" is the answer to Australia's feral animal problem is simplistic and ignorant.

Harvesting feral animals has proven inherently flawed and has certainly not solved land degradation or saved native species from extinction. While eradication of feral animals has proved successful on some islands, shooting and poisoning on the mainland has failed to control feral numbers.

Wearing our feral animals has never occurred. Fur coats are made from animals kept specially caged and killed so as not to damage pelts. The animal liberation movement has discouraged wearing fur coats because of the cruelty of the intensive farming system.

Eating feral animals obviously does not meet current health regulations. If graziers are required to spend large amounts of money keeping their animals pest- and disease-free, why should harvesters of feral animals be exempt? And, while shooting excess stock during drought may be humane, the job is expensive both in time and money.

Shoot 'em? Professional shooters, whether from the ground or helicopter, cannot guarantee a 'clean kill'. Thousands of target and non-target animals suffer each year from human error.

The CSIRO is currently working on methods to control fertility in feral animals. Hopefully the future will bring the technology to humanely eradicate all feral animals and give our soil and native animals a chance at survival.

—G. Wicks
Nimmitabel, NSW

Let me congratulate you on publishing the article "Beyond the Kangaroo". David Freudenberger is indeed on the right track. I recently spent a week in the bush in the Hunter Valley, camped rather unexpectedly with three recreational hunters who were concentrating on eradicating feral pigs, cats and foxes from the property. Two were farmers, and the other was from Sydney. All displayed a wide knowledge of wildlife conservation and of the damage being done to wildlife by these feral animals in particular. They regard themselves as true conservationists and so do I.

This same property has supported a full-time pig catcher and a professional

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Fox control: should we stick to our guns?

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Plastic eaten by fish can end up in the stomachs of seabirds, such as this puffin (*Fratercula arctica*).

shooter part time for many months, yet I still saw several pigs and foxes daily.

City people are generally ignorant of the understanding and concern that many bush people and hunters have for wildlife conservation and of the scale of the private effort being made to eradicate feral pests. Beside landholders there are large numbers of very fit men chasing pigs for the export trade. It is hard, dirty, dangerous work that does not pay well. Our wildlife would be in a much poorer shape without them.

At sunrise on the last morning of my stay I walked into a beautiful little gully with the glorious songs of a Lyrebird drifting down from the rainforest above. I could not help but wonder how long these magnificent singers will continue to withstand the onslaught of the fox and feral cat. I am fearful that their time is very short.

—D. Birrell
Bulli, NSW

Polluted Oceans

Receipt of my copy of ANH Winter 1994, with Nigel Wace's informative article on ocean litter collected at Anxious Bay, South Australia, coincided with the arrival of a similarly disturbing report from Canada. In the magazine *Beautiful British Columbia*, Summer 1994, Allen Eade and Greg Shaw refer to a recent Canadian Federal Department of Fisheries and Oceans report that some beaches have more than 1,000 pieces of debris per kilometre, about one piece for every step taken. Styrofoam and other plastics account for about 80 per cent of the garbage. It is part of the 700,000 tonnes of rubbish estimated by the US National Academy of Sciences to enter the world's oceans every hour.

Eade and Shaw quote a study by Dr Alan Burger, a leading ornithologist on the Pacific coast, who found plastic pellets in the stomachs of 75 per cent of sampled seabirds, surface feeders that had mistaken floating plastic pellets for food. Puffins were among the birds found with plastic pellets in their stomachs. Since puffins usually dive for food, it was concluded that they must be getting the pellets from the food they eat.

The Canadian report raises the question of long-term effects of ingestion of plastic. Are Australian fishing grounds affected and, if so, are they in any way at risk? Have studies similar to Alan Burger's been carried out on our own seabirds, and on our fish too?

—R.H. Morrison
Burnside, SA

*Ingestion of floating plastic by seabirds has been investigated in Australian waters. Studies have been made on petrels washed ashore in Victoria (*Emu *vol. 86, pages 228–238, 1986) and muttonbirds in Tasmania (*Australian Wildlife Research *vol. 13, pages 481–488, 1986). There was a review of plastic pollution in Southern Hemisphere seabirds in* Cormorant *(vol. 16, pages 1–2, 1988). An international conference on marine debris held in Miami in May 1994 had a number of papers on pelagic plastics and their effects, but none on Australian seabirds. Most seabirds regurgitate or pass ingested plastic, but particular concern was expressed about micro-plastics from cosmetics and industrial aeroblast cleaners getting into oceanic waters and their impact on all marine wildlife, including seabirds.*

—Nigel Wace
Australian National Universty

ANH 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 each issue will receive a $20.00 gift voucher from the Museum Shop catalogue. The winner this issue is R.H. Morrison.

QUOTES & CURIOS

QUIPS

COMPILED BY GEORGINA HICKEY

Beat of the Emperors

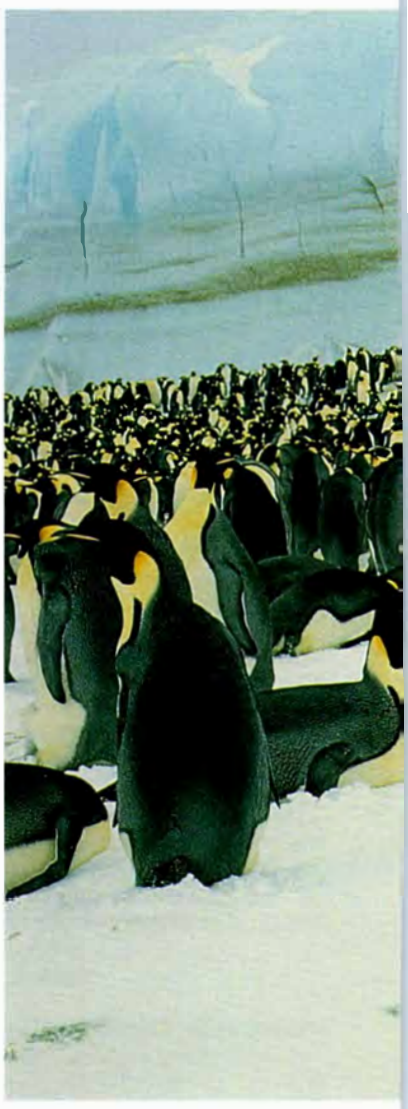
Adult Emperor Penguins (*Aptenodytes forsteri*) all look the same...even to each other. And so to identify sexual partners these Antarctic birds have developed a mutual display call, whose temporal patterning of syllables renders the calls of the two sexes clearly distinct, even to the human ear.

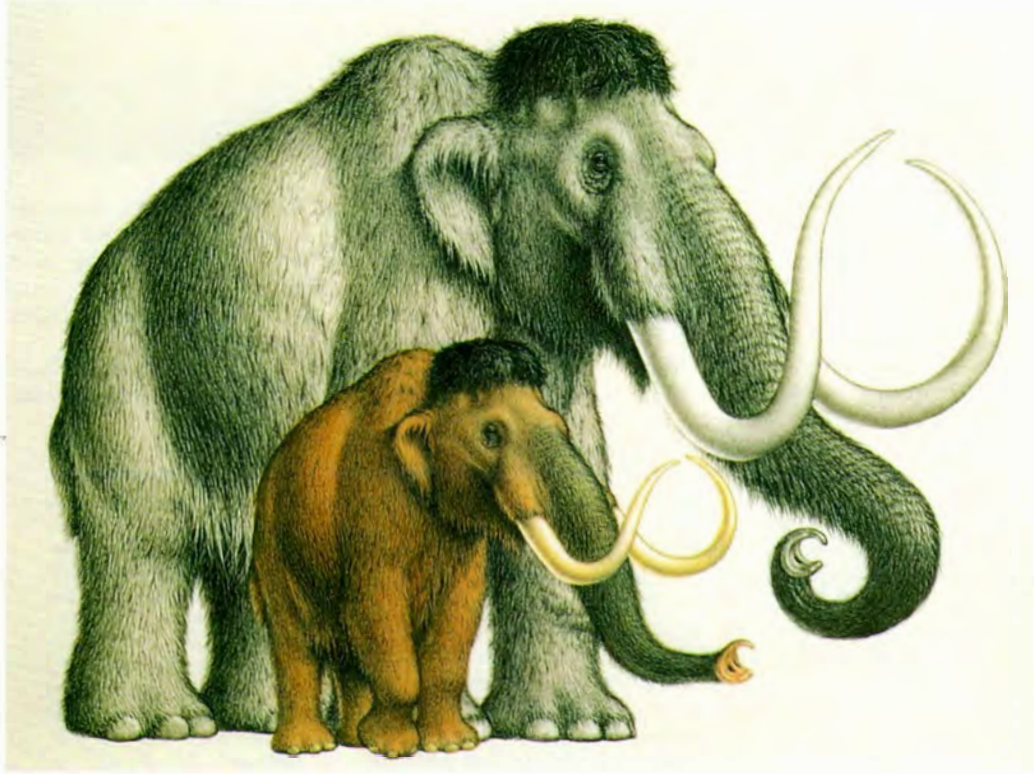
Once the relationship is formed, however, a more sophisticated method of identification is used. The Emperors, breeding on the sea-ice, do not build a permanent nest. Instead the male incubates a single egg upon his feet. While the males huddle together with their charges, the females set off towards the sea to feed up to 150 kilometres away. After two months they return to the colony to take up the responsibility of the chick. Met by a tightly huddled, noisy colony of thousands of seemingly identical males, they locate their partners with remarkable precision.

To determine how they do it, French biologist Patrice Robisson and colleagues recorded 58 mutual display calls from seven adult male Emperor Penguins. A computerised acoustic analysis revealed that the birds emitted a series of low-frequency beats with highly individual characteristics, enabling correct classification of the 58 calls.

Robisson and his colleagues believe that the Emperors' ability to produce beats may have evolved in parallel with the species' loss of territoriality. The King Penguin (*Aptenodytes patagonicus*) is the only other penguin species capable of emitting beats and it is also the only other penguin that does not have fixed nest sites.

—K.McG.





KAREL HAVLICEK

The discovery of fossil remains of dwarf mammoths represents the ultimate palaeontological paradox.

Midget Mammoths

The discovery and radiocarbon dating of fossils from an Arctic Ocean Island is forcing scientists to revise their thinking on mammoths. These woolly ancestral elephants weren't always enormous and weren't just creatures of prehistory.

Russian zoologist Sergei Vartanyan, from Wrangel Island State Reserve, and colleagues believe that teeth found on Wrangel Island, about 200 kilometres off the coast of Siberia, reveal a population of Woolly Mammoths (*Mammuthus primigenius*) that survived 6,000 years beyond the time the species was thought to have become globally extinct. Instead of dying out by about 12,000 years ago, well before the origins of modern human culture, mammoths seemed to have survived at least until the time of the Egyptian

NICK GALES/LOCHMAN TRANSPARENCIES

How do female Emperor Penguins identify their partners from the thousands of other seemingly identical males in the colony?

Pharaohs 4,000 years ago.

Just as intriguing as the age of the Wrangel fossil teeth is their size, at least 30 per cent smaller than the teeth of mainland Woolly Mammoths. In many dwarfed forms body size is reduced to a much greater extent than the teeth, so the Wrangel mammoths were probably "very small". They probably represent a population dwarfed by long-term development on an island, a process seen in other species.

How the midget mammoths survived the renowned late Pleistocene mass extinction of large mammals that wiped out their mainland relatives remains a puzzle. There are conflicting theories about the cause of the mainland extinctions but one is that environmental and climatic change altered the vegetation of the time, dramatically reducing the number of plant species and in turn affecting the animals. The researchers believe that Wrangel may have retained some of the Pleistocene grassland favourable to mammoths longer than the mainland, a possibility that the island's present-day vegetation appears to support.

—K.McG.

Menstrual Musing

Every woman must have wondered at least once during her reproductive life whether some failure of physiological design lies behind the monthly ordeal of menstruation. Painful cramping, lethargy due to iron loss and widespread cultural disdain have, after all, earned menstruation an image as one of nature's cursed and messy mistakes.

Now US evolutionary biologist Margie Profet, from the University of Washington, is forcing a radical re-think on the subject. Shrugging off centuries of ill-founded dogma and focusing on the role and benefits of the process, Profet has made the first serious attempt to interpret menstruation as an adaptation favoured by natural selection. There must be a good reason for menstruation, she reasons. Why else would such a physiologically expensive process persist?

Profet proposes that menstruation is a direct evolutionary response to internal fertilisation. As electron microscopy reveals, potentially harmful bacteria often attach to the heads and tails of sperm and can enter the womb and Fallopian tubes following sexual intercourse. Profet argues that menstruation is designed to rid the female body of these microbial interlopers.

According to traditional thinking, the uterine lining (the endometrium) builds up in preparation for a fertilised ovum and is simply sloughed off during menstruation if fertilisation fails to take place. But Profet is convinced that the shed endometrium is designed to carry away potential infection. Specialised spiral-shaped arteries in the uterus constrict and dilate in a sequence timed to firstly starve the endometrium, which effectively kills it, and then to flood it with blood that either expels it through the vagina or delivers a sufficient level of immune cells to kill micro-organisms. With a greatly reduced clotting ability and high concentration of immune system cells (macrophages), menstrual blood seems to be specifically designed for the purpose of washing over the uterine

L.F. & O.G. SCHICK

The Eastern Quoll (*Dasyurus viverrinus*) is just one of many mammals that menstruate. Is menstruation really a curse or a blessing in disguise?

lining and attacking and consuming alien cells.

Profet's theory suggests that menstruation should be widespread in mammals, all of which are fertilised internally. Unfortunately, research on menstruation in other non-human animals is scant. It is known that many, including other primates, quolls, bats and tree shrews, do menstruate. But further research is needed to establish whether it is a common mammalian attribute. It is not always obvious in other animals as the blood does not always exit the vagina but is reabsorbed by the body.

Profet believes other forms of uterine bleeding (periovulatory, implantation and postpartum) also have antipathogen functions. These forms of bleeding are important when sexual intercourse leads to pregnancy, since menstruation per se cannot occur then.

Although some eminent practitioners in relevant fields have welcomed Profet's views on menstruation as enlightening, refreshing and logical, other experts have dismissed her work as erroneous.

Profet, however, is becoming used to attracting attention for radical biological thinking. In looking for reasons for other so-called physiological mistakes she has developed theories explaining morning sickness (ANH Autumn 1990) and allergic reaction (ANH Winter 1993). The latter, she believes, is to provoke purgative reactions that rid the body of potentially toxic material. And morning sickness may prevent pregnant women from ingesting foods that might harm the foetus.

Although Profet's work stems from an evolutionary analysis, it potentially has important clinical relevance. For example, if she is proved right about menstruation, the treatment of irregular bleeding in women may need to be dramatically altered. Currently, it is routinely attributed to endocrine imbalances and hormone treatment is commonly prescribed. If, however, the cause of most irregular bleeding is found to be a physiological response to infection, current drug treatments may actually be detrimental.

—K.McG.

Female Doves Coo to Themselves

Sweet is the sound of doves cooing to one another. But all is not as it seems. New research shows that the female dove is actually cooing to herself.

Mei-Fang Cheng, from the Institute of Animal Behaviour at Rutgers University in New Jersey, USA, investigated the courtship behaviour of Ring Doves (*Streptopelia risoria*). This follows a set pattern of bowing and cooing, with the female always having the final coo. The pair then builds a nest together and an egg is laid about seven days later.

Previously it was thought that the calls and actions of the male during courtship stimulated the release of hormones from the pituitary gland in the female, causing development of the egg follicles and ultimately ovulation. However, when Cheng devocalised female doves and placed them in a chamber with an actively courting male and a series of prerecorded coos (either the female's own, another female's, or the male's), the greatest increase in follicle size was found in females that had heard their own nest coos played. Hearing another female's nest coo also produced an increase in follicle size, although to a lesser extent, but the sound of a male's coo had no effect.

Cheng concluded that it is the female's own coo that causes ovulation. But further studies have demonstrated that it is the excitement provided by the male during courtship that causes the female to coo.

That physiological changes can be induced by an animal's own vocalisation has fascinating implications. For example, in addition to attracting the mother's atten-

IRA BLOCK

A female Ring Dove incubates her egg on an artificial nest bowl.

tion, perhaps distress calling in infant animals causes the release of calming opiates in the brain. One may also wonder what chemicals are released by yelling at a football match. The implications for other human behaviours are enormous.

—Rachel Sullivan
Taronga Zoo

A Dietary Ménage à Trois

American Blue Jays (*Cyanocitta cristata*) eat acorns steadily during the autumn to give them energy to collect and cache food for the winter—food that includes acorns. However, acorns contain large amounts of tannins. These are compounds that are thought to protect plants from predation by impairing a predator's protein digestion, sometimes even damaging the digestive tract. While many predators have developed adaptive physiological mechanisms to overcome these effects, no such adaptations are known for Blue Jays. How might jays be neutralising the tannins in acorns?

Carter Johnson and colleagues from South Dakota State University and Virginia Tech thought it may have something to do with the weevil larvae that often live inside acorns and that have long been regarded as detrimental to oak forests. The researchers suggested that the larvae, if eaten in sufficient quantities, could minimise the effects of the tannins, allowing jays to make use of the carbohydrate and lipid energy stores inside the acorns.

The team tested their theory by feeding jays one of three diets: acorns-only, acorns plus 1.5 grams of larvae, or acorns plus five grams of larvae. Blue Jays on the acorns-only diet and the acorns plus 1.5 grams of lar-

JACK DERMID/OXFORD SCIENTIFIC FILMS

Blue Jays cache acorns for the winter. But how do they neutralise the toxic tannins within?

vae diet lost 15–19 per cent of their initial weight after three days, almost as much as if they had been starved. By contrast, jays on acorns plus five grams of larvae initially lost about five per cent of their weight but then stabilised. This seems to indicate that jays could live on acorns if they collected and ate sufficient numbers of larvae.

How larvae neutralise the tannins isn't clearly understood. But one thing is: it's not just the Blue Jays that may benefit from the larvae's activity; oak trees may benefit too. Some of the acorns that are carried far away and cached by Blue Jays may germinate. So acorn weevils, previously only thought to damage oaks, may actually be assisting them in their long-distance dispersal and, ultimately, survival.

—C.B.

Stings Go Better With Coke

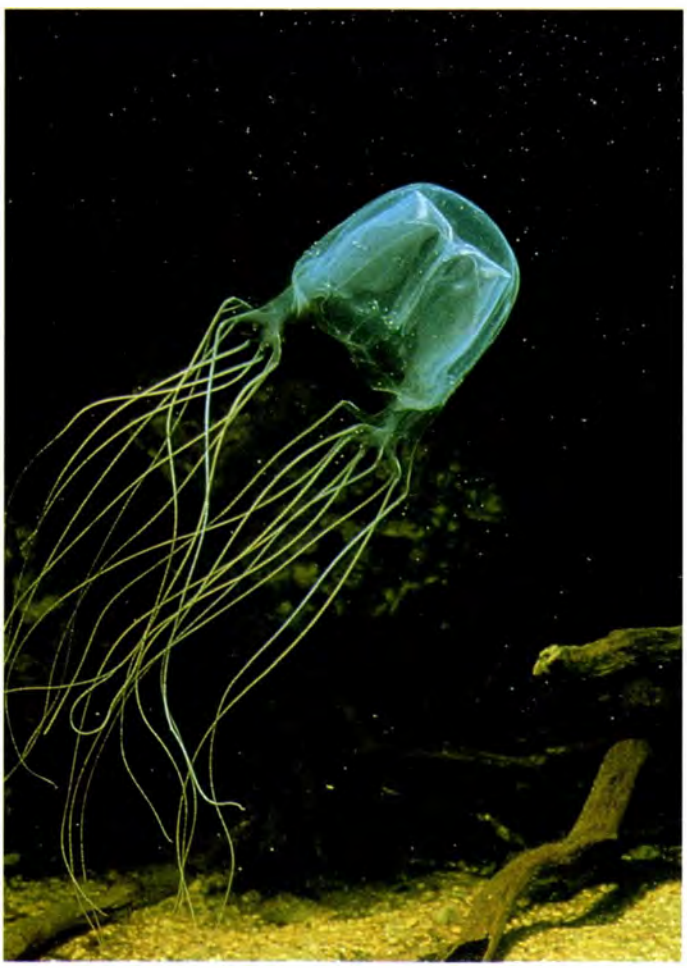
In 1980, in a breakthrough study by Robert Hartwick and colleagues from James Cook University of North Queensland, vinegar or weak acetic acid was shown to prevent stinging cells of the deadly northern Australian Box Jellyfish (*Chironex fleckeri*) from discharging their poison. The study also showed that methylated spirits, which had previously been used as a common treatment in Box Jellyfish stings, was in fact responsible for causing more stinging cells to discharge their poison. Today dousing with vinegar is the widely recommended first-aid treatment for Box Jellyfish stings.

This is all very well to know, but how practical is this knowledge? How often do you carry vinegar in your beach bag? Consequently a study comparing vinegar with other liquids more commonly found on the beach was conducted by Bart Currie, from the Menzies School of Health Research, and colleagues. Among the liquids tested were Coca-Cola, Fanta, lemonade, various fruit juices, tomato juice, milk, tea, various strength beers, wines, and even urine.

None of these liquids triggered the stinging cells but some—in particular four-day-old wine and Coca-Cola—were found to inhibit further discharge of poison. Coca-Cola reduced this by 30 per cent, while the four-day-old wine reduced it by 75 per cent. Only vinegar inhibited further firing of stinging cells by 100 per cent.

Even though four-day-old wine is probably just as uncommon on the beach as vinegar (indeed they are often one and the same thing!), the knowledge that Coca-Cola has some effect at inhibiting further poisoning by Box Jellyfish may well be enough to save someone's life. So, remember the saying: stings go better with coke!

—G.H.

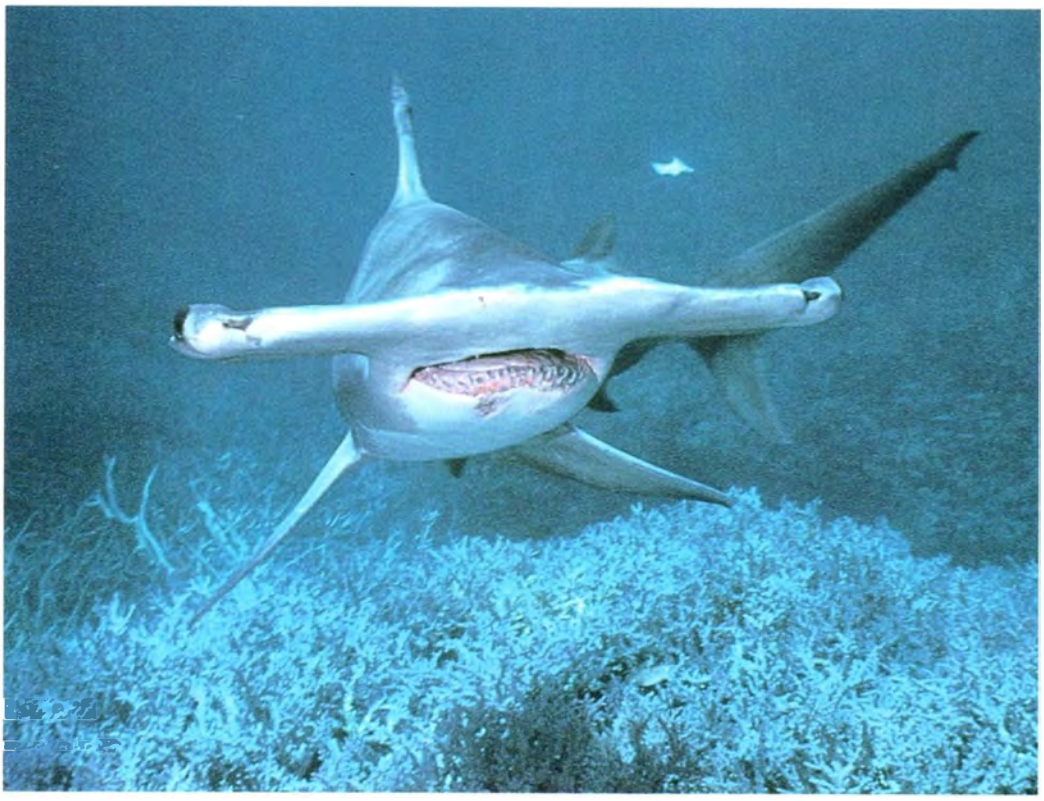


BEN CROPP

If you haven't any vinegar and you've been stung by a Box Jellyfish, try coke.

If I Had a Hammer

Hammerhead sharks (family Sphyrnidae) are so named for the exaggerated expansion of the head into what looks remarkably like a hammer. Scientists speculate that the hammer (or cephalofoil) functions as a bowplane, providing lift and enhancing manoeuvrability in water. In addition, the cephalofoil is covered with electrosensory cells called ampulla. Thus, the hammer shape of the head effectively spreads out these sensory cells, providing an increased area to detect and discriminate the source of electric fields. All animals produce electric fields, so heightened electrosensory



RON & VALERIE TAYLOR

The Great Hammerhead (*Sphyrna mokkaran*).

detection would be of great advantage to a shark that often looks for prey buried beneath sediment.

There are a number of species of hammerheads and they have cephalofoils of varying size. In the Winghead (*Eusphyra blochii*), the width of the head is half the length of the body. In fact, the head is so large that, when the animals are born, it is folded back along the sides of the body. At the other extreme is the Bonnethead (*Sphyrna tiburo*), which sports an oval-shaped head rather than a hammer-shaped one. Most species have what can only be called the 'normal' shaped cephalofoil although, when compared with the vast majority of sharks, there is nothing normal about the hammerhead.

