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AUTUMN 2001

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Grey Nurse Shark
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BEAR CUSCUS

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FRONT COVER

An adult male Bear Cuscus (*Ailurops ursinus*) from Sulawesi. Weighing up to ten kilograms, this is the world's largest recorded possum. Photo by Tom Heinsohn.

up front

Warning: stingers are present! These words are capable of keeping people out of Australia's tropical waters in droves. Stingers, or box jellyfishes as they are also known, include a number of species of box-shaped jellyfish and, one of these species, which occurs in tropical Australian waters, is considered to be the deadliest marine creature in the world. But this did not deter an ardent scientist from getting right in amongst them on his quest to find out how these animals live. What he discovered is that these lumps of jelly, made up of 96 per cent water, are active predators, completely in control of where they want to go and how they get there.

P. A. SUTHERLAND/OTHER WORLD IMAGES, USA

Centipedes, on the other hand, may not be deadly but they can certainly sting. These animals are familiar to many of us who have encountered them while gardening or bush walking, and they are really quite amazing. For a start, centipedes have been around for over 400 million years and, in contrast to their name, no centipede on Earth has one hundred legs. In "Centipedes: the Great Australian Bite", the Australian Museum's Greg Edgecombe introduces us to the world of centipedes—a world that has been largely neglected by science.

Just about everything to do with the Bear Cuscus is unusual. It's an Australian-style marsupial that lives deep in the tropical rainforests of the Indonesian island of Sulawesi (which many believe is a truly amazing place to find a marsupial) surrounded by monkeys and other typically Asian mammals; it's more active during the day than at night; and it's the biggest possum in the world even though it doesn't look much like a possum. Tom Heinsohn describes his first encounter with the Bear Cuscus as one of the most memorable experiences of his life. So turn to page 24 and meet an incredible and little-known marsupial that has managed the rare feat of having a foot in both hemispheres.

The people of Useless Loop in Western Australia seem to have taken Wopilkaras (Greater Stick-nest Rats) to their hearts. When scientists decided to attempt a reintroduction of these wonderful little marsupials back to the mainland, it required the combined efforts of conservation agencies, the CSIRO, local communities, private enterprise and volunteer organisations. Read "The Wopilkara's Return" on page 52 and not only meet a unique house-building rodent but find out what can happen when everyone works together.

Also in this issue we reveal why Grey Nurse Sharks are not the villans they have long been thought to be, the importance of cassowaries to a healthy rainforest ecosystem, why Australians have been colonising New Zealand for thousands of years, and the consequences of putting a price on our ecosystems.

—JENNIFER SAUNDERS

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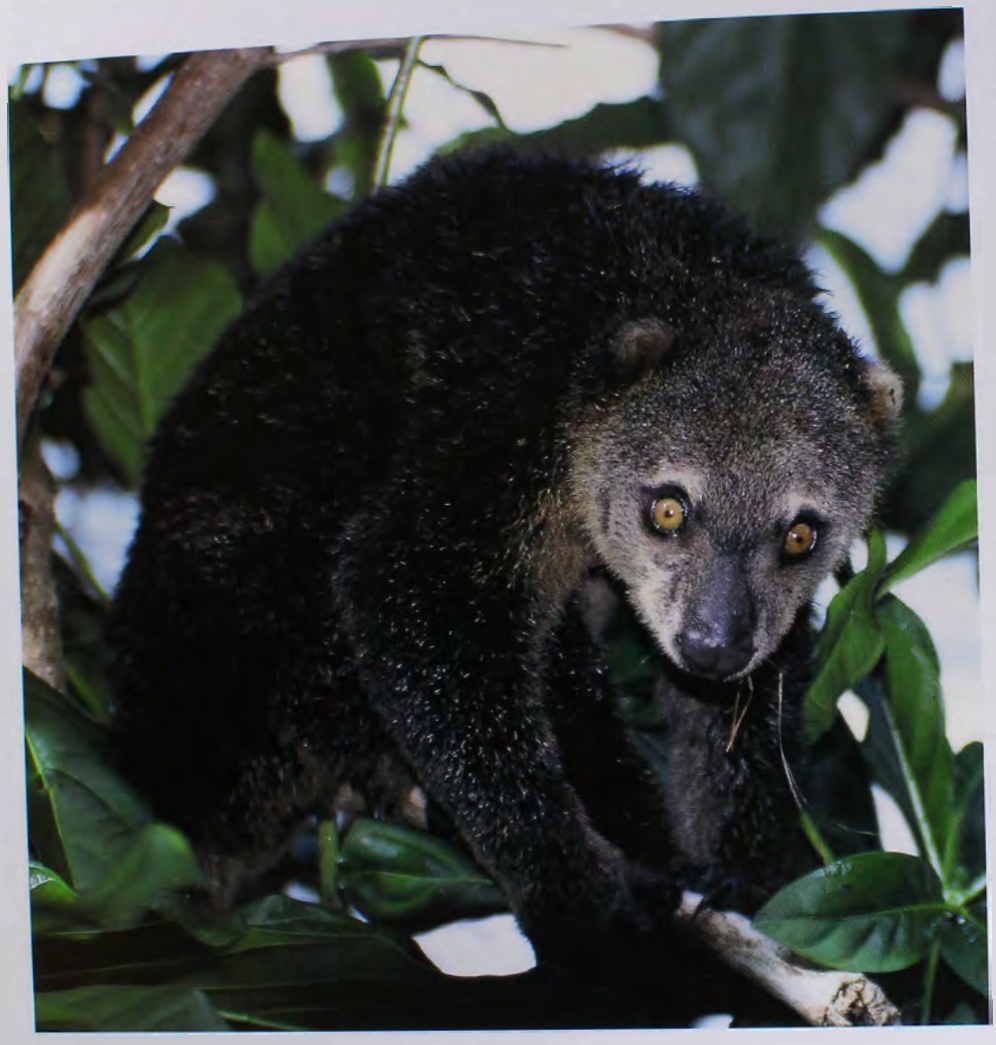

RARE & ENDANGERED

Grey Nurse Shark

Wrongfully accused of being a 'man-eater', the Grey Nurse Shark is now fighting for its survival.

BY NICK OTWAY

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WILD THINGS

Eastward bound

Most of the traffic that flows between Australia and New Zealand goes one way. East!

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Tropical waters

Colour, drama, fish of every kind and a mind-boggling array of invertebrates—just another day at the office for the inhabitants of a coral reef.

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THE LAST WORD

Not so easy being green

Putting a dollar value on wildlife for its protection could actually lead to its ultimate destruction.

BY DAVID HORTON

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COLUMNS

letters

Wild Pets

I share Michael Archer's concern about the damage to native wildlife populations by domestic Cats and Dogs (*Nature Aust.* Autumn 2000). However, I fear that substituting native wildlife as "domestic companions" would only create new problems.

Domestic animals are different from wild animals: they have been undergoing a process of artificial selection for thousands of years, with human beings moulding them to become more like how we want them to be. For example, most domestic Dogs are considerably different from their wolf ancestors, showing the more immature traits of their wild counterparts, being smaller, cuter, more affectionate, more dependent and less aggressive.

The wild animals that Archer suggests Australians take home are just that: wild. Having undergone natural selection, they possess characteristics that enable them to survive in the wild; characteristics that cannot be expected to disappear through hand-raising or selective breeding for a few generations, and that are not particularly suited to the home. Society still experiences difficulties with aggressive and territorial Dogs, despite their domesticity. What problems might we encounter with animals only a generation or two from the wild? They may show fearful, aggressive behaviour, scent-mark their territories, burrow, climb and hunt. They may cause property damage, and be active throughout the night.

Everyone has heard of the odd wild animal that has made a 'good pet', but I imagine there are many more cases of hand-raised animals that matured into unsuitable companions and were dumped in the bush to face uncertain futures.

—Julie Murphy
East Brunswick, Vic.

Time Matters

Jim Allen (*Nature Aust.* Spring 2000) argues for human arrival in Australia no earlier than 45,000 years ago. But three factors undermine his claim.

First, no radical revision to world prehistory is required by the colonisation ages of 50,000–60,000 years advocated for more than a decade by Rhys Jones (Australian National University) and us. The consensus view for the time of migration of modern human ancestors 'Out of Africa' is about 100,000 years (as correctly stated in the Nature Strips item "Neanderthal Cocktail" in the same issue), not 45,000–50,000 years as suggested by Allen.

Second, Allen worries about termite disturbance of archaeological deposits in northern Australia. Termite activity will mix together sand grains from different levels and produce a wide range of single-grain ages. But the published results of OSL dating of individual grains from Malakunanja show no such mixing pattern, the level of the lowest artefact being dated to about 56,000 years. Of course, any mixing would also affect ^{14}C ages because charcoal particles are similarly displaced by termite activity.

Third, additional support for first landfall before 45,000 years is provided by recent redating of the Devil's Lair archaeological deposit in the south-western corner of Western Australia. Stone artefacts were recovered by Charlie Dortch (Western Australian Museum) from levels dated to as old as 48,000–50,000 years using ^{14}C, OSL and ESR techniques. Significantly, the 'radiocarbon barrier' of 40,000 years was broken only by using the latest ABOX-SC ^{14}C technology, raising the possibility that some other sites close to the 'radiocarbon barrier', and dated using standard ^{14}C methods, may be more ancient than hitherto appreciated.

—Richard 'Bert' Roberts (University of Melbourne) & Mike Smith (National Museum of Australia)

Roberts and Smith fail to recognise the accepted distinction between anatomically modern humans, who reached the Middle East, but not beyond, about 100,000 years ago, and behaviourally modern humans, who appeared 45,000–50,000 years

Cute they may be, but would Eastern Quolls (*Dasyurus viverrinus*) make good domestic pets?

ago, as I stated. The successful human negotiation of the water barrier that kept Homo erectus *in Java and out of Australia for a million years was quintessentially modern behaviour. Behaviourally modern humans appear first in south-west Europe at 40,000–43,000 years ago, and do not occur anywhere between the Middle East and Australia until 43,000–45,000 years ago. Older dates than these for humans in Australia confront this picture.*

Termites are unlikely to mix widely separated sand grains without first bringing them to the surface, where luminescent clocks are likely to be reset, as discussed. Thus OSL dating of these grains will not identify mixing. However, Roberts and Smith have a point about charcoal particles. I understand that such particles have permeated the lower levels of the claimed 50,000–60,000-year-old Nauwalabila site, and have recently been ^{14}C-dated to less than 10,000 years, suggesting downward movement for which termites might be responsible. Perhaps similar tests could be applied to Malakunanja?

The new Devil's Lair data are still unpublished, but Roberts and Smith have seen my long subsequent critique of these data. Dortch identified the earliest undisturbed evidence for human presence as a hearth, now redated at about 40,000–41,000 years, and demonstrated that sands lower down have been compromised by water erosion. The claimed oldest date (48,000–50,000 years) comes from the layer containing the lowest of only four artefacts in these sands. The ambiguous association of this date and one small stone flake offers no archaeological support for the claim.

The suggestion that ^{14}C dates of more than 40,000 years have only been achieved using ABOX-SC is wrong. Carpenter's Gap, a site worked on by Roberts, for example, was dated using earlier ^{14}C techniques to 41,000 years, and at least 100 dates determined by older methods for samples from geological contexts exceed this boundary. That only three or four such dates exist for archaeological sites more likely reflects human absence rather than technological limitation.

The implication that ABOX-SC might increase the age of sites previously dated by earlier ^{14}C techniques is disingenuous. Roberts and Smith are aware that a three-year redating program of such sites in five States, using ABOX-SC, has largely confirmed the original dates, the claimed age for Devil's Lair being the standout exception. Such an overall result offers strong support for the younger chronology, as does Roberts' own work over the last decade redating many of these same sites using luminescence techniques.

A central theme of my article was that appeals to piecemeal and particularistic evidence are now unproductive. I look forward to Roberts and Smith engaging the fuller debate in more detail, somewhere down the track.

—Jim Allen
La Trobe University

Magpie Maids

About eight years ago, my wife and I moved to East Doncaster to a home adjoining a park. Because we like birds, we put food out on our lawn to attract some birds. A pair of Australian Magpies started coming and they soon became so tame that they'd sit on my knees to be fed.

The first year they brought two chicks with them but when the time came for them to start nesting again, the parents attacked the chicks until the youngsters eventually left, never to return. This pattern was repeated each year until the year before last when we realised one of the two chicks was still around. Last year the adults proceeded to nest again and produced two more chicks, and the older sibling (which I think is a female) helped feed the new chicks.

We thought this was a bit strange as they had not allowed any of their other chicks to stay around for the following nesting period. To our surprise the parent hen then disappeared for a while and turned up towards the end of last year with another single chick, which the same older sibling again helped feed. The result of all this is that now we have a flock of six Magpies coming for a feed every day and they all seem content to flock together, although this is the first time we have had more than the parents and new chicks for longer than the start of the next nesting period.

I am wondering if any of your readers have had similar experiences with this type of behaviour in Magpies.

—Alvin (Taddy) Lyons
East Doncaster, Vic.

Nature Australia **requests letters be limited to 250 words and typed if possible. Please supply a daytime telephone number and type or print your name and address clearly on the letter. The best letter in this issue will receive a copy of *Global spin*. The winner this issue is Julie Murphy.**

nature strips

COMPILED BY GEORGINA HICKEY

DANIELLE CLODE, RICHARD FULLAGAR, KARINA HOLDEN, MICHAEL LEE, KAREN McGHEE, RACHEL SULLIVAN AND ABBIE THOMAS ARE REGULAR CONTRIBUTORS TO **NATURE STRIPS**.

Fat-bellied Sex for Food

It's usually the male of the species that struts his stuff to attract mates. One major exception, however, is the dance fly family (Empididae), a large group of carnivorous insects in which females commonly compete for sex. The reason is that female dance flies have lost the ability to hunt and must rely on males to nourish them during mating with meals known as nuptial gifts.

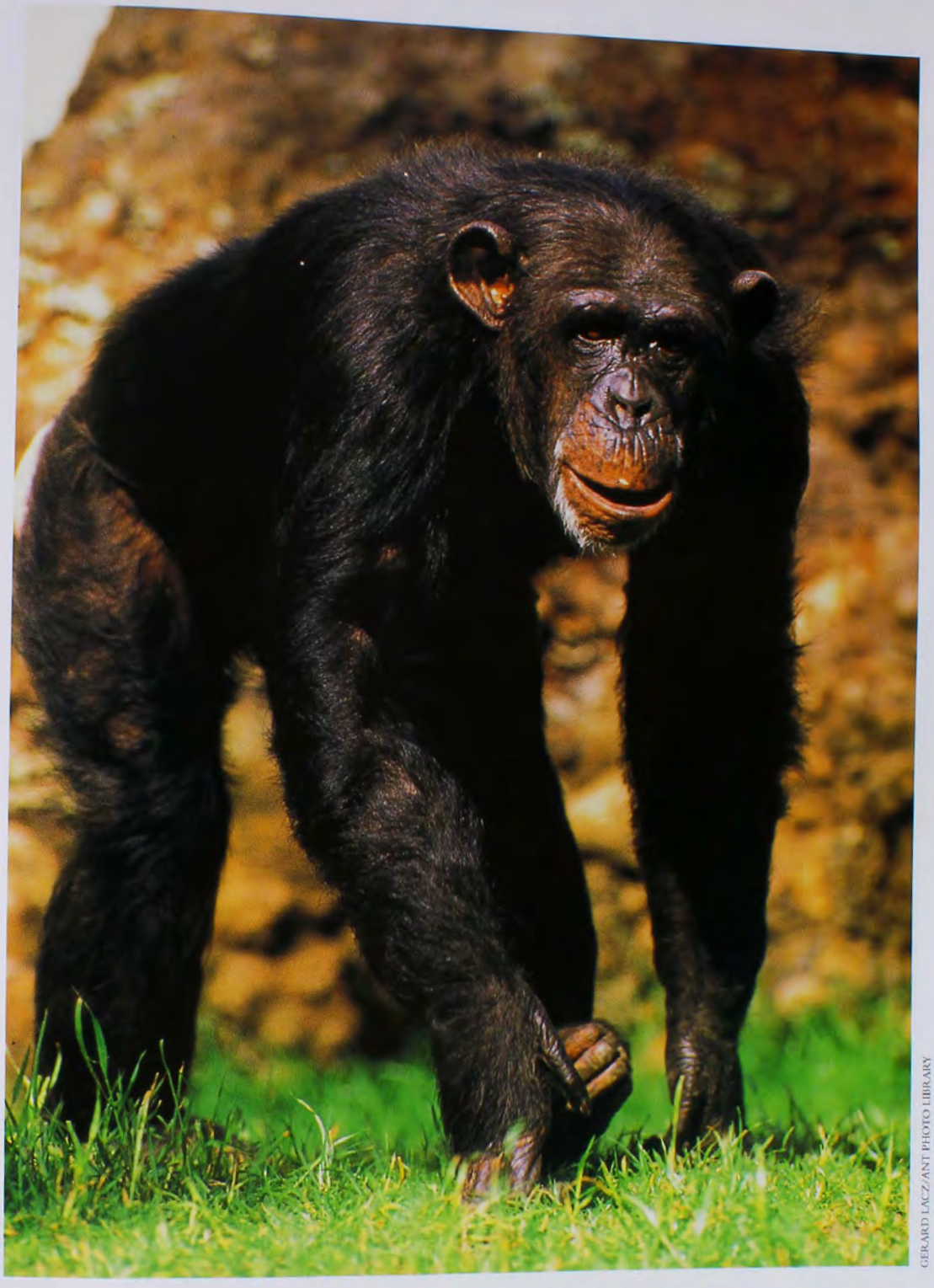
As a result, females of some species have developed physical traits to enhance their sexual attraction. For example, a fat belly is an irresistible temptation for the male Long-tailed Dance Fly (*Rhamphomyia longicauda*), according to David Funk (Stroud Water Research Center, Philadelphia) and Douglas Tallamy (University of Delaware). And, as they discovered, the females deceitfully exploit this to get a mate…not to mention that all-important meal.

Each evening at dusk, females congregate and hover at a common location to compete for mates, but only after swallowing air to inflate their abdominal pouches. They then accentuate their fat-bellied appearance by positioning their 'feathery' legs around the edges of their abdomen. Using plastic models suspended on thin nylon thread, Funk and Tallamy confirmed that males of this species prefer bulging-bellied females.

The reason why was revealed by dissections of females from a related species, *R. sociabilis*, which can't inflate their appearance because they don't have expandable abdominal pouches. The researchers found belly size in this species indicated the state of egg maturity. This is significant to a male because the further developed the eggs are, the greater chance he has of fertilising them. Female Long-tailed Dance Flies have evolved the wiles

DAVID H. FUNK

A female Long-tailed Dance Fly puffs herself up to attract a male.



GERARD LACZ/ANT PHOTO LIBRARY

Early human ancestors might have walked on their knuckles, like this Chimpanzee.

to take advantage of this to ensure they'll get fed regardless of the state of their eggs.

—K.McG.

Knuckling Down our Ancestors

Chimpanzees are our closest primate cousins, sharing 98 per cent of their genes with us, along with a host of sophisticated behavioural and cultural traits (see *Nature Aust.* Winter 2000). However, anatomically they are more like Gorillas. Chimps and Gorillas, for example, both walk on their knuckles using clenched fists. In contrast, other primates walk using the open palms or fingers of their hands, and humans, of course, balance on their hind legs.

A recent study on primate wrist bones, by Brian Richmond and David Strait of George Washington University, helps to reconcile this difference in the genetic and anatomical evidence. The researchers first examined the wrists of knuckle-walking apes and those of other primates that swing through trees and walk on their open palms. During knuckle-walking, each wrist is locked in position and extended straight out throughout the stride, whereas crawling on open palms forces the wrists and fingers to bend backwards at the end of each step (try it yourself when no-one's looking). These functional differences were reflected in the shape of the wrist bones: in knuckle-walkers the joint surfaces have notches and matching concavities that lock the wrist firmly in the extended (handshake) position, while in tree-swingers and palm-walkers the wrist bones lack these features, allowing more flexibility.

Richmond and Strait then examined the wrist bones of two early hominids, *Australopithecus afarensis* (which includes the famous 'Lucy') and *A. anamensis*, and found that the wrists retained some of these knuckle-walking features. Knuckle-walking therefore is not a trait unique to Chimps and Gorillas, but was also practised by the ancestors of the earliest humans, or at least their common ancestor. In modern humans, the arms are almost never used for walking and have apparently been so modified that nearly all traces of our knuckle-walking heritage have been lost. One of the fascinating questions that remain is why would an ancestor already suited to a life on the ground decide to walk upright?

—M.L.

Emerald Origins Cracked

The shrouded origins of some well-known jewels has lent them mystique. Now a study of the unique geological fingerprint of

HELLIO VAN INGEN/AUSCAPE

some of the world's most valuable emeralds has exposed some flaws in their supposed origins, and also revealed some ancient trade routes.

A team led by Gaston Giuliani and Marc Chaussidon (Petrographical and Geochemical Research Centre, CNRS, France) pinpointed the origins of several emerald artefacts dating from the Gallo-Roman period to the 18th century, by comparing the ratio of oxygen-18 and oxygen-16 isotopes in miniscule (2 x 10^{-11}-gram) samples of the emeralds.

The Egyptian pharaohs were thought to have been the first to trade emeralds in about 1500 BC, exchanging these for lapis lazuli in Afghanistan. Later, the Romans mined emeralds from Austria. According to historical records, these were the only places where emeralds were mined before the Spanish discovered Colombian emerald deposits in 1545. However, this new study shows that other ancient sources of emerald were known.