The fact that sharks closely related to hammerheads have conventionally shaped heads, and the existence of hammerheads with head shapes of varying size, suggested to researchers that the cephalofoil originated small, like the oval-shaped condition expressed in Bonnetheads, and gradually became larger and larger. Thus, the evolution of the caphalofoil was considered to represent a remarkable case of progressive evolution, from a simple ancestral condition to an exaggerated derived state. After all, you could see snapshots of the various evolutionary stages in the species alive today.

This picture of the progressive evolution of hammerheads has recently been turned on its head (if you'll pardon the pun). By comparing the DNA of hammerhead species, I have recently shown that the small, oval-shaped head is not an ancestral character but a derived feature. Furthermore, the species with the most exaggerated head shape (the Winghead) is the most primitive member of the group. Instead of progressive evolution, the cephalofoil appears to have evolved rather quickly into the 'normal' hammer-shaped head. Once this innovation had evolved, it was subject to different selection pressures in different lineages. On the Bonnethead lineage, the head shape became smaller and oval. Although we can only speculate, it may be that the smaller head is used as a shovel to dig up soft sediments in search of invertebrate prey upon which the Bonnethead regularly feeds. On the Winghead lineage, evolution continued to stretch the head, and the resulting hydrodynamic inefficiency due to increased drag may have been compensated for by a greatly enhanced capacity to sense the electric fields of prey.

Adaptations often have more than one function. In many cases, the functions may not be mutually compatible. Selection driving change with respect to one function may have grave consequences for other functional aspects. Largeness may be a successful strategy for sumo wrestling, but you'll be lunch if you had to run from a Grizzly Bear.

—Andrew Martin
Smithsonian Tropical Research Institute, Panama

GUPPY NEIGHBOURHOOD WATCH

LABAT/LANCEAU/AUSCAPE INTERNATIONAL

Guppies (*Poecilia reticulata*) are popular aquarium fish and good planners. In a kind of 'Neighbourhood Watch', Guppies have been shown to plan the size of their families on the basis of how many neighbours they have.

Japanese biologists Miki Nishibori and Masakado Kawata of Shizuoka University divided tanks in half with glass. In one half, they put varying numbers of Guppies, sometimes all female, sometimes all male, sometimes a mixture. In the other half, they put a mating pair and monitored their brood size.

The smallest average broods were produced by pairs with no Guppies next door. As the number of neighbours increased, the brood size increased, but when it got too crowded, brood size decreased again. Visual density, that is the number of Guppies seen living nearby, alone determined brood size and not what proportion of fish were male or female.

For Guppies, keeping an eye on your neighbours makes evolutionary sense. There is no point producing a lot of offspring if densities are low because the risk of predation increases when there are fewer fish to choose from. The same applies to very high densities, as there may not be enough food to support a crowd. Only at medium densities are conditions most likely to favour the survival of a maximum number of offspring.

—C.B.

COURTESY WILLIAM TANG

The male cone of the cycad *Zamia pumila* heats up when its pollen is ripe.

Cycad Sex

Flowers are the plant kingdom's most conspicuous and widespread attractants of insect pollinators. But evidence is mounting that many primitive flowerless plants have developed other successful ways and means to entice insects to act as mediators in the crucial process of pollination.

The cycad *Zamia pumila*, which is abundant in southeastern Florida, is one example. Its pollen sacs and ovules are borne on scales grouped together in cones and, like all cycads, it has male and female cones located on separate plants.

As a living representative of an ancient and mostly extinct plant group, *Z. pumila* was once assumed to have been pollinated by wind. But, following a series of experiments by William Tang, while at the University of Miami, in which wind and insects were alternatively excluded from reproductive structures of *Z. pumila*, two species of beetles were identified as the plant's most likely pollination agents.

One of the beetles (*Rhopalotria slossoni*) uses male *Zamia* cones as a mating site. The male reproductive structures (sporophylls) are also high in starch and so provide a nutritious and attractive brooding site for the developing larvae. The beetles appear to locate the cones by a sweet minty scent, released in the late afternoon when the insects are most active. As more recent research involving Tang has revealed, male *Zamia* cones act like many insect-pollinated flowers and generate heat when their pollen is ripe. Through the same type of chemical reactions used by flowers such as the tropical Voodoo Lily (see QQC, ANH Spring 1991), temperatures can be raised in the cones by as much as five degrees and this may help to disperse the scent.

To achieve reproductive success, *Zamia* needs to entice the beetles brushed with pollen from its male cones to its female cones. Sugar and amino acid-rich droplets produced by female cones may serve as pollinator rewards. And it is possible that female cones, which lack the starch-rich tissue, may nonetheless mimic the appearance of male cones so that beetles are deceived into thinking they too will provide good larval nurseries.

—K.McG.

What's the Point of It?

The Narwhal (*Monodon monoceros*) is a species of toothed whale that lives among the pack ice in the Arctic Circle. Its only tooth is a spiral tusk—a left incisor that grows up to three metres long. Scientists have long speculated about the function of the tusk, including suggestions that it is used as a weapon against predators, a spear for catching fish, or even an ice-pick to open up breathing holes in the ice. However, because all males and only two per cent of females have a tusk, it probably has some kind of sexual role. Perhaps the tusk helps males attract females. (Observations of captive females being 'turned on' by a broomstick indicate that the length of the tusk may be important.) Or perhaps the tusk deters other males.

The Narwhal's remote location, and the fact that this is only accessible to researchers for a few weeks of the year in the height of summer, means that behavioural observations of this whale have been rare. To shed more light on the function of the Narwhal's tusk, Kevin Brear and John Currey of the University of York and colleagues adopted a more indirect approach. They studied a tusk that had been removed from a Narwhal legally hunted by Inuit people in Canada and imported to England. In this way they could infer what stresses the tusk had evolved for, without getting near a living Narwhal.

A series of mechanical tests revealed that the overall design of the tusk enables it to better withstand impact from the side than at its end, suiting it for fencing with other males and not for an ice-pick role. The helical growth of the tusk makes it straighter and thus harder to buckle if it happened to hit something head-on. Also, the grain of the tusk was shown to change across its width, preventing cracks from spreading right through the tusk.

Although admitting that the tusks may be put to other purposes as well, the researchers conclude that the design of the tusks is suitable for use in ritualised but aggressive combat between males. Fencing manoeuvres would establish whether the tusk, whose length is assumed to be important, are what they seem and not just a sham.

—C.B.

Carrie Bengston (a science communicator for the CSIRO) and Karen McGhee (a freelance science writer living in Newcastle, NSW) are regular contributors to QQC.

AUSTRALIAN PICTURE LIBRARY/MINDEN PICTURES

The Narwhal's tusk: spear, sword, ice-pick or sexual lure?

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QUICK QUIZ

1. What does CALM stand for?
2. In which Australian State would you find the Great Sandy Desert?
3. Name the major island that lies about 220 kilometres off mainland Australia.
4. Which mammal has the longest sperm?
5. The highest recorded body temperature for any terrestrial animal is 54° C. Is this animal (a) an ant, (b) a bee, or (c) a cicada?
6. What is the name of the disease that commonly afflicts Koalas, causing blindness and sterility?
7. What is the definition of a light year?
8. Chains of volcanoes along the east coast of Australia form a distinctive shape. What is this best likened to?
9. Who is the woman depicted on the new Australian $10 note?
10. What is the faunal emblem of Victoria?

(Answers in Q&A)

Bluebottles and their relatives come equipped with spearing, grappling and killing mechanisms for which they as a group stand alone in the animal kingdom.

BLUETACK AND TENTACLES

BY STEVE VAN DYCK

AT A GLANCE IT WOULD seem that bluebottles and ancient whaling boats held nothing more in common than the open sea and the mercy of the wind. But below the sails of both, a lethal collection of spears, coiled ropes and toxic chemicals betrays a darker common agenda.

Like the old whalers, bluebottles (*Physalia* spp.) and their close relatives the jellyfish, anemones, sea fans and corals come equipped with spearing, grappling and killing mechanisms for which they as a group stand alone in the animal kingdom. They are cnidarians (pronounced 'nye-dare-ee-ans'), hollow-bodied, mostly marine organisms whose delicate florid appearances hide an arsenal of straining weapons.

A bluebottle is not a single animal like a sparrow or an earthworm, but a colony of organisms more like a beehive or termite colony. One of its members bloats up with nitrogen and oxygen to become the infamous, blue, transparent float that resembles a roughly sutured rat-skin bladder. Below it, other members are specialised as either feeding, breeding or stinging polyps. Such a remarkable cooperative is either male or female, and the eggs or sperm it produces are released directly into the water where fertilisation occurs in a 'hit-or-miss' affair. An even less suspected bluebottle secret is that of the two-faced nature of the gas bag. There are two basic bladder designs under which a colony's tentacle mass can hang. 'Right-handed' bags float off to the left of the wind direction and *vice versa*. That way at least not all the local bluebottles end up stranded on the same beach in a howling north-easter!

It is the stinging tentacles below, however, that are the overpowering marvel of its macabre invention. In our familiar Pacific form of bluebottle (*Physalia utriculus*) one tentacle, the main fishing ribbon, is longer than all the rest and may reach an extended length of 13 metres or more. Along it, bunched like Lifesavers on a string, are thousands of stinging buttons each containing hundreds of microscopic capsules called nematocysts. These spherical capsules contain a tightly coiled, hollow, drill-like thread bathing in venom. When a fish or human leg blunders into the tentacle, the capsules discharge their tubules, which are fired out at great force into the tissues of the prey, and the venom is then pumped through the lines.

Discharging bluebottle tubules are capable of penetrating crab shells and stinging through heavy-gauge surgical gloves. They can also spear their way into the thickest of human heels but, lucky for us, we don't feel them there. This is a merciful concession considering the satisfaction that comes from exploding stranded bladders on the beach!

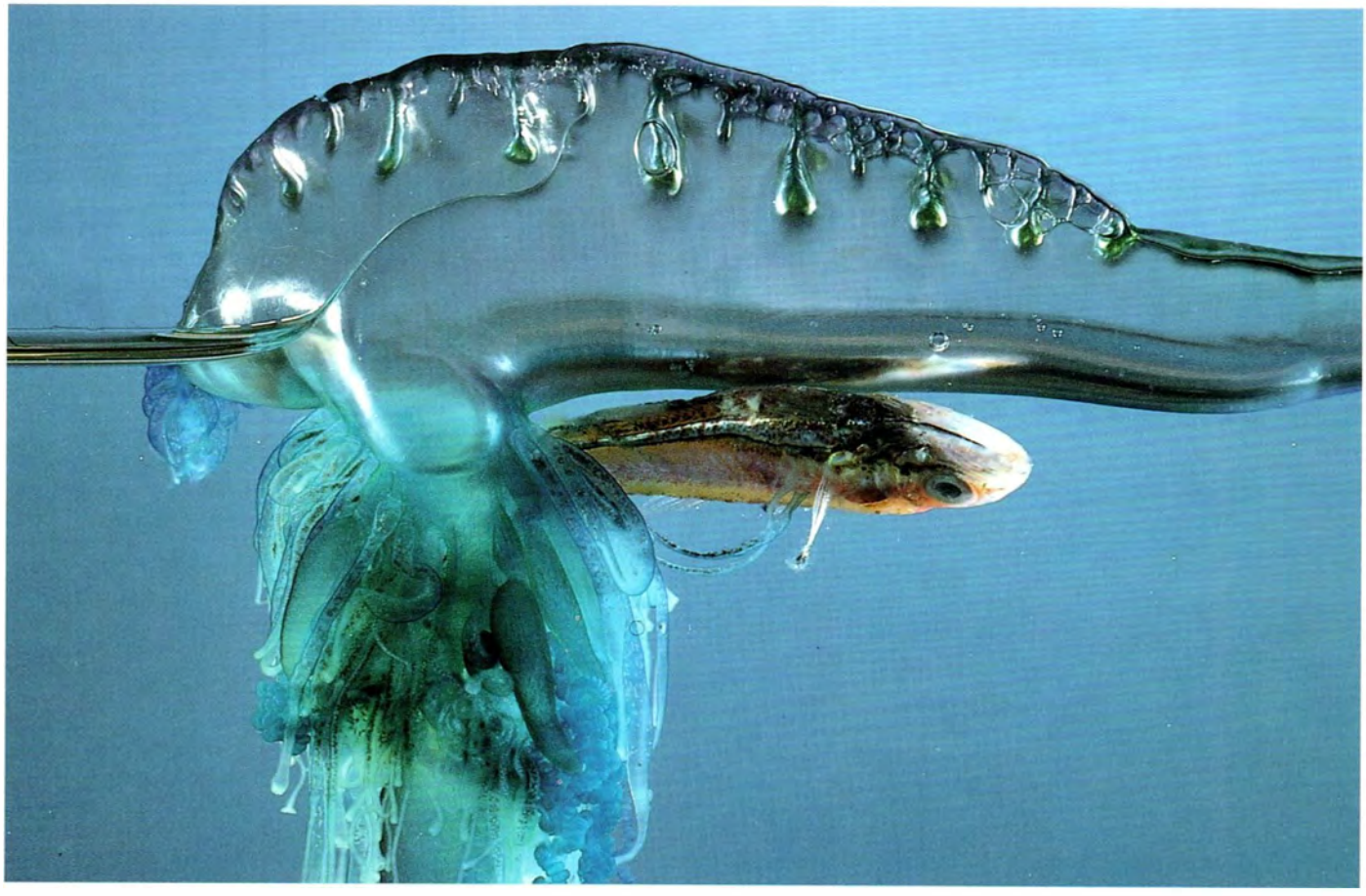
To be badly stung by a bluebottle is to despise that floating company in the surf forever. The pain, blistering, sweating, burning and itching may be followed by enlargement of the lymph glands, joint discomfort, nausea and vomiting. In rare cases victims may have difficulty in breathing.

Fortunately no-one in Australia has ever died from the sting of a bluebottle and, up until recently, most informed people took a small bottle of vinegar along with them to the beach to douse affected areas should a sting eventuate. The vinegar did not relieve the pain, but it was thought to prevent further tubule discharge while the adherent tentacles were picked off.

A line of stranded bluebottles is a familiar sight to most coast-loving Australians, who usually take this opportunity to get even with the little stingers.

A fish is caught by the Portuguese Man-o'-war's lethal artillery of stinging tentacles.

PHOTOS: KATHIE ATKINSON



Unfortunately, just when you thought you could remember it was vinegar and not metho or Calamine Lotion that was needed for bluebottle stings, it is now time to re-program! Vinegar is no longer flavour of the month!

In April 1993 the *Medical Journal of Australia* published the startling account of a much more dangerous type of bluebottle found beach-cast in vast numbers on the north Queensland coast. With floats measuring up to 15 centimetres long (our familiar *P. utriculus* is three to eight centimetres) and with up to 15 long blue and white tentacles, it is believed to be closely related to the western Atlantic bluebottle (Portuguese Man-o'-war) *Physalia physalis*, reported to be responsible for three deaths on the east coast of the United States. Treating the severe stings of the new north Queenslander to a well-meant splashing of vinegar may result in up to 30 per cent of the adherent undischarged stinging cells bursting open to inflict a further bout of envenomation and agony on the victim. Because most of us would find it impossible to tell the identity of a bluebottle by the appearance of its sting, treatment with vinegar is no longer recommended. (Vinegar is still recommended, however, for treatment of stings from the deadly Box Jellyfish, *Chironex fleckeri;* see QQC this issue.) The authors instead recommend the following first-aid treatment for all bluebottle stings: remove the victim from the water; monitor the airway, breathing and circulation and treat if necessary; wash off any remaining fresh adherent tentacles with sea water; apply cold/ice packs to relieve the skin pain.

Those of us who remember the old treatment of rubbing the affected area with sand will be grateful to note that maintenance of the tough, bronzed Aussie image no longer necessitates enduring such an unnecessary tertiary bout of agony. In fact, sand rubbing is now known to cause further discharge of stinging cells.

Despite the toxicity of bluebottles, some creatures eat them as a matter of choice. Sir Joseph Banks recorded that an albatross he once shot disgorged many that it had eaten, and some turtles are known to consume vast quantities. The dainty Sea-lizard (*Glaucus atlanticus*), a fantastic silvery-blue floating nudibranch, feeds on bluebottle tentacles and incorporates the undischarged nematocysts into a defence system of its own, and some young octopuses are also known to pick up fragments of broken tentacles and use them as weapons.

Humans, however, are to be dissuaded from eating them. In 1826, R. Madiana recorded an incident where a Negro cook was hanged for murdering his master by mixing dried, ground-up bluebottle (*P. physalis*) with his soup. The victim suffered dreadful stomach pains that persisted overnight until he died the following morning. Madiana, in defence of the hanged man, performed numerous experiments involving feeding sun-dried, powdered bluebottle to ants, fly larvae, a dog and a suckling puppy, all without devastating effects. Finally, to prove his point, he fed a fresh bluebottle to a chicken, which remained unaffected until it was caught and served to his family for dinner.

Other workers have questioned Madiana's methods, and are quick to point out that farmers in Guadeloupe (West Indies) and Colombia frequently and effectively use dried bluebottle tentacle to poison rats. I, myself, prefer to leave bluebottles well alone, save for the occasional indulgence with thong and heel at the high water mark...it is one of the few occasions when you can hit the bottle and leave the headache with somebody else. ■

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Steve Van Dyck is a curator in the Department of Vertebrates of the Queensland Museum where he has worked since 1975.

Their ecological flexibility was no protection from the habitat alteration wrought by the arrival and spread of Europeans.

GOLDEN BANDICOOT

BY ALARIC FISHER & JOHN WOINARSKI

A TRAGIC WAVE OF EXTINCtions has swept through the mammal fauna of arid and semi-arid Australia over the last century. Some members of the bandicoot family were among the most susceptible to this desolation, and their rate of decline was so rapid that they disappeared before much could be learned about their ecology or taxonomy. The fate of the Golden Bandicoot (*Isoodon auratus*) is similar to that of its relatives such as the Pig-footed Bandicoot (*Chaeropus ecaudatus*), Desert Bandicoot (*Perameles eremiana*) and Lesser Bilby (*Macrotis leucura*), but fortunately it has not been pushed over the brink of extinction. There is still the opportunity to redeem it, and a recent discovery in a remote corner of the Northern Territory adds further substance to that hope.

The historical distribution of the Golden Bandicoot incorporated the vast desert regions of Western Australia, Northern Territory and South Australia, extending eastward into western New South Wales and northward into the monsoonal tropics of the Kimberley and the Top End. It was a valued food source to many central Australian Aborigines who, along with early explorers and naturalists, testified to it as having been one of the most abundant of the medium-sized mammals. The species' extensive distribution and broad habitat range was quite remarkable, including sandy spinifex deserts, semi-arid heaths and woodlands, and grassy savannas, rugged sandstone ranges and vine-thickets in the monsoonal tropics.

This ecological flexibility was no protection from the habitat alteration wrought by the arrival and spread of Europeans, and the accompanying livestock, feral herbivores and predators, and new diseases and parasites. The Golden Bandicoot disappeared from the eastern margins of its range in the late 1800s, from the wetter areas of the eastern and south-western Kimberley and northern Northern Territory around the turn of the century, and persisted in the central deserts until approximately 1960. The arid limestone landscape of Barrow Island, off the central Western Australian coast, now provides a secure sanctuary for the small subspecies *I. a. barrowensis*, as well as a number of other threatened mammals. However, the larger mainland form (*I. a. auratus*) has been recorded recently from only a few scattered localities in the remote north-western Kimberley and nearby Augustus Island, and its future is far less certain.

The Golden Bandicoot was far from any list of 'possibles' when we set out to undertake a fauna survey of the Wessel Islands—an elongate chain stretching 100 kilometres out from the remote north-eastern corner of Arnhem Land. The value of islands as sanctuaries had prompted the Conservation Commission of the Northern Territory (CCNT) to initiate the progressive investigation of the Top End's islands, and the Wessel group was one of the first targets. With consultants Carol Palmer and Nic Gambold, and assisted by Dhimurru Land Management Corporation and traditional owner James Burripang, we spent eight weeks surveying 21 islands during the dry season of 1993. Despite extensive searching, spotlighting and the setting of some 7,000 traps, we found disappointingly few species, including a mere seven terrestrial mammal species, and apparently no bandicoots.

One of the more arcane techniques of fauna surveying is the collection of carnivore faeces, often containing bones and hairs, the latter highly diagnostic for mammal species. We collected a few samples of the dried scats of the wild dogs that patrol the beaches of the largest island, Marchinbar, and, some time after our return, sent them to scat-expert Barbara Triggs for analysis. An excited Barbara phoned a short while later to tell us that one of the samples contained bandicoot hairs unlike any of those in her reference collection. Discussions with James Burripang indicated that a small bandicoot was indeed present there. A rapid investigation of the bandicoot literature revealed that there were three specimens, collected from north-eastern Arnhem Land in 1939, held in the Australian Museum. These had at various times been labelled as the Northern Brown Bandicoot (*I. macrourus*), described as a new species *Isoodon arnhemensis* and thereafter generally regarded as the Golden Bandicoot. Barbara obtained hairs from these old specimens and found that they matched ours. The Marchinbar hairs were also sent to Norm McKenzie at the Western Australian Department of Conservation and Land Management (CALM), where they were also found to match Golden Bandicoot hairs from Western Australia.

Thus a species last seen in the Northern Territory about 40 years ago appears to persist on at least one island, providing of course that the dogs have not finished them off. Unfortunately, that is currently the limit of our knowledge, and this exciting find also poses further questions about this intriguing species. Was the species once common in Arnhem Land and, if so, what factors have led to its apparent decline on the mainland while the sympatric Northern Brown Bandicoot remains common? Should the considerably larger form found in the monsoonal tropics of Western Australia and the Northern Territory be regarded as a totally separate species to the Barrow Island form, which physiological studies have shown to be well adapted to an arid environment? How are these tropical forms related to a bandicoot population in Cape York (*I. obesulus peninsulae*), currently believed to be a subspecies of the Southern Brown Bandicoot of the temperate south?

Further research planned by both CALM and CCNT will hopefully help to clarify the distribution and status of the Golden Bandicoot, and address some of the questions about its taxonomy and the threats to the species. We may even hope that a recovery plan will eventually allow for its reintroduction to parts of its former range. Until such an event, sanctuary islands such as Barrow and Marchinbar will remain vital to the preservation of this species, and many like it. ■

Alaric Fisher is a PhD student at the Northern Territory University and Dr John Woinarski is a Senior Wildlife Research Officer at the CCNT. *The authors wish to acknowledge the assistance of the Australian Heritage Commission and Australian Nature Conservation Agency.*

KATHIE ATKINSON

Of the handful of rules I know, one of the most useful is the notion that all palm hearts are edible.

PALMS: PLANTS WITH HEARTS

BY TIM LOW

LEARNING ABOUT WILD FOODS would be safer if there were plenty of guiding principles, like "all figs are edible", or "most native peas are poisonous". Unfortunately, few such rules exist, and some touted in the past are nonsense, like the claim that red signals poison.

Of the handful of rules I know, one of the most useful is the notion that all palm hearts are edible. This holds true for most palms (family Arecaceae) throughout the world (although a few exceptions are known overseas). The heart or 'cabbage' is the inner white bud at the tip of the trunk, obtained by hacking away the palm frond bases. Cooked, or in some cases eaten raw, it has a pleasant sweet or starchy taste.

The palm rule was evidently known to 18th-century seafarers, for palms were among the foods eaten by both Captain Cook and Captain Bligh in Australia. In June 1770 at Endeavour River, Cook sent a party of men inland "to seek for refreshments; they return'd about noon with a few Palm Cabbages and a Bunch or 2 of wild Plantains [bananas]". Cook also ate hearts of the Cabbage Tree Palm (*Livistona australis*) at Botany Bay, remembering them as "small, but exquisitely sweet".

Palm hearts were probably an important food of many Aboriginal groups. Colonial policeman R.A. Johnstone recorded the Aboriginal harvest of Elegant Palm (*Ptychosperma elegans*) in northern Queensland in 1904: "The heart is...easily obtained by felling the palm, and taking the centre of the head, which is as white and crisp as good celery. It is sweet and juicy, and allays both thirst and hunger. The heart also of the cabbage-tree palm (*Livistona Australis*) [exact identity uncertain] is also eaten; sometimes it is roasted and mashed in water, which is sweetened by it and is then drunk".

PHOTOS: TIM LOW

Lawyer vine fruits are scaly with a reptilian appearance. A layer of brown edible pulp surrounds the large stone.

Walking Stick Palm fruits were an emergency food for two men whose Stinson plane crashed into Lamington Plateau in 1937. This small palm grows only in rainforests in northern New South Wales and southern Queensland.

Unfortunately, harvesting hearts kills most kinds of palms, even if the trunk is not felled. This led to the expression 'millionaire's salad' for hearts of the Coconut Palm (*Cocos nucifera*), since only a millionaire would destroy such a useful tree for one meal.

In South America, millions of wild palm hearts are canned for export, and some species are becoming rare. In Australia, Aboriginal harvesting had an impact on some palms. Botanist Peter Latz (Conservation Commission of the Northern Territory) believes the endangered Palm Valley Palm (*Livistona mariae*) of central Australia was reduced in numbers by past Aboriginal exploitation. But since harvesting ended, the species has increased significantly.

Hearts are not the only parts of palms worth eating. Some species bear edible fruits, including Walking Stick Palm (*Linospadix monostachya*), Black Palm (*Normanbya normanbyi*), and lawyer vines (*Calamus* species).

The Coconut Palm, of course, has an edible 'nut' containing sweet 'milk'. Harvested green, it is a popular snack food in tropical countries.

An interesting question is whether Coconut Palms are native to Australia. The varieties with big nuts found on tropical beaches most certainly are not. Indeed, they are significant weeds in some national parks and should be removed.