An emerald from a Gallo-Roman earring had an oxygen isotope fingerprint that corresponds with emeralds found only from the Swat mine in Pakistan, and another emerald, from the collection of the Nizam of Hyderabad in India, came from a mine in Afghanistan, thought previously to have only been discovered in 1976. Three other emeralds from this Indian treasure were traced to mines in Colombia. The Spanish were quick to recognise and exploit the country's gemological wealth, carrying the high-quality gems on galleons like the Atocha, which sank off Florida in 1622 (with its 2,300 precious green stones, one of which was analysed in the study and shown to originate from Colombia's Tequendama mine).

The study shows that the Silk Route was used to trade emeralds from Egypt, Pakistan and Austria between Asia and Europe until the beginning of the 16th century, when the Spanish established the Colombian emerald trade to Asia, initially across the Atlantic Ocean and later across the Pacific.

—R.S.

'Party-Pooping' Locusts

A whiff of something in the air signals Desert Locusts (*Schistocerca gregaria*) to come together and form huge migratory swarms. That something is a pheromone found in the insects' faecal pellets. Until now it was assumed that the locust itself produces the pheromone, but new research has shown it is produced by bacteria found in the locust's gut.

Microbiologist Rod Dillon and colleagues

What induces Desert Locusts to swarm?

(University of Bath, UK) made their discovery after establishing a germ-free colony of locusts. Locusts were raised in sterile conditions and fed irradiated (hence bacteria-free) grass. The faecal pellets of these locusts smelled much sweeter than those raised on a normal diet with a healthy gut flora. Chemical analyses revealed the difference in odour was due mainly to the absence of the volatile compound guaiacol in the faeces of germ-free locusts. Guaiacol, the researchers showed, is produced by the bacteria as a digestive waste product.

The gut bacteria have no ill-effect on the locusts. On the contrary, the bacteria help defend against microbial pathogens that may harm the locusts. And by utilising the chemical waste product of their internal microflora, locusts signal to others that

The Sonoran Coral Snake is one of two snakes known to fart in the face of adversity.

JOHN CANCALOSI/AUSCAPE

they are ready to get together to start a swarm. When other locusts detect the whiff of guaiacol, they coordinate their movements towards the party.

—K.H.

Snakes' Defensive Farts

When threatened, many snakes produce clear warning sounds. Some hiss, others rattle. But place a Sonoran Coral Snake in the same situation, and the best it can do is fart.

'Cloacal popping', as it is referred to in polite scientific circles, occurs in two rare and relatively small North American burrowing snakes—the Sonoran Coral Snake (*Micruroides euryxanthus*) and the Western

ARTE SCHUMACHER/NATURHISTORISCHES MUSEUM WIEN

The Venus of Willendorf. What was once thought to be a fancy hairdo may be early evidence of fine weaving.

Hook-nosed Snake (*Gyalopion canum*)—and was recently studied by Bruce Young and colleagues (Lafayette College, Pennsylvania).

Each pop lasts less than two-tenths of a second, may be repeated several times, and can be heard from up to two metres away. The pops sound very much like human farts, although slightly higher in pitch. When Young plays recordings of cloacal pops to his students, he has to swear that it is the snakes they are listening to, and not him!

The Sonoran Coral Snake produces fairly consistent, evenly spaced pops of low amplitude (about 50 decibels) and limited range in pitch or frequency (442–5,523 hertz). The Western Hook-nosed Snake, however, produces more variable pops, initially quite loud (about 70 decibels) with a broad frequency range (359–15,178 hertz), but then tapering off to 50 decibels and narrowing in pitch.

To make the sound, the snakes contract their cloacal sphincter, forcing air (and any other material that happens to be there) out. Multiple pops are created by relaxing the sphincter, drawing air in, and contracting again. The different acoustic properties of the two species can be explained by the different sizes of their cloacae and sphincters (small cloaca and large sphincter in the Western Hook-nosed Snake; and *vice versa* for the Sonoran Coral Snake). A large sphincter, for example, would produce initially loud noises but tire quickly, leading to the Western Hook-nosed Snake's diminuendo.

Young and colleagues point out that the only requirements for cloacal popping seem to be a cloaca and associated musculature (plus, of course, the inclination!). All snakes have the physical features, and the researchers therefore believe the behaviour may be more common than has been reported. They also note that those snakes known to fart in the face of adversity occupy the same geographic range, and suggest the behaviour evolved in response to a common predator.

—G.H.

Stone Clothes

Beautifully carved Venus figurines are famous as a source of speculation about sex and fertility in Europe 30,000 years ago. Various archaeological interpretations have hung on their exaggerated breasts and vulvas, their childbearing hips and bulging bellies—so much so that we have been blinded from seeing some of the finer details.

The Upper Palaeolithic is defined in part by new stone technologies, big-game hunting, a flowering of rock art, and distinctively modern humans. The nature of the evidence (mostly big bones and stone tools) has indicated a male world dominated by hunting. However, trace remains of textiles and other perishable items are beginning to paint a different picture.

Following their demonstration of textile impressions on 30,000-year-old clay fragments in the Czech Republic, Olga Soffer (University of Illinois) and colleagues turned their attention to the hand-sized ladies carved in stone and recognised similar patterns. The researchers showed that etchings that were once interpreted as hairdos and body art are in fact woven hats and rather revealing clothes. These include low-slung string skirts, bandeaux (essentially cupless bras), belts and headbands. The clothing must have held special significance (why go to the trouble of carving

L. NEWMAN & A. FLOWERS MACROIMAGE

Sperm-war tactics are used by the seasquirt *Phallusia julinea* to keep other species at bay.

such fine detail if it didn't?) and, coupled with its skimpy nature, was probably used for ritual purposes rather than protection.

Based on cross-cultural studies, Soffer and colleagues believe fine weaving and other perishable textiles of the Palaeolithic were mainly the products of female labour, and may have served as symbols of achievement and power. And if females did the weaving, they probably also did the carving (whoever carved the figures would have to have had an intimate knowledge of weaving, or at least been guided by someone that did).

Studies such as this help redress our view of women in ancient societies.

—R.F.

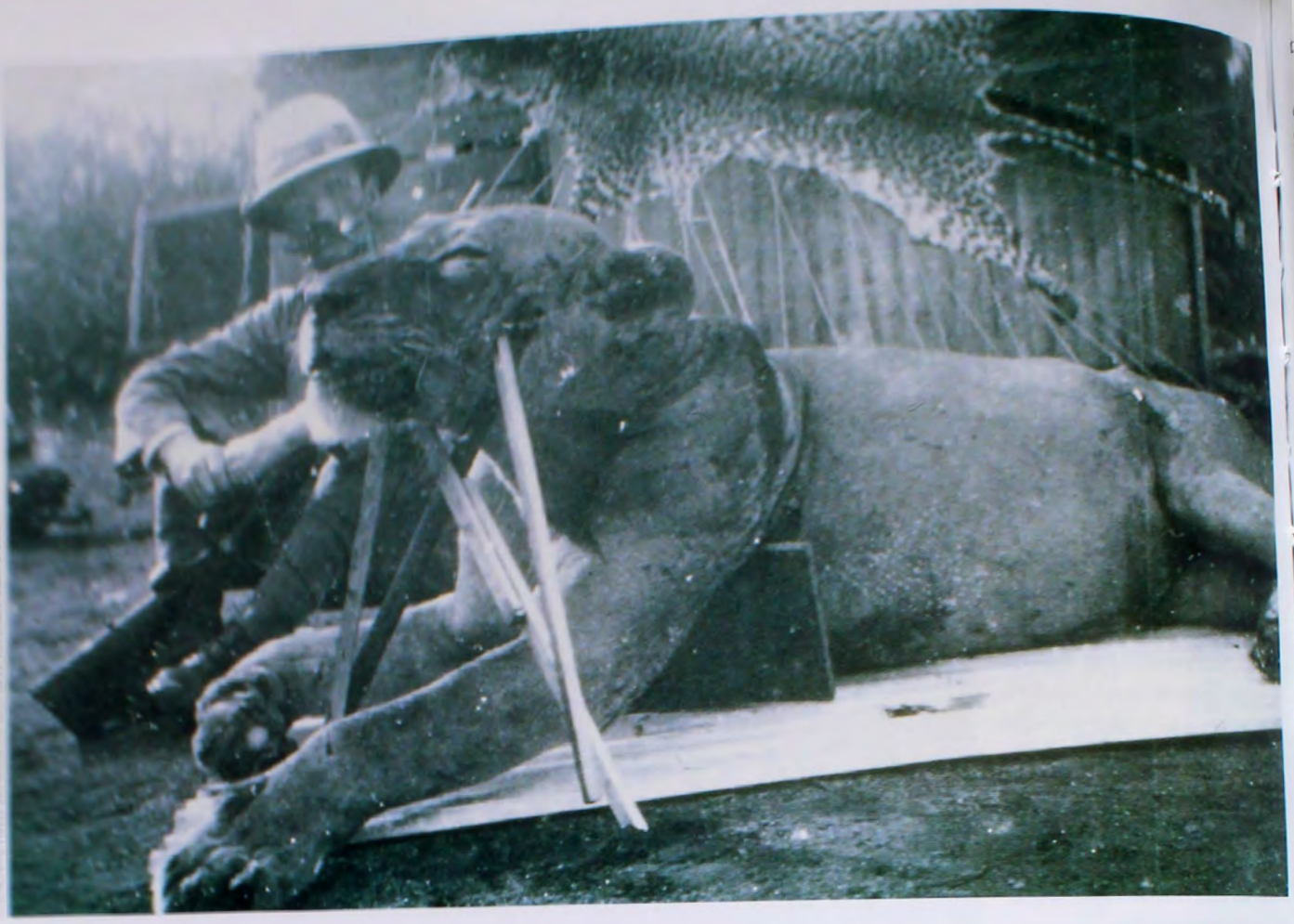
Sperm Attack

Sperm competition within species has been well documented, but what about between species? A recent study on seasquirts provides the first evidence of sperm wars between different species and could change the way ecologists view inter-species competition and colonisation.

Most seasquirts reproduce by external fertilisation, releasing clouds of sperm and eggs into the water. This means that sperm from one species can come into contact with an egg from another for which it is not intended. Or is it? It would appear that broadcast spawners have the perfect armoury to deter other species colonising nearby, by blocking the fertilisation process.

In a series of laboratory experiments, Charles Lambert from California State University, Fullerton, studied the mechanisms that block fertilisation in three seasquirt species (*Phallusia julinea, Ascidia nigra* and *A. sydneiensis*). As soon as a sperm meets an egg, the egg releases an enzyme called glycosidase that prevents the binding of all sperm but the first. However, if the sperm happens to be from a different seasquirt species, the same mechanism is still triggered, rendering that egg useless.

Although direct evidence from natural seasquirt battlefields is lacking, patterns of species densities in the Keehi Lagoon and Kewalo Basin (Honolulu) show that *Ascidia nigra* are much more abundant than *A. sydneiensis*. Lambert showed in the lab that sperm from *A. nigra* interfered much more (44 per cent)



John H. Patterson posing with the first of the Tsavo 'man-eaters'.

with the fertilisation of *A. sphaeriensis* eggs than the reverse (27 per cent), and thus suggests the patterns in the lagoon may be the result of inter-species sperm competition.

These sexual inhibitions of seasquirts may also help explain why so much sperm is produced. Certainly we can now look on a spawning sea squirt as both a lover and a fighter.

—K.H.

Lion with a Sore Tooth

Although people have uneasily coexisted with large carnivores since the dawn of humanity, outbreaks of man-eating occasionally erupt. One of the most notorious took place in Kenya in 1898–1899, when two huge male Lions killed and ate at least 135 railway workers, halting the construction of the Uganda Railway 200 kilometres inland at the Tsavo River. When construction crews deserted in terror, engineer John H. Patterson (no relation) put down his compass and took up his rifle, eventually shooting both man-eaters. He later sold their remains to the Field Museum of Natural History in Chicago, where the skins were mounted and placed on exhibit. The 1996 film "The Ghost and the Darkness" featured Patterson's desperate adventures and rekindled public interest in the Lions.

What led the Lions to attack railway workers at Tsavo and to feed on little else for nine months? Often, man-eaters and marauders have sustained a crippling injury that prevents them from pursuing their normal prey. We examined the skulls of the Tsavo Lions for such maladies, as well as another man-eater held at the Field Museum that killed six people in Mfuwe, Zambia, before being shot in 1991. One of the Tsavo Lions (Patterson's "first man-eater") had a broken canine tooth riddled with decay and with a painful root-tip abscess. Neighbouring lower incisors were missing and the upper teeth had shifted into awkward and dysfunctional positions. Chronic and painful injuries would have prevented the cat from using his canines to grab and kill large prey, like buffalo and zebra, and necessitated an alternative diet. The railway workers arrived in Tsavo at the wrong time.

The other man-eating Lions also sustained minor dental and jaw injuries, but these were the sort common among large predators and not incapacitating. Other hypotheses, such as prey shortages, man-eating cultures and the like, may have interacted with the 'infirmity hypothesis' to initiate their man-eating habits. However, at least in the case of the Tsavo man-eaters, museum specimens furnish us with a 'smoking gun'.

—Bruce D. Patterson
& Ellis J. Neiburger
Field Museum
of Natural History,
Chicago

Methuselahs of the Deep

What's the secret to a long life? Recent studies have shown that mice can live up to 50 per cent longer on a reduced-calorie diet, possibly because this slows their metabolism. But perhaps it's where you live

that's important.

Derk Bergquist and colleagues from Pennsylvania State University found a community of extremely old and slow-growing tubeworms (*Lamellibrachia* sp.) about half a kilometre beneath the sea on the continental shelf off Louisiana. These tubeworms make their living around cold hydrocarbon seeps (natural oil and gas vents), which release carbon compounds at a slow and steady rate. The tubeworms have no mouth or gut, but instead obtain their food requirements through a symbiotic relationship with bacteria that fix carbon from the water into organic molecules.

By staining the tubes and measuring growth after consecutive years, the researchers were able to estimate that some two-metre-long individuals were 170–250 years old. This not only makes them the oldest known non-colonial invertebrates, but also threatens to topple the crowns of the oldest known vertebrates. (One captive Galapagos Giant Tortoise, *Chelonoides elephantopus*, for example, was estimated to have been 177 years old.)

Could the tubeworm's constant environment be a clue to their longevity?

COURTESY CHARLES FISHER

Deep-sea tubeworm (*Lamellibrachia* sp.): oldest known non-colonial invertebrate.

Interestingly these tubeworms have close relatives that live in the far more chaotic and unpredictable environment of deep-sea thermal vents. But far from being slow starters, these hot-water worms are among the fastest-growing marine invertebrates in the world.

It may well be that choosing a stable, predictable environment can go a long way towards living to a ripe old age.

—A.T.

Moa off the Menu

Despite paltry traces of an earlier human contact, the first Polynesian settlement of New Zealand appears to have begun in

COLLECTION MUSEUM OF NEW ZEALAND TE PAPA TONGAREWA

New Zealand's 'Giant Moa' (*Dinornis giganteus*). How long did it take for moas to be wiped off the menu?

earnest during the late 13th century (about 700 years ago). This meant the beginning of the end for moas, those famous big birds (order Dinornithiformes) that weighed 20–250 kilograms and ranged over diverse New Zealand habitats. No-one seems to seriously doubt that human hunting and habitat destruction somehow caused the extinction of the 11 known species of moa. The only question hovers around the ecological processes involved, and how quickly it all happened. Richard Holdaway (Palaecol Research) and Chris Jacomb (Canterbury Museum) argue that moas, like any other long-lived bird, were highly vulnerable to human predation and that this megafaunal extinction was the fastest on record.

The time frame for the extinctions comes from a computer model that simulates decline in moa populations, given estimates of 158,000 birds, initial human populations of 100–200 people, and predation rates of one female bird per 10 or 20 people per week. Other factors considered were human population increase and habitat loss through forest clearance by the early settlers. The assumptions may be contentious, but the predictions are unequivocal: no more moa on the menu after 50–160 years. Revised dates for the presence and absence of moa bones in Monck's Cave, on the South Island, provide archaeological support.

If the model simulations suggest humans quickly wiped out 11 species of New Zealand moa, perhaps the same could be said for Australia's big bird *Genyornis*, which appears to some to have become extinct soon after the first Aboriginal arrivals (see *Nature Aust.* Summer 1999–2000). However, there is good evidence that *Genyornis* survived at some places (such as Cuddie Springs, north-western New South Wales) for at least 10,000 years after human settlement, which would indicate other variables were at play in continental Australia. Although the timing of human entry to Australia and the extinction events are hotly debated, the biological relationships revealed by ecological models of the past are vital for understanding present and future environments.

—R.F.

Dinosaur Pack Hunters

Because tyrannosaurid fossils are usually found alone, tyrannosaurs have long been thought to have been solitary predators. Not any more though. When Philip Currie (Royal Tyrrell Museum of Palaeontology) revisited a site in Canada's Alberta Badlands, first discovered and partially excavated in 1910, he found evidence to suggest that, not only did tyrannosaurs live together, but they were also pack hunters, practising division of labour like today's Lions or wolves.

So far, the semi-articulated remains have revealed at least 12 *Albertosaurus sarcophagus* buried together. Three of these are juveniles.

It is highly unlikely that a dozen individuals ended up together by chance, but the similar degree of skeletal disarticulation between the specimens suggests they were buried at the same time and subjected to the same sedimentary conditions. The paucity of herbivore bones at the site, and the absence of tooth marks or other evidence of predation, also indicates this was not a predator trap. Rather, Currie believes the most likely scenario is that the animals were living together before they died. (Why they died is unknown.)

And if they lived together, they probably hunted together. Comparative measurements of the hind limbs of juvenile tyrannosaurids suggest they were able to run with Ostrich-like speed, something they would have lost as they aged and more bone was deposited on the thigh bones. The implications of this are interesting, says Currie. While a mature animal was strong enough to bring down a contemporary herbivore, pack hunting and division of labour would have improved this advantage, with the faster, more agile juveniles cutting out potential prey from the herd and driving them towards the larger, more powerful adults.

—R.S.

Kicked out of Paradise

The birds of paradise show little family resemblance, particularly among the males. In fact, they seem to be united more by their differences than by their similarities. Most are characterised by remarkable sexual dimorphism, like the splendid Raggiana Bird of Paradise (*Paradisaea raggiana*), which adorns Papua New Guinea's flag. But not all members of the family are so gaudy. MacGregor's Bird of Paradise (*Macgregoria pulchra*) is a relatively dowdy species—a black crow-like creature, with bright yellow eye-rings and wing-patches being its only ornaments.

The placement of *Macgregoria pulchra* in the bird-of-paradise family (Paradisaeidae) has never been very well supported, but there has never been a good reason to move it elsewhere either. Joel Cracraft and Julie Feinstein from the American Museum of Natural History, however, have just provided that reason. Using mitochondrial DNA, Cracraft and Feinstein discovered that MacGregor's 'Bird of Paradise' is actually a member of the honeyeater family (Meliphagidae) and most closely related to New Guinea's smoky honeyeaters (*Melipotes* spp.). Field naturalists have long recognised the similarity in appearance between the Common Smoky Honeyeater (*M. fumigatus*) and MacGregor's 'Bird of Paradise', but Cracraft and Feinstein found that the two species also have similar bills, eggs, diet and, importantly, genes.

So instead of being the dull bespectacled member of a flamboyant family, MacGregor's 'Honeyeater' can now be thought of as a rather stylish member of a more humble flock.

—D.C.

When Worlds Collide

One of the world's biggest craters formed by an asteroid collision has been discovered east of Shark Bay, about 800 kilometres north of Perth.

Hidden by millions of years of sediment, the Western Australian crater has been dubbed 'Woodleigh' after the name of the property on which it was found. With a diameter of 120 kilometres, it's the largest structure of its kind ever found in Australia and fourth on a world scale. For sheer size, Woodleigh is beaten only by South Africa's 300-kilometre-wide Vredefort crater, the 250-kilometre-wide Sudbury crater in Canada, and Mexico's infamous Chicxulub crater, dubbed the 'dinosaur-killer' and estimated to be 170 kilometres wide.

Andrew Glikson, a geologist at the Australian National University, believes the asteroid that created Woodleigh crater would have been a massive six to eight kilometres in diameter and estimates it would have hit Earth about 365 million years ago.

Asteroid impacts often leave long-lived circular scars in the landscape. Understandably, however, these usually become obscured over millennia and extremely difficult to verify as being caused by an extraterrestrial collision. The first clues to the existence of the Woodleigh crater can be traced back to 1981 when quartz rocks were uncovered from about 200 metres underground during oil explorations. The rocks show tell-tale structural indicators of shock, characteristic of an abrupt and massive collision. Originally, however, the signs were thought to have been caused by drilling

W.S. PECKOVER/NATURE FOCUS

MacGregor's Bird of Paradise or MacGregor's Honeyeater?

COURTESY DAVID PAUL

The mildly mannered ant *Camponotus bendigensis* (left) has taken on the look of its aggressive neighbour *Myrmecia fulvipes*.

operations, and it was only in 1997 that Glikson was brought in to advise and interpret other key indicators gathered by Arthur Mory and Robert Iasky from the Geological Survey of Western Australia.

It took three years for the team's suspicions to finally be confirmed. Now the American space agency NASA is also taking an interest in Woodleigh due to similarities it shares with large craters on Mars.