The usual view is that Coconut Palms never established in Australia because Aborigines harvested any nuts or seedlings found on beaches. The nuts did find their way here; Joseph Banks wrote in 1770 that "Our second lieutenant found the husk of a Cocoa nut

full of barnacles cast up on the beach; probably it had come from some Island to windward".

Coconuts are not considered native because Captain Cook and most early mariners never saw the palms on Australian shores. But a few early travellers did see Coconut Palms in remote locations.

John MacGillivray, surveying the Queensland coast in the *Rattlesnake* in the 1840s, found what may have been self-sown coconuts on the Frankland Islands near Cairns. He reported: "Two small clumps of cocoa-nut trees, loaded with fruit, were found on the eastern side of the island, within reach of the spray, in a place where they might have originated from a floating nut or two thrown upon the beach. This is the only instance in which I have seen this useful plant growing wild in any part of Australia."

A Coconut Palm was also found wild by A. Thozet in 1864 at Emu Park near Rockhampton, and somewhat later by Richard Johnstone (at Dunk Island and elsewhere). Both authors speculated that the palms in question were self-sown, but their arguments are not convincing; coconuts were often planted by mariners as food for shipwrecked sailors.

The Coconut Palm is an extraordinarily useful tree. It yields food, drink, alcohol, medicine, oil for frying, engine fuel (see QQC Spring 1994) and soap-making, fronds for thatching, and fibre (coir) for mats and stuffing. It was an important resource of Melanesians in Torres Strait, who farmed coconuts long before Cook 'discovered' Australia. On Murray Island (Mer) some houses are still thatched from the fronds.

To the Aborigines of northern Queensland, a different group of palms was also very useful: the lawyer vines (*Calamus* species). These are rainforest vines (but palms nonetheless) with very elongated, supple stems. Unfortunately they are very spiny and a curse to bushwalkers.

The famous beachcomber of Dunk Island, E.J. Banfield, aptly described the threat they pose: "Perhaps the most impressive feature of the jungle—that which takes fast hold, clings most tenaciously, and leaves the most irritating remembrances—is what is known as the lawyer-cane or vine (*Calamus*). It is a vegetable of tortuous ambitions, that defies you, that embarrasses with attention, arrests your progress, occasionally envelopes you in a net-work of bewildering, slender, and cruelly-armed tentacles, that everywhere bristles with points..."

As compensation, lawyer vines supplied Aborigines with edible fruit, medicines, thorns for fish hooks, and canes that were made into ropes, baskets, fish traps, axe handles and canoe stays. Asian lawyer vines are the source of rattan cane furniture, and Australian lawyer vines have been harvested for this purpose. In colonial days lengths of cane were even used as chain measures in surveying.

In Palm Valley near Alice Springs, the rare Palm Valley Palm survives as a reminder of wetter times long ago. Its nearest relatives grow hundreds of kilometres to the north.

But to pioneering Australians the most useful palm was Cabbage Tree Palm. First Fleet convicts ate the cabbages and split the trunks to make huts and fences. Later colonists wove the leaves into baskets and hats. Joseph Maiden noted: "The unexpanded fronds [are] prepared by being immersed in boiling water, or boiled, then dried and bleached; the fibre thus obtained is much valued for the manufacture of hats...The District Forester at Windsor reported that for the last twenty years the Hawkesbury Agricultural Society has given an annual prize for the best cabbage-tree hat..."

Maiden also told how Walking Stick Palms were cut from rainforests for walking sticks and umbrella handles. Large numbers were shipped to Europe last century and local demand surged after World War I when crippled soldiers returned home. Palms are certainly useful plants. ■

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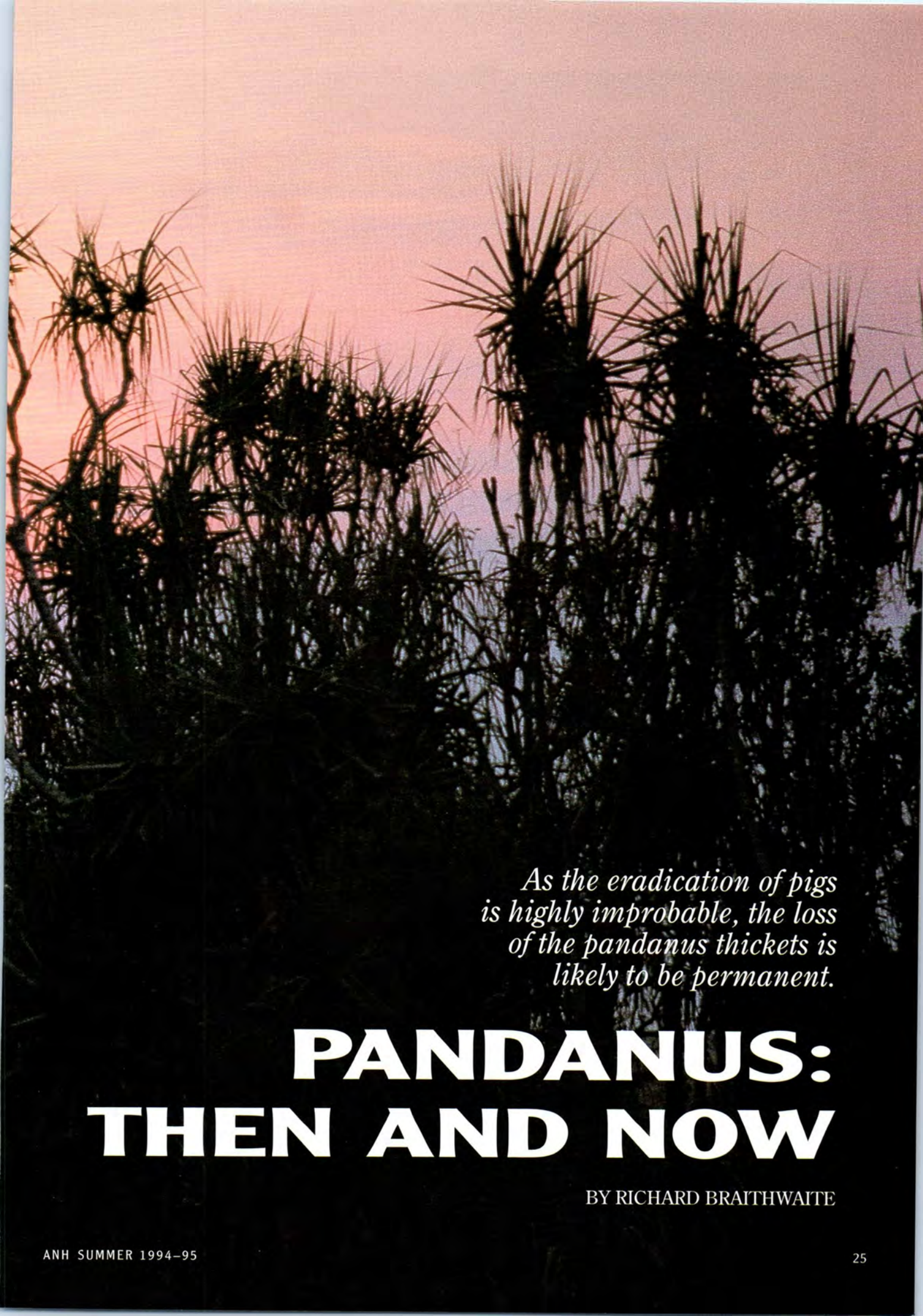
Tim Low is a Brisbane-based nature writer and consultant, and the author of four books about wild foods and medicines, all published by Angus & Robertson.

DONNA BROWNING/AUSCAPE INTERNATIONAL



As the eradication of pigs is highly improbable, the loss of the pandanus thickets is likely to be permanent.

PANDANUS: THEN AND NOW

BY RICHARD BRAITHWAITE

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

Sandstone Pandanus clings to rock faces of the escarpment country of Kakadu National Park.

THE PICTURE POSTCARD HAS MADE pandanus, elegantly silhouetted against a setting sun, the evocative symbol of tropical Australia. But this image is somewhat undeserved. Although well represented in Australia with about 40 species, the genus *Pandanus* is by no means exclusively Australian. About 600 species are scattered across the tropics and subtropics of Asia, Africa and Australia. Not only this, the density of pandanus in Australia has been greatly reduced.

Before the European invasion, the pandanus in northern Australia was more impressive and important than it is now. In 1845, before the arrival of buffalo and pigs to all parts of northern Australia, Ludwig Leichhardt described the presence of impenetrable thickets of pandanus in the Top End. Along the banks of the billabongs were walls of River Pandanus (*Pandanus aquaticus*) and along the fringes of the floodplains were tangles of Spring Pandanus (*Pandanus spiralis*). The Spring Pandanus has always extended from the black soil plains along the large rivers up along the sandy smaller drainage lines and into the open forest and woodland. A third species, Sandstone Pandanus (*Pandanus basedowii*), clings to the rock faces of the escarpment country.

The two lowland species of the Top End, River and Spring Pandanus, reached their greatest numbers in the 100 kilometres closest to the northern coast. Today they do not form thickets. When Leichhardt reached the buffalo-impacted areas near present-day Oenpelli in August 1845, his description of pandanus changed from "belt, grove or thicket" to "scattered stands or trees". Similarly, when Knut Dahl moved north-east from the Daly River and encountered the expanding distribution of buffalo and pigs in the Adelaide River area in 1894, he also talked of scattered pandanus.

In the mid 1980s, the national Brucellosis and Tuberculosis Eradication Campaign (BTEC) greatly reduced the population of buffalo. While

Both buffalo and pigs eat the shoots and leaves that sprout from the bases of pandanus trees and any juvenile plants, thus thinning out the thicket.

the relief from buffalo has allowed a dramatic recovery in other habitats, the pandanus thickets have not returned. In some areas, small sections thicken up, but the next time you see them they have been thinned out again. The extensive thickets the explorers saw have never returned. Curiously, small (0.1 hectare) fenced areas of scattered pandanus established in 1977 at the CSIRO Kapalga Research Station near the South Alligator River, within present-day Kakadu National Park, had returned to thickets within three years. Both buffalo and pigs were excluded by these fences, implying that pigs, which are now slightly more common, are suppressing the regeneration of the pandanus thickets. As the eradication of pigs is, from current perspectives, highly improbable, the loss of the pandanus thickets is likely to be permanent.

Both buffalo and pigs eat the shoots and leaves that sprout from the bases of pandanus trees and any juvenile plants, thus thinning out the thickets. With the decimation of buffalo following BTEC, grasses have replaced the former bare ground between the now scattered individuals of pandanus. Modern biologists refer to such thinned-out Spring Pandanus habitat bordering the floodplains as 'pandanus-lawn'.

AN INDIVIDUAL PANDANUS PLANT, ALSO known as screw-palm or screw-pine, has a complex and beautiful architecture. Each tree is of a single sex and typically four to eight metres high with two-metre-long leaves arising spirally in tufts at the end of branches. The leaves have three longitudinal lines of prickles, protection against small marsupial mouths but not against those of the larger introduced mammals. The previous season's leaves hang down forming a dense skirt when not burned. Larger trees sucker from the base and, if a collection of trees was to form a thicket, it would offer small animals the protection of an extremely complex habitat.

The crevices between the bases of adjacent leaves harbour many insects, including the attractive and highly flattened native cockroaches (*Cosmozosteria subzonata*) with their shiny black carapace with two to four cream stripes. It is likely that there are invertebrate species that are endemic to the habitat, but this has not been studied. There are certainly a number of vertebrates that show a strong association with pandanus, even in its current relatively sparse density. The Northern Dwarf Tree Frog (*Litoria bicolor*) is extremely

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Along with pigs, the Asian Water Buffalo (*Bubalus bubalis*) eats the suckers around the base of pandanus preventing the reformation of thickets.

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Black-footed Tree Rats are able to access the kernels by chewing through the hard woody end of the pandanus fruit.

abundant and is usually found between the pandanus leaf bases. It is commonly preyed upon by the elegant Green Tree Snake (*Dendrelaphis punctulata*), which is also usually associated with pandanus. The Crimson Finch (*Neochmia phaeton*) feeds mainly on insects and is always associated with pandanus. It has even been observed pecking holes near the mid-ribs of green pandanus leaves and obviously eating small portions of the leaves. The Purple-crowned Fairy-wren (*Malurus coronatus*) has a rapidly contracting geographic range, with locations in the Kimberley and the Gulf country of Queensland. The decline of this and other terrestrial species is clearly linked with the destruction of pandanus thickets by large introduced mammals.

The Spring Pandanus tree also creates a special ground environment. After a fire, one can see a platform of soil around its base. Normally this is obscured by a layer of cast-off pandanus leaves. This litter protects the soil from high temperatures, adds organic matter, inhibits erosion and may act as a site of aggregation for soil eroded from nearby. Whether there is a layer of litter or not, the architecture of the tree also facilitates the establishment of well-structured friable soil.

The spiral arrangement of the leaves on the branches produces a dense canopy that intercepts most of the rain drops. The uppermost and inner leaves on each of the upward-pointing branches are nearly vertical. These funnel the intercepted rain to their bases, which quickly fill and overflow down the spiral into the next and older generation of leaves. As the water works its way down through the canopy like champagne trickling down a stack of glasses, more and more is directed out to the tips of the leaves, which are increasingly inclined towards the ground. The water may eventually drip from a dense set (12 per square metre) of evenly distributed leaf tips a little over a metre from the ground. Like water off the back of a spoon, the intricate architecture of the trees thus slows and breaks down the eroding force of the raindrops of the intense tropical downpours. The degree to which this effect occurs depends on the length of the leaves and the size of the canopy. Some isolated stands on the floodplains have leaves only about 120 centimetres long, while in monsoon forest, leaves of 180 centimetres are common. Nonetheless the accumulations of friable soil are commonplace and are sites favoured by rodents and goannas for burrow systems.

Although some rodents, such as the Pale Field-rat (*Rattus tunneyi*), eat pandanus roots, they mainly eat grass and sedge parts, and may enrich the nutrient status of the soil under the pandanus by depositing their faeces there. Unfortunately, these special places at the base of the pandanus are also attractive to pigs. In addition to eating the sprouting leaves, they dig the soil, probably obtaining edible pandanus roots and rodents.

The small mammals that seem strongly associated with pandanus are the Grassland Melomys (*Melomys burtoni*) and the Red-cheeked Dunnart (*Sminthopsis virginiae*). They would have been much more abundant when the thickets were there to offer shelter from predators. The Dusky Rat (*Rattus colletti*) is an irruptive species that certainly periodically dropped to much lower densities after the establishment of buffalo and pigs. The pandanus thickets would have served as a refuge and

REG MORRISON/AUSCAPE INTERNATIONAL

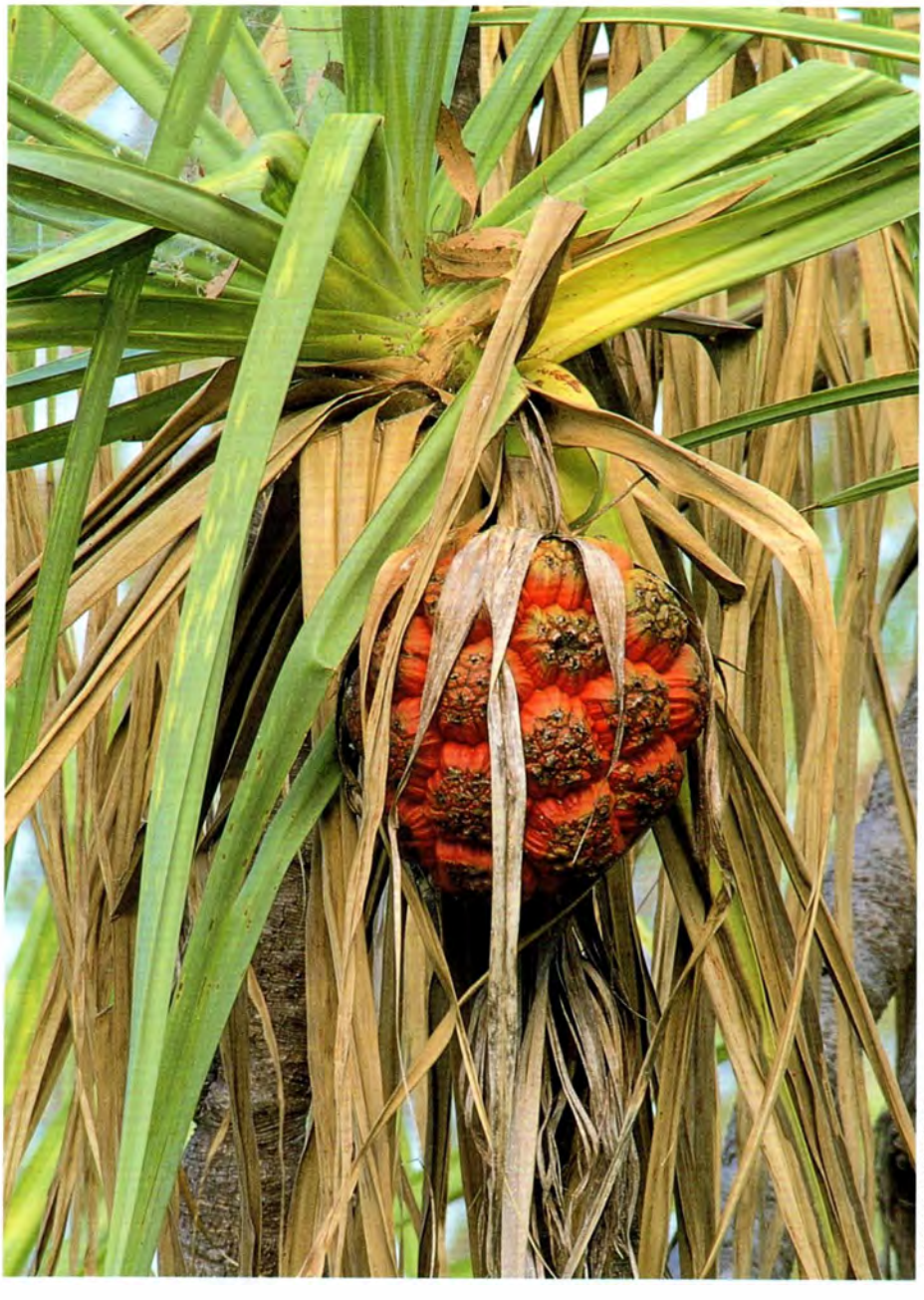
River Pandanus lines the edge of deep permanent water bodies in places like Kakadu National Park.

prevented the extreme lows seen in recent times. The Water-rat (*Hydromys chrysogaster*), currently uncommon in northern Australia, would have been more common in the vicinity of pandanus thickets. Leichhardt observed several retreats of flying-foxes (*Pteropus* spp.) in the densest shadiest parts of pandanus thickets in the Alligator Rivers region. In this situation their camps would have been safe from Aboriginal hunters. These days you only see flying-fox camps in monsoon, mangrove and paperbark forests.

Other mammals that are generally regarded as obligate tree-hole users build nests in the dense skin of dead leaves. The Common Brush-tailed Possum (*Trichosurus vulpecula*), Brush-tailed Rabbit-rat (*Conilurus penicillatus*), Black-footed Tree-rat (*Mesembriomys gouldii*) and a number of microchiropteran bats all do this. One cannot help but wonder whether species that are only known in the subcoastal Top End from single specimens, such as the Golden-backed Tree-rat (*Mesembriomys macrurus*), or sightings unconfirmed by specimens, such as the Spectacled Hare-wallaby (*Lagorchestes conspicillatus*), were dependent on the prickly protection of pandanus thickets. This subcoastal area with its large rivers and extensive fertile floodplains supports a high density of predators. The Dingoes of the north are large and abundant, and feed mainly on the waterbirds and small mammals associated with the wetlands. Similarly, an abundant and diverse raptor community concentrates on the wetlands. Heavy predation is endemic to these wetland areas. The former dense thickets with their unpleasant spines would have represented protection for any small animals in the area. In addition to mammals, these include at least 18 other bird, five snake and five lizard species not restricted to pandanus.

River Pandanus, with its stilt-type roots that are generally in standing water, also affords protection to a wide range of aquatic vertebrates. This microhabitat is particularly used as shelter by the abundant Arafura File Snake (*Acrochordus arafurae*).

Pandanus leaves are fleshy at the base and edible to a variety of mammals including humans.



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A cluster of the ripe and very edible fruit of the Spring Pandanus.

Pandanus leaves are fleshy at the base and edible to a variety of mammals including humans. Buffalo are able to subsist even on a diet of exclusively dry leaves. However, the most edible part is the large fruit, which is produced in clusters each dry season. By June the fruit has soft fleshy material (endoderm) embedded between tough fibres. Sulphur-crested Cockatoos (*Cacatua galerita*) and other large parrots tease the soft pulp out with their beaks, but leave the shredded fibres attached to the woody base. Looking remarkably like old shaving brushes, such damaged fruit are often found tens of metres from any pandanus tree. The Sulphur-crested Cockatoo appears to be the major disperser of pandanus seed, which remains in the basal part of the fruit. The Northern Snapping Turtle (*Elseya dentata*) feeds on the pandanus fruit when they fall into waterbodies and may also aid in seed dispersal.

KATHIE ATKINSON

Probably many animals opportunistically eat the fleshy endoderm but Aboriginal people generally roast or soak the fruit first to remove the somewhat astringent taste. On the other hand, the delicious nut kernels, which are 24–34 per cent protein, 44–49 per cent fat and taste like pine nuts, are extremely well protected by hard woody material. Of the native fauna, only the large Black-footed Tree-rat and Brush-tailed Rabbit-rat regularly chew their way into the kernels. This lack of native seed predators probably accounts for the asynchronous flowering and fruiting of Australian species; about one in 20 seems to fruit in any year. In New Guinea, where there are many more native predators and a much longer history of pigs, the fruiting is much more synchronous with all plants flowering and fruiting together every few years. The theory is that irregular but superabundant fruiting ensures that the huge amount of seed is not all eaten by the satiated predators. In Australia, the introduced pigs eat large numbers of pandanus fruit and Betty Meehan of the Australian Museum found Aboriginal people at Maningrida in the 1960s largely subsisted on the kernels from July to October each year. It is unclear how widespread this custom was and to what extent it became important as a result of access to steel axes, which greatly improved the efficiency of extraction of the kernels. Aborigines also use pieces of the fibrous fruit for camp fires, and make mats and baskets from fibre prepared from pandanus leaves.

The Spring Pandanus tree is probably the most combustible of any in northern Australia. It is the only tree that will always take the flame up into the canopy and burn intensely at almost any time. The trees are not killed. Perhaps the pandanus are freed from competition from other plant species by the fires, allowing the development of monospecific stands. Pandanus trees were sometimes ignited by Aborigines to provide light for nocturnal ceremonies. The thickets were also of value for collecting animals. The anthropological zoologist Donald Thomson has suggested that setting fire to pandanus stands was a standard way of killing and cooking small mammals in eastern Arnhem Land in the 1930s—an instant barbecue. Very little of this practice seems to occur now. The fragmentation of the once extensive pandanus thickets by buffalo and pigs has clearly decreased their attractiveness to animals seeking protective shelter. And the decline in food reward has presumably led to the decline in the burning practice.

An exposed, isolated and old Spring Pandanus tree with short leaves and burnt-off dead foliage.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

The Green Tree Snake is the snake most strongly associated with pandanus trees.

THE SUBCOASTAL AREA OF THE TOP END has extensive stands of pandanus irregularly distributed along the edge of the floodplains. They are part of the heterogeneous set of vegetation types commonly known as 'the margin'. In contemporary times, they have seemed less important than the monsoon forest and paperbark forests—habitats that now offer more resources to animals. However, when the pandanus-lawn areas were pandanus thickets, a host of animals would have used them. In this part of the landscape adjacent to the floodplains, the presence of a rich predator community has had a great effect on the community of the smaller vertebrates. We now know that monsoon forest birds feed extensively outside the small monsoon forest patches in which they breed. In other words, they use a constellation of vegetation types. It appears likely that the pandanus thickets served a similar function for other species, particularly the smaller mammals. That is, they were partly a habitat in their own right but were also a refuge for animal species that used the adjacent floodplains and margin vegetation types.

From our present perspective, the pandanus thickets are unlikely to return. A low density of buffalo and a varying one of pigs seem sufficient to prevent the reformation of pandanus thickets. Buffalo and pigs will not be eradicated. The only alternative is for pandanus areas to be fenced, in order to exclude buffalo and pigs but not the smaller creatures that would use them as refuges. This is an unlikely prospect for the renaissance of what seems to have been a key habitat in the maintenance of the pre-European wetland animal community. ■

JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

The Golden-backed Tree-rat frequents pandanus and regularly eats the kernels from the fruit. Today this mammal is extremely rare in the Northern Territory.