—K.McG.

Yellow-bellied Ants

Ants aren't generally seen as shy, retiring types. Too many of us have had close encounters with the large pincers and painful stings of bulldog ants (*Myrmecia* spp.). But not all ants are so pugnacious. Indeed the common *Camponotus* or sugar ants are more often victims than aggressors. One species, however, seems to have bucked the system.

The mildly mannered *Camponotus bendigensis* shares the open woodlands of south-eastern Australia with the strikingly similar yet aggressive *Myrmecia fulvipes*. This unusually small bulldog ant advertises its vicious nature with characteristic warning colours—black, with bright red legs and a golden abdomen—to deter birds and other predators. While many ants are reddish or yellowish, no other ants are known to have this particular bold black, red and yellow combination—except the distantly related *C. bendigensis*. Both ants are also very alike in body size and shape, and have nearly identical UV-reflectance patterns. David Merrill (Harvard Medical School) and Mark Elgar (University of Melbourne) believe *C. bendigensis* has evolved a very similar appearance to cash in on its neighbour's reputation and, if so, it is the first well-documented case of an ant mimicking another ant.

In addition to physical similarities, they found that they were behaviourally and socially similar as well. Both are most active at dawn and dusk, have the same sort of solitary foraging behaviour, and share a reduced-caste system. Merrill and Elgar believe that *Camponotus bendigensis* may have taken advantage of its original similarity in size to *Myrmecia fulvipes* and adapted its body pattern, foraging behaviour and even caste system to mimic its neighbour. The researchers go so far as to suggest that the mimicry may deceive not only predators but the role model as well (which has been known to dine on the odd sugar ant). In the ant world, it seems, there are ways for the meek to inherit the Earth.

—D.C.

Cautious Cricket Callers

It might never be the case in Disney films but, in the natural world, it's often the biggest showoffs that get the girls. In fact, female choice is thought to have driven the evolution of elaborate male displays as indicators of mate worthiness in many species.

The problem with flashy

dances, songs or physical traits, however, is that they often attract the attentions of predators as well as prospective partners. But a recent study by Ann Hedrick, from the University of California at Davis, reveals that showoff males can compensate for this major drawback by being cautious.

Hedrick has been studying a species of field cricket from California, *Gryllus integer*, for almost two decades. In past research she has shown that females of this species prefer males that can trill (or call) the longest without interruption.

The ability to produce these long calling-bouts is an inherited characteristic passed from fathers to sons. However, because mice, birds, toads and other predators use the songs to locate the crickets, the most outstanding callers can be at a greater risk of attack than their more mediocre competitors.

In laboratory tests on field-caught crickets, Hedrick found that the males with the longest, most conspicuous calling-bouts were more timid than their counterparts with shorter songs. They hid for longer before emerging from shelter when introduced to new and potentially dangerous surroundings, and they took longer to resume calling after being presented with a simulated potential threat.

By adopting this cautious behaviour, male crickets with the most conspicuous calls improve their chances of staying alive long enough to let females be impressed by their songs.

—K.McG.

FURTHER READING

Bergquist, D.C., Williams, F.M. & Fisher, C.R., 2000. Longevity record for deep-sea invertebrate. Nature *403: 499–500.*

Cracraft, J. & Feinstein, J., 2000. What is not a bird of paradise? Molecular and morphological evidence places Macgregoria *in the Meliphagidae and the Cnemophilinae near the base of the corvoid tree.* Proc. R. Soc. Lond. B *267: 233–241.*

Currie, P.J., 2000. Possible evidence of gregarious behaviour in tyrannosaurids. Pp. 271–277 in Aspects of theropod paleobiology, *ed. by B.P. Peréz-Moreno, T. Holtz Jr, J.L. Sanz and J. Moratalla. GAIA Spec. Vol. No. 15.*

Dillon, R.J., Vennard, C.T. & Charnley, A.K., 2000. Exploitation of gut bacteria in the locust. Nature *403: 851.*

Funk, D.H. & Tallamy, D.W., 2000. Courtship role reversal and deceptive signals in the long-tailed dance fly, Rhamphomyia longicauda. Anim. Behav. *59: 411–421.*

Giuliani, G., Chaussidon, M., Schubnel, H.-J., Piat, D.H., Rollion-Bard, C., France-Lanord, C., Giard, D., de Narvaez, D. & Rondeau, B., 2000. Oxygen isotopes and emerald trade routes since antiquity. Science *287: 631–633.*

Glikson, A., 2000. Discovery of the world's 4th largest impact, and the tale of two craters. Cambridge Conference Network Essay, *14 April 2000.* [http://abob.libs.uga.edu/bobk/ccc/ce041400.html]

Hedrick, A.V., 2000. Crickets with extravagant mating songs compensate for predation risk with extra caution. Proc. R. Soc. Lond. B *267: 1–5.*

Holdaway, R.N. & Jacomb, C., 2000. Rapid extinction of the moas (Aves: Dinornithiformes): model, test, and implications. Science *287: 2250–2254.*

Lambert, C., 2000. Germ-cell warfare in ascidians: sperm from one species can interfere with the fertilization of a second species. Biol. Bull. *198: 22–25.*

Merrill, D.N. & Elgar, M.A., 2000. Red legs and golden gasters: Batesian mimicry in Australian ants. Naturwissenschaften *87: 212–215.*

Mory, A.J., Iasky, R.P., Glikson, A.Y. & Pirajno, F., 2000. Woodleigh, Carnarvon Basin, Western Australia: a new 120 km-diameter impact structure. Earth and Planetary Science Letters *177(1–2): 119–128.*

Neiburger, E.J. & Patterson, B.D., 2000. Man eating lions: a dental link. J. Amer. Assoc. Forensic Dentists *24(7–9): 1–3.*

Richmond, B.G. & Strait, D.S., 2000. Evidence that humans evolved from a knuckle-walking ancestor. Nature *404: 382–385.*

Soffer, O., Adovasio, J.M. & Hyland, D.C., 2000. The "Venus" figurines: textiles, basketry, gender, and status in the Upper Paleolithic. Curr. Anthrop. *41(4): 511–537.*

Young, B.A., Meltzer, K., Marsit, C. & Abishahin, G., 1999. Cloacal popping in snakes. J. Herpetol. *33(4): 557–566.*

QUICK QUIZ

1. *What is the name of the climatic event that results from a cooling of the surface of the Pacific Ocean and leads to floods in Australia?*
2. *Where does the invasive weed Bitou Bush originate?*
3. *Which Australian World Heritage Site would you visit to see the 'Walls of China'?*
4. *What are aurora borealis and aurora australis also known as?*
5. *Which species of rosella is featured on the Rosella tomato-sauce label?*
6. *Who is the famous conservationist, scientist and author of the 1962 book* Silent spring, *which linked use of DDT to massive ecological disruption?*
7. *What is the term given to visible light that is emitted by an organism?*
8. *Where is Australia's nuclear reactor located?*
9. *What is the name given to an eagle's nest?*
10. *North Americans call it the Monarch; what do Australians call it?*

(Answers on page 82)

Masks, high heels and spurs!

Masked Lapwings have a weakness for laying their clutch of three or four olive ping-pong balls just about anywhere.

RAOUL SLATER/LOCHMAN TRANSPARENCIES

A Masked Lapwing sits protectively on its nest with one of its chicks. The bright yellow spurs on its wings are clearly visible.

BY STEVE VAN DYCK

When World War 2 ended and hot-blooded Australian diggers were reunited with their sweethearts, the frantic clanging of their wedding bells broadcast the glorious dawning of the Laminex Age. These were whirlwind days when, to kitchen-conscious newlyweds, having three flying ducks, a Mix Master and an electric frypan in their new house had profound social significance.

Most of the next generation were conceived under the azure aura of the all-electric era. For such a generation, the iceman, the coalscuttle and the exploding gas hot-water contraption over the bath became evaporating memories. But the electric frypans of the '50s, bless their thermopiles (and the school fetes that recycled them), lived on. Most of them still work, although the little orange light may have flickered itself to death. And even if your model did throw a diode after 30 years of hamburgering, you could still unscrew the bottom, throw away the bakelite bit, and use the metal top like a real frypan on the stove's gas burner.

My deference to the Sunbeam frypan had more 'poultry' foundations and stemmed from the time my father once brought home a Masked Lapwing's egg (we called them 'Spur-winged Plovers' then). Masked Lapwings (*Vanellus miles*) have a weakness for laying their clutch of three or four olive ping-pong balls just about anywhere...on playing fields, flat roofs, in drive-in theatres, car parks, factory grounds and on the dividing strips of freeways. Maybe my father had rescued the egg from in front of the mower, I can't remember, but there it was—brown-blotched, fragile and begging to be sat on.

In those days there was only one course to take—the electric frypan had to be borrowed from the kitchen for a month, as long as it might take for a plover to hatch. I half-filled an Ovaltine tin with damp sand, rested the egg on it, poked a long thermometer in through a hole in the lid and, after a lot of switch-jiggling between 'simmer' and 'off', got the temperature to hover around an acceptable 102° F (39° C).

The next four weeks were Purgatory. I turned the egg a couple of times a day, pressed it close to my ear for tell-tale cheeps, but nothing encouraging happened. Finally, on the last weekend it could hatch if it was fertile, I had to go away for three days on a prearranged trip.

To this day I can remember with chagrin the terse list of instructions I left for my poor parents should the egg hatch: "Keep it on a towel in the frypan. Feed it on termites and the chicken crumbs in the bottle by my bed. Give it some water. Most of all—don't try and help it out of the egg!!!"

I left with misgivings, wondering how the parents of two teenage boys could possibly cope with the responsibility of looking after a growing plover egg. But as luck would have it, the weather turned sour, the trip was cancelled after only one day away, and I came home to hear the frypan cheeping and to see a small leathery beak chipping its way out of the ruptured shell. The egg-burger was done and I was nearly a father!

But if only the weekend trip hadn't been aborted! After about eight hours I couldn't stand its pathetic calls any longer and, screwing up the incriminating set of instructions, I started on my mission of mercy and proceeded to help the chick out by

removing bits of broken shell with a sterile needle.

The more I interfered with it, the further I set it back, because, unknown to me, it had not yet completely absorbed its yolk sac. This meant that a large network of blood vessels still existed outside the chick's 'navel' to be absorbed only during the last hours before hatching. And so, to my mortification, the baby lapwing weakened and died before it got free of the last bits of its shell. Our house was very 'I-told-you-so' quiet that night and, from then on, omelettes and egg-burgers done in that frypan never tasted too good.

How often I'd dreamed of that young chick following me around the backyard, growing its long leathery yellow mask, wild golden eyes and developing the cloak-and-dagger looks that make Masked Lapwings a touch intimidating when they grow up. Particularly the way they skulk around, watching you out of the corner of their eye, ready to lunge at anything suspicious. And their sharp call in the black of night sounds like something just robbed of its wits. Combine the attitude with the 20-millimetre spur jutting out from each 'shoulder' and you've got a bit of a worry when it's your turn to play the stroke on the putting green right near their nest!

In spite of all the rage, the dive-bombing and the piercing volley of vocal shots fired in the defence of their eggs or chicks, I can't remember ever reading an account documenting damage inflicted by a strafing lapwing. I have read of them standing up on their high heels to pick at the noses of sheep that wandered too close to their eggs, but as to lacerations caused by their generously spurred wings...no. This is both surprising and understandable. The cutlass on a Masked Lapwing's 'shoulder' (its wrist really) is no laughing matter. The delivery of any sort of serious aerial blow with such a sharp weapon, however, could leave the lapwing impaled on the intruder or crippled with a broken wing, not much use to your life-long mate or your dependent chicks.

It seems that the enigmatic spurs are used more in showing-off than finishing-off. They only come into play during in-house disputes (territorial/matrimonial) and then it just boils down to 'I'll show you mine if you show me yours' and the matter is settled without bloodshed.

But what about the droopy leather mask? What secret does it conceal? Certainly a drop or two of 'compassion' behind those cold, golden eyes. An adult was once seen carrying a hatchling to the ground off a two-storey roof where the breeding pair had nested on dazzling white crushed quartz. The adult flew down gently holding the chick's leg in its beak while the chick hung on with its beak to the adult's yellow mask.

Spurs, high heels, leather masks, hysterical screaming in the middle of the night, all sounds just a bit unwholesome. I thought moving out of the city would bring natural fortification to my children's moral fibre...sounds like a case of 'out of the frying pan into the fire' to me!

FURTHER READING

Marchant, S. & Higgins, P. (eds), 1993. Handbook of Australian, New Zealand & Antarctic birds. Vol. 2. Raptors to lapwings. *Oxford University Press: Melbourne.*

Davies, R., 1967. Unusual nesting sites of the Spur-winged Plover. Aust. Bird Watcher *3: 30–31.*

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Masked Lapwing

Vanellus miles

Classification
Family Charadriidae (plovers and lapwings), 65 spp. worldwide. Subfamily Vanellinae (lapwings), 24 spp. Old World and South America, 3 spp. in Aust. Two subspp. that differ in size of mask and black shoulder 'stole'.

Identification
Size of very long-legged domestic Bantam. Belly white, back and wings grey-brown, rump white. Wing tips and tail tips black. Cap of head black (black shoulder 'stole' in southern subsp.) Imposing, canary-yellow mask (bigger in northern subsp.). Eyes gold, legs pink, wings spurred. Call a sharp 'keer-ki-ki-ki-ki-ki-ki-ki (alarm) or single 'click' uttered day or night.

Distribution and Habitat
Eastern, central and northern Aust., incl. Tas. Also in southern PNG and NZ, visitor to Molluccas and Lesser Sunda Iss. Practically anywhere with short grass and water close by. Serious threat to aircraft on runways. Species benefits from clearing and dam construction.

Diet
Omnivorous, incl. worms, snails, spiders, cockroaches, flies, grasshoppers, beetles, ants, wasps, plant, frogs, gravel and bread.

Reproduction
Monogamous, territorial. Breeds any season in north, June–Dec. in south. Nest a small depression in the ground lined with grass, rootlets, leaves, Rabbit dung. Both sexes incubate 3–4 olive green, brown-splotched eggs, for 28–30 days. Parents feign injury to draw attention from nest. Empty eggshells dropped in water or reeds to distract potential predators. Chicks leave nest almost as soon as they have hatched, find their own food, and may separate from each other by up to 200 m. Parents protect them for up to 6 months. Often forms flocks in autumn and winter, but remains in general area. Successful breeding takes up to 9–11 months of year. Pair bond for life.

Grey Nurse Shark

The Grey Nurse Shark became the first protected shark in the world.

BY NICK OTWAY

GREY NURSE SHARKS (*Carcharias taurus*) have an unfortunate history along the east coast of Australia. In the 1950s and '60s they were thought to be responsible for the shark attacks off Sydney's beaches. Wrongfully accused because of their fierce appearance (they have long, curved, fang-like teeth for impaling fish) and large size (up to 3.2 metres long), the so-called 'man-eating' Grey Nurse Sharks were executed on every possible occasion. The net result of the indiscriminate spearing was a dramatic drop in their numbers, as evidenced by reduced catches in protective beach-meshing programs.

By the late '70s Grey Nurse Shark numbers had further dwindled and, with the realisation that the Grey Nurse Shark was not a 'man-eater', lobbying for protection of the shark commenced. In 1984, the New South Wales Government declared the Grey Nurse Shark a protected species. In so doing, the Grey Nurse Shark became the first protected shark in the world. Despite this, surveys in 1991 and 1995 at Seal Rocks, combined with further reduced catches in the protective beach-meshing programs at Newcastle, Sydney and Wollongong, suggested that the Grey Nurse Shark population had still not recovered.

Why would this be the case? The likely answer lies with the shark's bizarre reproductive biology. The Grey Nurse Shark is a live bearer, with only two pups born per litter. Although batches of up to 15 embryos start developing in each of the two uteri, the most advanced embryo in each uterus eats the remaining embryos in the batch, a phenomenon known as inter-uterine cannibalism. This is then followed by an 'oviphagous' phase in which the developing pups eat pea-sized eggs produced by the mother. The gestation period is also very long, lasting from nine to 12 months with birth occurring when the pups are about a metre long. More importantly, research in the USA and South Africa has shown that females have a resting stage of about a year, with pupping occurring every second year. Consequently, only one pup per female is produced per year, on average.

BECAUSE OF THEIR *fierce appearance, Grey Nurse Sharks were executed on every possible occasion.*

With this in mind and the reduced catches in the beach-meshing programs, New South Wales Fisheries initiated a research project to quantify the numbers of Grey Nurse Sharks along the New South Wales coast and to examine ways of enhancing the shark's conservation. In early 1999, shortly after the research program commenced, the Grey Nurse Shark was declared a threatened species with 'vulnerable' status under the Fisheries Management Act.

To accomplish the coast-wide surveys, we enlisted the help of scuba divers from universities, dive clubs, commercial aquaria and the commercial-diving industry. With the scuba-diving community's involvement, for which we are very grateful, we were able to cover the entire New South Wales coast, sampling 50 to 60 sites from Eden to Tweed Heads and into southern Queensland (Stradbroke Island). To our knowledge these surveys are the first of their kind in the world because of the large community input focusing on the conservation of a shark.

The surveys required that divers make visual observations over a 15-minute period at the chosen sites. When Grey Nurse Sharks were present, the divers recorded the total number of individuals, their sex and estimated length. Several surveys have now been completed with only 207 Grey Nurse Sharks observed in the entire 1999 winter period. More than half the sites had no Grey Nurse Sharks, 13 sites had aggregations of five or more (totalling over 100), while the rest of the sites had just one or two individuals.

The results of these coast-wide surveys suggest that the Grey Nurse Shark population in New South Wales waters has not recovered since it was made a protected species and, subsequently, its status was upgraded to 'endangered' in April last year. The next phase of the research will involve further surveys, tagging and an evaluation of the role of Marine Protected Areas in enhancing the conservation of the Grey Nurse Shark.

FURTHER READING

Otway, N.M. & Parker, P.C., 2000. The biology, ecology, distribution, abundance and identification of marine protected areas for the conservation of threatened Grey Nurse Sharks in southeast Australian waters. NSW Fisheries Final Report Series No. 19:1–101.

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BEN CROPP

Eastward bound

A large proportion of the plants and animals living in New Zealand today are descended from colonists from Australia.

PHOTOS: TIM LOW

Australia's Lilly-pilly has become a major weed in New Zealand, thanks to native New Zealand birds spreading its seeds.

BY TIM LOW

TIME HAS TREATED NEW ZEALAND harshly. Over millennia the island chain has been gouged by glaciers, convulsed by volcanoes and largely dunked beneath the sea. Animal and plant diversity is low, reflecting this turbulent history. Diversity would be very much lower were it not for New Zealand's giant neighbour lying off to the west. A large proportion of the plants and animals living in New Zealand today are descended from colonists from Australia. They include kiwis, honeyeaters, water birds, bats, butterflies and plenty of plants. Many, over time, have evolved into unique species and genera, but the newer arrivals are still recognisably Australian. New Zealand's most common shrub is Manuka (*Leptospermum scoparium*), a tea tree from Australia, and her most common forest bird is the Australian Silvereye (*Zosterops lateralis*).

This process of colonisation is made fascinating by the fact it still goes on today. Australian animals, seeds and spores keep crossing the Tasman Sea. Silvereyes only established in New Zealand in the 1850s, Masked Lapwings (*Vanellus miles*) in the 1930s and Welcome Swallows (*Hirundo neoxena*) since then. Among plants, Narrow-leafed Wilsonia (*Wilsonia backhousei*) was first noted in 1990, and Swamp Mazus (*Mazus pumilio*) and Stalked Brooklime (*Gratiola peduncalata*) in 1996.

There are many ways to reach New Zealand. Seeds float across. The sea currents that flow along eastern and southern Australia meet in the Tasman Sea, then veer off to New Zealand, arriving in Cook Strait, a hot spot for Australian seashore plants. Only around here do Narrow-leafed Wilsonia and Grey Saltbush (*Atriplex cinerea*) grow. Grey Saltbush, a common shrub in Australia, remains very rare in New Zealand because of its dioecious habit, plants having either male or female sex, which means a single seaborne seed cannot establish a population.

Other colonists come by air. Tiny seeds of ground orchids are easily borne aloft, and over the past century ten new orchids have made New Zealand home, joining earlier orchid immigrants, and adding colour and charm to the woods and fields. Birds fly over regularly, sometimes carrying seeds, which may explain how an alpine plant such as Carpet Heath (*Pentachondra pumila*) can grow on both sides of the Tasman. And when the winds are right, Australian butterflies and moths appear. The Common Eggfly (*Hypolimnas bolina nerina*) and Australian Painted Lady (*Vanessa kershawi*) are regular visitors, eggflies arriving in most years. They are thought to make the 2,000-plus-kilometre journey in one to three days, depending on wind speeds, often descending upon Auckland in immaculate condition. Even the golden orb-weaving spider *Nephila edulis* reaches New Zealand, hatchlings presumably wafting over the sea on gossamer strands.

New arrivals usually don't last long. Most butterflies and spiders succumb during winter without breeding. The field guide to the birds of New Zealand shows page after page of Aussie vagrants—ducks, woodswallows, martins and birds of prey—seen in New Zealand one or a handful of times. But enough newcomers survive and breed to ensure that New Zealand biodiversity is regularly augmented. Under New Zealand law, new birds automatically

Grey Saltbush is one of many seashore plants that reached New Zealand via floating seeds. Its seeds germinate more readily after a spell in seawater.

win protection as native fauna.