Further Reading

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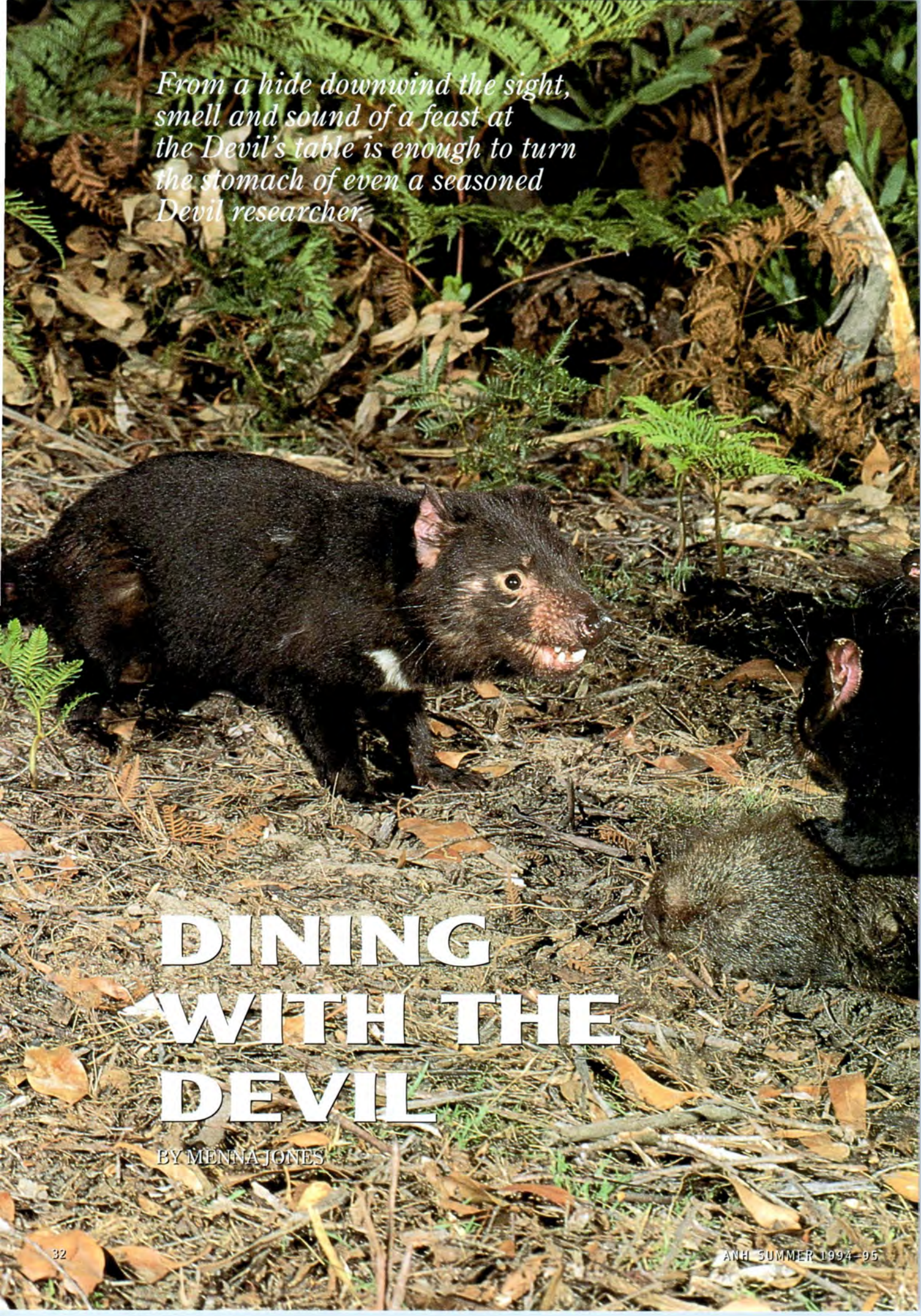
Richard Braithwaite is an ecologist with the CSIRO Division of Wildlife and Ecology in Darwin where he is Program Leader. He has researched conservation issues in northwestern Australia for 14 years.



From a hide downwind the sight, smell and sound of a feast at the Devil's table is enough to turn the stomach of even a seasoned Devil researcher.

DINING WITH THE DEVIL

BY MENNA JONES

A new arrival at a wombat carcass is challenged by the Devil at the rear. The young Devil at the front standing on the carcass is screaming, too anxious to feed even though it is being ignored.

PAT WISE

"I JUST CAN'T BEAR TO LOOK AT IT. That animal is so revolting!" exclaimed a tourist, rapidly disappearing inside as a Tasmanian Devil shouldered its way through the group of possums at the feeding platform next to the Cradle Mountain Lodge in northern Tasmania. Other tourists retreated a fraction from the railing that separated them from the feeding platform. The Devil returned the apprehension, shrinking from the noise and lights, and proceeded to nose through the food scraps for bits of meat, snapping at a possum's tail when its owner was careless enough to dangle it within reach.

Carnivores of all shapes and sizes have long inspired horror in some people, resulting in their persecution and endangerment worldwide. This fear presumably arises from the potential for being on the menu. Scavengers, in particular, have received bad press, being associated with rubbish dumps, carcasses and bad smells. The popular image of the Tasmanian Devil is of a ferocious and odious animal that, during the night, voraciously butchers anything of animal origin. The very name 'Devil' suggests evil and the powers of darkness. How did the Devil get this name and is this reputation deserved?

TASMANIAN DEVILS (*SARCOPHILUS HARRISII*) are squat, dog-like animals, not unlike a short-legged Bull Terrier in appearance, with a massive head and neck, powerful jaws and strong teeth. Males weigh nine to 12 kilograms, females five to eight. They are jet black with a 'henna' sheen to the short coat and variable white markings on the chest, flanks and rump. Their hindquarters slope, giving them a characteristic rocking, cantering gait. Fat stored in the tail gives it a 'carrot'-like shape.

On finding a strong-smelling, black animal, red mouth full of destructive-looking teeth, ears glowing red and screaming on a dark night in one's poultry shed, it is not difficult to imagine an early settler making the association with the Devil. (When confronted with a stressful situation, Devils blush, their delicate and hairless ears turn a deep red.) But does their behaviour also live up to their name?

On finding a black animal, red mouth full of teeth, ears glowing red and screaming, it is not difficult to imagine an early settler making the association with the Devil.

As the generic name *Sarcophilus* (literally 'flesh-lover') implies, Tasmanian Devils are meat-eaters or carnivores and are particularly efficient scavengers of dead flesh. Early one morning I followed a large male Devil back to the forest edge after he had spent three hours of the night in several sessions gorging on a dead wombat. From the rear his distended belly was twice the normal size of his body. Some of their gastronomic feats are legendary, rivalling Monsieur Creosote from "The Meaning of Life". Stories abound of deceased draught horses disappearing overnight, just the metal shoes remaining! Although the time frame for this is somewhat distorted, the general rule is, as long as it has some meat or flesh smell to it, Devils will try to eat it. Some of the more unusual items I have found in Devil droppings are bits of rubber thongs, silver foil and plastic, numerous sharp Echidna spines, parts of leather boots and Reeboks, jagged pieces of skulls including teeth, a blue tea towel, and undigested carrots and corn. A rather smelly pair of woollen socks I left outside my tent one night had the soles chewed off by the morning!

Most of the Devil's diet, however, consists of native animals, largely Common Wombats (*Vombatus ursinus*),

TASMANIAN DEVIL

Sarcophilus harrisii

Classification
Family Dasyuridae (carnivorous marsupials)

Description
A squat, black animal, with white markings on chest, shoulders and rump. Large head and neck, with powerful jaws and strong teeth. Males averaging 10 kg, females 6 kg. Average life span 6 years.

Distribution and Status
Widespread in Tasmania, but most common in eucalypt forests and woodlands. Wholly protected. Common, especially in the north-east. Probably secure.

Habits
Nocturnal. Dens in underground burrows. Voice includes a range of sounds from snorts, low barks and continuous growling, which increases in intensity to yowling and screaming, especially when fighting over food.

Food
Mostly wombats, wallabies, possums, small mammals and birds. An efficient scavenger, eats anything of animal origin and consumes all of a carcass except the largest bones.

Breeding
One litter a year of up to four young. Mates in March, giving birth three weeks later. Four-month pouch life, young left in grass-lined den from August until weaned in January. Lasting pair bonds not formed.

DAVE WATTS

A Devil emerges from the edge of the bush and stops to observe other Devils feeding on a carcass before approaching.

Red-necked Wallabies (*M. rufogriseus*), Tasmanian Pademelons (*Thylogale billardierii*), Common Brushtail Possums (*Trichosurus vulpecula*), Common Ringtail Possums (*Pseudocheirus peregrinus*), and smaller creatures like Sugar Gliders (*Petaurus breviceps*), Dusky Antechinuses (*Antechinus swainsonii*), Long-tailed Mice (*Pseudomys higginsi*) and birds.

Devils feed together on larger carcasses of wallabies and wombats, mainly because a single Devil can't defend all sides of the carcass by itself. The competition is tolerated while there is enough to go around, but becomes more intense as the carcass gets smaller. The larger the carcass, the more Devils that can feed at the same time, spacing themselves at least whisker distance apart. The record is 22 Devils feeding simultaneously on a dead cow.

Communal feeding at carcasses is noisy and violent. There is continual jostling for positions, with Devils shouldering each other, biting neighbours' jowls and chasing less dominant individuals away. To defend a position, Devils confront each other head on, growling in a monotone and displaying a fantastic array of teeth, sharp and white in young animals, yellowed and worn in older individuals. The growling escalates with a crescendo and ends in a screech with both Devils on their hind legs and jaws interlocked. Such displays of aggression, however, are mostly 'sabre-rattling', with very few injuries occurring.

Each Devil needs to feed for about an hour and a half to satisfy its appetite. Newcomers must wait until one of the Devils is no longer hungry enough to defend its position. Larger or older Devils stand a better chance of joining

Newly weaned juvenile Devils are adept at scampering five metres up small trees. This one is climbing above adults feasting on a carcass from which it was excluded.

I once observed Devils accessing a thick-skinned dead wombat through the soft belly and literally eating the animal inside out. Tales also exist of Devils camping inside the rib cage of a cow.

in the feed. Adult Devils sometimes back into a carcass taking the brunt of the bites on their rump, resulting in the battle-scarred appearance of old animals. Juvenile Devils, if hungry enough, are able to gain access to the carcass but more typically they stand with their front feet on the carcass, screeching incessantly in the ear of the nearest adult Devil, too anxious to eat even though the adult has allowed it in to feed.

From a hide downwind the sight, smell and sound of a feast at the Devil's table is enough to turn the stomach of even a seasoned Devil researcher. I once observed Devils accessing a thick-skinned dead wombat through the soft belly and literally eating the animal inside out. The Devils crawled completely inside, creating the macabre spectacle of a convulsing skin with gooey Devils re-emerging. Tales also exist of Devils camping inside the rib cage of a cow they were eating.

Devils are well-adapted for scavenging. They consume all parts of a carcass, excluding only the heaviest bones such as wombat skulls. Fierce competition encourages Devils to bolt their food, swallowing large chunks whole. I have found the whole forearm of a wallaby in a dropping. However, their massive jaws and strong teeth usually enable them to pulverise most of the carcass. Bones are cracked on the second molar tooth, which is reduced to a blunt stump by the time the Devil is three years of age—about halfway through its life. The third and fourth molars, whose function is to slice meat, remain sharp throughout the animal's life. While numerous bone splinters are characteristic of Devil droppings, the white, calcareous powder often present indicates that substantial amounts of bone are digested. In this way, Devils are similar to hyenas and differ from other carnivores that do not have teeth specialised for scavenging.

While primarily scavengers, there have also been numerous observations of Devils perhaps opportunistically chasing, grabbing onto and in a few cases killing animals ranging from possums to wombats in size. They appear to capture prey either by ambush or persistence, wearing the prey down. Devils are not swift runners but can maintain a steady 'lope' over many kilometres. The exact proportion of their

Two Devils are fighting near a carcass. Subordinance is expressed by the Devil on the right with open mouth, crouching stance and raised tail. Both Devils are screaming at each other.

DAVE WATTS

DAVE WATTS

diet derived from hunting or scavenging is not known. Extrapolating from studies done by Hans Kruuk at the Serengeti Research Institute in the 1960s on the African Spotted Hyena (*Crocuta crocuta*), an animal that plays an ecologically similar role to the Devil, I suggest that they are quite flexible and opportunistic in their feeding behaviour. They are probably capable of living entirely from hunting but will take free meals from animals already dead by preference. The only land animals that are known to live entirely from scavenging are vultures, which can see and move quickly over large distances. Mammals cannot do this and the number of animals dying naturally in the bush is usually not enough to sustain the high densities of Devils.

Given their efficient scavenging habits and their ability to kill, it is not surprising that some livestock farmers are wary of Devils. While improperly housed poultry is fair game, there have been gruesome stories of dogs disappearing from the ends of chains. Nick Mooney, of the Tasmanian Parks and Wildlife Service, has watched Devils around flocks of sheep and deals with farmers' enquiries. He concludes that healthy sheep with lambs are quite safe from Devils and only weak or sick animals are at risk. "Them black bastards" is an expression I have frequently heard referring to Devils by rural Tasmanians, although occasionally I thought with a hint of proprietary endearment. Some farmers consider Devils to play an important role in keeping paddocks clean of dead animals, thus reducing the chance of fly strike on sheep, and they are probably right.

ALTHOUGH HIGHLY SOCIAL, DEVILS ARE not territorial and do not form lasting pair bonds. David Pemberton, in his PhD study of Devils in north-eastern Tasmania, found that each animal uses an area in the order of 10 to 20 square

Dining with the Devil can certainly be a messy affair.

DAVE WATTS

kilometres, defined as its home range, which it shares with many other Devils. They use a number of dens in their home range which are usually underground burrows. On the front legs of Devils and in a halo around the face are long whiskers with which they feel their way in the dark, somewhat like 'touch-parking'.

Devils emerge from their den after dark and may travel up to 15 kilometres during the night. They are basically forest animals, shy of open spaces, and travel on the forest floor. Spool-and-line tracking, a technique whereby a long spool of sewing thread is glued to the animal's fur so it leaves a fine thread behind it as a trail, reveals very detailed information about the animal's use of habitat. I have followed Devils' trails along cliff edges, across streams on logs, into dens and have occasionally found remains of meals.

The climbing abilities of young Devils, especially those reaching roosting hens, are well known. Spool-and-line tracking has revealed that even large male Devils weighing ten kilograms are capable of climbing several metres up a small tree. But why do they climb trees? After attempts to lure Devils up trees of different types and sizes explicitly to test their climbing ability, I concluded that they don't generally look for food up trees but may climb to gain a vantage point, much as they visit cliff tops. While a sleeping bird may be fair game, possums outstrip Devils in agility above the ground and it is unlikely that Devils would be able to catch them.

DENISE GREIG/NPIAW

Devils mate repeatedly over a ten-day period in March, during which time the male constantly guards the female and both of them fast.

BY POPULAR IMAGE, THE DEVIL IS A ferocious and odious animal that races around the bush baring a mouthful of vicious-looking teeth and terrifying all in its path. But does the Devil deserve this reputation?

While decidedly uncivil towards other Devils, most of their scrapping is bluff. Ferocious is not a word that comes to mind when I think of Devils. My experience of studying Devils in the wild leaves me with an impression of a belligerent but wary little animal, generally shy but occasionally inquisitive of people and definitely ruled by its stomach. Devils normally flee at the sight of humans. Trapped Devils, while sometimes becoming cantankerous, generally lie very still just trembling quietly with fear. Handled gently but with respect for the potential of serious damage, wild Devils rarely attempt to bite. They will try to creep away, freezing if you move, similar to the game of 'Grandmothers' Footsteps' we used to play as children. They are classic 'scaredy-devils'. I have also known Devils to become 'trap-happy', where certain individuals will get themselves trapped night after night for the reward of a free feed. After the first few captures, they curl up and sleep in the trap waiting to be released. Returning after an absence I sometimes find droppings in unset traps where hopeful Devils have come looking for food.

My experience of studying Devils in the wild leaves me with an impression of a belligerent but wary little animal, generally shy but occasionally inquisitive of people and definitely ruled by its stomach.

Hideous yowling in the night fit to 'raise the Devil', whole carcasses disappearing by morning, dogs gone off chains, the Devil certainly lives up to parts of its reputation. But as supreme predators ourselves, the human persecution and dread of carnivores based on their eating habits, particularly when we rarely feature in their diet, is a little irrational. We've all got to eat! Playing on these fears, however, the open-mouthed threat display of the Devil—the 'toothy' image—is the one promoted to the public and popularly emulated on the American Bugs Bunny cartoons.

Most town-dwelling Tasmanians and visitors have little contact with Devils.

DAVE WATTS

The author, Menna Jones, with one of her study animals.

This is despite the fact that Devils inhabit at least the outer suburbs of Tasmanian cities. They do make their presence known, however, if they mate and rear young under someone's house. This is a rather noisy and smelly affair, particularly when the female brings food home for the young. Devils, particularly juveniles, become more noticeable when they start to roam from their dens. They can often be seen on roadsides, resembling little wind-up toys as they flee from cars in blind panic, tails stuck straight up in the air, every hair standing on end.

One of the great pleasures of studying wild mammals is the special feeling that comes from observing the dramas of life in a world normally hidden from human view. At nightfall, people go inside shutting out the dark, but the bush comes alive with a second shift. Wombats trundle past snuffling, ringtail possums chirrup from the tree-tops and Devils emerge growling. These special experiences more than make up for the days spent slushing through wet bush in wind-driven sleet and the inconvenient hours that come with working on nocturnal animals.

The largest remaining marsupial carnivores in the world, Devils are very special animals. They have fared better than their larger Australian relatives, the Thylacines. Despite being quite rare earlier this century, numbers of Devils have been steadily increasing for the last 30 years and their status is considered to be secure. They seem to coexist quite well with some human activities

HOW TO SEE DEVILS IN THE WILD

Devils occur all over Tasmania and their tracks and characteristic droppings can be seen on walking tracks. The droppings are grey in colour, white when dry, and contain lots of fur and usually bone fragments. Tracks are small and square, with four toes on the hind feet and five on the front.

The best places to see Devils are in the north-east of the State at Mt William National Park where they are very common, or at Cradle Mountain or Asbestos Range National Parks in the north. Rangers can advise on where to go for a slow drive at night to see Devils and other wildlife on the road. The best chance of seeing them in daylight is in January when there are lots of newly weaned young that are hungry and the nights are short.

DAVE WATTS

Front (right) and hind (left) Devil footprints.

KATHIE ATKINSON

Devils or black angels? The true nature of the animal belies its popular image.

such as forestry and livestock grazing and even perform a useful function in cleaning up the bush. They are the bush undertakers. An integral part of the ecological system in Tasmania, these belligerent little battlers may long continue to growl and snort their way around the bush, scrapping with their neighbours and crunching their way through deceased wildlife. And, while it is easy to see how they gained their name and popular image, their true nature belies their reputation. ■

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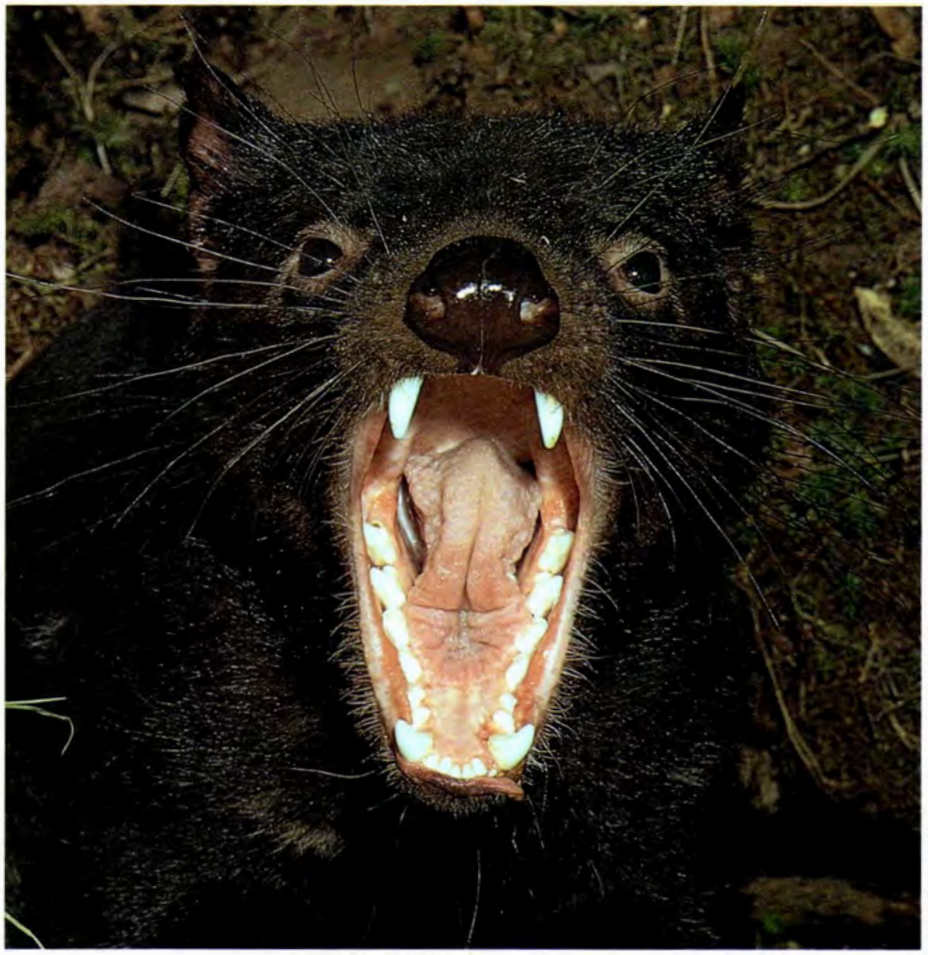
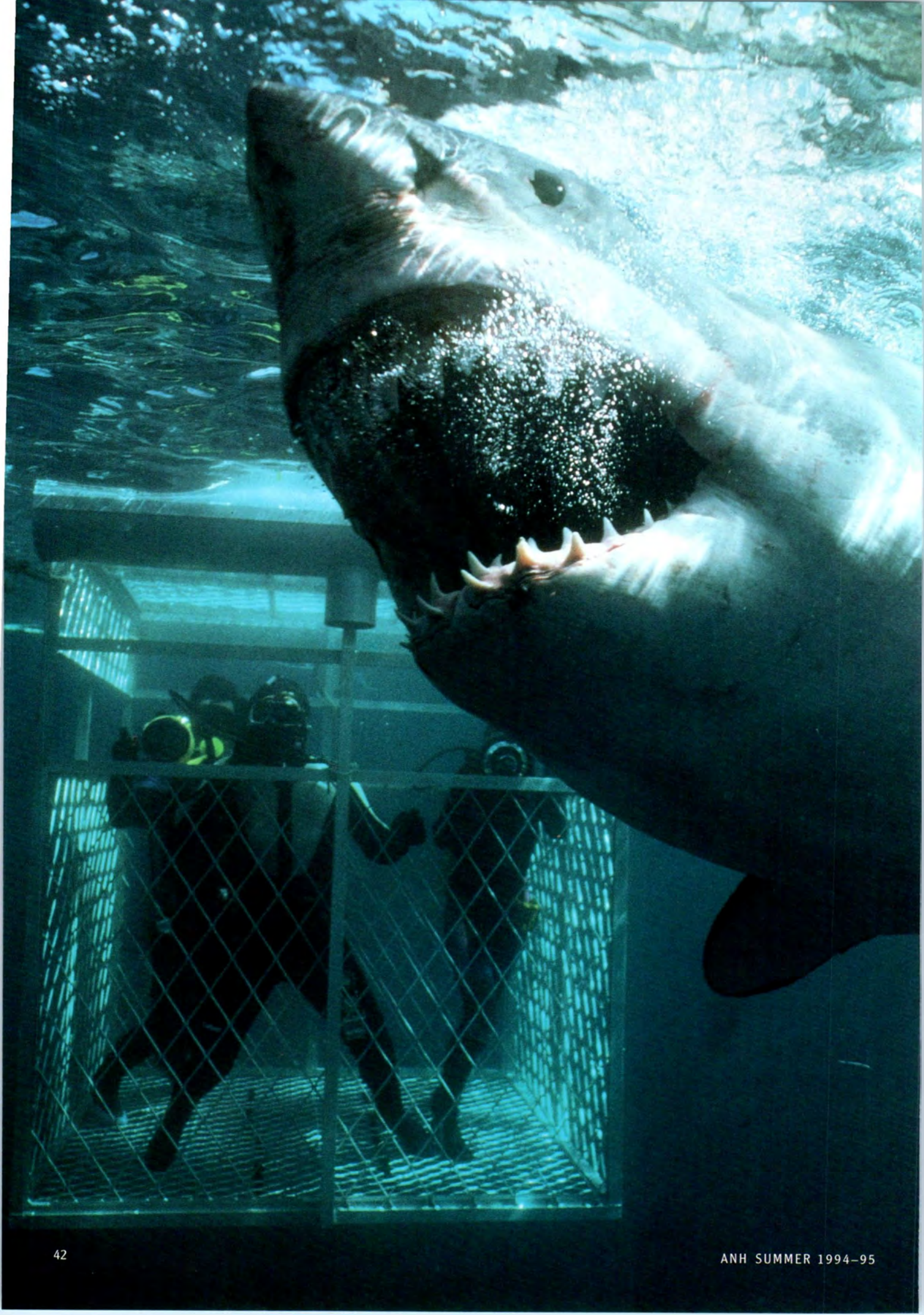
*Menna Jones is a doctoral student at the University of Tasmania in Hobart, where she has been studying the assemblage of marsupial carnivores, the Devil, the Spotted-tailed Quoll (*Dasyurus maculatus*) and the Eastern Quoll (*D. viverrinus*). Her interests are in evolutionary ecology.*



JEAN-PAUL FERRERO/AUSCAPE INTERNATIONAL

This ferocious image is how most people picture the Tasmanian Devil, but the display is mostly bluff.



Imagine a shark more than twice the size of the largest ever recorded Great White!

BIG TOOTH

BY JOHN LONG

SHARKS ARE PERHAPS THE MOST feared and ill-famed group of marine creatures. Whenever a human is 'taken' by a shark the media goes wild, revelling in all the gory details. Rarely do they point out the fact that each year humans consume many more millions of sharks than sharks consume humans. There are about 360 species of living sharks, of which fewer than a handful have any reputation for being 'human-eaters' or even occasional attackers of people.

KEVIN DEACON/OCEAN-EARTH IMAGES

Today's Great White Shark is the result of some 400 million years of very successful evolution.