The number of colonists that have established over the last century is so high it suggests that humans are helping the process along. This obviously holds true for the birds. Most of the newcomers—including lapwings, swallows and White-faced Herons (*Egretta novaehollandiae*)—prefer farmland to forest. Insects that rely on imported plants have also been helped. They include the Pea Blue Butterfly (*Lampides boeticus*), which breeds on exotic pea plants, the Old Ladymoth (*Dasypodia selenophora*), which uses feral wattles (*Acacia* species), and fig wasps (*Pleistodontes* species) that pollinate Australian figs (*Ficus* species). Even the arrival of new orchids may not be entirely natural. They do best in Manuka scrubland, a vegetation type found mainly on land previously cleared by European or Maori farmers.

The Australianisation of New Zealand has been bolstered by direct introductions. Acclimatisation societies in the colonial era brought in Common Brushtail Possums (*Trichosurus vulpecula*) and wallabies, along with Australian Magpies (*Gymnorhina tibicen*) and Black Swans (*Cygnus atratus*). In the scrubs on Kawau Island, north of Auckland, I have seen the Parma Wallaby (*Macropus parma*), a threatened species back home, and also the Tammar Wallaby (*M. eugenii*). Many Australian plants have escaped from New Zealand gardens to become serious weeds, including Lilly-pilly (*Acmena smithii*) and hakeas (*Hakea* species), and these are now banned from sale. Others have come in accidentally as seeds in cargo or on socks. New Zealand biologists often can't decide if certain plants, insects and spiders are native or exotic, not knowing if they came from Australia naturally or in cargo long ago.

Because prevailing winds and seas flow east, New Zealand has done little to enrich Australia. We have gained one new bird, the Kelp Gull (*Larus dominicanus*), which came in 1945 and which is now displacing our endemic Pacific Gull (*L. pacificus*). Only a few plants are thought to have reached Australia from New Zealand aeons ago, for example the willow herb *Epilobium brunnescens*. More significant are the garden plants from New Zealand now escaping here as weeds, such as Mirror Plant (*Coprosma repens*) and New Zealand Flax (*Phormium tenax*). We also have New Zealand marine creatures invading our seas, including the highly invasive New Zealand Turret Shell (*Maoricolpus roseus*).

Australian plants and animals will keep entering New Zealand, and global warming will improve their chances of surviving. Animals that find New Zealand too chilly today may well make homes there in the future. Expect to see more Australian butterflies in Auckland—a charming thought—and also more spiders.

FURTHER READING

Early, J.H., Parrish, G.R. & Ryan, P.A., 1995. An invasion of Australian blue moon and blue tiger butterflies (Lepidoptera: Nymphalidae) in New Zealand. Rec. Auckland Inst. Mus. *32: 45–53.*

Heather, B. & Robertson, H., 1996. The field guide to the birds of New Zealand. *Viking: Auckland.*

de Lange, P.J., Murray, B.G. & Gardner, R.O., 1998. Atriplex cinerea *(Chenopodiaceae) in New Zealand.* NZ J. Bot. *36: 521–529.*

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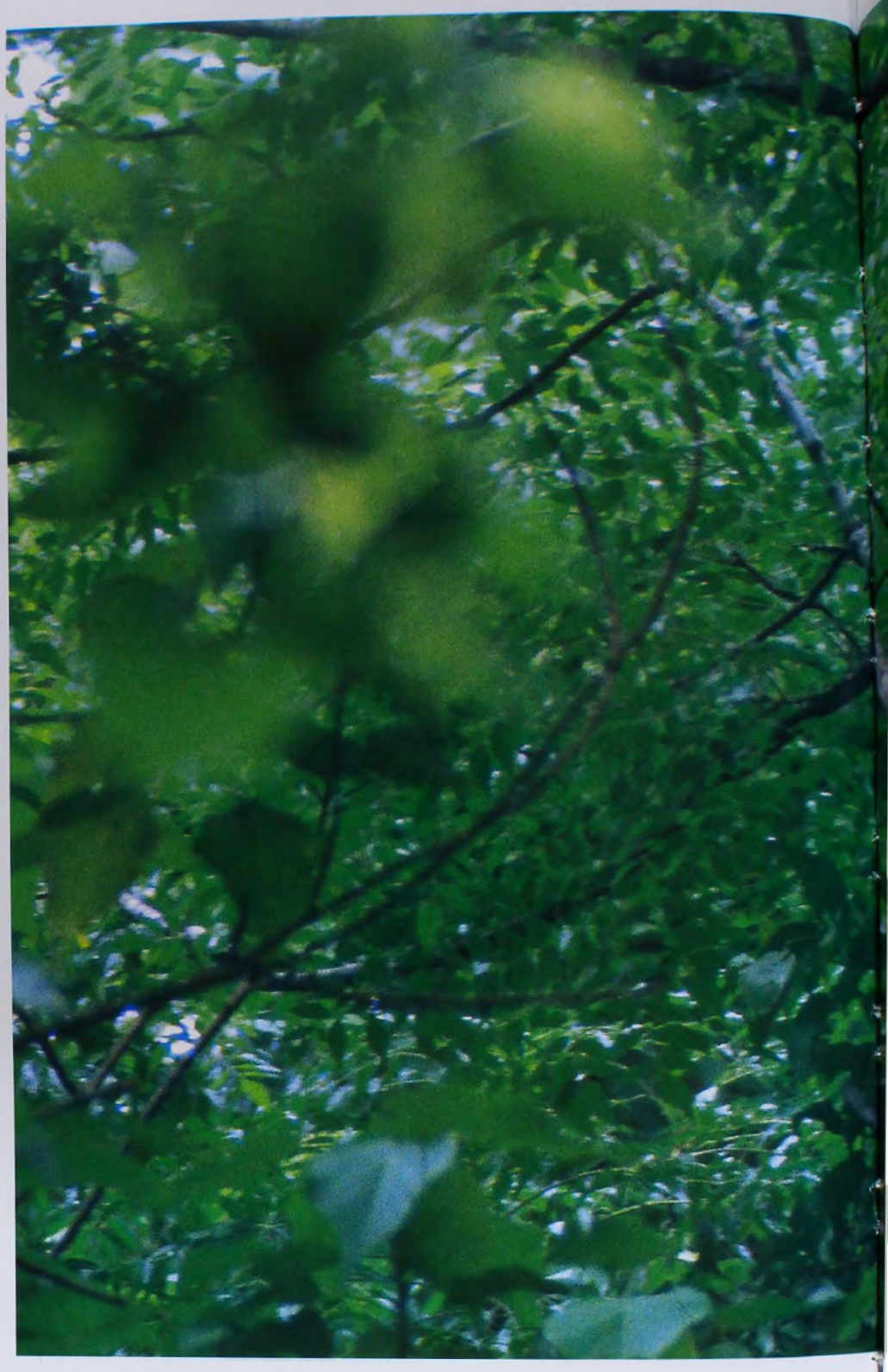
My first encounter with a giant Sulawesi Bear Cuscus was one of the most memorable experiences of my life.

A GIANT AMONG POSSUMS

BY TOM HEINSOHN

TOM HEINSOHN

A Bear Cuscus in lowland rainforest, North Sulawesi. Unlike most cuscuses, this species is active during the day. Between bouts of feeding on leaves, it spends much of its time resting and digesting.



To look at a Sulawesi Bear Cuscus can be a little unsettling. Like Spielberg's imaginary creature ET, it somehow doesn't quite belong. Although obviously a cuscus with its partially naked, prehensile tail and small ears, it is far too large and solid to fit within one's normal conception of a possum. Indeed, it is closer in size to a tree-kangaroo, with the sturdy woolly body and large feet of a Koala. One of the most vexing things about it, however, is its face, which is strangely reminiscent of a bear, a lemur, a possum and a sloth all rolled into one. Very little is known about the Bear Cuscus. Like many elusive creatures of the equatorial rainforest, it has barely been studied. What little we do know about it can be told in just a few pages.

Although wild individuals may commonly weigh in the vicinity of five kilograms, the Bear Cuscus (*Ailurops ursinus*) has been recorded at up to ten kilograms, making it the world's largest recorded possum. The only other possum that comes close to it in size is the seven-kilogram Black-spotted Cuscus (*Spilocuscus rufoniger*) from New Guinea. This compares with more typical phalangerid possums (cuscuses and brushtails) that usually weigh between one and four kilograms.

The Bear Cuscus is also unusual in that it is the only cuscus recorded to be more active during the day than at night. All other cuscuses appear to be largely nocturnal. This is reflected in the structure of the eye. While all the other cuscuses have ovoid or cat-like pupils, the Bear Cuscus has a round pupil that may be less efficient in the dark. Indeed, this atypical cuscus has many primitive features that suggest it may be an ancient survivor from an early lineage of ancestral possums. In addition to the round pupils, these primitive attributes include an unusual box-like snout, other features of the skull, and unusually long limbs and large feet.

However, it is much more than size and appearance that makes the Bear Cuscus weird. For an essentially Australian type of marsupial, it has a very strange geographical distribution. Rather than being found in New Guinea or Australia as one might expect, it is found on the Indonesian island of Sulawesi and some of its satellites. Lying just to the east of Borneo and to the south of the Philippines, this long isolated and essentially oceanic island is at the far north-western edge of the Australasian zoogeographic region. Indeed some biologists consider Sulawesi to be more a part of Asia, which is a truly surprising place to find a marsupial. That it is somewhat out of place is underscored by the fact that the Bear Cuscus shares the forest canopy with typically Asian mammals such as tarsiers, macaques and squirrels. Furthermore, as Sulawesi straddles the equator, the Bear Cuscus is one of the few Australasian marsupials to penetrate into the Northern Hemisphere.

The Asian influence includes a

TOM HEINSOHN

Living amidst the dense foliage of the rainforest canopy, Bear Cuscuses can be difficult to spot. With their dark shadowy colours they tend to blend in. The leaves that hide them are also their principal food.

number of mammal species that are now endemic to Sulawesi and its nearby satellites. These include two pigs, two anoas (dwarf buffalos), a civet, several macaques, two tarsiers, several squirrels, and a range of endemic rats and shrews. Although Asian in ancestry, many of these have undergone considerable evolution in Sulawesi and speciated into unique island forms. Some, such as the primitive Babirusa or 'deer-pig' (*Babyrousa babyrussa*), a slender, very atypical member of the pig family, have no close living relatives on the Asian mainland or nearby islands. Indeed, the most recent mammals like it come from the 12-million-year-old Siwalik fossil site in India, indicating that the ancestors of the Babirusa probably arrived on Sulawesi millions of years ago. It would seem that the enigmatic Bear Cuscus inhabits a land that time forgot—a 'Madagascar' of the Malay Archipelago.

Bear Cuscus

Ailurops ursinus

Classification
Order Diprotodontia, family Phalangeridae. This cuscus is the only living member of the proposed primitive subfamily Ailuropinae.

Identification
Large size, head to tail tip approx. 120 cm (half of which is tail). Adult weight 5–10 kg. Distinguished from other possums by combination of large size, long limbs, large feet, long tail (the lower section of which is naked), small woolly ears, lemur-like face and dark brown colour.

Habitat
Closed forest, including lowland rainforest and montane forest. Recorded from sea level to 2,400 m.

Distribution
Endemic to Sulawesi zoogeographic subregion. This includes Sulawesi and some of its satellites, such as the Togian Islands, Peleng, Muna and Buton Islands.

Biology
Very little recorded about its behaviour, other than that it often occurs in pairs, that it is arboreal, and is probably more diurnal (active by day) than nocturnal. Density at a lowland rainforest area in N. Sulawesi estimated at 1 pair per 4 ha. Very little known about reproduction, but the usual observation of a single dependent juvenile riding on its mother's back may indicate it typically has a single pouch young. Diet appears to consist mostly of leaves, but supplemented by fruit.

Status
Listed as 'unknown' in recent publications, but should probably be considered vulnerable given an increase in threats to both the cuscus and its habitat, principally from overhunting and deforestation.

A Bear Cuscus demonstrating the use of its prehensile tail. The tail helps to anchor it while reaching for leaves and fruit, and also helps it to travel through the rainforest canopy.

How did the Bear Cuscus make it to Sulawesi? It appears that it may have rafted there on a mat of vegetation or floating tree from Greater Australia (the combined Australia–New Guinea area), perhaps 30 million years ago or more, in the Middle Tertiary. Whereas it later became extinct in Greater Australia, in Sulawesi it found a safe evolutionary haven in which to ride out geological time. One other marsupial occurs there. This is the endemic Dwarf Cuscus (*Strigocuscus celebensis*), a mere kilogram in weight. Like the Bear Cuscus, its ancestors probably also rafted there from Greater Australia millions of year ago.

WHAT LITTLE WE do know about the ecology of the Bear Cuscus comes from some studies carried out on Sulawesi's northern peninsula and a few scattered observations from other parts of the island. These reveal that the Bear Cuscus is arboreal, spending most of its life in trees and only occasionally venturing to the ground. As would be expected of a possum with such habits, it seems to be largely restricted to closed forest where it can travel the highways of the sky by moving from tree to tree via adjacent branches. Indeed, being a cuscus with a characteristically long, partially naked, prehensile tail, sharp claws, an opposable toe on the hind foot, and unusually long limbs, it is well equipped to move through the forest canopy. It crosses gaps between trees by bracing itself with its tail and hind feet prior to reaching out with extended forepaws to grip and pull in an adjacent branch. This is then used as a ladder into the new tree. Alternatively, it may hang from its tail to reach another branch. It is generally slow-moving but, under certain circumstances, such as threat from a predator, it is probably capable of sudden leaps and bounds, as has been observed in other cuscuses.

Although protected by its large size, arboreal habits and Sulawesi's lack of large carnivores, some Bear Cuscuses are probably taken by the Black Eagle (*Ictinaetus malayensis*) and Reticulated Python (*Python reticulatus*), both of which are known to prey on small to medium mammals including possums. Other predators, such as the tree-climbing Sulawesi Palm Civet (*Macrogalidia musschenbroeckii*) and Water Monitor (*Varanus salvator*), may be capable of taking young cuscuses.

Leaves make up the bulk of the Bear Cuscus' diet, but like many folivores (foliage-eaters) it will supplement this with fruit, particularly green. This differs from the habit of the Sulawesi Dwarf Cuscus, which is thought to be largely frugivorous (fruit-eating), but may also be partially folivorous. As the leaves of many plants contain defensive compounds to protect them from herbivores, Bear Cuscuses, like other generalist folivores, probably have to be selective in their diet, by choosing species, leaf ages and leaf parts that are low in these compounds. Young and mature leaves, leaf buds, and flowers from a variety of tree species, as well as some lianas and mistletoes, are eaten, but there appears to be an overall preference for young leaves. In common with Koalas in Australia, which may be inactive for about 80 per cent of the day while they digest leaves, Bear Cuscuses spend about 65 per cent of their day resting.

All that is known of the social habits of Bear Cuscuses is that they are often found in pairs. Their estimated density in the lowland rainforest at Tangkoko–Duasudara Nature Reserve in North Sulawesi is one pair per four

TUI DE ROY/AUSCAPE

A Spectral Tarsier in North Sulawesi. These tiny primates emerge from tree hollows or thickets at dusk for a night of foraging. Their diet consists mostly of insects.

hectares. In terms of reproduction, it is not uncommon to see a female with an advanced juvenile riding around on her back with its prehensile tail wrapped around the base of hers. This may indicate that Bear Cuscuses typically have a single pouch young, although we really don't know. Further studies are also needed to determine whether they have seasonal peaks of reproductive activity, or whether they breed throughout the year given the equatorial nature of their island home. This of course may vary with altitude or with their position on the island in relation to the north-west and south-east monsoons. Some parts of Sulawesi do, after all, have marked wet and dry seasons, while other parts are more constantly moist. Furthermore, although generally regarded as creatures of lowland forest, Bear Cuscuses have been found in montane forests, with one recorded at an altitude of 2,400 metres in Central Sulawesi's Lore Lindu National Park.

MY FIRST ENCOUNTER with a giant Sulawesi Bear Cuscus was one of the most memorable experiences of my life. It happened during a visit to the delightful Tangkoko–Duasudara Nature Reserve at the far tip of Sulawesi's northern peninsula in February 1997. For several days, heavy, almost continuous downpours during the night had prevented me from doing much spotlighting for the Bear Cuscus. Doubting that they were fully diurnal, I was initially hoping to locate some of these elusive animals by there eye shine, in order to gain some unique night-time data. However, this was not to be, so I ended up concentrating on daylight searches. Walking along forest trails with my eyes in the canopy, occasionally stopping to scan dark leafy recesses with binoculars, I was finally rewarded after three days. There, peering down at me through a small gap in the foliage, was that curious face, with its lemur-like eyes, prominent nose and short woolly ears. To see the giant Sulawesi Bear Cuscus was like travelling back in time into the ancient possum world of Greater Australia during the Middle Tertiary.

For an hour or more, it would fleetingly appear through gaps in the foliage, occasionally demolish a smallish leaf, and then disappear again. It seemed quite unconcerned by my presence on the ground below. Finally I lost sight of it, but then a second cuscus (or maybe it was the same one) appeared in the more open canopy of an adjacent tree. It was sitting on a branch, perhaps resting or surveying its territory. I quietly climbed a neighbouring tree and was able to study the animal from a relatively short distance away.

The presence of a woolly scrotum revealed it was a male. I had just enough time to take a few photos, before the scene was interrupted by the arrival of a noisy troop of Crested Black Macaques (*Macaca nigra*). The Bear Cuscus began to climb away and disappeared into a hidden leafy recess in the upper canopy. Moments later a large dominant male macaque, followed by adult females with babies and several subordinates of different

ages, walked past on the ground below me, as several others approached through the trees. It was a truly magic moment, for where else in the world would an encounter with an ancient endemic marsupial be followed by one with a troop of endemic monkeys? It is no wonder that Sulawesi is one of the islands that most inspired the great naturalist and pioneering biogeographer Alfred Russel Wallace, after whom Wallace's Line was named*.

To avoid being bitten by a startled macaque (they have pronounced baboon-like muzzles and sharp canine teeth), I decided to announce my presence by whistling. This initially caused a small commotion, but the monkeys soon settled down and I was able to quietly observe them before they too slipped away into the deep recesses of the bush. Later that day, at sunset, I waited just outside the hollow of a strangler fig and was able to observe a pair of Spectral Tarsiers (*Tarsius spectrum*), tiny nocturnal insect-eating primates, as they emerged from their sleeping place for a night of foraging. This confirmed that I was indeed in Wallacea, the transitional island realm of eastern Indonesia where the influences of Asia and Australia mingled to produce a bizarre composite fauna.

On the way back to Tangkoko village, I stumbled across a spent shotgun cartridge. This symbolised one of the major threats to the great natural museum of Wallacea—poaching and overhunting, particularly in Christian areas where there are fewer dietary taboos and most species are eaten. The small vulnerable Tangkoko–Duasudara Nature Reserve had already suffered drastic declines in the endangered Crested Black Macaque, Lowland Anoa (*Bubalus depressicornis*) and the giant Bear Cuscus, while the fabled Babirusa had become locally extinct. Once abundant, this living fossil can now only be found in a few remote localities. By far the greatest threat to Sulawesi's biodiversity, however, is ongoing deforestation and land degradation brought about by an expanding population and excessive logging.

ERWIN & PEGGY BAUER/AUSCAPE

The endangered Babirusa is an unusual and ancient member of the pig family found only on Sulawesi and some neighbouring islands. The function of the bizarre recurved upper tusks is still not fully understood.

That evening in the settlement adjacent to the park, a local villager showed me the trophy skull of a male Babirusa, complete with its bizarre recurved upper tusks. It was just like the evocative illustration in Wallace's famous book *The Malay Archipelago*, which caused a stir when it was published in 1869 by launching the region's bizarre creatures into the public imagination. I wonder whether future generations will be able to see living fossils, such as the Babirusa and Bear Cuscus, for themselves, or only as illustrations in books or as digitised images on television screens. Are these wonders of the natural world doomed to become mere creatures of the archives, or will Sulawesi's national parks be their saviour? It made me realise how privileged I had been to climb into the canopy with the king of all cuscuses—a veritable time traveller from the Middle Tertiary of Greater Australia.