KEVIN DEACON/OCEAN-EARTH IMAGES

This *Carcharocles megalodon* tooth is from the Jurabi Member, Cape Range (Western Australia) and is about four million years old. These teeth have been found in many marine deposits all over the world and can measure up to 18 centimetres in height.

The most infamous shark would have to be the Great White, also known as the White Death or White Pointer and officially known as *Carcharodon carcharias*. Reaching lengths of six metres, these fish are truly a cosmopolitan species, but primarily inhabit the coastal and offshore waters of the continental and insular shelves, perhaps with a preference for cold- to warm-temperate seas. They are active predators, as opposed to other large but filter-feeding sharks like the Whale Shark (*Rhincodon typus*; see ANH Autumn 1990) or Megamouth Shark (*Megachasma pelagios*; see ANH Autumn 1992). As juveniles they eat mainly fish, their serrated teeth being more slender, with tiny side cusps (basal denticles). As adults the Great Whites have teeth that are still serrated but more broadly triangular and better suited for eating mammals. They often feed around seal colonies and thus may sometimes take divers, who can easily be mistaken for seals. Although other sharks are known to have taken a bite from or made tentative attacks on humans, the Great White poses the greatest threat to humans because of its combination of large size, powerful jaws, teeth well adapted to cutting through flesh, relatively efficient locomotion and metabolic rate, and broad prey spectrum.

However feared the Great White is today, it is nothing compared with its extinct fossil relatives. Imagine a similar shark but one more than twice the size of the largest ever recorded Great White—a shark with razor-sharp, saw-edged teeth up to 18 centimetres tall, and a mouth over a metre in width, perhaps with a two-metre span between the upper and lower jaws. Such sharks, which are estimated to have reached 16 metres in length and to have weighed as much as 52 tonnes, are well known from their fossilised teeth found in marine deposits around the world. These gargantuan predators first started cruising the oceans about 35 million years ago and disappeared about two million years ago.

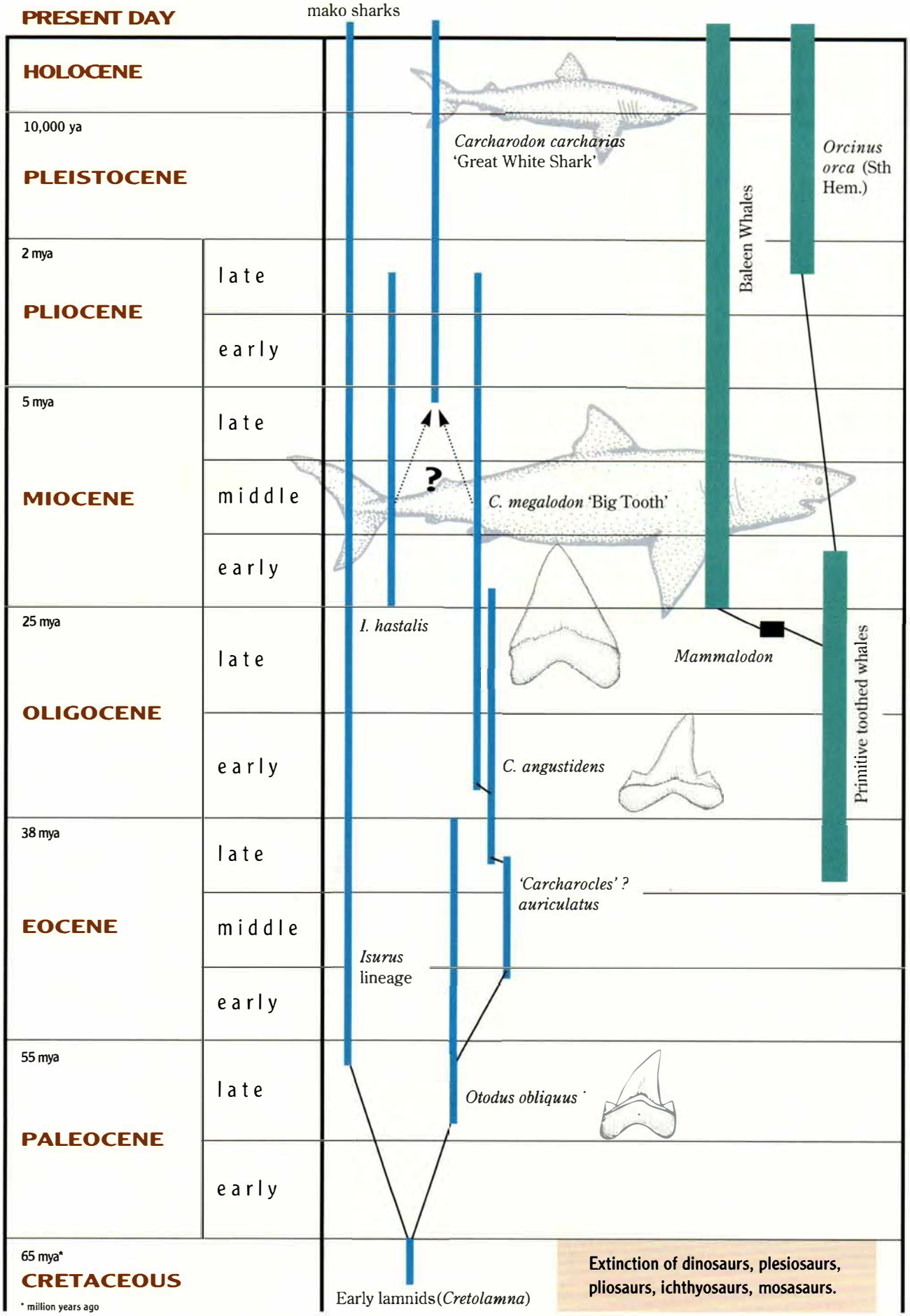
However feared the Great White Shark is today, it is nothing compared with its extinct fossil relatives.

The outward appearance of sharks has changed relatively little since their first appearance, some 400 million years ago. Their sleek styling, triangular fleshy fins, and sharp teeth that are replaced throughout life are all hallmarks of a very successful evolutionary story. From nature's viewpoint, sharks have had little reason to undergo major evolutionary changes and, in fact, much of their evolution has occurred at a subtle, almost imperceptible level, involving such changes as improved tooth shape and harder tooth tissues. This is fortunate for the palaeontologist wishing to study the origins of sharks. Not only are the teeth well represented in the fossil record, but DNA studies have shown that changes in teeth alone can be used to reliably reconstruct shark evolution.

So what do the teeth of the greatest predatory shark of all time tell us? Where did it come from? Why did it disappear? Was it really an ancestor of the modern Great White?

For many years these giant fossil teeth were classified as belonging to an

EVOLUTION OF 'BIG TOOTH'

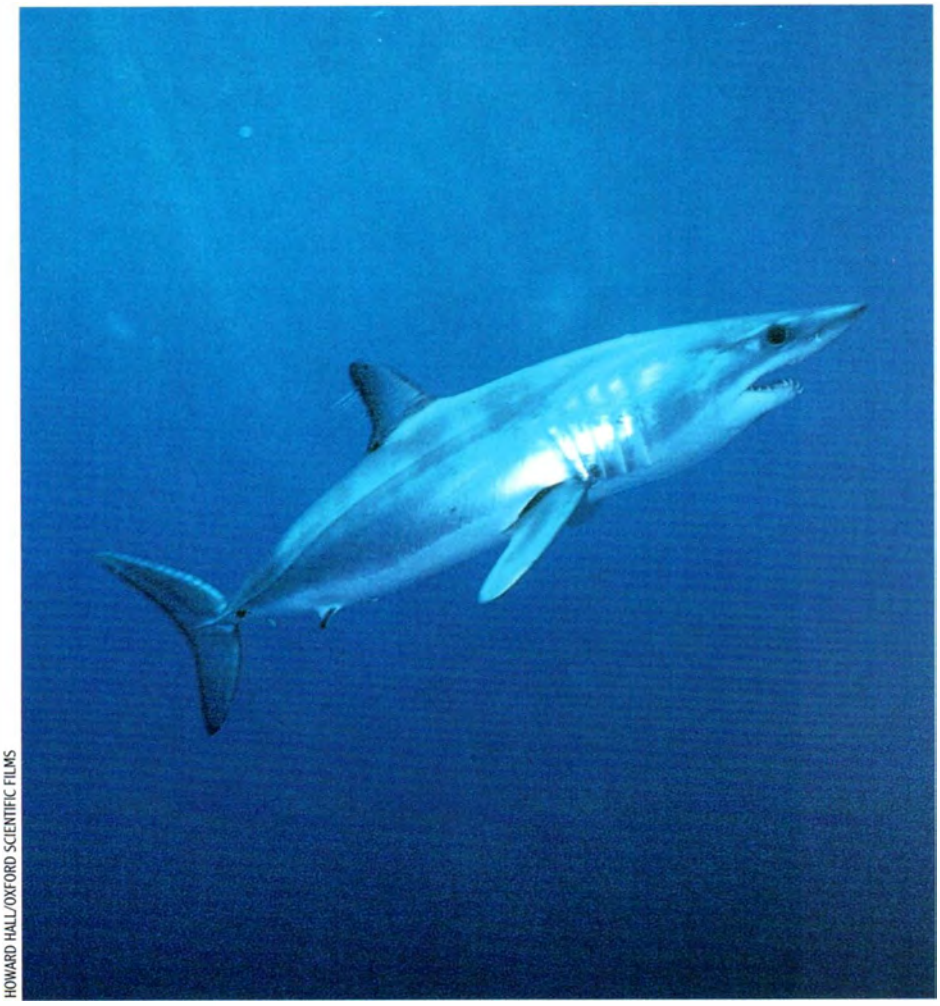


extinct species of great white shark, named *Carcharodon megalodon*, the specific name literally meaning 'big tooth'. Recent studies have put forward an alternative evolutionary lineage leading to the giant predator, although this is not accepted by all scientists. Some workers argue that the modern Great White Shark (*Carcharodon carcharias*) actually evolved from large *Isurus* sharks, relatives of the living Porbeagle and mako sharks. Teeth of the giant extinct mako *Isurus hastalis* are similar in form to those of *Carcharodon carcharias*, and the evolutionary transition from one genus to the other would have only involved the simple development of serrated edges in *Carcharodon*. The giant serrated teeth once called *Carcharodon megalodon* have instead been referred by some workers to a different genus, *Carcharocles*. The evolutionary lineage leading to 'Big Tooth' (*Carcharocles megalodon*) has been hypothesised through an older, slightly smaller ancestral species, *Carcharocles angustidens*, which first appeared in the Eocene, about 40 million years ago. Teeth of *C. angustidens* were also serrated but about half to two-thirds the size of *C. megalodon*'s and with a pair of denticles at the base.

The *Carcharocles* lineage began with the appearance of the giant shark *Otodus obliquus* in the late Paleocene, about 60 million years ago. The early forms of this species had broad unserrated teeth, up to eight centimetres in height. According to UK fossil shark expert David Ward, towards the end of its reign it developed serrated teeth indistinguishable from those of the earliest *Carcharocles, C. auriculatus*.

However, the traditional hypothesis of the evolution of the Great White Shark is based on the similarity between teeth of the extinct *'Carcharodon' megalodon* species with those of the living Great White. The oldest known occurrence of *Carcharodon carcharias* is probably late Miocene (around six million years ago), well after the first appearance of *'Carcharodon' megalodon*. Thus it has been argued that the Great White may have originated from the *'Carcharodon' megalodon* stock. If this ancestral lineage is correct, then the extinct species would have to remain in the genus *Carcharodon* and the name *'Carcharocles'* would not be valid for these taxa. At this stage the evidence is equivocal for either interpretation.

This anatomically accurate 1:8 scale model of *Carcharocles megalodon* was built by the Calvert Marine Museum in the USA as part of their two-year project to build a full-sized reconstruction of the shark. When finished, the skeleton will be just over 11 metres.



HOWARD HALL/OXFORD SCIENTIFIC FILMS

Some scientists argue that the Great White Shark evolved from large *Isurus* sharks—ancestors of this mako shark.

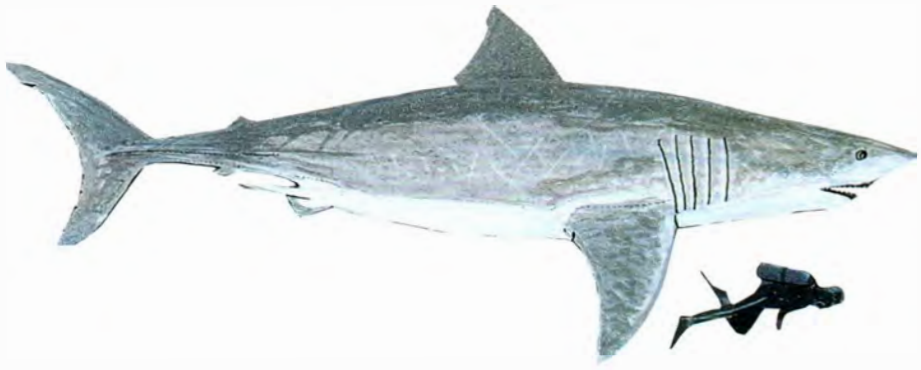
THESE SHARKS ALL BELONG IN THE FAMily Lamnidae, otherwise known as mackerel sharks. They are characterised by having an anal fin, five gill slits, two spineless dorsal fins, a mouth reaching well behind the eyes, and lacking an outer eyelid cover (nictitating membrane). Other lamnid sharks, apart from the Great White and the makos, include the bizarre Goblin (*Mitsukurina owstoni*) and Megamouth Sharks.

The rise of these giant predatory sharks was a slow, steady progression. Lamnid sharks at least five to six metres long cruised the oceans when dinosaurs were alive on land during the Cretaceous Period, from about 140 to 65 million years ago. Large calcified vertebrae found in rocks of this age in Queensland and associated with fossil teeth belonging to the genus *Cretolamna* represent the largest

CALVERT MARINE MUSEUM

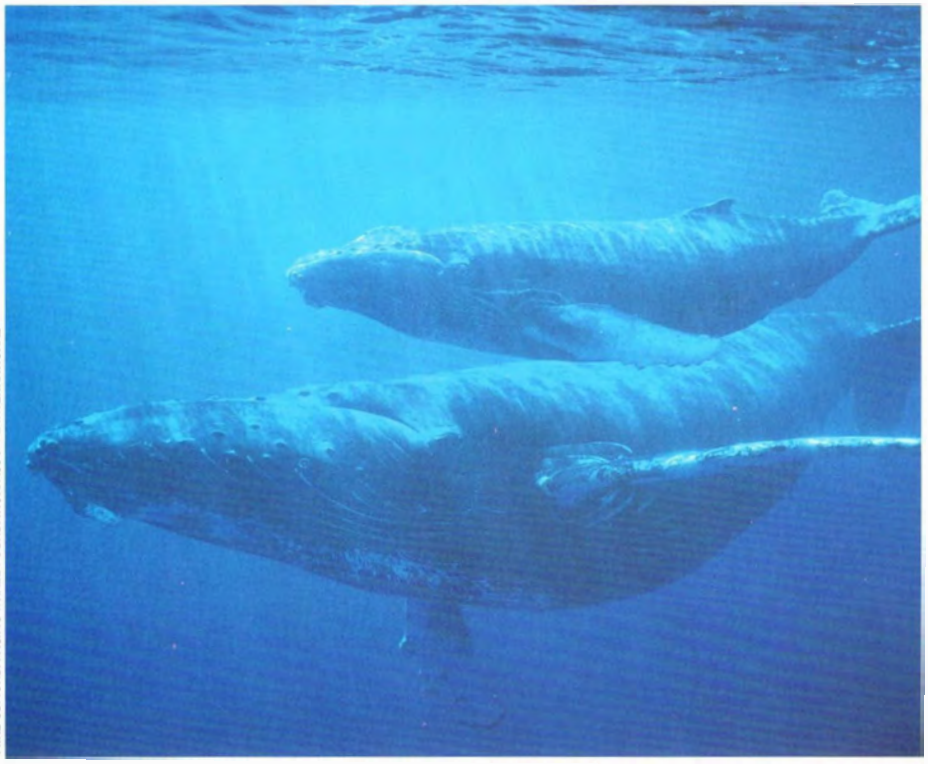
sharks from the Age of Dinosaurs. Despite the great number of extinctions that ensued at the close of the Cretaceous, sharks seemed to have gone through virtually unaffected. The same lineage of Cretaceous lamnid sharks kept increasing in size, obviously 'relishing' the demise of the giant reptilian marine predators (the plesiosaurs, pliosaurs, mosasaurs and ichthyosaurs), all of which had become extinct by the end of the Cretaceous, as had the dinosaurs. By the end of the Paleocene, about 55 million years ago, the teeth of *Otodus obliquus*, some up to eight centimetres high, appear in deposits all around the world. These predatory sharks were now growing up to about seven metres long and no doubt fed mainly on large fishes. At this time marine mammals had not yet appeared on the scene. The first whales and sea cows were not to appear for another 15 million years until the Eocene Epoch (about 40 million years ago).

It seems to be an interesting coincidence that the first abundant appearance of the largest predatory shark, *Carcharocles megalodon*, at the beginning of the Miocene, is the time when the first of the giant filter-feeding baleen whales appeared. Although there are a few records of the species from older Oligocene deposits in New Zealand, by the early Miocene *Carcharocles megalodon* was widespread throughout the world's oceans. This is also about the time when Drake's Passage, between Antarctica and South America was formed, heralding the onset of the circum-Antarctic current, which provided an upwelling of cold sea water rich in nutrients. The oldest fossil whale linking the primitive toothed whales (archaeocetes) with primitive filter-feeding whales (mysticetes) was found in Upper Oligocene (25 million-year-old)



JOHN LONG

A diver's worst nightmare! This illustration gives an idea of just how big (up to 16 metres long) the ancestors of today's Great White Sharks may have been. This diver is drawn swimming alongside a ten-metre-long *Carcharocles megalodon*—a shark that was cruising the oceans as little as three million years ago.



MIKE OSMOND/PACIFIC WHALE FOUNDATION/AUSCAPE INTERNATIONAL

Did the largest predatory shark ever known evolve in response to the appearance of baleen whales, whose calves provided a rich food source?

deposits of Victoria; a small whale, probably four or five metres long, named *Mammalodon colliveri*. This suggests that the baleen whales may well have originated somewhere in the Southern Ocean; indeed at this time Australia was far more southerly in latitude, being situated about halfway between its present position and Antarctica. Perhaps *Carcharocles megalodon* evolved at this time in response to a new food source—the appearance of the giant filter-feeding mammals. To date there is no direct fossil evidence that *Carcharocles megalodon* actually preyed on baleen whales, although an active, swimming, predatory shark 16 metres long would no doubt have found the young baleen whales easy pickings if they could wrestle them away from the protection of the adults. The warm-blooded flesh of the gentle giants would have provided much more energy for sustaining the giant colder-blooded predators than any of the other lower vertebrate food sources available to them. Modern Great White Sharks can maintain a higher ambient body temperature than the waters around them, but still require great amounts of food to maintain such a high metabolism. Furthermore the tooth shape of *C. megalodon* reinforces the idea that they were primarily mammal-eaters, as broad serrated teeth are generally better suited to cutting mammalian flesh than the more elongated gripping teeth that are commonly found in fish-eating sharks.

At least by the start of the Pliocene, about four million years ago, the giant baleen whales began migrating south into the Antarctic Circle, a region of great bioproductivity ideal for filter-feeders. Pat Quilty of the Australian Antarctic Division has found the four- to three-million-year-old fossil remains of baleen whales on Marine Plain near Casey, one of Australia's Antarctic bases. Discoveries of late Pliocene fossil leaves near the Beardmore Glacier in 1991 proved that at this time forests of southern beech (*Nothofagus* sp.) were still growing on the Antarctic mainland (see ANH Autumn 1994). This marks the start of the great freeze-up, the turning point when Antarctica went from a forested environment to a barren landscape of polar ice. So at this time, the migration to Antarctic waters may have also enabled the great whales to escape from their cooler-blooded shark attackers, which could not tolerate such cold waters. No modern sharks can tolerate the extreme cold of Antarctic waters with their surface temperatures of approximately -2° C.

Today the large baleen whales feed in the southern oceans but return to northerly latitudes to breed and calve, well within the territory of the Great White Shark. However their main predator, one that can hunt them even in Antarctic waters, is the Killer Whale or Orca (*Orcinus orca*). In cold Antarctic waters packs of Killer Whales are known to attack large baleen whales, homing in on the large fleshy tongue. In the Northern Hemisphere fossil Killer Whales date back as far as the late Miocene, about ten million years ago, so may not have ventured into the southern feeding grounds of the great baleen whales for some time afterwards. In Australia and New Zealand the killer whale fossils are relatively young, occurring only within the last two million years or so, and this suggests that in the southern oceans they were not in competition with the gargantuan predatory sharks back in the Miocene or Pliocene.

CARCHAROCLES MEGALODON IS THOUGHT to have become extinct about two to three million years ago. The cause of its demise is still uncertain, but circumstantial evidence presented here suggests that the onset of southern migration in one of its supposed prey items—the great baleen whales—may have played a role. The youngest well-dated fossil teeth of *C. megalodon* have come from Flinders Island in Bass Strait, signalling Australia as the possible final resting place of the giant predatory sharks.

But are they really extinct? A 1918 eyewitness account by hardened crayfishermen at Port Stephens in New South Wales makes one wonder about whether such monsters may still be cruising our oceans. The fishermen were so scared by what they saw that they refused to go out for many days after sighting a giant monster shark in the vicinity of Broughton Island. They claimed to have seen an immense shark taking their crayfish pots, mooring lines and all. Each pot was about a metre in diameter and contained up to three dozen crayfish. In the company of a local fishing inspector, author David Stead interviewed the men who purported the shark was as long as the wharf on which they stood (35 metres), and that the water literally boiled over when the fish swam past. Its head was said to have been at least as large as the roof of the wharf shed at Nelson's Bay. Stead concluded by stating that these were men who grew up being used to the sea, who were experienced at telling whales and sharks apart, and who were usually fearless of anything the sea had to offer. One last point on which they all agreed was the "ghostly white colour" of the fish. Their accounts convinced Stead that such a monster really did exist in modern times, a late survivor from the depths of prehistoric time when giant predatory sharks were once widespread in the oceans of the world.■

Further Reading

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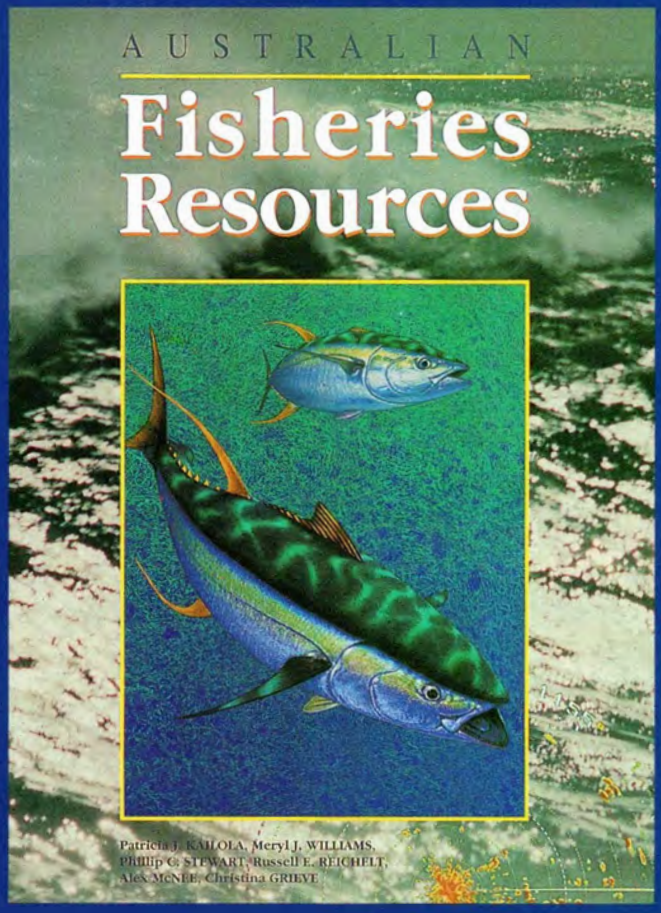
John Long is Curator of Vertebrate Palaeontology at the Western Australian Museum. His primary research is on the early evolution of fishes, including the early fossil sharks of Australia, Antarctica and South-East Asia.

FISHING FOR FISH FACTS?



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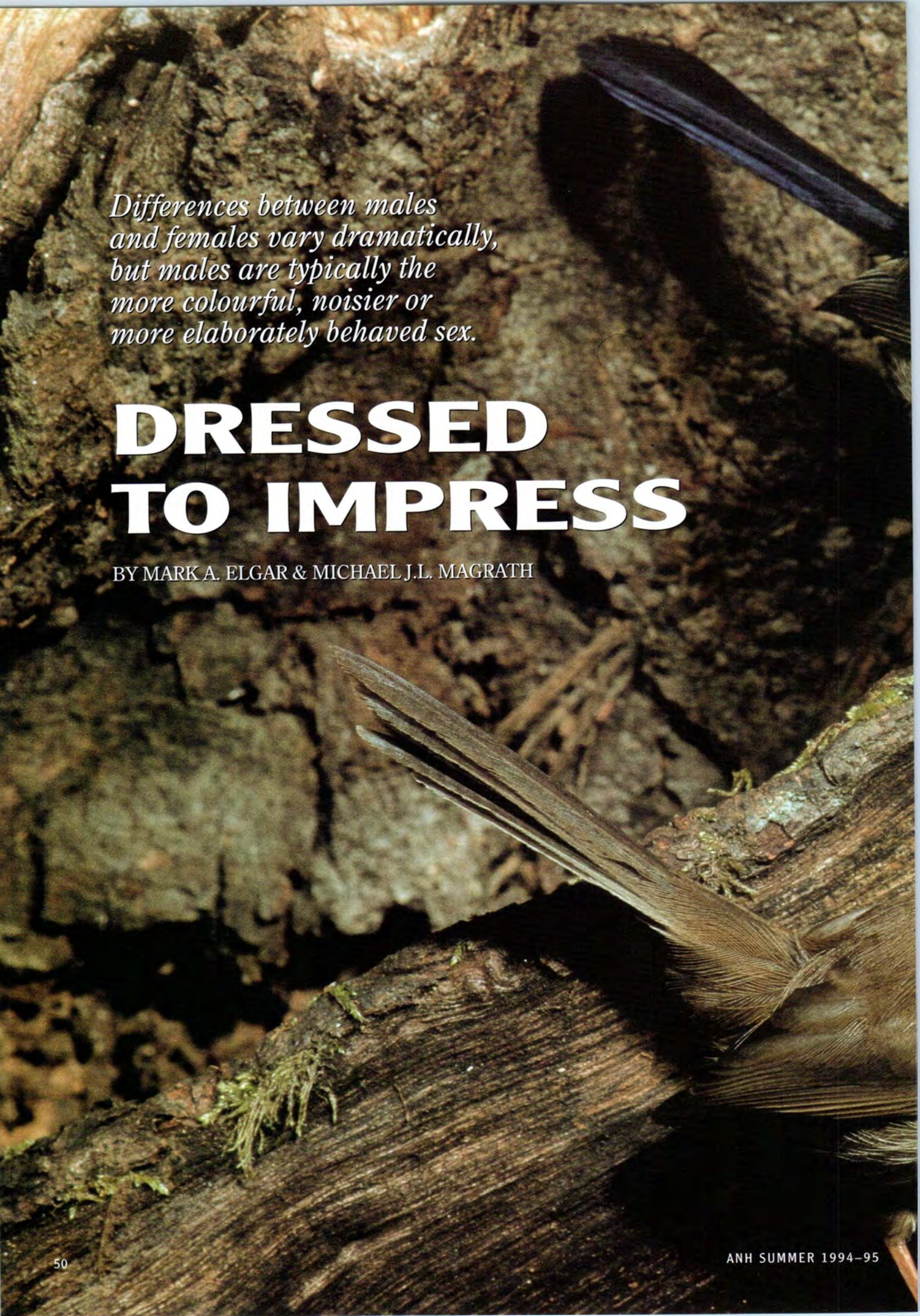


Differences between males and females vary dramatically, but males are typically the more colourful, noisier or more elaborately behaved sex.

DRESSED TO IMPRESS

BY MARK A. ELGAR & MICHAEL J.L. MAGRATH

Male Superb Fairy-wrens that sport their spectacular blue nuptial plummage earlier in the breeding season appear to attract more matings.

KAB. RICHARDS/NPIAW

BRIAN J. COATES

The male Blue Bird of Paradise displays his spectacular flank and tail plumes in an attempt to attract a female.

In the highland forests of Papua New Guinea, male Blue Birds of Paradise (*Paradisaea rudolphi*) engage prospective female mates in an extraordinary display of colour, movement and song. The performance begins with the male singing from a perch. After a short while he slowly rotates backwards and, once he is hanging upside down, he shakes himself with repeated movements, extending his iridescent blue plumage while making a soft monotonous song. The behaviour of the male ensures that the colours and patterns of his extravagant flank and tail plumes are displayed to the greatest advantage. The male's dance also highlights the striking difference between males and females. While the plumes of the male combine in glorious hues of blue, the female is relatively dull and quite difficult to distinguish from the background vegetation.

Differences between males and females in, for example, the length and colour of feathers is described as sexual dimorphism. Birds of paradise are not the only group to show such remarkable sexual dimorphism. Males and females of some jumping spiders (family Salticidae) are coloured so differently that early taxonomists sometimes thought they were different species! Furthermore, colour is not the only secondary sexual characteristic that differs between the sexes: males of many species, including frogs, crickets and birds, make calls or sing, while the females are usually silent. And males of other species, such as some deer and antlered flies, possess antlers or horns that are used for physical combat between males. Although these weapons could be used in defence against potential predators or competitors, their absence in females suggests

they serve some additional function.

The nature and extent of the differences between males and females vary dramatically from species to species, but males are typically the more colourful, noisier or more elaborately behaved sex. Male Musk Ducks (*Biziura lobata*) impress their females by leaning back and splashing them with water using their legs, while male fairy-wrens (*Malurus* spp.) court females more charmingly by presenting them with a colourful flower petal or berry. Such patterns of behavioural and morphological differences between the sexes are remarkably general across a wide range of species. A curious exception is our own species, for which contemporary Western fashion dictates that females wear brightly coloured clothes and accessories, while males are generally attired more drearily. So why are the males of sexually dimorphic species usually more extravagantly adorned? Indeed, the brightly coloured ornaments of males represent an interesting evolutionary paradox that has fascinated biologists for over a century.

Charles Darwin was among the first to realise that the extravagant ornaments of males represent a serious challenge to his theory of evolution. According to Darwin, natural selection favours features that improve the chances of survival and reproductive success of individuals. It is easy to see how dull, cryptic and camouflaged colouration will be favoured because individuals with this plumage will be less obvious to predators than those with more colourful or prominent feathers. But how could the extravagant plumes of male Blue Birds of Paradise help them survive and reproduce? If anything, the male's plumage probably makes him easier for predators to catch. For our own species, it would be like running through the jungle in a bridal gown!

The problem was addressed by Darwin in his theory of evolution by sexual selection. Darwin reasoned that secondary sexual characteristics, such as plumage colouration, weapons or courtship behaviour, are all associated with mating. For example, these characteristics are often expressed only during the breeding season, with males of many species, such as the Superb Fairy-wren (*Malurus cyaneus*), becoming dull and cryptic at other times of the year. In other species, such as the Superb Lyrebird (*Menura novaehollandiae*), males do not possess all the distinguishing feathers of their full plumage until they are sexually mature at six or seven years of age. In Darwin's words, sexual selection is "the struggle between individuals of one sex, generally the males, for possession of the other sex. The result is not death to the unsuccessful competitor, but few or no offspring". In other words, secondary sexual characteristics have evolved by sexual selection, which is the result of competition between members of one sex for the opportunity to mate with the other sex.

How could the extravagant plumes of male Blue Birds of Paradise help them survive and reproduce? For our own species, it would be like running through the jungle in a bridal gown!

But why should there be greater competition among individuals of one sex? More particularly, why is it that males are usually the competitive sex? The answer lies with one of the fundamental differences between the sexes: males can improve their reproductive success by mating with many different females, but the reproductive success of a female is limited by the rate at which she can produce young. This means that for most species, far fewer females than males are sexually receptive at any one time. Hence males compete among themselves for a chance to mate with females.

A male jumping spider (*Epeus* sp.) from Indonesia.

DAVID KNOWLES/LOCHMAN TRANSPARENCIES

KATHIE ATKINSON

A pair of Zebra Finches in the wild. Studies of mating behaviour in captive Zebra Finches is complicated by the fact that certain colours and arrangements of leg bands are more attractive to females.

SEXUAL SELECTION MAY OCCUR IN TWO ways. The first, called male–male competition, involves males competing directly for access to females. Male–male competition is responsible for the evolution of male weapons, such as antlers and horns, which are used in direct physical combat. The male of several scarab beetles uses his long horn, which is attached to his head, to attack and dislodge other males from areas where females are found. There are also more subtle ways of winning the competition between males. As soon as a male Big Greasy Butterfly (*Cressida cressida*) has mated with a female, he makes sure that only his sperm fertilises the female's eggs by depositing a substance over her genital opening. This substance hardens and prevents rival males from subsequently mating with the female, in much the same way as a chastity belt.

The second process of sexual selection is known as female choice. Females of most species invest far more time and energy raising progeny than males do. A female frog that mates with a male of the wrong species, or a male that is genetically inferior, may lose an entire year's supply of eggs. However, the loss to a male frog of making a similarly poor mating decision would amount to little more than a waste of time. Females should therefore be more particular about their mating partner than males, especially since more males than females are generally available to mate at any one time. The principle of female choice is that a female discriminates between courting males according to their secondary sexual characteristics.

The characteristics by which females are thought to choose between males are numerous. Mating males of an as yet undescribed species of bush cricket (*Requena* sp.) provide their female mate with both sperm and a package of food. The female uses the nutrients from the food parcel to help produce eggs. Larger males can provide a larger package than smaller males, and a larger package allows the female to make more eggs. Not surprisingly, when females are given a choice between males of different sizes, they prefer to mate with the larger males.

However, females still make choices even in the absence of any obvious material benefit. Female Satin Bowerbirds (*Ptilonorhynchus violaceus*) inspect the bowers of several males before mating with one male, and then depart to nest and raise the young on their own. The female appears to be interested in his collection of treasures, because males that decorate their bowers with more objects mate with more females. Like many frogs and toads, female Smooth Toadlets (*Uperoleia laevigata*) are more attracted to males with low-frequency calls than males with higher-frequency calls. Female Zebra Finches (*Poephila guttata*) have rather more bizarre tastes: in a captive population in which all individuals had coloured leg bands used for identification, males with red bands enjoyed higher mating success than those with green colour bands. Further experiments revealed that male Zebra Finches with a symmetrical arrangement of coloured leg bands were more attractive to females than males with an asymmetrical combination of the same colours. These remarkable results have worrying implications for biologists who use coloured leg bands in their studies of the mating behaviour of birds in natural populations!

Not surprisingly, when females are given a choice between males of different sizes, they prefer to mate with the larger males.

But why should females show any preference for males with ornaments in the first place? Darwin based his idea on the assumption that females were, by nature, whimsical. Many of his colleagues pointed out that this assumption was an inadequate foundation for a scientific idea and his theory of sexual selection by female choice was ignored for 50 years. The concept of female choice was rescued in 1930 by Ron Fisher, who argued that each sex could possess genes for both male adornment and female choice, but only males express the adornment and females the choice. Accordingly, females that have a preference for mating with, say, males with slightly longer tails will produce both sons with slightly longer tails, and daughters with the preference for males with slightly longer tails. The crucial point is that a positive feedback develops between the female's preference and the male's characteristic: as the length of males' tails increases in the population, so too does the intensity of the females' choice. The process has become known as 'Fisher's runaway sexual selection'.

Many secondary sexual characteristics are evident only during the breeding season or when sexual maturity has been reached. Male Superb Lyrebirds do not possess their full plumage until six or seven years of age.

HANS & JUDY BESTE/AUSCAPE INTERNATIONAL

JIM FRAZIER/MANTIS WILDLIFE

WESLEY TOLHURST

ANOTHER 50 YEARS PASSED BEFORE female preference was confirmed in a classic experiment by Malte Andersson, who showed that female Long-tailed Widow Birds (*Euplectes progne*) prefer males with longer tails. Widow birds are small, African, sparrow-like birds, the males of which have tails that are much longer then their body. When Andersson cut the tail feathers of some males and stuck them to the tails of other males, he found that females preferred to pair with males that had elongated tails over males with normal or reduced tails. So why don't male widow birds have even longer tails if they confer a mating advantage? Recent studies of another Kenyan bird, the Scarlet-tufted Malachite Sunbird (*Nectarinia johnstoni*), provide a clue. Similar cut-and-paste experiments with

Female Satin Bowerbirds inspect the bowers of several males before choosing a mate. They appear to favour males with more highly decorated bowers.

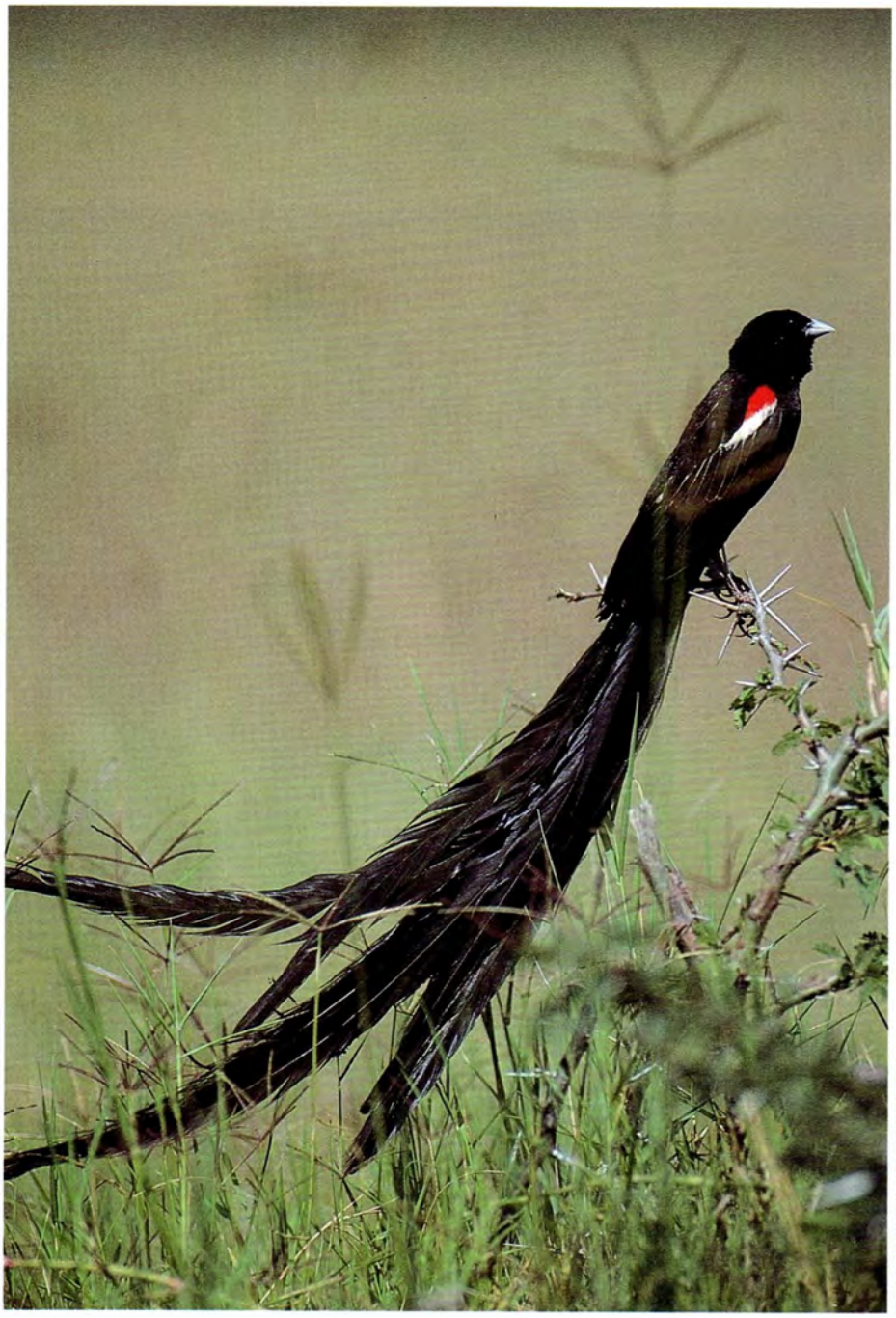
The call of this male Dainty Tree Frog (*Litoria gracilenta*) is a secondary sexual characteristic. Females may discriminate between courting males on the basis of these characteristics.

tail feathers revealed that males with elongated tails were less efficient at foraging than those with unmanipulated tails. Males with longer tails may be sexier, but their chances of survival will be lower as a result of their impaired foraging abilities, a consequence that is likely to apply to many other species. In other words, when the decrease in male survival counter-balances the increase in sexual attraction of the male, Fisher's runaway sexual selection will grind to a halt.

Another explanation for the evolution of elaborate male ornaments is that they provide females with reliable information about the quality of the male, which is not a necessary assumption for runaway sexual selection. As we explained earlier, females ought to prefer males of high genetic quality, reflected perhaps in their abilities at foraging, avoiding predators or even immunity to parasites and pathogens. Since elaborate male displays are likely to be a handicap to everyday survival, females may prefer males with these characteristics precisely because they provide a reliable indication of male genetic quality: the male with the most impressive display is the most attractive because he can survive despite his handicap.

The idea that male ornaments are a reliable indication of male quality was originally suggested about 20 years ago by Amotz Zahavi. Initially the idea met with considerable scepticism, but clarification of the assumptions over the last few years has led to its widespread acceptance. The key assumption is that, although all males may carry the genes for the handicap (such as a long tail), only males in good condition develop it entirely. An interesting version of the handicap principle, suggested by William Hamilton and Marlene Zuk in 1982, is that male ornaments indicate resistance to parasite or pathogen infection. Any bird fancier will testify that the plumage of a diseased bird is generally less glossy than that of a healthy bird. Thus, a female that chooses a male with the most elaborate displays, brightest colours or longest tails will be mating with a male that has the least pathogens. If the resistance to the pathogen is heritable, then she will be sure of producing offspring that have high resistance to those pathogens.

But the quality of a male's attire may not be the whole story. In some species, the size or colour of an ornament may not differ much between individual males, so females may have to be even more choosy. For example, the familiar blue plumage of the male Superb Fairy-wren is usually only sported during the breeding season, with most males adopting a less risky, cryptic plumage in the winter months. However, the time at which males re-acquire their breeding plumage varies dramatically between individuals, and may provide females with additional information about the quality of prospective mating partners. In this case, a male dressing to impress must not only sport the right colours, but be the earliest to slip them on! ■



STAN OSOLINSKI/OXFORD SCIENTIFIC FILMS

Why do female Long-tailed Widowbirds prefer males with longer tails?

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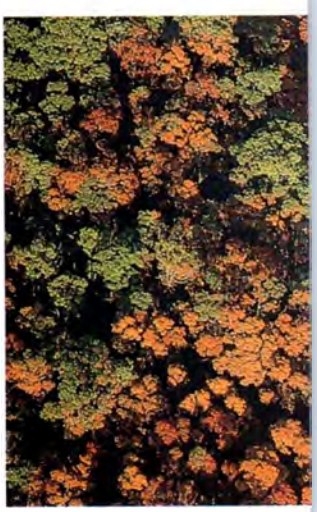
Mark Elgar is a lecturer in the Department of Zoology at the University of Melbourne, where he teaches animal behaviour, evolution and conservation biology. His research interests include invertebrate mating behaviour, cannibalism, and relationships between spiders and ants. Michael Magrath is a graduate student in the Department of Zoology at the University of Melbourne. His research interests include the influence of mating behaviour on the evolution of parental care in birds. A complementary article on male–male competition will be published in an upcoming issue of ANH.



MAN-MADE LANDSCAPES

BY LINDSAY STEPANOW

Most of us live in artificial environments engineered to provide us with energy, food, shelter and entertainment. Our world is concrete, metal, glass and plastic. Much of the original landscape is replaced by monoculture crops and animals, machinery and buildings, or scoured away to bare rock and earth. Humans live in a landscape of their own making.

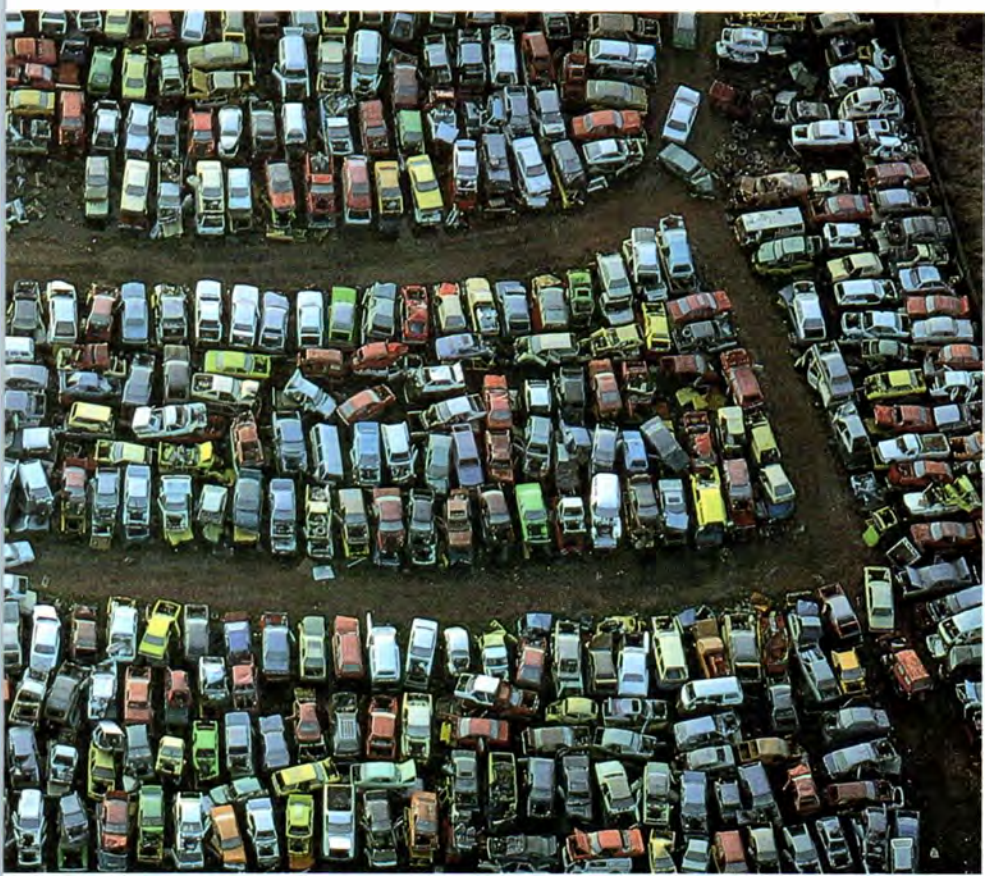
Some people might claim that these environments are ugly but the lack of perspective and two-dimensional flatness provided by the aerial viewpoint abstracts these landscapes, allowing us to see them in a new light and to perceive their true extent and beauty.

For me the interesting and revealing images of our world are not restricted to nature's wilderness. The urban areas, factories, quarries, crops, burnt or flooded forests, and eroded land all make fascinating photographic studies.

This project was assisted by the Australia Council, the Federal Government's Arts Funding and Advisory body.

MAN-MADE LANDSCAPES

P H O T O A R T



P H O T O A R T

MAN-MADE LANDSCAPES

Frogs worldwide have evolved almost 30 different ways of reproducing.

TREE FROGS: PUTTING THEIR EGGS IN MORE THAN ONE BASKET

BY STEPHEN J. RICHARDS

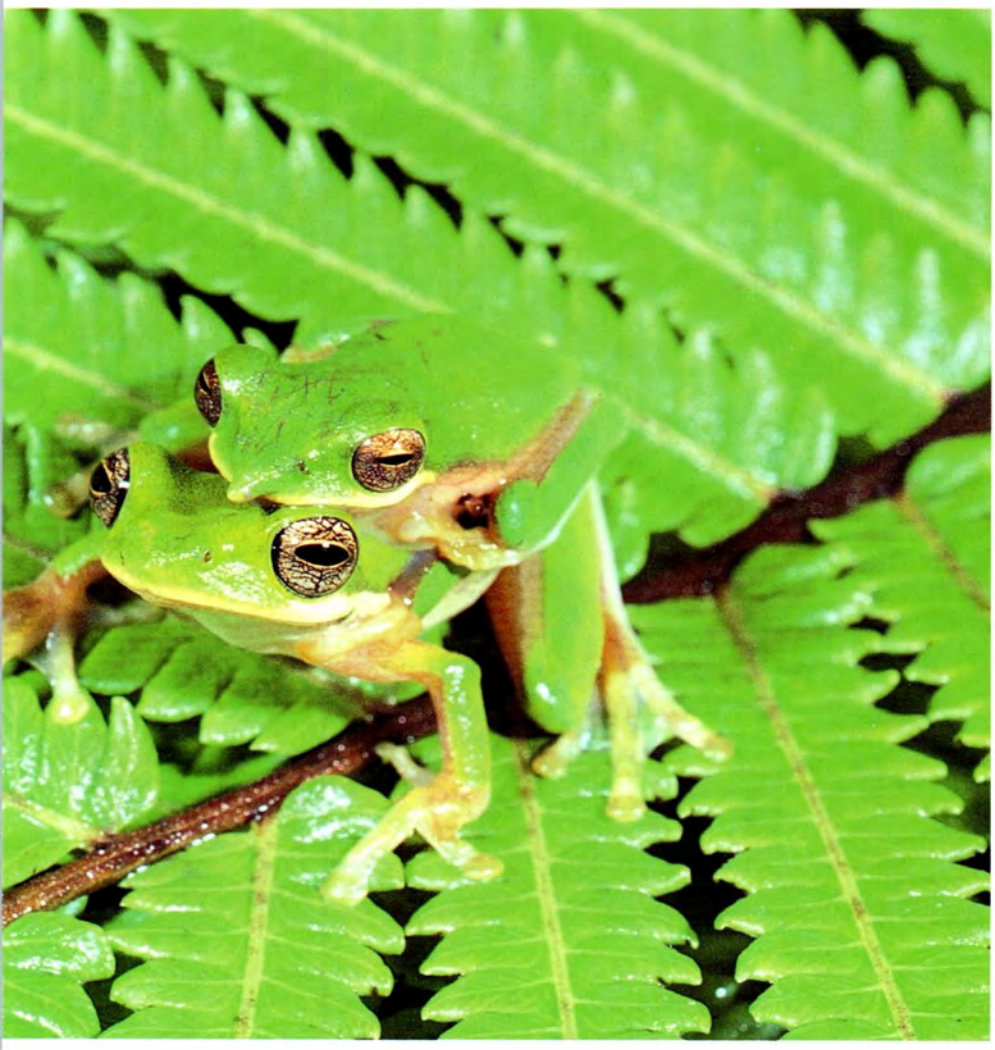
FOR MOST AUSTRALIANS THE TERM 'tree frog' conjures up images of a bright green frog with large toe pads climbing our walls at night or perched high on a palm leaf. Species such as the common Green Tree Frog (*Litoria caerulea*) do fit this description but in fact the family Hylidae, into which all of Australia's tree frogs are placed, is an exceptionally diverse one. Two genera of tree frogs, *Litoria* and *Nyctimystes*, are currently recognised in Australia and New Guinea. One other Australian genus, *Cyclorana*, is included in the Hylidae but do not look like tree frogs at all.