* *Wallace's Line is an imaginary line, described by the famous naturalist Alfred Russel Wallace, that separates the Oriental and Australasian zoogeographical regions. It runs between Bali and Lombok, Borneo and Sulawesi, and to the south of the Philippines.*

FURTHER READING

Dwivahreni, A.A., Kinnaird, M.F., O'Brien, T.G., Supriatna, J. & Andayani, N., 1999. Diet and activity of the bear cuscus Ailurops ursinus, *in North Sulawesi, Indonesia.* J. Mamm. *80(3): 905–912.*

Flannery, T.F., 1994. Possums of the world: a monograph of the Phalangeroidea. *Geo Productions/Australian Museum: Sydney.*

Flannery, T., Archer, M. & Maynes, G., 1987. The phylogenetic relationships of living phalangerids (Phalangeroidea: Marsupialia) with a suggested new taxonomy. Pp. 477–506 in Possums and opossums: studies in evolution. Vol. 2, *ed. by M. Archer. Surrey Beatty and Sons: Sydney.*

Whitten, A.J., Mustafa, M. & Henderson, G.S., 1987. The ecology of Sulawesi. *Gadjah Mada University Press: Yogyakarta.*

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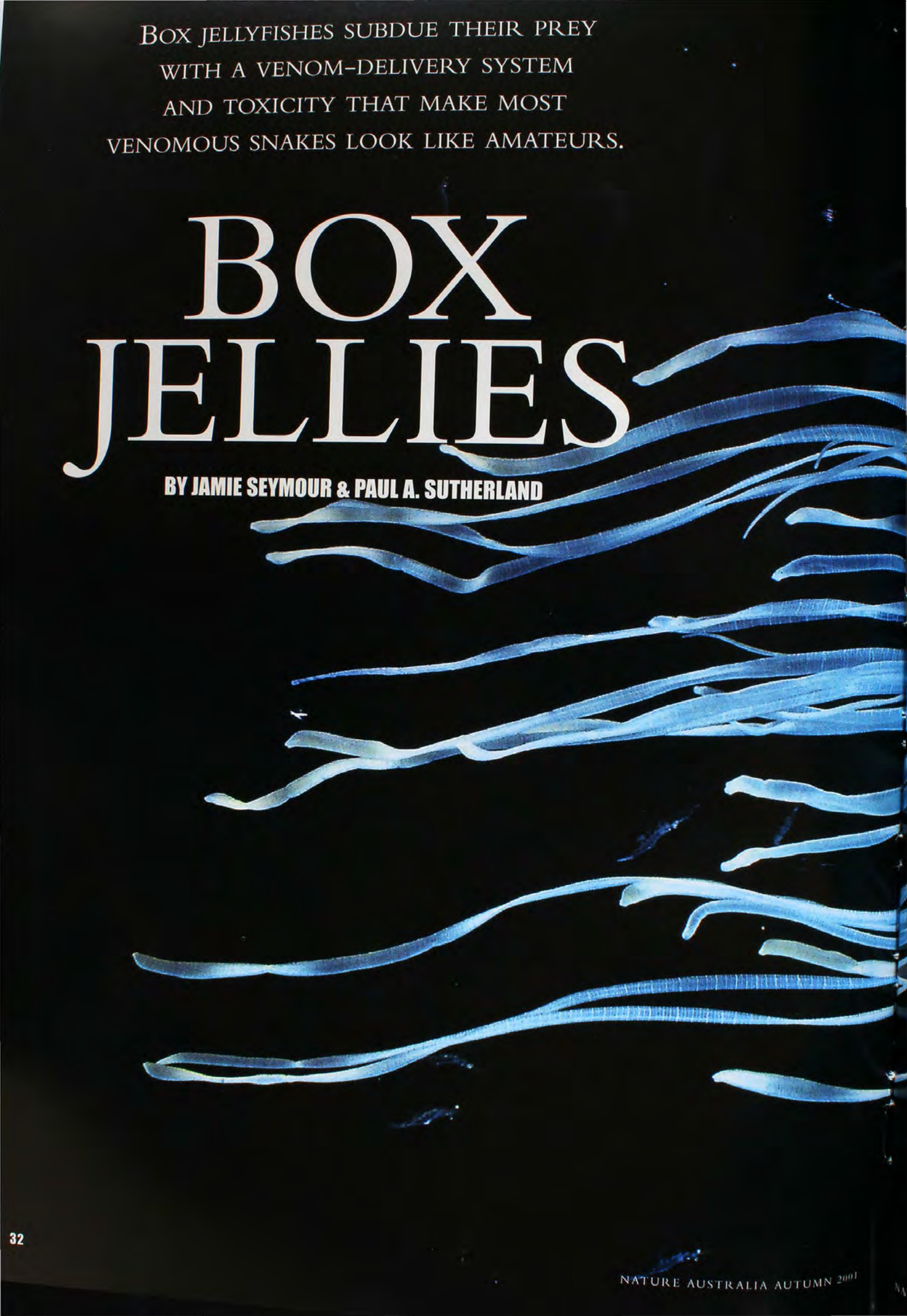
BOX JELLYFISHES SUBDUE THEIR PREY WITH A VENOM-DELIVERY SYSTEM AND TOXICITY THAT MAKE MOST VENOMOUS SNAKES LOOK LIKE AMATEURS.

BOX JELLIES

BY JAMIE SEYMOUR & PAUL A. SUTHERLAND



A chirodropid or multi-tentacled box jellyfish. This group of box jellyfishes contains the deadliest marine creature known, *Chironex fleckeri*.

GARY BELL

DRIFTING AT PEACE IN the ocean currents, at the mercy of the wind and tides, feeding on microscopic animals in the water column...this is most people's idea of life as a jellyfish. But for one group of jellyfishes, the cubozoans or box jellyfishes, nothing could be further from the truth. These creatures are stronger, faster and, in some cases, bigger and even better that their close cousins, the true jellyfishes or scyphozoans.

Box jellyfishes are so named because of their cubic body (or bell) structure. There are two types. Chirodropids, or multi-tentacled box jellyfishes, have more than one tentacle at each corner of the bell. This group contains the infamous Box Jellyfish (*Chironex fleckeri*), which holds the somewhat envious title of the most venomous marine creature in the world, having the potential to kill a full-grown adult human within minutes. In general, species within this group can be quite large. Some of our captive *C. fleckeri* are over 30 centimetres across the bell, and there are unconfirmed reports of individuals up to 40 centimetres across with as many as 15 tentacles on each corner.

The carybdeids, or single-tentacled box jellyfishes, have only one tentacle at each corner of the bell, giving them a total of four. They tend to be smaller, although in some cases no less venomous, than the chirodropids. Included in this group are the Irukandji (*Carukia barnesi*), found in northern Queensland, and the small 'Jimbles' (*Carybdea rastoni*), common in western Australian waters.

Both groups occur throughout the waters of the world, although the majority are confined to warm tropical waters. There are at least ten named species of box jellyfishes in Australia, however in the last two years we have located five new (as yet to be described) species from northern Queensland waters alone.

Most box jellyfishes are active predators that subdue their prey with a venom-delivery system and toxicity that make most venomous snakes look like amateurs. It is not surprising then that, from Gladstone on Australia's east coast north to Exmouth on the west, these animals are responsible for keeping the majority of humans from bathing in the sea between late November till the start of May. During this time, people who wish to swim in the ocean are limited to beaches enclosed by stinger nets. These are basically fishing nets suspended below an inflated tube, and weighted down with a length of chain to keep them in contact with the sea floor. With the use of winches, they are moved up and down the beach as the tide rises and falls, keeping the jellyfishes outside and the humans inside.

Since the inception of stinger nets, the number of people killed by box jellyfishes has been reduced dramatically,

R. HARTWICK

As juveniles, box jellyfish are small polyps, resting on rocks on the bottom of estuaries. Even at this stage, they are armed with stinging cells to help catch plankton, which they eat when small.

P.A. SUTHERLAND/OTHER WORLD IMAGES USA

One of the major reasons why more people in Australia do not die from box jellyfish stings is stinger nets. These nets were designed by researchers at James Cook University and can be found on most of the popular beaches in northern Queensland.

but deaths still occur outside the nets, the last in Cairns in January 2000. For a group of animals that have such a profound effect on the general populous, surprisingly little is known about their general biology, but the little we do know seems to belie their position on the evolutionary ladder.

BOX JELLYFISHES HAVE a host of high-tech facilities at their disposal. Some species, such as *Chironex fleckeri*, have the ability to swim at speeds of up to three knots (five kilometres per hour). This may not seem all that fast, but over 24 hours it means they theoretically have the capacity to travel up to 70 kilometres, which is certainly farther than we could swim in that time! It also means they can swim in directions they want to go, and are not purely at the mercy of currents. Not bad for a lump of jelly! However, possession of a V8 power plant is not much use unless you have a guidance system to steer with.

Enter the gyroscopes of box jellyfishes. On each facet of the bell (or body of the jellyfish), nestled equidistant between the corners where the tentacles attach, are structures called rhopalial niches. Within these structures are two important organs. The first is the statocyst. This small (one-millimetre-wide) structure holds a calcium carbonate nodule, or statolith, which is suspended by a series of hairs. As the animal changes position in the water column, the nodules pull on the hairs (in response to gravity) and together they enable the jellyfish to tell if it is facing straight up, straight down or at an angle to the sea floor. This is important to the animal, especially

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Adult *Chironex fleckeri* are quite capable of catching and subduing quite large mobile prey, such as fish.

P.A. SUTHERLAND/OTHER WORLD IMAGES USA

when feeding (see later).

Interestingly, recent research we have done has shown that these statoliths can be used to age the animals. Sectioning statoliths reveals growth rings, just like in trees, only these rings indicate days, not years. From these growth rings we have been able to calculate that, for at least two box jellyfish species in northern Queensland, they may grow up to a centimetre a week, and may live for over 200 days.

The possession of statocysts in box jellyfishes though is in itself not surprising, as most jellyfishes have them.

A perfect specimen of *Chironex fleckeri* for attachment of an ultrasonic transmitter. It has only been with the advent of these small transmitters that researchers have been able to peek in on the personal lives of these animals.

However, associated with box jellyfish statocysts are eyes. Yes, box jellyfishes have eyes. And not just one set; some have three eyes per rhopalial niche, giving them a total of 12. In each of these niches, one of the eyes is usually directed towards the stomach and the other two directed out, presumably to help locate prey. At present we do not know whether these eyes are image-forming, but given that *Chironex fleckeri* and the closely related 'Quaddie' (*Chiropsalmus* sp.) swim up to meet us as we approach their holding tanks, and the fact that we have seen pairs of them hunting in what appears to be a cooperative manner, it wouldn't surprise us if future research shows they have the ability to produce at least crude images. Past research has certainly shown that they have lenses and pigmentation cells in their eyes.

And what exactly do they eat? Unlike the majority of 'true' jellyfishes, box jellyfishes aren't restricted to feeding on plankton throughout their lives. Many species in Australian waters switch to eating actively swimming animals such as small shrimp and fish as they grow. And some of the larger species can handle even bigger prey items. A 25-centimetre-wide *Chironex fleckeri*, for example, may easily catch, kill and digest a fish of equal size in less than three hours. To be able to subdue prey this size requires a range of specialised equipment.

The first is an effective venom, one capable of causing paralysis and/or death within seconds. There is little doubt that box jellyfishes like *Chironex fleckeri* possess such a venom. These animals have been responsible for over 65 human deaths in Australia alone in the last 50 years. The second is an extremely effective venom-delivery system. Box jellyfishes, like other jellyfishes, have an enormous number of nematocysts or stinging cells on their tentacles. The stinging cells, when stimulated, evert a hollow tube (like the finger of a rubber glove blown inside out), which punctures the prey. Once the tube is embedded in the prey, venom is transferred into the tissue. Alone, any one of these cells is not all that effective at immobilising and killing, but given that a piece of tentacle measuring one square centimetre may have tens of thousands of nematocysts on it, it is easy to understand how a lot of venom can be injected in a very short time. Interestingly, not all marine animals are susceptible to the stings of box jellyfishes. Green Turtles (*Chelonia mydas*), for example, feed extensively on *C. fleckeri* and we have seen them scoffing them down like marshmallows.

Once the prey is caught, the tentacles rapidly retract, drawing the prey up towards the bell of the animal and into the mouth. To facilitate the movement of food into the mouth, box jellyfishes

P.A. SUTHERLAND/OTHER WORLD IMAGES USA

Box Jellyfishes

Classification
Phylum Cnidaria, class Cubozoa (box jellyfishes), orders Chirodropidaea (multi-tentacled) and Carybdeidaea (single-tentacled).

Identification
Usually cubodial (box-like) in shape, although some are rectangular; usually transparent with a small (1–2 mm) dark spot (the eyes within the rhopalial niche) midway between the corners (pedalia) on the lower edge of each facet of bell. Size range 1 mm to at least 30 cm.

Distribution and Habitat
Worldwide, but mainly restricted between the Tropics of Cancer and Capricorn. Multi-tentacled forms (chirodropids) found predominantly in the tropics, but the single-tentacled forms (carybdeids) are also found in some temperate oceans. Most of the chirodropids are found in coastal marine foreshores, usually around creek mouths. Carybdeids are also found around coral reefs.

Reproduction
In northern Aust., chirodropid populations mainly present during summer months (Nov.–May), with breeding occurring towards end of stinger season (Feb.–May). Carybdeid populations can also be found in southern parts of Aust. during winter months, but exact breeding times unknown. Adults normally shed eggs and sperm into water, but some (predominantly carybdeids) have internal fertilisation. For Aust. chirodropids, planulae settle to produce polyps, which metamorphose into single medusae at start of 'wet' season (Oct.–Nov.).

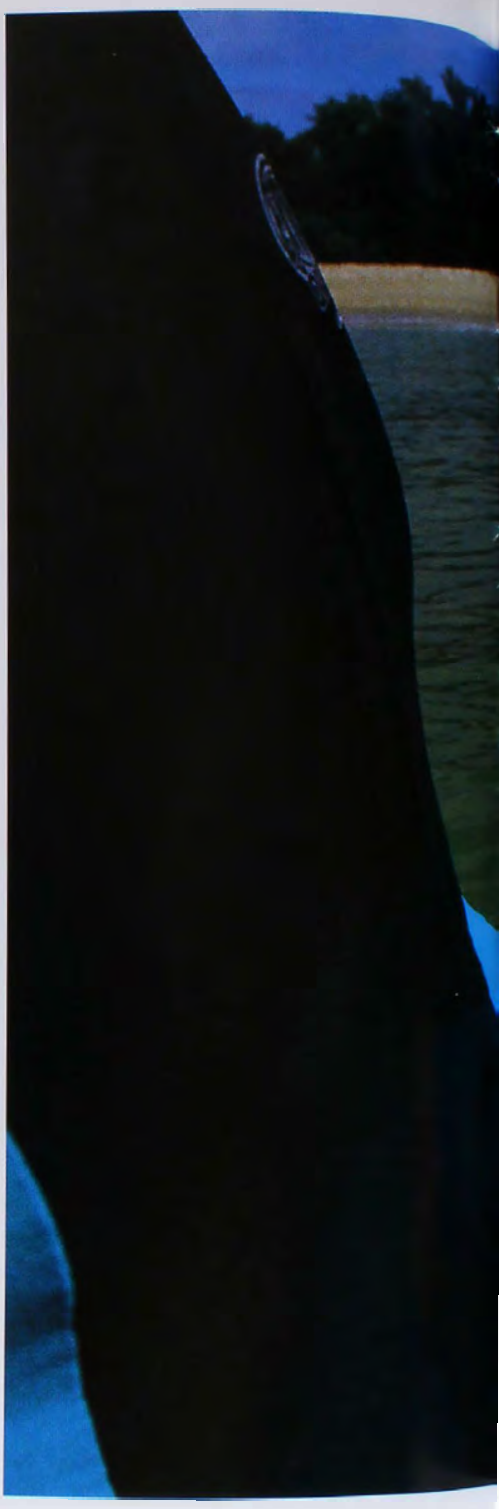
Diet
Predominantly marine invertebrates, incl. polychaetes, shrimps, copepods and other crustaceans, as well as larval and adult fish.

First Aid
Remove victim from water; send for medical help; dose affected area in vinegar for at least 30 secs, which stops more stinging cells from firing; apply CPR if required.

BOX JELLYFISHES HUNT PRIMARILY IN THE SHALLOWS

along sandy beaches or around mangroves in creeks, usually during calm weather, in just the sort of places humans like to swim.

KELVIN AITKEN/ANT PHOTO LIBRARY



will often turn upside down (this is where the statoliths come in) and slowly drift to the bottom, letting gravity do the work for them. By some as yet unknown process, when the tentacles come in contact with the mouth and stomach, no nematocysts fire off. Put another way, the animal has the good sense not to sting itself. The discharged

It is not commonly known that box jellyfishes have eyes. They are grouped on each facet of the bell midway between the pedalia (which hold the tentacles) at the bottom edge of the bell. They appear as small black specs to the casual observer.

P.A. SUTHERLAND/OTHER WORLD IMAGES USA

Attaching a transmitter to a 'lump of jelly' is never easy, but superglue used for human surgery works beautifully, as long as your fingers do not get in the way!

nematocysts then drop off from the tentacle as it is withdrawn, leaving the prey item in the stomach.

Having got the food to the stomach, box jellyfishes now need to convert it quickly into energy. For this they have evolved an ingenious system that allows rapid digestion and uptake of nutrients. Most true jellyfishes, which are basically just swimming stomachs with tentacles for catching food, have specialised portions of the stomach that serve to increase the surface area used for absorption of nutrients. Box jellyfishes, however, have taken this one step further. Their stomachs are connected by canals to special hollows (called lumens) in the tentacles. Recent research we carried out on Quaddies suggests that food is pre-digested in the stomach and then transported via these canals to the hollow tentacles where it is absorbed. Given that many adult box jellyfishes may have up to 50 tentacles, most over two metres in length, this adds up to a very large area in which absorption can take place.

Further compounding the box jellies' nutritional conundrum is the fact that they have a very high metabolic rate. A

former student at James Cook University showed that Quaddies have a metabolic rate at least ten times higher than their more ordinary cousins. This means they utilise energy at a much faster rate and can therefore be more active, a necessity if you hunt mobile prey such as fishes. But this advanced predatory skill-set comes at a cost. If box jellyfishes are brought into the lab and not fed, they will lose almost 30 per cent of their body weight in less than three days.

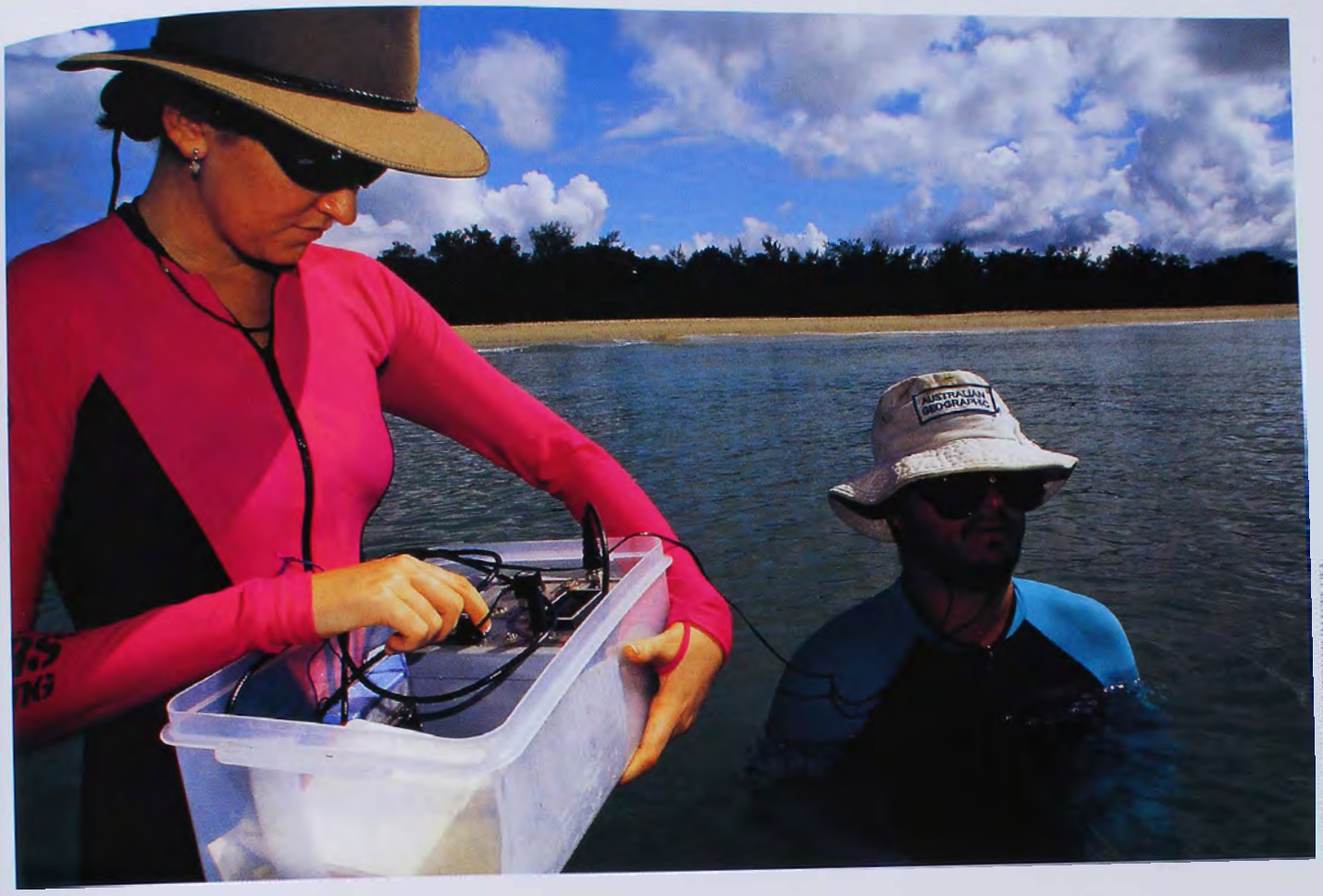
It seems that these animals have to feed almost continuously otherwise they go into a spiral decline, losing weight and shrinking in size. Surprisingly, this is not a fatal blow for jellyfishes, as they can re-grow when food becomes available again. Still, it means they need to live in areas where food is readily abundant, and this is what causes the interactions between them and northern Australian swimmers. Many box jellyfishes hunt primarily in the shallows along sandy beaches or around mangroves in creeks, usually during calm weather, in just the sort of places humans like to swim. But when the weather becomes rough, they disappear. One of our challenges has been to try to find out where they go during rough weather.