Cyclorana species are squat burrowing frogs that lack toe pads and spend most of their lives in a cocoon under the ground. They emerge after heavy rains, lay their eggs in ephemeral ponds, feed, and then burrow again to await the next rains. The reproductive strategy of *Cyclorana* species is typical of most frog species. Hundreds or thousands of eggs are laid in water where they develop, unaided by the parents, into tadpoles and remain until they metamorphose. This 'typical' strategy is seen as a response to high predation pressure on eggs and tadpoles in the aquatic environment. By laying many eggs, adult frogs ensure that at least a few will survive to maturity.

The genera *Litoria* and *Nyctimystes* are most diverse in New Guinea and the eastern and northern tropics of Australia. The reproductive strategy of all known *Nyctimystes* species is to lay large, unpigmented eggs under rocks in torrents of mountain streams. These develop into tadpoles with large suctorial mouthparts that cling to, and graze algae from, these rocks.

Some *Litoria* species living in montane rainforests have also adopted this breeding strategy. Others have evolved a quite different strategy. In the early 1960s egg masses of a small New Guinea tree frog, *Litoria iris*, were found hanging on leaves over streams in the central highlands. The eggs were pale green and laid in masses of clear jelly. Subsequently in 1977 a species of small tree frog, *Litoria longirostris,* was described from the McIlwraith Range on Cape York Peninsula. Included in the collector's notes was the brief but tantalising observation that clumps of eggs were seen stuck on a tree buttress near the frogs. It was not until 1993 that a research team from Queensland's Department of Environment and Heritage was able to confirm that this species does indeed lay 'aerial' egg masses. Again, the embryos were green and were surrounded by clear jelly.

Recent research in New Guinea has shown that this reproductive strategy may be more common than previously thought. At least two additional species, *Litoria havina* and *L. ollauro*, have been reported to lay eggs in aerial egg mass-



A pair of *Litoria havina* in amplexus on ferns over a swamp. The male of this species has a distinctive 'rostral spike' on the end of his nose.

es, and a number of others are suspected of doing so. One of these species, *L. havina*, is remarkable in that the male has a long 'rostral spike' on the end of his nose. Although an olfactory function has been suggested to explain the structure of the spike, it is more likely to be used in a visual context; in the sympatric 'spike-nosed' tree frog *Litoria pronimia*, the spike is erect during vigorous bouts of calling but frequently becomes flaccid when calling ceases. Whether females select calling males with longer rostral spikes remains to be determined.

Male *Litoria havina* call from ferns and bushes overhanging swamps in the perpetually wet foothills of the Star Mountains in central New Guinea. Females, which lack the 'rostral spike' are attracted to the males' whistling calls and pairs amplex (where the male grips the female in preparation for egg laying) on vegetation above the swamp. The female then lays her eggs, which are fertilised by the male as they emerge. Deposited directly onto leaves above the swamp, the egg mass is protected and kept moist by voluminous quantities of clear jelly. Whether the rainfall supplies enough water to swell the jelly mass immediately after egg-laying, or whether the female somehow supplies this water, remains a mystery. The constant high humidity in the rainforests where these frogs live prevents the jelly mass from drying out and killing the embryos, which develop into small tadpoles high above the swamp.

During heavy rain the tadpoles break free of the jelly and drop into the water, where they are immediately capable of swimming. The black and gold striped tadpole of this species, which darts rapidly into detritus on the floor of the swamp to escape predators, is surely one of the most beautiful known tadpoles in the region.

The evolution of this strategy is almost certainly another response to high predation pressure on eggs and tadpoles by aquatic predators. By removing embryos from the aquatic environment, frogs are increasing the chances of their tadpoles surviving to metamorphosis. A recent discovery in northern Queensland has illustrated yet another way that tree frogs can isolate their eggs and small embryos from pools and streams. In rainforests north of Townsville, the common Lesueur's Frog (*Litoria lesueuri*) constructs small, circular basins in the banks of sandy creeks. These basins are separated from the stream by one wall, and in each basin the frogs lay a single clutch of eggs. Populations of this species outside the rainforest are not known to construct these basins, laying their eggs amongst rocks in flowing streams. Prior to the discovery of these basins in 1989 this reproductive strategy was known only for a small group of tree frogs from Central and South America.

The advantages of depositing eggs in these basins are less clear than for the aerial nests. The basins certainly exclude some potential predators, but also expose embryos isolated in the basins to other predators such as birds. Unfortunately (for the tadpoles) the basins dry out rapidly as water levels in the stream drop during early summer, and tadpole mortality from desiccation

A *Litoria havina* egg mass laid on ferns. The embryos can be clearly seen through the jelly mass.

PHOTOS: STEPHEN J. RICHARDS

MICHAEL CERMAK

Litoria lesueuri **may construct small, circular basins in the banks of sandy rainforest creeks in which to lay its eggs.**

is extremely high at this time of the year.

One advantage is that water temperatures in the basins may get higher than those in the stream. When this occurs tadpoles can develop faster, and may quickly become too large for some predators and too fast for others. Alternatively, the basins may simply be a mechanism to keep the eggs from being washed away in the current. In any event it appears that this strategy is successful only when water levels remain high enough in the streams to erode the basin wall and eventually allow the tadpoles to swim free. That these conditions are frequently met is evidenced by the large number of Lesueur's tadpoles that can be found in these rainforest streams.

The general trend to isolate eggs from the aquatic environment is apparent in most other groups of frogs (see ANH Winter 1989), and is common in other tropical areas where humidity levels are constantly high. At a single rainforest site in Ecuador tree frogs are known to have five different reproductive strategies, and frogs worldwide have evolved almost 30 different ways of reproducing. These strategies vary from simple selection of different egg-laying sites to complex paternal or maternal care of embryos. Gastric brooding by the two Australian *Rheobatrachus* species is one of the most familiar examples of parental care in frogs.

Conversely, the three strategies described here are the only known cases of 'atypical' breeding behaviour by tree frogs in the whole of Australia and New Guinea. The reasons why tree frogs in this region are so conservative when it comes to the way they breed remain unclear. However it probably reflects, at least to some degree, a general lack of knowledge about the biology of our tropical frog fauna. As more research is conducted in the increasingly accessible rainforests of Australia and New Guinea where tree frogs abound, many more interesting facets of tree frog biology and reproductive behaviour are almost certain to be discovered. ■

STEPHEN J. RICHARDS

A *Litoria havina* egg mass almost ready to drop into the stream. This egg mass was observed hanging in this position for at least two days.

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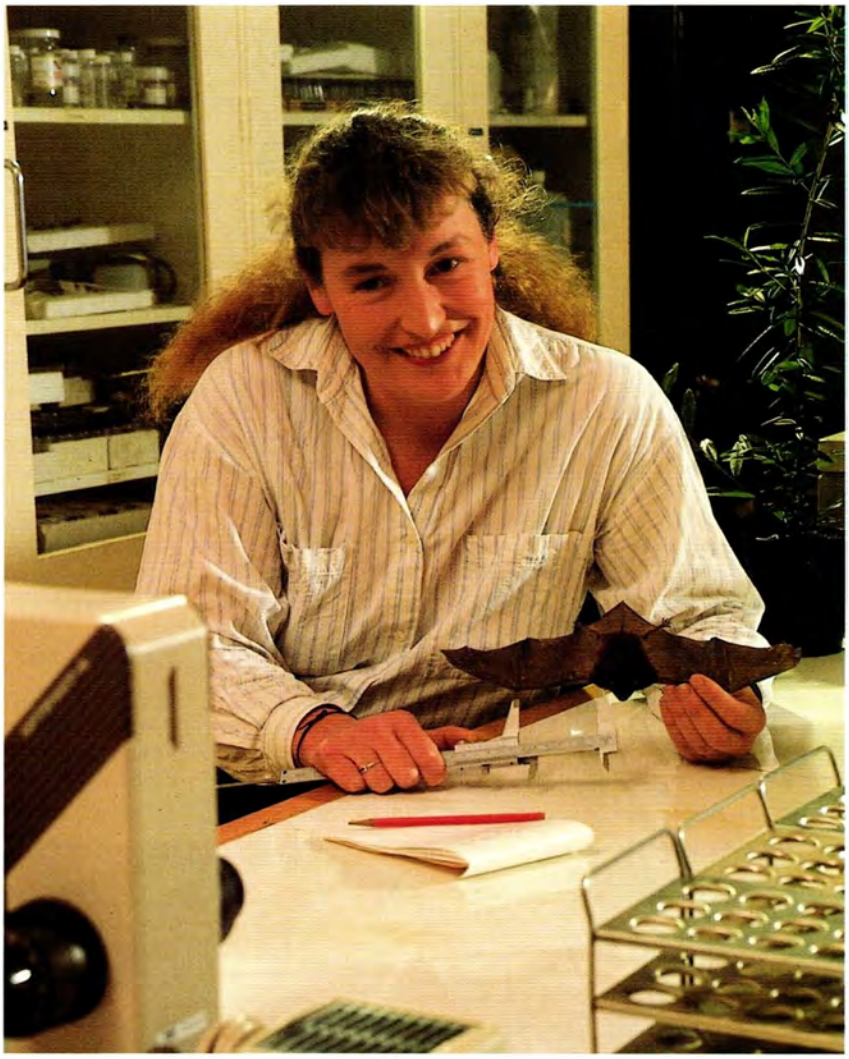
Stephen Richards is a PhD student and Research Officer at James Cook University of North Queensland. He is interested in all aspects of the ecology and conservation of rainforest frogs in Australia and New Guinea.



Researching

Research is done to better understand our forests.
We can monitor the animals' movements and study habitats.
Sometimes we'll reserve areas of forest, for particular wildlife needs.

Forestry Tasmania

GROWING OUR FUTURE

IOAO FT1996

Those of us committed to tertiary education are regularly reminded that zealous advocates for the irrational can be found in every audience.

'SINE' OF THE TIMES?

BY MICHAEL ARCHER

THE SAME USA THAT HAS given the world products of genius like lunar landings and virtual reality also pollutes it with a putrescent avalanche of gobbledegook like Jimmy Baker's televangelism, Scientology, mind-warped spoons and Noah's 'Arkeology', giant steps backward in the maturing intellect of humanity. In a Gallup Poll in the USA (which claims 97 per cent sampling accuracy), 44 per cent of those interviewed, of whom 25 per cent were college graduates, supported the statement that "God created man pretty much in his present form at one time within the last 10,000 years". A poll of 1,000 university students in California, Texas and Connecticut revealed that more than half were creationists. A third said they believed in aliens, ghosts, Big Foot and the lost city of Atlantis. Francis Harrold, Professor of Archaeology at the University of Texas, who helped conduct the survey, cautioned that "For a leading scientific nation, this is not a good sign of the effectiveness of our science education".

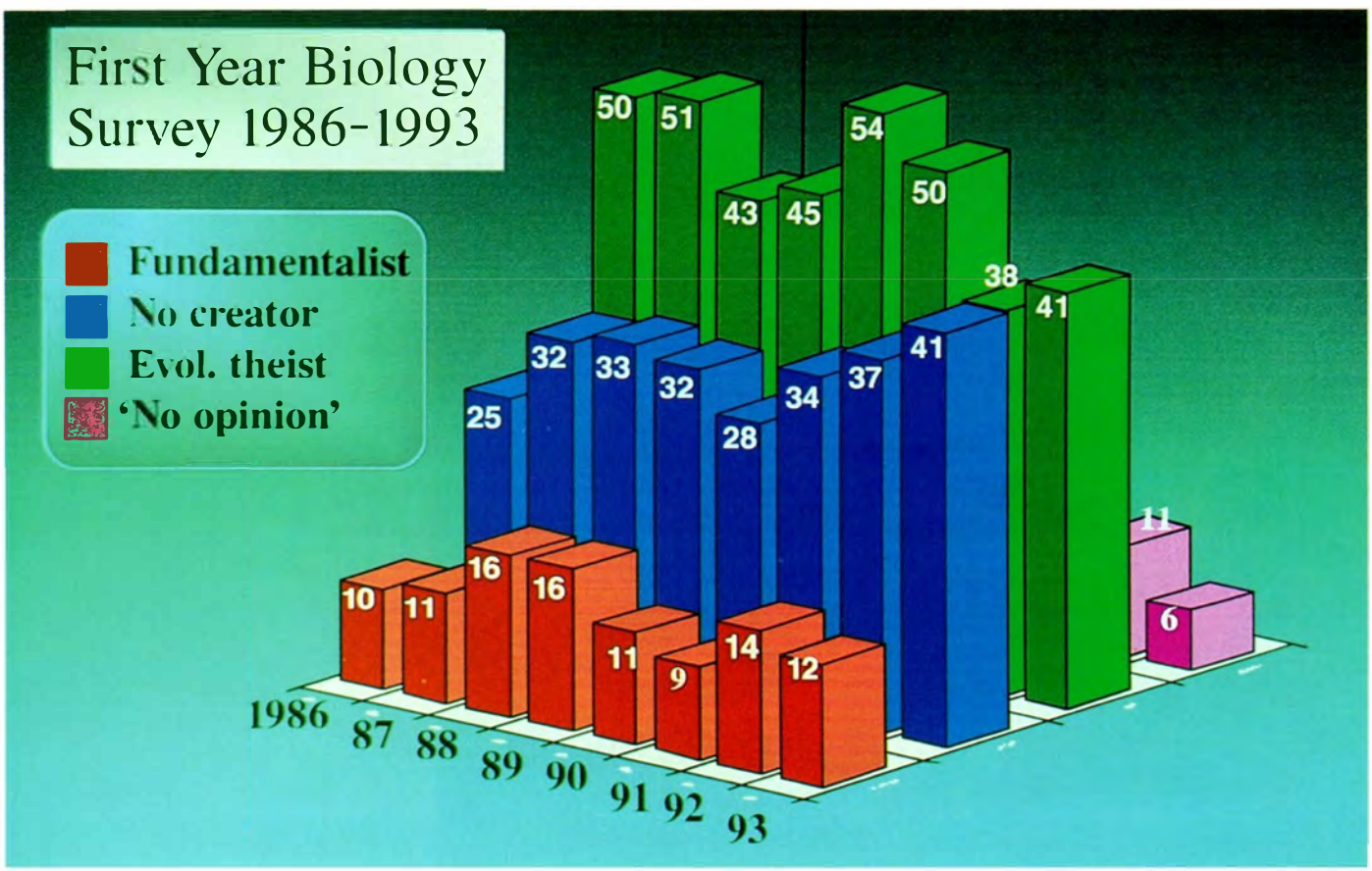
In Australia concern about the spread of anti-intellectual gobbledegook has its ups and downs but those of us committed to tertiary education are regularly reminded that zealous advocates for the irrational can be found in every audience. In a survey of university medical students conducted in 1993 by Professor Roger Short (Monash University), 27 per cent of students considered that species did not evolve and 21 per cent believed that God created Eve from Adam's rib. Even after a course on evolutionary biology, the same proportion of students clung to their convictions about the miraculous nature of the first couple. A similar study conducted by the Australian Institute of Biology and published in 1992 involved 4,255 first-year biology students at 17 Australian universities and found fundamentalism alive and well with, for example, the University of Sydney hosting 17 per cent committed to the literal truth of Biblical Creation.

In 1986, in order to assess the extent of the creationist commitment in University of New South Wales biology students, I asked first-year biology students to answer a question very similar to the one posed in the US Gallup Poll. The survey slip read:

Evolution/Creation Survey

Please circle the number of the statement you believe to be the most correct. Do not put your name on this paper—it should be anonymous.

1. God created people (*Homo sapiens*)



pretty much in their present form at some time within the last 10,000 years.

2. People developed over millions of years from less advanced forms of life, but God guided the whole process, including our development.

3. People developed over millions of years from less advanced forms of life. God had no part in this process.

4. I honestly have no opinion about this matter.

Please fold this paper and drop it into the box near the door on your way out. Thank you for helping us with this ongoing survey!

Students who circled number 1 declared themselves to be religious fundamentalists (Christian, Islamic or whatever) unable to accept the scientific evidence for evolution or a 4.5-billion-year-old Earth. To these students, God's 'truths' (as revealed in religious texts) about the Creation week and the young age of the Earth are the basis for rejecting the wisdom of modern science. In this category would have been Creation 'Scientists', Jehovah's Witnesses, Mormons, some Baptists and other anti-evolutionary faiths.

Students who circled number 2 allowed that evolution spanning millions of years may have been God's method of Creation. This compromise point of view has been called 'theistic evolution' and its supporters include most 'mainline' Christians such as Catholics, Anglicans and Presbyterians.

Students who circled number 3 were convinced about the reality of evolution and an old age for the Earth but were also convinced that God had nothing to do with it. In this group would have been non-religious, or at least non-Christian, non-fundamentalist students.

Before I conducted this survey, several of my biology colleagues snorted at the thought that any of our students would be 'creationists' committed to a literal interpretation of the Bible and, largely for this reason, were even disinclined to regard the teaching of evolution and biology as essential—because they assumed that all university students took for granted the venerable observation that nothing in biology makes sense without evolution. As a result, the response to the 1986 survey was a bit of a shock to our staff—at least ten per cent of our first-year biology students were creationists, committed to a view that made evolution (and much of modern science) a pointless subject to teach because their religion told them it was an impossibility.

To see if this response would change from year to year, I have run the survey every year since. The results are summarised in the graph. The numbers of students responding in each year were: 300 (1986); 200 (1987); 399 (1988); 302 (1989); 248 (1990); 313 (1991); 255 (1992); and 251 (1993).

While the data have yet to be explored statistically, there are some curious first impressions. First, declines (1988, 1991–1992) in 'mainline' faith seem in general to correspond with rises in both fundamentalism as well as non-religious views, just as rises in 'mainline' faiths (1989–1990) usually correlate with declines in the other two. Second, of the three 'opinionated' categories (1–3), fundamentalism is the only one that does not show any substantial change in percentage over the eight-year period of the survey, a fact that suggests fundamentalism has not undergone a significant change in the student community. Third, although the duration of the survey has only been eight years, there is at least a suggestion of a 'sine wave' (undulating) pattern in the opinionated responses (1–3) with a periodicity (time period between peaks) of about four to five years.

No less interesting are the long-term trends in evolutionary theism and non-religious views. Although evolutionary theists were twice as common as non-religious students in 1986, in 1993 they crossed the finishing line neck and neck (41 per cent). This represents, over the last eight years, a net drop of nine per cent in the ranks of the evolutionary theists and a net rise of 16 per cent in the ranks of the non-religious students.

For those of us concerned about whether university students are receptive to learning science, the more or less stable and low number of anti-evolutionists should be reassuring. Unlike students in the United States, the capacity to learn science in the vast majority of Australian students seems, at least at the moment, to be relatively unfettered by religious prohibitions.

But before we relax, convinced that there is a diminishing problem here, there is that curious business of the 'sine' waves of fluctuating commitment. If the waves continue their ups and downs at the present rate, we may expect another advance of the 'army of darkness' in 1994–1995. Perhaps the take home message is that the show ain't over while the flat line sines. ■

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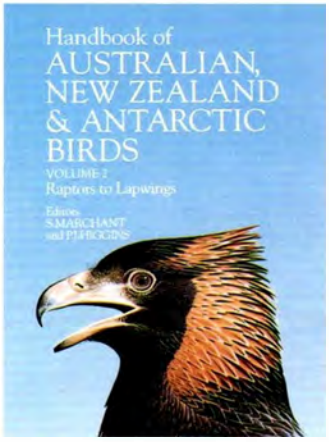
Professor Michael Archer lectures in biology and geology at the University of New South Wales. Most of his non-teaching hours are devoted to the study of the fossil faunas of Riversleigh.

REVIEWS



Handbook of Australian, New Zealand and Antarctic Birds

Ed. by S. Marchant and P.J. Higgins. Oxford University Press, Melbourne. Volume 1, Parts A & B, 1990, 1,100pp., $295.00rrp. Volume 2, 1993, 984pp., $295.00rrp.

In what is perhaps the most ambitious publication project in Australasian ornithology, the Royal Australasian Ornithologists Union has undertaken to produce the comprehensive compilation of information on the birds of the region. This handbook has been long overdue. There have been numerous previous publications devoted to the bird life, but nothing has come close to the level of detail contained here.

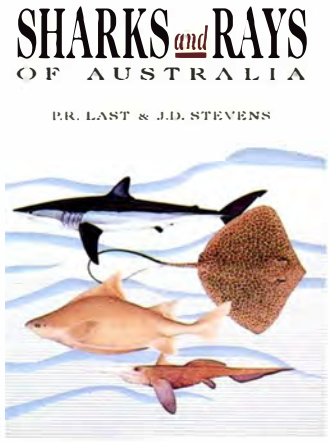
The entry for each breeding species contains subsections on field identification, habitat, distribution and population, movements, food, social organisation, social behaviour, voice, breeding, plumage, moulting, measurements, weights, structure and geographical variation, and an extensive list of references. Species that do not breed in the region or occur only as vagrants receive a less detailed treatment. A gazetteer locates all place names within the area of coverage. The published literature has been reviewed and summarised, to which is added considerable previously unpublished data. The production is coordinated by a bevy of subeditors, each overseeing one of these subsections. The text is complemented by range maps, black and white text illustrations showing aspects of behaviour, sonograms, breeding diagrams and numerous excellent colour plates by Jeff Davies.

The result is a tremendous compendium of information. Volume 1 totals 1,100 pages and required publication in two parts. Part A covers Emus through petrels and Part B pelicans through ducks—a total of 196 species, of which 162 breed in the area. Volume 2 deals with birds of prey through lapwings. The 984 pages cover 118 species, 92 of which are breeders.

There are, however, some drawbacks, the foremost being the time to completion. Scheduled to ultimately comprise six volumes, the Handbook will not be completed until 2003. Over this period, the early volumes will become increasingly out of date as new information becomes available, and the format precludes ease of updating. Much of the work that produces such advances, of course, will be stimulated by the Handbook and its identification of the gaps in our knowledge.

These and other minor quibbles not withstanding, there is no doubt that this series will remain the standard reference on Australasian birds for many years. No-one seriously interested in the birds of Australasia can afford not to have an accessible copy. The hefty price and long-term commitment, however, will probably preclude many people from owning a set. Nonetheless, they should ensure that one is available for consultation through a library, museum or university. The Handbook is simply too important to miss out on.

—Walter E. Boles
Australian Museum



Sharks and Rays of Australia

By P.R. Last and J.D. Stevens. CSIRO Australia, ACT, 1994, 513pp., plus 84 colour plates. $59.95rrp.

This is a great book. It is the culmination of many years of work by two of Australia's foremost ichthyologists, and covers the entire chondrichthyan (sharks, rays and chimeras) fauna of Australia, which totals nearly 300 species.

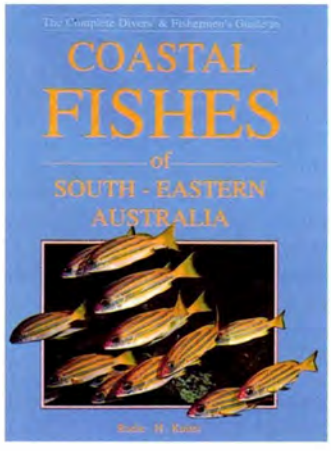
The book begins with an introduction that is packed full of interesting information. This is followed by an excellent glossary and four pages of figures outlining chondrichthyan terminology. The bulk of the book comprises the species accounts arranged by family. For each species, concise text describes the field characters, distinctive features, colour, size, distribution (with a map) and references. Each account closes with a remarks section that covers facts on the species' biology, interest to fisheries and other information including potential danger to humans if appropriate.

Although I am full of praise for this book, there are a few small problems. Occasional discrepancies exsist between the figures and the colour descriptions in the text, and a few of the maps show slight inaccuracies in distributions.

This book will be invaluable to anyone, professional or amateur, who wishes to identify Australian elasmobranchs. It is written in an easy-to-follow style that avoids difficult terms wherever possible. A major strength of the book is the excellent illustrated keys. There are keys to families, genera and species that utilise easy-to-see external features and are illustrated with over 1,400 figures.

Sharks and rays of Australia is not a pretty picture book. It does not contain colour photographs of sharks cruising through crystal-clear water or of Wobbegongs camouflaged on the bottom. It does, however, have 300 superb paintings on 84 colour plates that illustrate each species. Priced at around $60.00, *Sharks and rays of Australia* is excellent value and is destined to become the 'chondrichthyan bible' of the future.

—Mark McGrouther
Australian Museum



Coastal Fishes of South-eastern Australia

By Rudie H. Kuiter. Crawford House Press, NSW, 1993, 437pp. $69.95rrp.

Rudie Kuiter is among the best underwater photographers in Australia and his book, *Coastal fishes of south-*

eastern Australia, has been a labour of love. Even though he has no formal training, his knowledge of fish is comparable to that of Australia's most experienced ichthyologists. His many hours under water and perceptive observations have led to the discovery of a number of new fish species. Rudie's contributions have been such that a genus of fish has been named *Kuiterichthys* in honour of his contribution to Australian ichthyology.

This book is very comprehensive and includes not only species resident year-round in south-eastern Australia (northern New South Wales to western Victoria, but not Tasmania), but many tropical species that are temporary visitors in summer. This makes the book relevant to other areas, particularly southern Queensland.

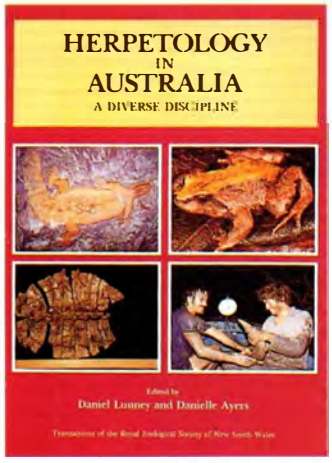
The fish are arranged by family and there is a pictorial guide to each family at the front of the book, as well as keys to each family within the book. The keys are easy to use and concentrate on relatively unambiguous external characters. Common and scientific name, fin counts, an anatomical description, distribution and size information is given for each species.

The pictorial guide to families would be more useful if arranged by fish shape. Orientation could be improved by hierarchical titles and a running head on each page. The keys to family are difficult to find; perhaps they should have been combined at the beginning of the book with the pictorial guide. Within a family, genera and species are not arranged alphabetically and a list of additional references would have encouraged keen readers to seek further information. However, none of these is a major criticism.

This is an excellent, good-looking compendium of information on fishes of south-eastern Australia. It is very reasonably priced considering the high quality of reproduction and scope of the book. It should become part of the library of coastal anglers, divers, snorkellers, marine biology students, professional ichthyologists and anyone interested in fishes of the region. Of use to students and academics is the additional supplement with identification keys to species of larger families and families with difficult-to-distinguish species, and available from the publisher or ordered by your book shop for $10.00.

Although it is filled with excellent photographs, this is more than just a picture book; it is an essential reference for identifying fishes of south-eastern Australia. If you are into fish, you should be into this book.

—Tom Trnski
Australian Museum



Herpetology in Australia: A Diverse Discipline

Ed. by D. Lunney and D. Ayers. Royal Zoological Society of New South Wales, NSW, 1993, 414pp. $80.00rrp.

The first precept of good writing, even scientific writing, is to avoid being boring. This is sometimes very difficult to achieve. However, the impossible has been accomplished in this volume of papers on Australian reptiles and amphibians (the subject of herpetology) edited by Dan Lunney and Danielle Ayers. The volume was compiled as an overview of herpetology in Australia on the eve of the Second International Congress of Herpetology held in Adelaide at the end of 1993. The work was produced under a very tight timetable, and this urgency seems to have overcome most inhibitions and second thoughts, resulting in a series of almost magazine-like articles that will please a variety of readers.

There is, however, one class of readers who should avoid this volume for the sake of good mental health. Individuals who are prone to 'eco-depression' will have their condition tested by much of the material in this book. The vast majority of the contributions are related to conservation (perhaps reflecting the interests of the editors) and are reminders that amphibians and reptiles are continuing to decline in the face of the degradation and loss of habitats due to human activity. Although the articles are written in a highly professional and objective style, a clear underlying message is that many amphibian and reptile populations in Australia are in unremitting decline and that most research is simply providing a well-documented record of their final years.

However, many readers will be positively drawn to the work. For example, the bureaucratically inclined will be ecstatic to find individual articles summarising the current laws and regulations governing the 'use' of amphibians and reptiles in each and every one of the States and mainland territories. These articles are mandatory for those recidivists who persist with the ecosystem-threatening activities of photography, tadpole catching and snake keeping. In contrast, these articles can be ignored by those working tirelessly on habitat improvement through agriculture, mining and urban development. Those wishing to abolish the second tier of government will also find much interest here.

For we lazy readers who have been promising for ages to review those fields peripheral but important to our own, the job has been made easier by three articles. One is a very readable resumé of the palaeontology of Australian amphibians and reptiles by Paul Willis. This is a large field that is difficult to track for the non-palaeontologists. However, here is an overview of what fossils we have, their age and place of origin, and who is studying them. There is also a

very interesting overview of the herpetology of the Northern Territory by John Woinarski. Never before has the history and current work in the herpetology of a major area of Australia been so thoroughly treated. There is also a timely review of the environmental factors influencing the decline of Australian frogs by Timothy Ferraro and Shelley Bergin.

For those readers for whom an evening of deep introspection is the thing, there is Klaus Henle's 'view from abroad' on the current status of Australian herpetology. Henle spent his PhD years at the Australian National University studying the ecology of some lizards in south-western New South Wales, and now offers his expert views on a variety of scientific and 'political' issues. Reading his thoughts is like overhearing oneself being discussed candidly by two 'friends': painful in the process but good for the resolve to 'do better'.

The whimsically inclined will be fascinated to read Adam Stow and Ric Shine's discovery that snakes apparently 'feel better' if their cages (the snakes') are somewhat less than thoroughly cleaned.

Readers who appreciate what might be called the 'rhetorical' aspects of life will enjoy the odd book review. And for those gentle readers who think that animals in nature always die quietly in their sleep at a ripe old age and go straight to heaven, the editors have included the brief thoughts of an animal ethics person.

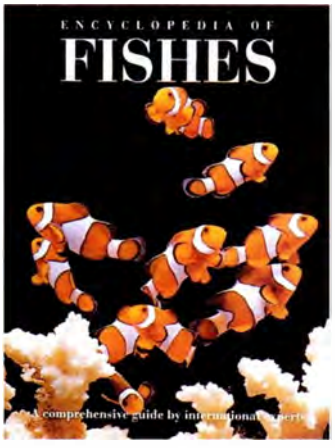
Bibliophiles will wallow in the list of 470 odd 'herpetological' theses produced between 1912 and 1992 that Glen Shea has tracked down. The many unpublished results in these theses support the argument for not awarding any degree for work that is not accepted, at least in part, for publication in a refereed journal.

Addicted readers of adventure stories will be gripped by Gordon Grigg's account of 20 years of research on Saltwater Crocodiles in northern Australia. Here are man-eaters, planes, boats, big egos, and scientific sleuthing, all served up at a fast pace.

Those readers for whom a big night is a bit of hard science and then an early lights out are catered for by Glen Shea's exposition on the male reproductive cycle of the Eastern Blue-tongue Lizard. Graphs, lines, equations, and histological sections of reproductive tubes will swim before their eyes as they sink into unconsciousness.

Finally, there is even some entertainment for the thoroughly mad among us: trying to discover the rational for the organisation of the articles in this volume.

—Allen Greer
Australian Museum



Encyclopedia of Fishes

Ed. by John R. Paxton and William N. Eschmeyer. New South Wales University Press, NSW, 1994, 240pp. $49.95rrp.

Fishes are extraordinarily diverse in shape, size, colour, mobility, behaviour and reproductive biology. They occupy all parts of the globe where there is water, from the bone-chilling waters of polar regions, to the warm waters of the tropics and from the highest lakes to the deepest trenches. Despite this, the authors have succeeded in giving the reader an excellent appreciation of the diversity of forms and lifestyles of fishes; something that is hard to do in 240 pages. This book will greatly increase the readers' awarness of the world of fishes and everyone will enjoy the wealth of beautiful photographs and drawings that are found in all sections of the book.

The editors are admirably qualified to produce a book of this type; they are well known for their other published contributions on fishes and both have considerable expertise on the taxonomy of fishes. As well as this, a number of distinguished authors have contributed chapters. These include Gerry Allen, Howard Choat, Bob McDowall, Gareth Nelson, Jack Randall and Keiichi Matsuura, to name just a few of the 47 authors. The name "encyclopedia" is perhaps misleading; it implied to me an organisational format like many other encyclopedias. The book is not organised as a dictionary type of list, nor is it an exhaustive document on the taxonomy and/or lifestyles of fishes. It is, however, an authoritative introductory guide to fishes that will delight divers, aquarium hounds and others who want to increase their general knowledge of fishes. Anyone with technical expertise on fishes will enjoy the illustrations (where else would you find a picture of a Warty Prowfish expelling toxic fluid?) and additional background information on specific groups of fishes.

The book is organised into two broad sections. The first fifth of the book is entitled "The World of Fishes" and is composed of chapters that introduce fish, describe the system of classification, the evolutionary origins of fishes, habitats, behaviour and endangered species. This section is necessarily dilute, and the emphasis must represent personal preference, but I would have liked to have seen more information on the diversity of life histories of fish, including reproduction and larval phases. I did, however, appreciate the efforts of the authors to provide a good number of pictures of the early life history stages in the chapters on individual groups of fish. These pictures are uncommon and rarely collated into one book.

The second section of the book is divided into 38 chapters on broad groups of fishes that range from the "Jawless Fishes" to the "Triggerfishes and Their Allies". Each section starts with a range map, taxonomic details, number of species and a note about conservation. The content of the text varies greatly between authors; some have emphasised aspects such as distribution, behaviour and reproduction (such as for damselfish), while others have focused on taxonomic diversity (for dories). The coverage of representatives of different groups had to be highly selective for a book of this size. I checked the index for the common names of 30 well-known species (ten from Australia, Europe and North America). Fifteen of them were listed, but only one ninth of the Australian names were present—names such as Gemfish, Orange Roughy, Snapper (*Pagrus auratus*) and Tailor were not to be found. You would not buy this book to find the names of fish caught during your recreational fishing holiday. If you want a field guide to fishes of Australia look at the excellent guides illustrated by Roger Swainston, but Paxton and Eschmeyer's *Encyclopedia of fishes* would make an excellent companion to any field guide.

I was disappointed that the editors chose not to give a guide to further reading for the enthusiastic 'fisho' and a glossary of terms would also have been useful for those who want a quick reference to words such as 'myotomes', 'protandry' and 'diadromous'. In general, however, the text was easy to read.

Frank Talbot's wish in the forward was "May this book aid the enjoyment and understanding of the wonderful world of fishes for you...". I believe it will for people who want to increase their general knowledge of fishes and appreciate superb photographs of these intriguing animals. Moreover, the book is great value considering the wealth of illustrations. Instructors of popular introductory courses on the diversity and lifestyles of fishes should seriously consider this book as part of their reading list.

—M.J. Kingsford
University of Sydney

Blue Mountains Dreaming: The Aboriginal Heritage

Ed. by Eugene Stockton. Three Sisters Productions, NSW, 1993, 160pp. $14.95rrp.

For those interested in the New South Wales Blue Mountains and its earliest inhabitants, this is an excellent book. Its editor, Eugene Stockton, is one of the pioneers of Blue Mountains prehistory and archaeology. He grew up in the Blue Mountains and his life-long interest in archaeology began as a teenager in this environment. The book's nine chapters are written by six people, all of whom are past or present Blue Mountains residents interested in local Aboriginal history.

Three chapters by Stockton are on pre-European Aboriginal occupation, Aboriginal sites and Aboriginal art. Evidence for pre-European Aboriginal occupation comes principally from archaeological excavations, which in this area began in the 1930s.

The type, number and distribution of some 700 Aboriginal sites now recorded in the Blue Mountains are discussed. This large number of recorded sites is interesting as the Blue Mountains have often been seen as inhospitable and sparsely occupied by Aboriginal people. Distribution of the sites and pre-European occupation are discussed in the context of past and present climate, physical landscape, resources, and biases introduced by researchers' interests. Other chapters deal with topics such as language, post-European contact and food resources that were available to Aboriginal people.

This book is packed full of information about Aboriginal occupation of the Blue Mountains. It is well presented with maps and illustrations of Aboriginal sites and the environment. The text is written for a general audience so it is clear without unnecessary technical jargon. The level of factual information and references, however, will make the book of interest to professional researchers and students at all levels, as well as to Aboriginal people and the interested public. A book at a reasonable price and well worth getting.

—Val Attenbrow
Australian Museum

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Mammals of the South Pacific *By T. Flannery. Reed Books, NSW. $85.00.*

Lives of Whales and Dolphins *By R. Connor. Reed Books, NSW. $29.95.*

The Future Eaters *By T. Flannery. Reed Books, NSW. $39.95.*

Coastal Marine Ecology in Temperate Australia *By A.J. Underwood and M.G. Chapman. New South Wales University Press, NSW. $34.95.*

Salinisation of Land & Water Resources *By F. Ghassemi, A.J. Jakeman & H.A. Nix. New South Wales University Press, NSW. $69.95.*

JANUARY

Australian Frogs *By M. Tyler. Reed Books, NSW. $34.95.*

The Rise of Fishes: 500 Million Years of Evolution *By J. Long. New South Wales University Press, NSW. $49.95.*

Kangaroos *By T. Dawson. New South Wales University Press, NSW. $24.95.*

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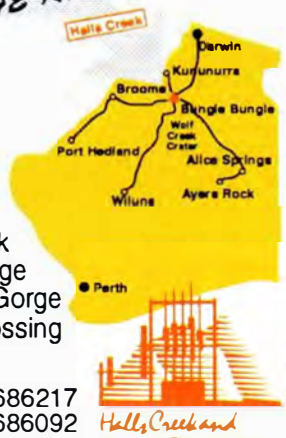

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Contact Name: Neroli & Bill Price, Contact Officers

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Contact: Sheila Witt, Hon Secretary

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25 Ross St, Gladesville, NSW 2111.
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Contact: Lisa Burmeister, Communications Manager

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Q&A

GRENVILLE TURNER/WILDLIGHT

The mysterious migrations of Spangled Drongos are slowly beginning to be understood.

Drongos on the Move

Q: *Every year, for a number of years now, we have had two Spangled Drongos (sometimes with family) come to our house to feed. They are around from July to August and then they are gone for the rest of the year. We always know when they are 'migrating' because they come three or four times during the last day to be 'filled up' with mince. They are quite tame and will take mince balls on the wing or be hand fed on the railing. Do you have any idea where they would possibly go to for the other nine months of the year?*

—C.G. Illingworth
Annerley, Qld

A: The movements of the Spangled Drongo (*Dicrurus bracteatus*) in Australia have long been puzzling. In Sydney, for example, they are winter visitors, whereas in other parts of the country they appear in summer. In a soon-to-be-published study, Kevin Wood found that Spangled Drongos are present throughout the year in eastern Australia and that there are three distinct patterns of movement that occur simultaneously in different parts of the country with a certain degree of overlap.

In Queensland, from Torres Strait south to Rockhampton and probably to northern New South Wales, there is a southwards movement in spring. At this time the Spangled Drongos tend to concentrate near the coast. In autumn, they return north but across a broader front. Birds in south-eastern Queensland and north-eastern New South Wales move in spring from lower altitudes into the ranges, returning to the coastal districts in autumn. This probably explains the movements of your birds. From about Forster, New South Wales, to Victoria, there is a comparatively smaller-scale northwards movement in spring and a southwards return in autumn, producing the 'against the grain' arrival in Sydney. The reasons for these differences are still not understood. Nor is it known if they involve different age classes or whether there is an interchange of individuals between the differently moving populations. Obviously there is still much work to be done.

—Walter E. Boles
Australian Museum

Seeing Black and White

Q: *About ten years ago I used to park my car on St Kilda Road. Nearby, there lived a white Blackbird. He seemed determined to spread his albino genes about the place as he was a very fine singer. Just last week I was in the Botanical Gardens when I spotted another Blackbird and I wondered if he was some distant descendant of my albino friend. I am sure I read somewhere that the avian ovum (egg) carries the 'Y' chromosome and I wondered if the locus for colour was on the Y. If it was, it could account for the paler colour of the hen, and maybe the pied fellow I saw was the result of an albino–normal mosaic effect. Or am I mixing my genetic metaphors and simply setting a tortoise shell cat among the pied Blackbirds?*

—Amanda le Bas
Selby, Vic.

A: Albinism, partial or total, in European Blackbirds (*Turdus merula*) is a relatively common and well-documented phenomenon throughout its range. Although noted in a number of texts, the genetic causes for such a high incidence of pigment aberration in this

KATE LOWE

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, ANH Magazine. Please don't forget to include your name and address. The first correct entry will win a $20 gift voucher from the Museum catalogue. Spring's Pic Teaser was a feather louse.

species is poorly understood. It is particularly conspicuous in adult males. The presence of a pied condition in the Botanic Gardens does not indicate a relationship with your earlier albino individual (on the other hand, it is not impossible either).

In birds the sex chromosomes situation is reversed from the familiar arrangement in mammals where XX represents female and XY represents male. It is the female bird that is heterogametic (that is, it has the two different sex chromosomes), whereas the male is homogametic (both sex chromosomes are the same). The standard notation is also different for birds, so females are WZ and males ZZ. I am unaware of any evidence that suggests albinism in this or any other species of birds is sex-linked.

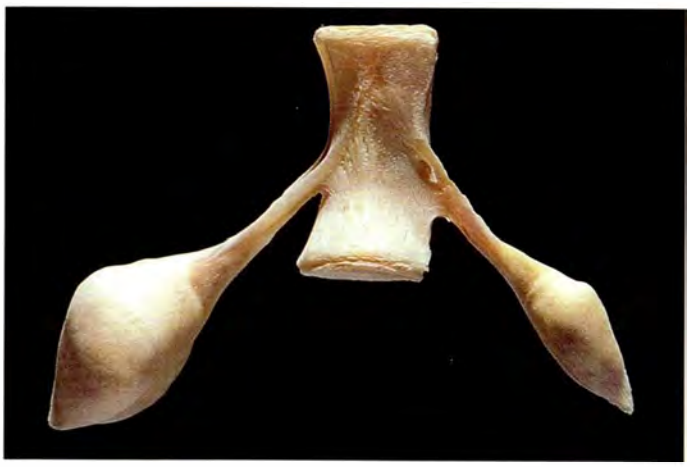
Although the paler colour of the hen is genetically determined, it is not simply a result of her being heterogametic. The plumage of adult female and immature birds of both sexes is normally much paler than that of the solidly black adult male. Blackbirds can be aggressive birds, particularly towards other pairs during the breeding season. The paler colouration may help reduce aggression by an adult male towards females and younger, non-breeding (and thus non-rival) males.

—Walter E. Boles
Australian Museum

Swollen Fish Bones

***Q**: I recently caught a fish that had large lesions on its vertebrae. Are these due to a toxin or are they some kind of tumour?*

—Shane Hobson
Newcastle, NSW



A fish vertebra showing large lesions.

A: The enlargement of areas of fish bones such as this is known as hyperostosis. Translated it simply means above normal bone growth. Hyperostosis is known to occur in about 80 species of fishes across at least six orders and 20 families. Bone sites that are affected and how they grow appear to be fairly consistent within a species. Why it happens, however, is unknown. It has been suggested that hyperostosis may be a response to pollution, or possibly a disease, however evidence suggests that it has a genetic base. If you are concerned because you found the bones on your dinner plate after a meal, don't be. Hyperostosis of the bones doesn't appear to have any effect on the edibility of fish.

—Mark McGrouther
Australian Museum

Answers to Quiz in Quips, Quotes & Curios (page 16)

1. Conservation and Land Management
2. Western Australia
3. Tasmania
4. Honey Possum
5. (a) An ant
6. Chlamydial disease
7. The distance that light travels in one year
8. A boomerang
9. Mary Gilmore
10. Leadbeater's Possum

AUSTRALIAN MUSEUM

Native wildlife has been shielded from the public by draconian legislation and regulation.

FLAWS IN THE LAWS OF NATURE

BY PETER MIRTSCHIN

THE DECLINE IN AUSTRALIAN wildlife has reached levels of high concern. We have lost 20 vertebrate species in the last 20 years, bringing the total vertebrate extinctions since European settlement to 41 species and subspecies and 139 currently threatened. There has also been a substantial drop in the numbers of large venomous snakes since 1979, and the well-reported disappearance and decline of several frog species. Among the reasons for these declines are a significant loss in vegetation cover, and direct and indirect effect of feral animals. Cats and foxes alone are conservatively estimated to kill 6.4 billion native animals per year.

Given the above problems, one would expect governments to be seriously attacking the problems and engineering a reversal of the above trends. For the last 20 years Australians have spent over $120 million per year propping up the nine wildlife authorities around Australia. The fact that our wildlife is still declining, that feral animals are still rampant and that the environment is continuing to be degraded is stark evidence of our money being unwisely spent.

One of the biggest problems, I feel, is that most Australians have lost touch with their native wildlife, which has been effectively shielded from the public by unnecessarily draconian legislation and regulation.

Although the ability to keep native animals as pets or for interest is possible, there are still at least 45 cat owners to every person registered to keep native animals. A comparison of the regulative conditions imposed on the keeping of cats compared with native animals is useful. For most native animals, the requirements include a permit to take the animal from the wild, a permit to keep it in captivity, another permit to show it in public and still another to transfer it within some States. On top of this there are strict enclosure requirements, and fines and/or court appearances if the law is broken. By contrast, with the exception of a few councils, there are no permits or restrictions for cat owners.

KATHIE ATKINSON

Dog, cat, or flying fox. Which should we be encouraged to keep as a pet?

The cost ineffectiveness of draconian wildlife regulation can be illustrated by this simple example. Recently, the nine Australian wildlife authorities and one customs authority, with their considerable taxpayer-funded resources, admitted that in 70 prosecutions in the nine-year period between 1984 and 1993, they saved 956 animals and eggs from wildlife traffickers. Sounds impressive? Or not? One feral cat is estimated to kill 800 native animals in one year. So for the price of one bullet, almost the same savings in wildlife can be made in an instant. Two bullets, and you're in front. No assessment has ever been made of the effectiveness, in terms of saving wildlife populations, of the current system. Apart from a few exceptions, this example suggests that, as well as being counter-productive, effort in other directions would be more profitable.

Throughout Australia, books on the keeping of dogs, cats, horses and various exotic birds as pets abound, but there are very few books on the keeping of native animals. Why? There is simply no demand for them because people are discouraged from keeping them on account of the laws. The average Australian is highly familiar with cats and dogs but has generally little empathy for native animals. If, on the other hand, people were encouraged to keep native animals, they would learn by direct experience about the basic requirements of these animals, giving owners an appreciation of the environmental requirements of the species and a greater understanding towards the needs of conservation. Only when there has been a substantial increase in the level of environmental empathy by most Australians will there be a marked increase in the rehabilitation of degraded land, waterways and wetlands, and a real political force to allocate substantial funding to eradicate or control feral pests.

A proposal that took almost a year to compile by a wide group of herpetologists in South Australia recommended the establishment of a system where three categories of wildlife were recognised. The threatened group, those that are of unknown status, and those that are not at risk. It was proposed that those in the latter group be made available to anyone from the public in limited quantities. Predictably the proposal was rejected by the South Australian authority.

Wildlife authorities must understand that, before we can give Australia back to our wildlife, we must first give our wildlife back to Australians. To achieve this, a more user-friendly, uniform and specific (rather than blanket) wildlife regulation system throughout Australia is needed and the authorities themselves must get out and promote the keeping of native animals as an alternative to exotic animals. ■

Peter Mirtschin is a practical conservationist who operates Australia's largest venom extraction facility, Venom Supplies in South Australia.

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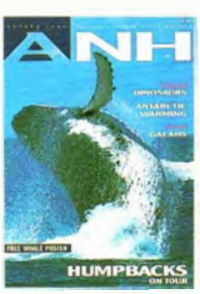

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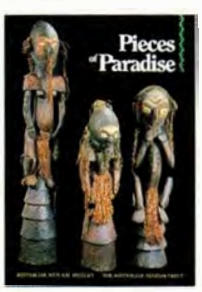

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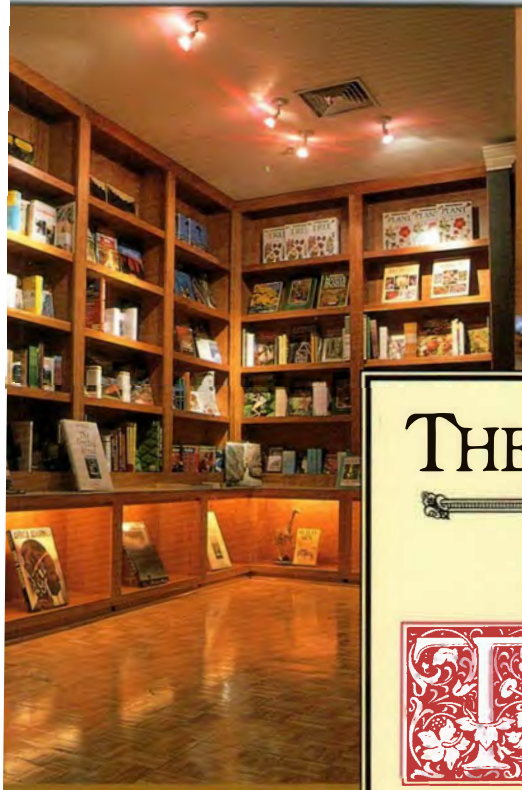

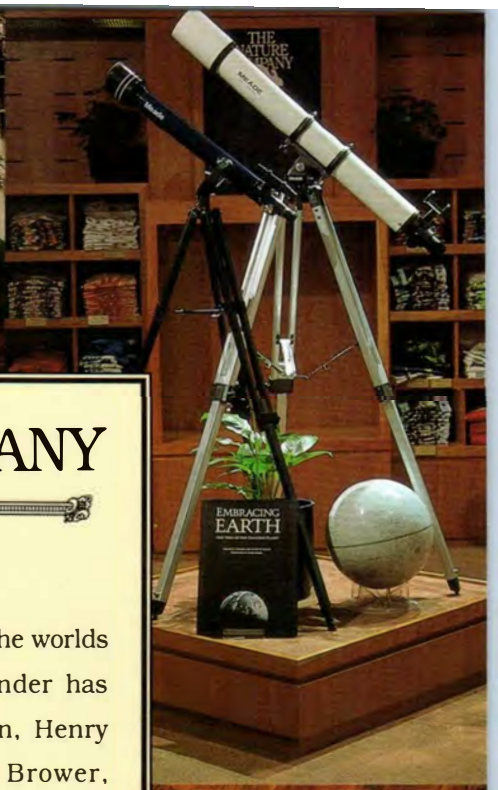

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