HOW DO YOU FOLLOW a nearly transparent creature in murky waters? Thanks to modern technology, we can track them using small (22 x 18-millimetre) acoustic ultrasonic tags, which emit pulses of sound in the range of 20–75 kilohertz. If you can secure one of these tags to a jellyfish, you can track it from as far away as 500 metres for periods of 21 days. There is a problem though: how do you attach a transmitter to a tub of jelly? Enter the medical profession. One major problem in cosmetic surgery is the scarring left by stitches. To overcome this, cosmetic surgeons have developed a non-toxic superglue for joining cut tissues. Fortunately, this glue also sticks to jellyfishes, so by placing a small amount of glue on the transmitter and some on the jellyfish, the transmitter can be easily and securely attached to the outside of the animal.

Having tagged several of these animals, we now know that many go offshore and lie on the bottom when conditions get rough, but more importantly we have been able to paint a picture (albeit a little murky at present!) of what they do during periods of normal activity. It seems that some of the jellyfish have very compact home ranges (often only 500 metres along a beach front), moving just off shore (200–500 metres) as the tide goes out and back into the shallows (where they do most of their feeding) when the tide comes back in. However, others disappear overnight,

H.A. SUTHERLAND/OTHER WORLD IMAGES USA

One of the single-tentacled box jellyfishes, or carybdeids. They are usually small and can be beautifully coloured.



P.A. SUTHERLAND/OTHER WORLD IMAGES USA

Teresa Carrette and Jamie Seymour attempt to locate a tagged box jellyfish using an underwater microphone and an ultrasonic receiver

never to be 'heard' of again. This is not surprising considering the distances some box jellyfishes can theoretically travel in 12 hours. The trick is to follow these animals at night, but given that the majority of animals we have tagged have been in crocodile-infested waters, I can't see this happening in the near future!

What happens when a box jellyfish becomes sexually mature? Although still unconfirmed, it has been suggested in the past that box jellyfishes migrate up streams or creeks near the end of the stinger season (usually April to May), and release eggs and sperm into the water. What happens to the adults is still a mystery, but presumably they die. The resulting 'planulae', which are basically little balls of cells, then swim through the water column looking for a suitable place to settle, normally on the undersurface of rocks in creeks. Once settled, they metamorphose into a small polyp, much like a baby coral but without the calcareous skeleton. Here the polyp grows and asexually buds off further polyps until, at the start of the wet season, usually around October–November, the polyp metamorphoses into a single box jellyfish, approximately one to two millimetres in diameter. These little jellyfish then make their way to the shallows of the beaches where they spend their time eating and growing, feeding on marine life and starting the cycle over again.

And just think—all this from an animal that is 96 per cent water!

FURTHER READING

Barnes, J.H., 1966. Studies on three venomous Cubomedusae. Pp. 307–332 in The Cnidaria and their evolution. Symposium of the Zoological Society of London No. 16. *Academic Press: London.*

Fenner, P.J. & Williamson, J.A., 1996. Worldwide deaths and severe envenomation from jellyfish stings. Med. J. Aust. *165(2): 658–661.*

Hartwick, R.F., 1991. Distributional ecology and behaviour of the early life stages of the box-jellyfish Chironex fleckeri. Hydrobiologia *216/217: 181–188.*

Hamner, W.M. & Doubilet, D., 1994. Australian box jellyfish—a killer down under. Natl Geog. *186(2): 116–130.*

Hamner, W.M., Jones, M.S. & Hamner, P.P., 1995. Swimming, feeding, circulation and vision in the Australian box jellyfish, Chironex fleckeri *(Cnidaria: Cubozoa).* Mar. Freshw. Res. *46: 985–990.*

Williamson, J.A., Fenner, P.J., Burnett, J.W. & Rifkin, J. (eds), 1996. Venomous and poisonous marine animals—a medical and biological handbook. *University of New South Wales Press: Sydney.*

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CENTIPEDES WERE
"STONE-OLD WHEN DINOSAURS WERE YOUNG".

CENTIPEDES: THE GREAT AUSTRALIAN BITE

BY GREG EDGECOMBE

IT'S HARD NOT TO RESPECT centipedes. These multi-legged marvels figured out how to go about their business—hunting in soil and litter—not long after animals came to live on land, more than 400 million years ago. As one centipede worker put it, centipedes were "stone-old when dinosaurs were young".

'Centipede' is the common name for the joint-legged animals that zoologists classify in the class Chilopoda. Although 'centi-' and '-pede' would imply that centipedes have 100 feet, the known range is from 15 to 191 pairs—and none in fact has exactly 100 legs or pairs of legs. Indeed, all species of centipedes have an odd number of leg pairs. Only one (mutant) individual has ever been found with an even number of leg pairs (reported in 1999). Clearly the developmental genetics that control the number of leg pairs in centipedes is at odds with getting even!

KATHIE ATKINSON

The 'fangs' of centipedes are the modified first legs of the trunk, which become a functional part of the head and contain a poison gland.

All centipedes have the first pair of legs behind the head modified into a pair of fangs (maxillipedes). These contain a poison gland. Centipedes are almost exclusively predatory, stabbing prey (usually small invertebrates such as springtails and insects) with their maxillipedes and injecting venom into the wound. They use their robust mandibles (jaws) to chew pieces of their prey, which they manipulate with their two pairs of maxillae (legs that are specialised as mouthparts). While the fangs of smaller centipedes can't pierce human skin, a bite from any of the larger species is best avoided. The largest Australian species, *Ethmostigmus rubripes*, in the family Scolopendridae, is about 14 centimetres long, a good deal smaller than the aptly named *Scolopendra gigantea*, a 30-centimetre species from Central and South America. Large scolopendrids can even take vertebrate prey, such as mice and lizards. In 1930, *Nature Australia* (then called *The Australian Museum Magazine*) reported that a Bull Terrier in Sydney had shuffled off its mortal coil after an encounter with *Ethmostigmus*, but human deaths from centipede bites are extremely uncommon worldwide and unknown in Australia.

DESPITE THEIR SIMILAR basic body plan, centipedes are a diverse lot. They are divided into five main groups, or orders: Scutigeromorpha, Lithobiomorpha, Geophilomorpha, Scolopendromorpha and Craterostigmomorpha.

The scutigeromorphs are the only ones with faceted or 'compound' eyes. The other groups have either a single-lens eye (ocellus) on each side of the head, a small cluster of ocelli, or no eyes at all. Scutigeromorphs have whip-like antennae and 15 pairs of very long, multi-jointed legs that remind me of false eyelashes. This leg construction allows them to run at an amazing speed for an animal just a few centimetres long—*Scutigera* has been clocked at 40 centimetres per second, and it takes off in top gear. High speed enables scutigeromorphs to pounce on fast prey such as flies, and they're better adapted to hunting in the open than other centipedes. Their legs bear rows of small spines that look like saw blades. Those of us who are centipede-enamoured can't help but liken their fastidious grooming behaviour to kittens—the long legs and antennae receive careful cleaning by passing them along the maxillae to remove moulds and parasites (other centipedes groom themselves this way as well).

Scutigeromorphs are also unique among centipedes in their manner of

Centipedes

Classification

Phylum Arthropoda, superclass Myriapoda (millipedes, centipedes, symphylans, pauropods), class Chilopoda (about 2,800 named spp. worldwide, 125 named spp. in Aust., and many more undescribed spp.). Five orders: Scutigeromorpha (130 spp. worldwide, 19 named spp. in Aust.); Lithobiomorpha (about 1,100 spp. worldwide, 18 named spp. in Aust.); Geophilomorpha (about 1,000 spp. worldwide, 43 named spp. in Aust.); Scolopendromorpha (about 550 spp. worldwide, 44 named spp. in Aust.); Craterostigmomorpha (1 or 2 spp. in Tas. and NZ).

Habitat and Habits

Most commonly in leaf litter, under bark and logs, and in soil, ranging from sea level to mountaintops. Usually solitary predators; encounters between individuals of same spp. often aggressive. Most spp. hunt more actively at night. Few natural enemies (e.g. some snakes, rats, mites). Shedding of legs and regenerating them in the next moult is a defence against predators. Other defences include noxious secretions from glands on ventral body surface (Geophilomorpha) and producing sticky, silk-like threads from the last legs (Lithobiomorpha).

Breeding

Breeding season typically a few months per year, the season varying between spp. Courtship rituals often elaborate, lasting many hours (e.g. male taps female's last legs with his antennae to entice her to take up his sperm packet, or spermatophore). Males of all centipedes except scutigeromorphs deposit the spermatophore on a web; scutigeromorphs produce a spermatophore but no web. Some species are parthenogenetic (female clones). Clutch size for species that brood eggs ranges from 3–86. Sexual maturity typically reached in about a year, life span usually a few years (up to about six years).

MICHAEL CERMAK

Scutigeromorph legs assume their unique, whip-like form by having one of the segments (the tarsus) subdivided into many short joints.

breathing. All centipedes take in air by means of branching tubes called tracheae. The scutigeromorphs have special tracheal lungs that open at slits (spiracles) in the exoskeletal plates (tergites) on the upper surface of the body. Other centipedes have their spiracles located on the sides of the body rather than on the top.

'Stone centipedes' (order Lithobiomorpha) resemble the scutigeromorphs in having 15 leg pairs. Like other centipedes, however, they have spiracles on the sides of their body, a flattened head and body that allow them to hunt in narrow spaces, and organs on the last legs that seem to be the source of sex-specific pheromones. Unique to the 'stone centipedes' are a large claw and two or more bullet-like spurs on the female's gonopods—a pair of leg-like structures located behind and between the last pair of walking legs. These centipedes use the claw and spurs to roll their eggs in soil (for camouflage) before abandoning them.

Centipedes in the order Geophilomorpha (which means 'earth loving') are so named for their soil-dwelling habits. Leg number varies greatly between species (27–191 pairs) and also often within species, whereas the number of legs in species from other orders is rigidly fixed. The geophilomorphs are also the only centipedes that have tergites equal in length; the rest of the centipedes usually have alternating long and short tergites. This body design, combined with a more flexible exoskeleton, allows geophilomorphs to be the most adept burrowers among the centipedes. All geophilomorphs are blind. Their comb-like mandibles are adapted to

C. ANDREW HENLEY

Ethmostigmus rubripes **is the largest species of centipede in Australia, inhabiting a range of environments from desert to rainforest.**

Millipede or Centipede?

Millipedes belong to the class Diplopoda; centipedes to the class Chilopoda. They are the two most species-rich groups within the superclass Myriapoda. The other two myriapod groups are the small, soil-dwelling Symphyla and Pauropoda; these have only 12 and 9–11 pairs of legs, respectively, fewer than centipedes (15–191) and usually fewer than millipedes (11–375 pairs). Millipedes are most easily distinguished from centipedes by having two pairs of legs on most body segments behind the head (versus one leg pair per segment in most centipedes), no trailing pair of legs behind the body (as in centipedes), and a harder (calcified) exoskeleton (centipedes are flexible if touched). Habits may also allow easy distinction, as only centipedes are able to run fast and bite. Millipedes are detritivores (chewing decaying vegetation) rather than carnivores. 'Millipede' is as much a misnomer as 'centipede'—no species is known with 1,000 legs!

Whether all the myriapods have a single, unique evolutionary origin is a hotly debated topic. Most evidence from DNA sequences favours a unique history for the Myriapoda, but some anatomists consider millipedes, pauropods and symphylans to be closer to insects than to centipedes. Other studies (notably of the eyes and nervous system) suggest that insects may be more closely related to crustaceans (such as crabs and prawns) than to myriapods.

sweeping and rasping more liquefied food than other centipedes.

The order Scolopendromorpha includes the largest, most aggressive, and perhaps most frequently noticed centipedes. These include the striking blue-green centipedes with orange, pink or green legs that slither away when you turn over a log in the bush. All Australian species have 21 pairs of legs. One widespread genus that occurs in Australia is the cosmopolitan *Cryptops*, whose species are blind burrowers in the soil and rotting logs.

Australia's claim to centipede fame is *Craterostigmus tasmanianus* from Tasmania. The British centipede researcher Reginald Innes Pocock first described *Craterostigmus* in 1902, announcing it in the title of his paper (in suitably Edwardian prose) as "a new and annectant type of chilopod". The species is so peculiar that it has

Portraits of maternal devotion? Maternal care in epimorph centipedes (the scolopendromorphs and geophilomorphs) involves the same basic behaviour. The mother humps her body over the egg cluster (top), and continues to stand guard over the hatchlings (centre). She does not feed while brooding. All centipedes that have brood care hatch with their full (adult) number of legs, which can be seen in the bottom photo where the mother has been removed. After the hatchlings moult twice, they leave the brood or risk being eaten by their mother.

PHOTOS: KATHIE ATKINSON

remained classified in its own separate order, the Craterostigmomorpha. Among its odd features is a pointed 'capsule' at the back end of the body that encloses the anal/genital region. It opens along its length on the underside, and looks rather like a pointy change purse. It's also unusual in having 21 tergites lying over 15 pairs of legs (most other centipedes have one pair of legs per tergite, except for scutigeromorphs, which appear to have a few of their tergites fused). Anatomical oddity in *Craterostigmus* extends to the front end as well for, unlike other centipedes, the long maxillipedes project beyond the margin of the head. Besides Tasmania, the only other place that *Craterostigmus* occurs is New Zealand, and this appears to be a different species.

Craterostigmus has been studied intensively in recent years. The conclusion of most of these studies is that *Craterostigmus* is the closest relative of the scolopendromorphs and the geophilomorphs, the latter two orders together forming a group called Epimorpha. Similarities between *Craterostigmus* and Epimorpha are found in anatomy (for example in the muscles of the trunk) as well as in a surprisingly dedicated manner of maternal care. In all of these centipedes, the mother humps her body around a cluster of eggs and guards it. In the Epimorpha, the mother continues to stand guard over the young hatchlings, which are immobile for their first two moults after emerging from the egg. Other centipedes lay their eggs singly, concealed in soil, and abandon them. The hatchlings are active from birth. A difference between Epimorpha and *Craterostigmus* is that the former hatch from the egg with their adult number of segments, whereas *Craterostigmus* and members of the other two orders add

segments after hatching.

DNA sequences provide a new source of information about centipede evolution. Gonzalo Giribet (Harvard University), Ward Wheeler (American Museum of Natural History) and I have returned to a question that puzzled Pocock: how do the major groups of centipedes interrelate, and where does *Craterostigmus*, the Australasian enigma, fit in? We have now analysed gene sequences for nearly 40 species of centipedes, including representatives of all the major groups. The agreement between the molecular data and the behavioural and anatomical evidence for relationships is encouraging. Both sets of data, considered on their own and in combination with each other, tell us that *Craterostigmus* is the closest relative of the Epimorpha.

Because their exoskeleton is unmineralised, centipedes (like most litter-dwelling invertebrates) have a very patchy fossil record. Still, the fossils show that the living orders have extremely long histories, going well back into the Palaeozoic Era. The earliest centipede fossils, from the Late Silurian (418 million years ago) of Britain, are scutigeromorphs, and already have the spiny, 'saw-blade' legs of modern scutigeromorphs. A beautifully preserved Middle Devonian (385-million-year-old) species from New York is assigned to its own order, with a fairly advanced position in the evolutionary tree for Chilopoda. This implies that some unfossilised splits between major groups must have occurred before the Middle Devonian. Centipedes from much younger (Tertiary) amber deposits are essentially modern. Fossil centipedes are as yet unknown from Australia.

DESPITE THEIR IMPORTANCE in soil and litter ecosystems, Australian centipedes have been largely ignored by taxonomists for the last 80 years. Only the family Scolopendridae has received a comprehensive, modern revision, undertaken by Lucien Koch of the Western Australian Museum in the 1980s. My particular interest is with the Lithobiomorpha, in large part because these animals have fascinating geographic distributions. Lithobio-

Other arthropods (such as this march fly being devoured by a scolopendrid) are typical prey of centipedes.

JIRI LOCHMAN LOCHMAN TRANSPARENCIES

A dasyurid (*Ningaui ridei*) drags a scolopendromorph centipede from the safety of a rock.

T. SHIVANANDAPPA/AUSCAPE

Large scolopendrids sometimes prey on vertebrates. This centipede (*Scolopendra* sp.) is feeding on a gecko.

morphs like *Paralamyctes* clearly reveal the Gondwanan heritage of Australia. This genus is known from five species in South Africa, two in Madagascar, two in New Zealand and one in Chile. This kind of distribution across the fragments of the former supercontinent Gondwana would lead us to predict that *Paralamyctes* must have once occurred in Australia, too. Sure enough, I have found six new species of *Paralamyctes* in rainforests of eastern Australia, together ranging along much of the Great Divide, from the wet tropics of Queensland to Tasmania. The distribution of *Paralamyctes* probably dates to the Cretaceous Period (at least 100 million years ago), before Gondwana split to the point that small terrestrial animals like centipedes were unable to disperse across the newly formed marine barriers. *Paralamyctes* no doubt would also have occurred in the southern beech (*Nothofagus*) forests of ancient Antarctica.

Another lithobiomorph, *Australobius*, shows how much more we have to learn about the centipedes of Australia. The genus was originally named in 1920, based on a species known from a single specimen from Kuranda in northern Queensland. By the 1970s, however, *Australobius* was recorded widely across the Indo-Malay region, with many species. Today the genus is known to range as far north as Nepal. Despite its decidedly Aussie name, the Australian record of *Australobius* came into question because no other members of its family (Lithobiidae) are native in Australia. The possibility that *Australobius* was introduced into northern Queensland had to be considered. Fortunately, museum collections and field studies suggest a different—and more encouraging—story. The Kuranda species, *Australobius scabrior*, has been discovered in dozens of pristine bush sites all along the Great Divide in Queensland, where it is most commonly found beneath eucalypt bark; it even extends as far south as Sydney. Aussie *Australobius* seems to be a native after all.

SOME CENTIPEDES *have even managed to colonise the intertidal zone. They hunt in seaweed clusters on the shoreline.*

A few of the commonly encountered centipedes in Australia are introduced species. The European House Centipede (*Scutigera coleoptrata*) lives up to its common name—it is usually sighted in the basement. One of our introduced centipede species, *Lithobius obscurus*, entered the taxonomic literature with the name *Lithobius sydneyensis* because it was described as a new species from Sydney. However, later discoveries of the same species in port cities including Auckland, Cape Town and Montevideo led to the

realisation that this species is feral in Australia, and was probably spread via cargo. It's actually a native from the western Mediterranean. The reverse case, of an Australasian species being introduced abroad, is illustrated by the lithobiomorph *Lamyctes emarginatus*, which has spread to temperate areas of Europe, North America and even Greenland. Its success as a 'tramp species' is probably due to its ability to reproduce by parthenogenesis (without males).

The diversity of centipedes in Australia is highest in rainforest and wet sclerophyll forest. The centipedes most frequently encountered in the arid zone are the large scolopendromorphs. A few species, such as *Scolopendra morsitans* and *Ethomostigmus rubripes*, are distributed across most of mainland Australia, from Cape York to Victoria, and from rainforest to the central desert. Some centipedes have even managed to colonise the intertidal zone. In Australia, a few species of the geophilomorph *Tuoba* are distributed all along the coasts. They hunt in seaweed clusters on the shoreline. In general, though, leaf litter, soil, and under logs and bark are the preferred habitats of most centipedes. There have been few detailed ecological studies on Australian centipedes, a point driven home by the celebrated *Craterostigmus tasmanianus*. In the 1960s, Sidnie Manton (Queen Mary College, London), one of the all-time masters of arthropod studies, interpreted the peculiar head structure of *Craterostigmus* as an adaptation for hunting in termite colonies. The long, projecting maxillipedes would allow *Craterostigmus* to probe into rotting wood in search of termites. An intuitively satisfying story for sure—except that *Craterostigmus* has never been collected from anywhere near a termite colony! We have much more to learn about these animals.

The French specialist on centipedes and millipedes H.W. Brölemann prefaced a 1912 study on Australian centipedes with the noble words "May this attempt to win sympathies to the cause of the much disregarded Myriapoda meet with some success". Nearly a century later, intrepid myriapodologists are still attempting to win sympathies to the cause of centipedes. If immaculate grooming and devoted maternal care weren't enough to win over hard-hearted chilopodophobes, then a track record as great survivors in the animal kingdom should help. Few other modern groups shed so much light on ancient worlds.

FURTHER READING

Edgecombe, G.D., Giribet, G. & Wheeler, W., 1999. Phylogeny of Chilopoda: combining 18S and 28S rRNA sequences and morphology. Pp. 293–331 in Filogenia y Evolución de Artrópodos, *ed. by A. Melic, J.J. de Haro, M. Mendez and I. Ribera. Boletin de la Sociedad Entomológica Aragonesa, Zaragoza No. 26.*

Harvey, M.S. & Yen, A.L., 1989. Worms to wasps: an illustrated guide to Australia's terrestrial invertebrates. *Oxford University Press: Melbourne.*

Lewis, J.G.E., 1981. The biology of centipedes. *Cambridge University Press: Cambridge.*

Mesibov, B., 1986. A guide to Tasmanian centipedes. *The Author: Zeehan, Tasmania.*

Mesibov, R., 1995. Distribution and ecology of the centipede Craterostigmus tasmanianus *Pocock, 1902 (Chilopoda: Craterostigmomorpha: Craterostigmidae) in Tasmania.* Tas. Natur. *117: 2–7.*

Shelley, R.M., 1999. Centipedes and millipedes with emphasis on North American fauna. The Kansas School Naturalist *45(3): 1–16.*

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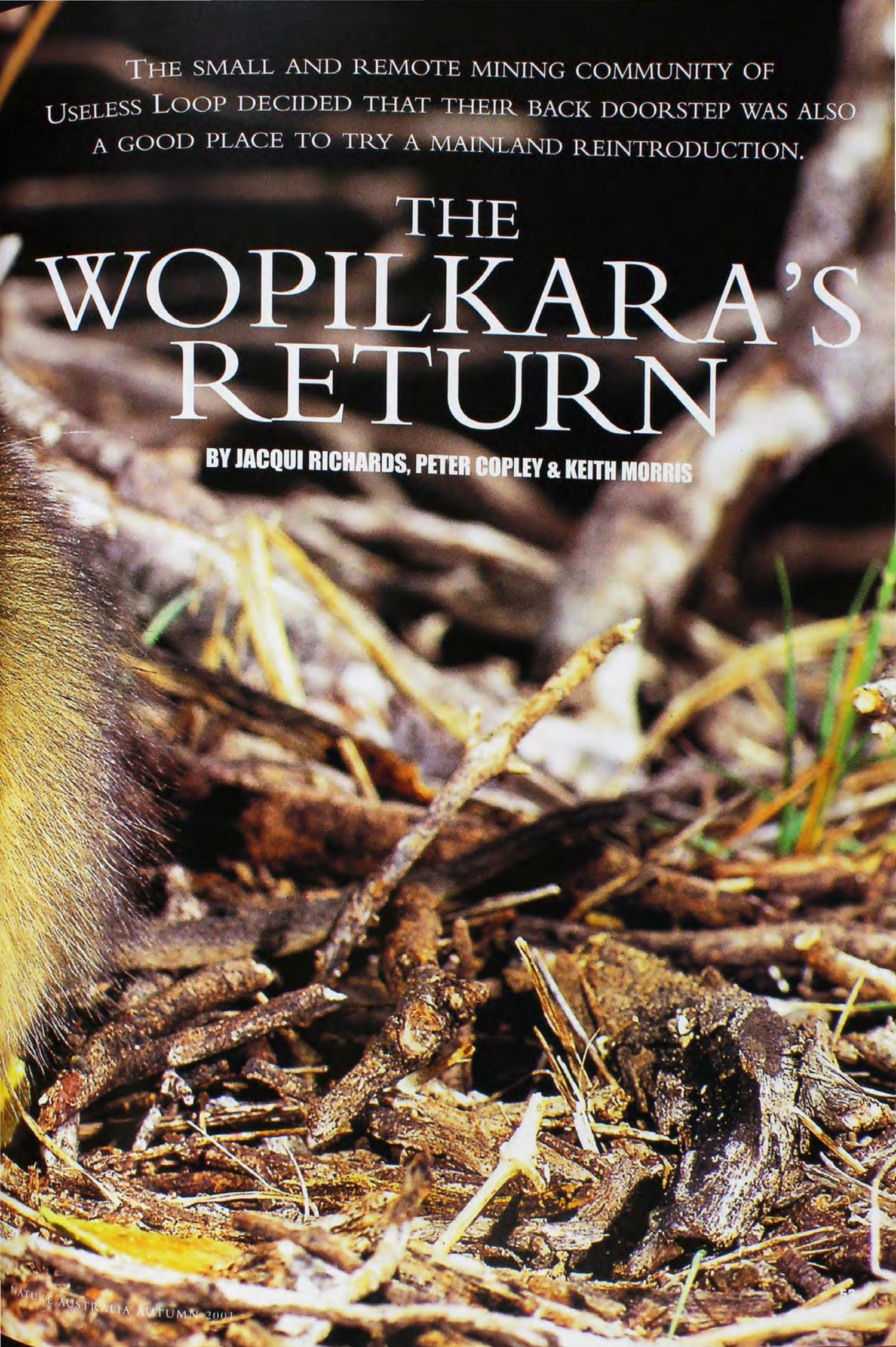
GONZALO GIRIBET

***Henicops* species, the most common lithobiomorphs in Australia, inhabit wet forest. Like several other lithobiomorphs, *Henicops* shows close links between Australia and New Zealand.**

Greater Stick-nest Rats are herbivorous, consuming a diet of semi-succulent chenopods such as saltbush and bluebush. They are impressively dexterous, manipulating their food with their front paws while balancing on their hind feet.



THE SMALL AND REMOTE MINING COMMUNITY OF USELESS LOOP DECIDED THAT THEIR BACK DOORSTEP WAS ALSO A GOOD PLACE TO TRY A MAINLAND REINTRODUCTION.

THE WOPILKARA'S RETURN

BY JACQUI RICHARDS, PETER COPLEY & KEITH MORRIS

RATS IN GENERAL tend to have a bad name, so you could be forgiven for believing that a 'stick-nest rat' might just be another one of those large, smelly rodents that keep you awake at night scampering over the ceiling. But you'd be mistaken. One glance is all it takes to see that these charming native rodents are anything but 'rat'-like. Their large ears, blunt nose and fluffy coat make them look more like a small Rabbit with a long, slender tail and, combined with their waddling gait, they are more likely to attract than repulse you.

The Greater Stick-nest Rat (*Leporillus conditor*), also known by one of its Aboriginal names 'Wopilkara', has been extinct on mainland Australia since the 1930s. The last mainland record was from the Nullarbor Plain in Western Australia. Their distinctive, large stick-nests, however, remain beneath rock overhangs in breakaway cliffs or caves, as monuments to their former range throughout southern arid and semi-arid Australia. Where sticks have long gone, 'cave bitumen' or 'amberat' remains—a build-up of faeces and urine on portions of the nest and rock ledges that accumulated as a dark, bituminous deposit, often several centimetres thick. Skeletal remains found in surface deposits of caves, and oral history passed on by Aborigines, have revealed a much broader former range for the species than would be recognised purely from past accounts of live animals. Their distribution once extended across the southern portion of Australia, from Shark Bay in Western Australia, through South Australia to western New South Wales and north-western Victoria.

Thomas Mitchell, an early explorer in western New South Wales, was the first European to observe stick-nest rats. In 1838 he wrote about "a species of rat...remarkable for the ingenious fabric it raised to secure itself from the native dog and birds of prey". Early explorers knew these animals as the 'House-building Rat' because of their unique ability among Australian rodents to build large, domed stick-nests that offer protection from predators and escape from climatic extremes. Nests may be up to two metres high and five metres across, but are usually a metre high and 1.5 metres in diameter. They are constructed of green vegetation and stones, as well as the sticks that give them their name. Distantly related North American woodrats (*Neotoma* spp.) and the Bush Karoo Rat (*Otomys unisulcatus*) of the Kalahari Desert in Africa build similar structures—a classic example of convergent evolution.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Greater Stick-nest Rats construct large dome-shaped nests of sticks. These nests are often built around the base of a shrub, and are often up to one metre high and 1.5 metres wide.

Aborigines were extremely familiar with the ways of stick-nest rats, using this to their advantage. As described by explorer John MacDouall Stuart in 1861, "When the natives discover one of these nests they surround it, treading firmly around the base in order to secure any outlet; they then remove the top of the cone, and, as the mice endeavour to escape, they kill them with the 'waddies' which they use with such unfailing skill. When the nest is found by only a few natives, they set fire to the top of the cone, and thus secure the little animals with ease."

As early as 1866 naturalist Gerard

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Three Greater Stick-nest Rat young nearing independence clamber on and around their nest while their mother forages within sight of her brood.

Krefft reported that the Greater Stick-nest Rat "is one of many species which will soon be extinct, as I found that it had already retreated before the herds of sheep and cattle across the Murray". Saltbush and bluebush dominated much of the understorey vegetation of the arid zone of Australia, and leaves and fruits of these and other perennial, semi-succulent shrubs formed a large component of the rat's diet. With the introduction of Sheep and Rabbits, these critical food supplies and the protective cover they afforded were quickly depleted. And in this precarious state, made worse by periods of sustained drought, the stick-nest rats soon succumbed to predation from introduced and native predators such as Foxes, Cats, Dingoes, owls and snakes.

Fortunately, like a handful of other native mammal species that have become extinct on the mainland since European settlement, about 1,000 Greater Stick-nest Rats survived on offshore islands—in this case, West and East Franklin Islands. The Franklin Islands, both about 200 hectares in extent, are situated 19 kilometres off the west coast of South Australia in the Nuyts Archipelago.

EARLY EXPLORERS *knew these animals as the 'House-building Rat'.*

Less fortunate was the Lesser Stick-nest Rat (*Leporillus apicalis*). It too became extinct on the mainland but, unlike the Greater Stick-nest Rat, there were no island populations to act as backup. It is one of a myriad of species that has gone forever. Its mainland range was slightly broader than the Greater Stick-nest Rat's, spanning central Australia from the North-west Cape in Western Australia, through South Australia, southern Northern Territory and extending into western New South Wales and south-western Queensland. Gerard Krefft, one of the few to write of its habits, "...tamed them so that they kept about the camp, mounting

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Greater Stick-nest Rat

Leporillus conditor

Classification

Order Rodentia, family Muridae. Also known as Wopilkara.

Identification

Up to 450 g. Long, rounded ears and fluffy coat of soft, grey-brown fur, ventral surface grey-white. Blunt nose, large eyes, tail usually shorter than head and body with a small brush of hairs at tip. Long, broad hind feet with distinctive white markings on upper surfaces. Gentle disposition during handling; rarely bites.

Distribution and Habitat

Formerly across southern semi-arid and arid zones of Aust. in shrubland communities. Currently restricted to Franklin Islands off south coast of Aust., plus reintroduced populations on Reevesby and St Peter Islands and near Roxby Downs in SA, and Salutation Island and Heirisson Prong in WA.

Breeding

Can breed throughout the year, sexually mature at 6 months, usually 1–2 (but up to 4) young per litter and up to 3 or 4 litters per year. Short oestrous period of 14 days; gestation period 44 days; age at weaning 30–40 days. Young initially carried around attached to mother's teats.

Behaviour

Sedentary lifestyle, predominantly nocturnal. Constructs and occupies distinctive large stick-nests. Up to 10 animals live communally in a nest, often in family groups. Can build several nests and use all on a regular basis, with well-worn pathways linking these nests. Life span usually 2–3 (but up to 5) years. Females have well-defined home ranges of up to 1.6 ha on Franklin Island, with small core-activity areas. Male home ranges are larger, up to 2.6 ha, with less well-defined core-activity areas.

Diet

Herbivorous (leaves and fruits of succulent plants, and chenopod shrubs such as saltbush and bluebush).

Status

Vulnerable. Total wild population on Franklin Islands about 1,000. Total reintroduced and captive populations 3,000–6,000 but number in reintroduced populations can fluctuate between years.

the supper table at teatime for their share of sugar and damper."

THE POPULATION OF Greater Stick-nest Rats on the Franklin Islands provided the source animals for a captive-breeding program established in 1985 by National Parks and Wildlife South Australia at Monarto, near Adelaide, as part of a national recovery plan for the species. These rats are perfect for captive-breeding—they are placid and easy to handle, and breed profusely. They can produce up to three and occasionally four young per litter, and as many as four litters per year. Despite the apparent sanctuary afforded by their substantial stick-nests, the mothers seldom leave their young at home alone. Instead they carry them around attached firmly to their teats until they are about four weeks old. As Le Souef noted in 1922, during a trip to the Nullarbor Plain, the "little hairless things...were dragged along on their backs" and "although the mother ran with great rapidity over some rough stony ground, the young did not become detached". While carrying young around is common in marsupials with pouches, it is rare for rodents, which usually leave them in the nest.

In July 1990, 40 captive-bred animals were taken to Salutation Island in Shark Bay, Western Australia. The 160-hectare island is only a few kilometres from the mainland, but is free of introduced animals, and the habitat is similar to the rats' former home on the Franklin Islands. Salutation Island is a nature reserve and has no other mammal species. The rats quickly established home ranges in the vicinity of their release site, initially sheltering during the day under dense shrubs, or among limestone boulders along the coastline. By 1998, the population had skyrocketed, with an estimate of over 900 rats and a multitude of large communal stick-nests dotted across the island. In captivity, up to ten rats may occupy a single nest, consisting of a female, young from one to three successive litters, and usually an adult male. However, in the island populations, nests are also occupied by individuals or male–female pairs.

Similarly successful translocations have also been made to Reevesby and St Peter

MARIE LOCHMAN/LOCHMAN TRANSPARENCIES

CALM Veterinarian Colleen Sims, CSIRO scientist Jeff Short and Useless Loop Primary School teacher Sandra Callow weigh and measure a Greater Stick-nest Rat on Salutation Island, ready for transport to the reintroduction site at Heirisson Prong.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

Greater Stick-nest Rats were released into a 17-hectare enclosure of natural vegetation on Heirisson Prong. Electric wires, a mesh skirt along the ground and an overhang prevent the incursion of any predators.

Islands in South Australia. These reintroductions have been so successful that the species was downgraded from 'endangered' to 'vulnerable' in 1999. However, early attempts to translocate animals to the mainland were unsuccessful. Releases at Yookamurra Sanctuary and Venus Bay Conservation Park in South Australia failed due to predation by Foxes, feral Cats, Barn Owls (*Tyto alba*) and Southern Boobooks (*Ninox novaeseelandiae*). A more recent release into a fenced 14-square-kilometre enclosure free of Cats, Foxes and Rabbits near Roxby Downs in South Australia is currently being monitored, with some predation by Gould's Goannas (*Varanus gouldii*) already observed.

The small and remote mining community of Useless Loop in Shark Bay decided that their back doorstep was also a good place to try a mainland translocation. After all, subfossil remains demonstrated that Greater Stick-nest

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

CSIRO scientist Jacqui Richards releases the first Greater Stick-nest Rat back to mainland Western Australia. Local students from Useless Loop Primary School assist by offering shredded paper for cover and sunflower seeds as supplementary food for the rats' first night in their new home.

Rats had once lived there. The proposed reintroduction site was at Heirisson Prong—a long, narrow, 12-square-kilometre peninsula, fenced at its base to exclude introduced predators. Two threatened species of mammals had already been successfully released there (the Burrowing Bettong in 1992, and the Western Barred Bandicoot in 1995), and so it made sense to also reintroduce Greater Stick-nest Rats.

The idea was to transfer rats from the well-established population on Salutation Island to Heirisson Prong. So in August 1999 a team of community members and scientists placed circles of traps baited with universal mammal bait (peanut butter and rolled oats) around a number of occupied nests. Unfortunately the results were not quite as predicted. For some reason only five per cent of the traps were successful, resulting in the capture of just three females and five males. Unperturbed by the low catch rate, the animals were weighed and measured, then transported by boat and car to their new home at Heirisson Prong. Two males were radio-collared, allowing us to keep track of their movements over the ensuing weeks after their release.

The rats were released to a 17-hectare enclosure of native vegetation within the peninsula. They settled in to their new abode very quickly, moving all around the enclosure and putting on weight almost overnight. Ignoring artificial nests, the rats opted for the comfort of ready-made Rabbit warrens, usually situated under prickly Dead Finish or Kurara (*Acacia tetragonophylla*) bushes.

A second translocation from Salutation Island was carried out two months later. This time, trap success was 50 per cent and provided an additional 16 females and six males for the fledgling colony at Heirisson Prong. Breeding had commenced shortly after the initial translocation, with the first new recruit found in December 1999, despite very dry conditions. Then good rains from a cyclone in early autumn prompted further breeding, with young appearing by May 2000. It is now up to the rats to live up to their reputation of prolific breeders, and then expand to recolonise the peninsula.

DESPITE THE ERADICATION of introduced predators at Heirisson Prong, the new colony of Greater Stick-nest Rats is not free from the risk of predation. Gould's Goannas and King Brown Snakes (*Pseudechis australis*) abound on the peninsula, and are out in force in late spring and summer. The first casualty after release was one of the original radio-collared males. By chance, it was not the collar signal that alerted us to its fate, but a flicker of movement seen out of the corner of someone's eye. A goanna was rolling around on the ground beside a shrub, and when we walked towards it we realised it had its jaws firmly wrapped around the head of a rat. The rat's death was both sad and disappointing, but it alerted us once again to the risks

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

The coastline of Salutation Island is graced with pockets of limestone cliffs and overhangs. These sheltered areas are often used by Greater Stick-nest Rats for nest sites, while others live amongst the rocks and crevices along the shoreline.

involved in any translocation. While we could assist the animals to some extent with the control of introduced predators and initial supplementary food, the Greater Stick-nest Rats would ultimately have to fend for themselves to survive on the mainland. As they had achieved this feat for many years prior to European settlement of Australia, our hope is that the environment has not changed so radically as to affect their chance of recolonising at least a small, intensively managed portion of their former mainland range.

These rats may be naive when it comes to predators, but when it comes to their bellies, they know when they're onto a good thing. We were happy to find that the rats from the August translocation had put on weight since their arrival; a good sign that they were settling in. It was obvious that the animals had been feasting on the abundance of suitable vegetation and sunflower seeds, provided by the Useless Loop primary-school children during their release. When we went to fill the feeders in October in preparation for

Stick-nest Rat urine provides key to past environments

The study of Australia's subfossil record (from the last 20,000 years) provides scientists with a window into past biogeographic and climatic processes. Subfossil plant material is most commonly found in the wetter areas of Australia. The more arid inland areas of Australia lack this comprehensive fossil record and, as a consequence, less is known about the long-term history of the region. However, the nests of stick-nest rats have provided an opportunity to examine past vegetation and climate in these areas of their former mainland distribution.

Stick-nest rats urinate and defecate on portions of their nests and the adjoining rock ledges, forming a cement of dark bituminous material, often known as 'cave bitumen' or 'amberat'. These sticky deposits are soluble in water, and therefore only remain in areas protected from rainfall and seepages. The amberat preserves an assortment of materials such as stones, plant fragments, pollen, and bone, hair, skin and faeces not only of the stick-nest rats but of other animals like owls (and their prey) that shared the same habitat. Stuart Pearson (University of Newcastle), Lynne McCarthy (University of Wollongong) and fellow researchers have dated over 60 inland nests from 100 to 10,900 years old. Data from some of the older nests in the Flinders Ranges in South Australia suggest that woodlands with grassy understoreys were more widespread in the early to mid-Holocene (8,800–5,300 years ago) than today, pointing towards wetter climatic conditions at that time. The more recent nests have been less useful in discerning climatic patterns, but have recorded dramatic regional extinctions of several mammal species, some of which correspond with the arrival of Cats and European Foxes.

LYNN PEDLER

Greater Stick-nest Rats can rear up to four young per litter. For the first month of their lives they attach firmly to their mother's teats and are dragged along wherever she goes.

the new arrivals, we were delighted to see the first nest under construction. However, these comic little creatures had built their nest right inside the feeder on top of the pile of sunflower seeds. Talk about hogging the food! This supplementary food supply has since been discontinued and they now make do with a diet of native vegetation available within the enclosure.

Most Australian mammals are nocturnal. Greater Stick-nest Rats are no exception, but they can also be active during the day. For the quiet and patient observer, the stick-nest rats of Heirisson Prong can often be found sunning themselves at the edge of their nests in the late afternoon. They appear to spend much time grooming and scratching, no doubt trying to rid themselves of the odd flea. If disturbed, they quickly dash into the safety of the nest—a good predator-avoidance strategy that we hope will see them safely into the future.

Some additional lessons have been learnt about the biology of Greater Stick-nest Rats through our translocation trials. These rodents may be naive with respect to predators, but by having an adequate natural food supply, ample cover and being able to produce multiple offspring each year, we believe they have a good chance of re-establishing themselves in areas of mainland Australia where introduced predators are controlled. The Greater Stick-nest Rat has benefited from a major cooperative effort between Western Australian and South Australian conservation agencies, CSIRO, local communities, private enterprise, and the international volun-

teer organisation Earthwatch to save the species from the threat of further decline and extinction. Similar co-operative efforts will no doubt see the successful re-establishment of this species at a number of other locations across mainland Australia. In the meantime, we feel certain that the unkindly image of a 'dirty rat' will change for any person lucky enough to sight a Wopilkara waddling along in its natural environment.

FURTHER READING

Copley, P., 1999. Natural histories of Australia's stick-nest rats, genus Leporillus *(Rodentia: Muridae).* Wildl. Res. *26: 513–539.*

Pearson, S., 1999. Late Holocene biological records from the middens of stick-nest rats in the central Australian arid zone. Quarternary Internatl *59: 39–46.*

Robinson, A.C., 1975. The stick-nest rat Leporillus conditor *on Franklin Island, Nuyts Archipelago, South Australia.* Aust. Mamm. *1: 319–327.*

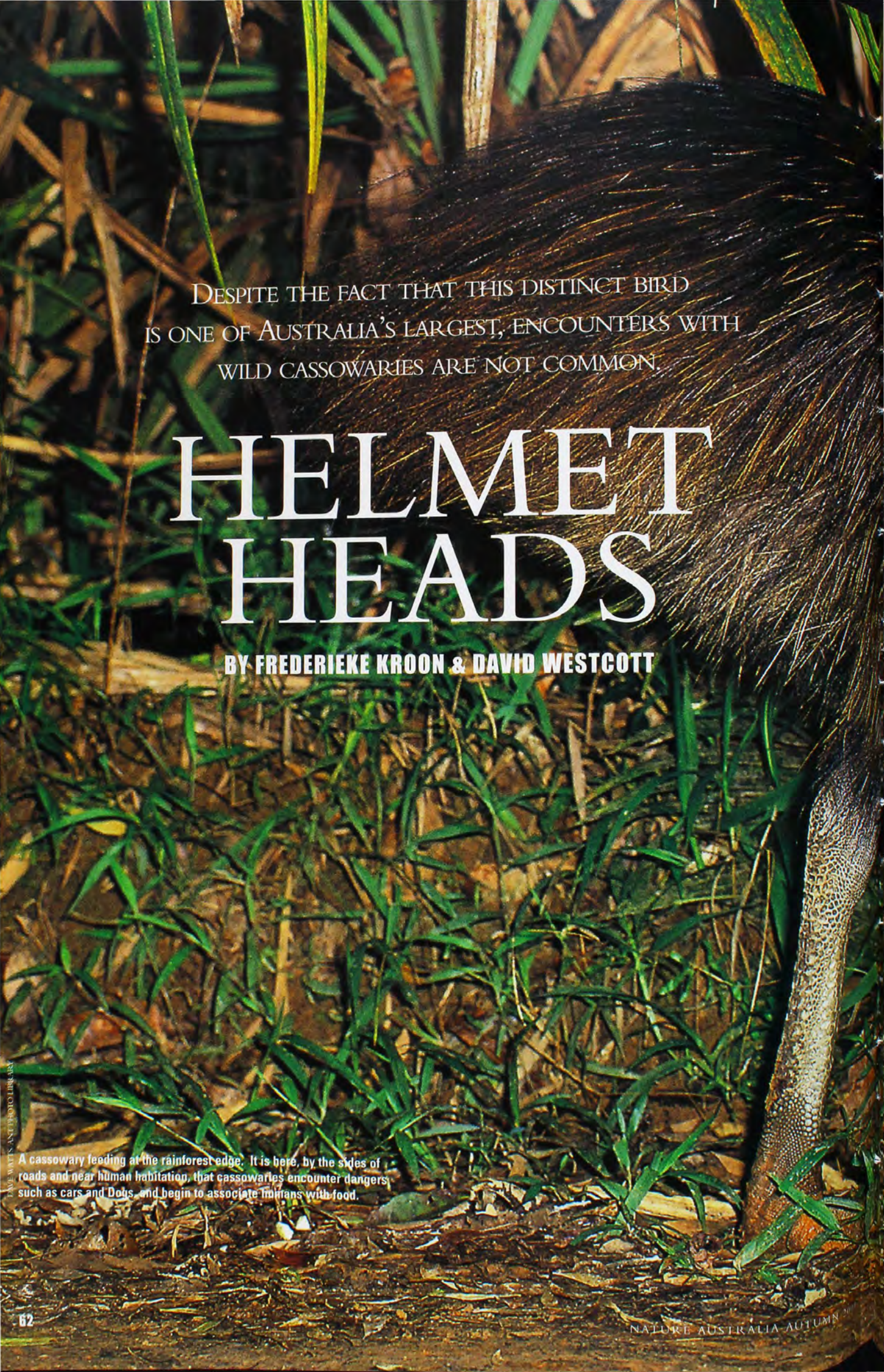
Smith, A.P. & Quin, D.G., 1996. Patterns and causes of extinction and decline in Australian conilurine rodents. Biol. Conserv. *77: 243–267.*

Watts, C.H.S. & Aslin, H.J., 1981. The rodents of Australia. *Angus and Robertson: Sydney.*

JACQUI RICHARDS, PETER COPLEY AND KEITH MORRIS ARE SCIENTISTS AT CSIRO WILDLIFE AND ECOLOGY, NATIONAL PARKS AND WILDLIFE SOUTH AUSTRALIA, AND THE WESTERN AUSTRALIAN DEPARTMENT OF CONSERVATION, RESPECTIVELY. THEIR RESEARCH FOCUSES ON, AMONG OTHER THINGS, THE CONSERVATION AND MANAGEMENT OF REMNANT POPULATIONS OF THREATENED SPECIES. THE AUTHORS WOULD LIKE TO THANK THE NATURAL HERITAGE TRUST, USELESS LOOP PRIMARY SCHOOL STAFF AND STUDENTS, MEMBERS OF THE USELESS LOOP COMMUNITY, JEFF SHORT, PAUL BROWN, COLLEEN SIMS AND EARTHWATCH VOLUNTEERS WHO ASSISTED WITH THE RECENT TRANSLOCATIONS OF GREATER STICK-NEST RATS TO HEIRISSON PRONG.

JIRI LOCHMAN/LOCHMAN TRANSPARENCIES

A Greater Stick-nest Rat's nest is never finished. This rat is gnawing pieces of grass to a suitable length to intertwine into its nest.



DESPITE THE FACT THAT THIS DISTINCT BIRD IS ONE OF AUSTRALIA'S LARGEST, ENCOUNTERS WITH WILD CASSOWARIES ARE NOT COMMON.

HELMET HEADS

BY FREDERIEKE KROON & DAVID WESTCOTT

A cassowary feeding at the rainforest edge. It is here, by the sides of roads and near human habitation, that cassowaries encounter dangers such as cars and Dogs, and begin to associate humans with food.

DAVE WATTS/NT PHOTO LIBRARY

"BOOM-BOOM-BOOM-BOOM...". The deep, soft drumming came from nearby in the rainforest shadows. We knew right away that it was a cassowary letting us know we'd been seen. Quietly, we turned and waited. Soon the bird peeked out at us from behind the rocks and palms. It watched us for a minute or two, occasionally reaching back to peck and preen. Then curiosity got the better of it; it calmly stepped into full view and came right up for a better look. It moved around to look at us from a couple of different angles and then retired to watch us from a short distance.

We were thrilled to have seen a cassowary in the wild. Despite the fact that this distinct bird is one of Australia's largest, standing up to two metres in height and weighing as much as 76 kilograms, encounters with wild cassowaries are not common. Like their relatives the Emus, cassowaries don't fly; instead they move in a steady, confident manner through the rainforest's tangle of trees, vines and lianas. And they do so with an unexpected ease and, surprisingly, almost silently. Often our only indication of a cassowary has been that deep, soft drumming and, despite searching our surroundings, we've seen or heard nothing more. Even more commonly, it is a pile of dung, or perhaps a footprint, that alerts you to their presence.

But cassowaries aren't always timid and shy. Reports from bush workers of suddenly looking up from the task at hand to find a cassowary coming in to check up on what they are doing, are not uncommon. We were once told, "If you want to bring a cassowary in, all you've got to do is drive a star picket into the ground. Before you've finished there'll be one of those big buggers right there checking to make sure you got it in straight." Unfortunately, we've never found cassowaries to be quite that accommodating or predictable.

The Southern Cassowary (*Casuarius casuarius*), also known as the Australian or Double-wattled Cassowary, is one of only three extant species of cassowary worldwide. Together with Emus, they comprise Australia's contribution to that now widely dispersed Gondwanan group known as the ratites. Today the Southern Cassowary occurs in tropical north-eastern Australia, and the southern lowlands of New Guinea. New Guinea harbours the two other species, the highland Dwarf Cassowary (*C. bennetti*), and the Single-wattled Cassowary (*C. unappendiculatus*) from the island's northern lowlands.

Within Australia, the Southern Cassowary is restricted to rainforest and associated vegetation. Appropriate habitat occurs from the Paluma range, just north of Townsville, in an almost continuous narrow strip along the coastal ranges to just south of Cooktown, and then intermittently in the larger rainforest patches of the eastern seaboard of Cape York Peninsula. While cassowaries need rainforest, they are by no means restricted to it. In her pioneering work on the species, Joan Bentrupperbäumer of James Cook University reported regular use by cassowaries of a variety of non-rainforest vegetation types and suggested that during certain seasons these habitats may provide important fruit resources for the cassowaries of coastal areas.

The name cassowary is derived from *kesuari*, a Malay word for one of the birds' dominant features, their large brown casque. The casque consists of a central core of calcified cartilage, covered with a shiny, tough and horn-like skin. Cassowary casques are unique and, in the absence of any clear and obvious function, they have been the focus of much speculation. Among the suggested functions are that they act as helmets to protect the skull as the bird rushes, presumably blindly, through the forest, or as padding to enable the birds to head-butt trees to knock down fruit; they may be resonance organs for vocalisation; alternatively, or in addition, they may be used as indicators of the age and quality of individuals. Whatever function the casques serve for cassowaries, the fact that they come in different sizes and shapes, and become worn and scarred with time, means that they differ between individuals. This makes them a wonderful tool for recognising individual birds—a fact exploited to good effect by researchers, managers and enthusiasts.

RUTHFOTO

A male cassowary settles comfortably on his emerald clutch. A typical clutch would contain about four eggs, each weighing nearly 600 grams. Incubation lasts for seven to eight weeks.

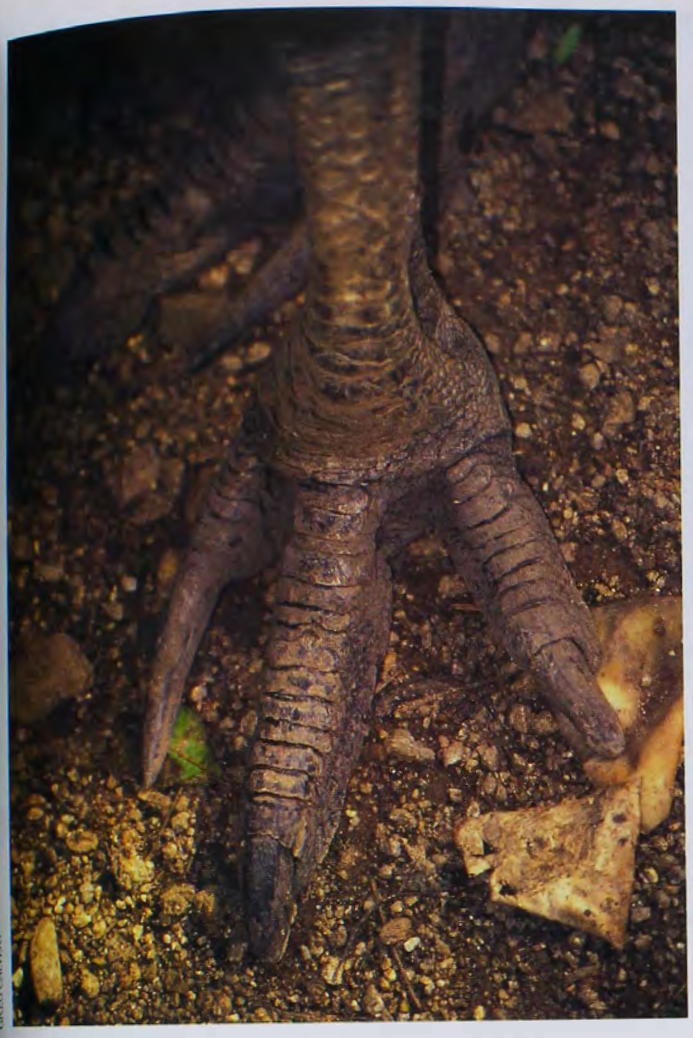
JEAN-PAUL FERRERO/AUSCAPE

Despite their brilliant head and neck colouration, cassowaries can still blend easily into the high-contrast rainforest environment. The distribution of colour as well as casque shape and markings differ between individuals and appear to be a means of individual identification.

THE BROWN BIRD that examined us that day was a subadult, about 18 months old. A small ridge of a casque could be seen on its head, a slight wash of colour on its neck, and in its tail the first black feathers. In a few years, this bird would be a mature adult, with a large brown casque, a heavy coat of shiny black feathers, pendulous wattles, and a distinctive blue, red and purple neck and head. Positive sex identification is difficult for those of us who aren't ourselves cassowaries. However, females tend to be larger and have a shorter tail that does not drop below the level of the body, as it does in males; and sometimes the male's phallus protrudes from his cloaca during defecation. Behaviour can also be a guide. If one is lucky enough to chance upon an active cassowary nest or a parent with chicks, then the adult is a male.

The main component of the cassowary's diet is fruit. While some fruits are taken directly from plants, most are well beyond reach. Instead the birds tend to concentrate on those fruits that have fallen or been knocked down by wind, rain or other animals. In the dry season fallen fruits can form a veritable carpet on the forest floor and cassowaries can afford to be fussy, taking only the most nutritious and least spoiled. At present, we have records of over 200 fruit species consumed by cassowaries. However, the diet of cassowaries varies in different areas so no doubt our list is far from complete.

A diet of fruit poses significant nutritional problems for vertebrates. While fruits are often rich in carbohydrates, many provide relatively little in the way



GREG CALVERT

KROON & WESTCOTT

(Left) The dinosaur-like, three-toed foot of a cassowary showing the long, inner claw that contributes so much to their fearsome reputation. However, attacks by wild birds are uncommon, and mostly a result of birds becoming habituated to being fed by people. (Right) Cassowary tracks in soft dirt and damp places such as creek banks can be one of only a few clues to the presence of the birds in an area.

of other nutritional necessities such as lipids and proteins. Cassowaries employ a number of solutions to this problem. One solution is to be just a little less than strict when it comes to frugivory. Bracket fungi regularly turn up in their dung, particularly in lean periods. Nor are cassowaries averse to a little meat. Items such as snails are not uncommon in their dung and even the remains of nestling birds, frogs and small lizards sometimes appear. We have on a number of occasions watched wild birds stop in mid stride to snap, usually unsuccessfully, at a resting march fly. Another way around the nutrient problem is simply to consume extremely large amounts of fruit. At a single fruit fall cassowaries may eat hundreds of individual fruits, adding up to a single meal of several kilos. Perhaps not surprisingly, tree species that produce large fruit crops appear to be favoured by cassowaries. An alternative solution is to include a wide variety of fruits in the diet. On her study site in the coastal lowlands, Joan Bentrupperbäumer recorded about 30 species of fruit being eaten in a single month. In our work we have recorded as many as eight fruit species in a single dung.

Satisfying their dietary needs requires that cassowaries spend the greatest portion of their day walking between fruit sources and feeding. In the lowlands Joan found that home ranges averaged 75 hectares. Our radio-telemetry data indicates that home ranges of upland birds are larger, sometimes several square kilometres. This perhaps reflects smaller or more dispersed fruit crops and fewer fruit species in upland areas. When confronted with an abundance of fruit, birds travel slowly through the forest, averaging less than 100 metres per hour. However, when food is less abundant or if birds are exploring a new area, they can average up to two kilometres per hour over an entire day.

These movement rates, in combination with the time that seeds remain in a cassowary's gut, mean that cassowaries can disperse seeds hundreds of metres, even kilometres, away from where the seeds were consumed. This seed dispersal 'service' is thought to have important consequences for plant populations and the dynamics of rainforests. By moving seeds into new or favourable environments, for example, cassowaries may play a significant role in regeneration and succession.

It is not only the journey that the cassowary takes while a seed is inside it that can have implications for that seed; the journey through the bird itself can alter its future. In our shadehouse we have compared the germination of seeds that have been eaten by cassowaries with

Standing tall to get a better look at the intruder, a cassowary is a truly impressive sight.

JEAN-PAUL FERRERO/AUSCAPE

HANS & JUDY BESTE/OCHEMAN TRANSPARENCIES

A male cassowary with one of his chicks. Cassowary chicks become independent of their father's care at between seven and 16 months of age.

Southern Cassowary

Casuarius casuarius

Classification
One of the ratites (along with Aust's Emu. NZ's kiwis, S. America's rheas and Africa's Ostrich); family Casuariidae (3 spp. in total).

Identification
Heaviest native bird (males weigh 45–50 kg, females up to 76 kg). Body covered in long, black, shaggy feathers; skin of head and neck brightly coloured in shades of blue, purple and red; 2 pendulous wattles on front lower portion of neck; head with large, leathery casque about 17 cm high. Juveniles brown with cream stripes. Immatures pale brown deepening to black with age; casque initially small, reaching full size after birds attain adult plumage.

Distribution and Habitat
North-eastern Qld, NG and associated islands. Occurs in dense rainforest and associated vegetation.

Behaviour
Generally solitary, forms pairs at start of breeding season (roughly June to Dec.), but female leaves as soon as eggs (3–7) are laid. Eggs green and about 10 x 16 cm. Male incubates eggs and cares for chicks until independence at 7–16 months of age. Nest is a collection of leaves added to rainforest litter.

Diet
Fallen fruit, supplemented with fungi, invertebrates and small vertebrates.

Status
Population approx. 1,500 in Wet Tropics Region. No estimates for Cape York populations. The Qld Govt has listed northern Cape York population as 'vulnerable' and Wet Tropics population as 'endangered'; listed as 'endangered' at Federal level.

Threats
Habitat loss and fragmentation, Dogs, traffic and Pigs.

those that have not. Some species are more likely to germinate, and do so more rapidly, if they have passed through a cassowary. However, this comes at a cost. For seed predators such as the Giant White-tailed Rat (*Uromys caudimaculatus*), piles of cassowary dung, which look and smell like warm fruit salad and may weigh up to six kilograms, are a gourmet platter. Seed predators frequently pick through the dung, consuming the seeds they find palatable and cutting short any bright future the seeds may have had.

Australia's tropical rainforests are unusual in global terms in that they are home to remarkably few vertebrate seed dispersers. Cassowaries are one of a handful of species that can disperse large quantities of fruit, and are one of the only animals capable of dispersing the largest rainforest fruits over considerable distances. Because of this role, there is widespread concern that if these birds were to be lost, there may be adverse long-term impacts on the structure and functioning of our rainforests.

The question of how many cassowaries there are is therefore an important one. Estimates, based primarily on the amount of cassowary dung and other signs (such as footprints) found during surveys, indicate that as few as 1,500 may occur in the Wet Tropics Region. Because cassowaries are so hard to find in their natural habitat, the accuracy associated with this estimate remains uncertain. Who's to know, for example, whether ten dung piles represent one cassowary with the trots, or ten constipated cassowaries? Two projects are currently examining alternative survey methods. Andrew Dennis of Queensland Parks and Wildlife Service (QPWS) is examining the utility of camera traps. When an infra-red beam is broken, a photo of the bird is taken. From these photos individuals are identified and the number of different birds in the area can be determined. In another project, with geneticist David Groth of Curtin University, we are examining the possibili-

BECAUSE CASSOWARIES ARE SO HARD TO FIND IN THEIR NATURAL HABITAT, *the accuracy associated with this estimate remains uncertain. Who's to know, for example, whether ten dung piles represent one cassowary with the trots, or ten constipated cassowaries?*

ty of using cassowary dung for DNA fingerprinting. Analysis of cassowary DNA in the dung, which comes from cells sloughed from the bird's gut, will hopefully give an accurate answer as to how many cassowaries produce the dung found in an area. It may also help determine family relationships.

CONCERN FOR THE FUTURE of cassowaries dates from the beginning of the last century. From these earliest warnings through to today, habitat loss from expanding agricultural and residential interests has been singled out as the major threat. In 1997 it was estimated that in the coastal lowlands, an area most likely to have supported high cassowary densities, 81 per cent of all natural vegetation had been cleared. Other threats include Dogs, traffic, and potentially feral Pigs. Cassowary chicks and subadults can fall prey to a single Dog, while a pack of large Dogs can bring down an adult. Approximately 40 cassowaries have been killed on Mission Beach roads alone since 1989, highlighting the traffic concern. Pigs, on the other hand, are thought to destroy nests, and may also compete with cassowaries for food. Both QPWS and community conservation groups have worked extremely hard to address these concerns by preserving and rehabilitating cassowary habitat, rehabilitating injured birds, establishing Dog and Pig control programs, and through their lobbying and education activities.

Also deserving of recognition are individuals such as Sandra and Garry van Rees. In October 1998 a young cassowary chick wandered onto their Ostrich farm near Miriwinni. When no adult came to collect her, the van Rees, with permission from QPWS, took 'Peta' in and raised her. In July 1999 she was released as a subadult back into the wild. Using radio-telemetry we were able to follow her as she settled in to her new home, the Goldsborough Valley. Despite having grown and prospered over her four months in the wild, Peta was found dead in November, the victim of an unknown accident. This period of first independence is when cassowaries are at their most vulnerable and Peta's fate is probably common for wild birds. Today the van Rees are caring for another orphan, 'Clim', a young chick from Mission Beach. In his pen, Clim, a grape enthusiast, receives minimal contact with humans in an attempt to prevent him from habituating to people, which could be his downfall once he is released back into the wild.

Although not currently endorsed, breeding cassowaries for future release into the wild is also being explored. At his Johnstone River Crocodile Farm, Mick Tabone first started keeping cassowaries when an injured bird was brought to his farm about six years ago. Since then, he has cared for injured birds, in pens planted with cassowary food trees. Today, he has two healthy adults at his farm, 'Henrietta' and 'Wally'. While some captive birds breed well, Wally and Henrietta are not cooperating: they fell out of love after Henrietta accidentally kicked Wally. They are kept in separate pens until Cupid's dart strikes again.

Cassowaries have had more than their fair share of bad publicity in recent times and are widely considered aggressive and dangerous. Their size, their long, sharp inner toe, and their strong legs can combine to deliver a formidable kick in any direction. Those who deal with the birds in captivity treat them with caution; both Garry van Rees and Mick Tabone would much rather handle their adult Ostriches or crocodiles than their cassowaries. Also potentially dangerous are wild birds habituated to being fed by people; they can become demanding and threatening, and may try to obtain food forcibly. Our encounters with birds in the wild, however, have been very different. While such big animals deserve caution and respect, we have never felt threatened and have always been excited and elated by our cassowary encounters. Hopefully this kind of cassowary experience is the one that Australians will always be able to enjoy.

FURTHER READING

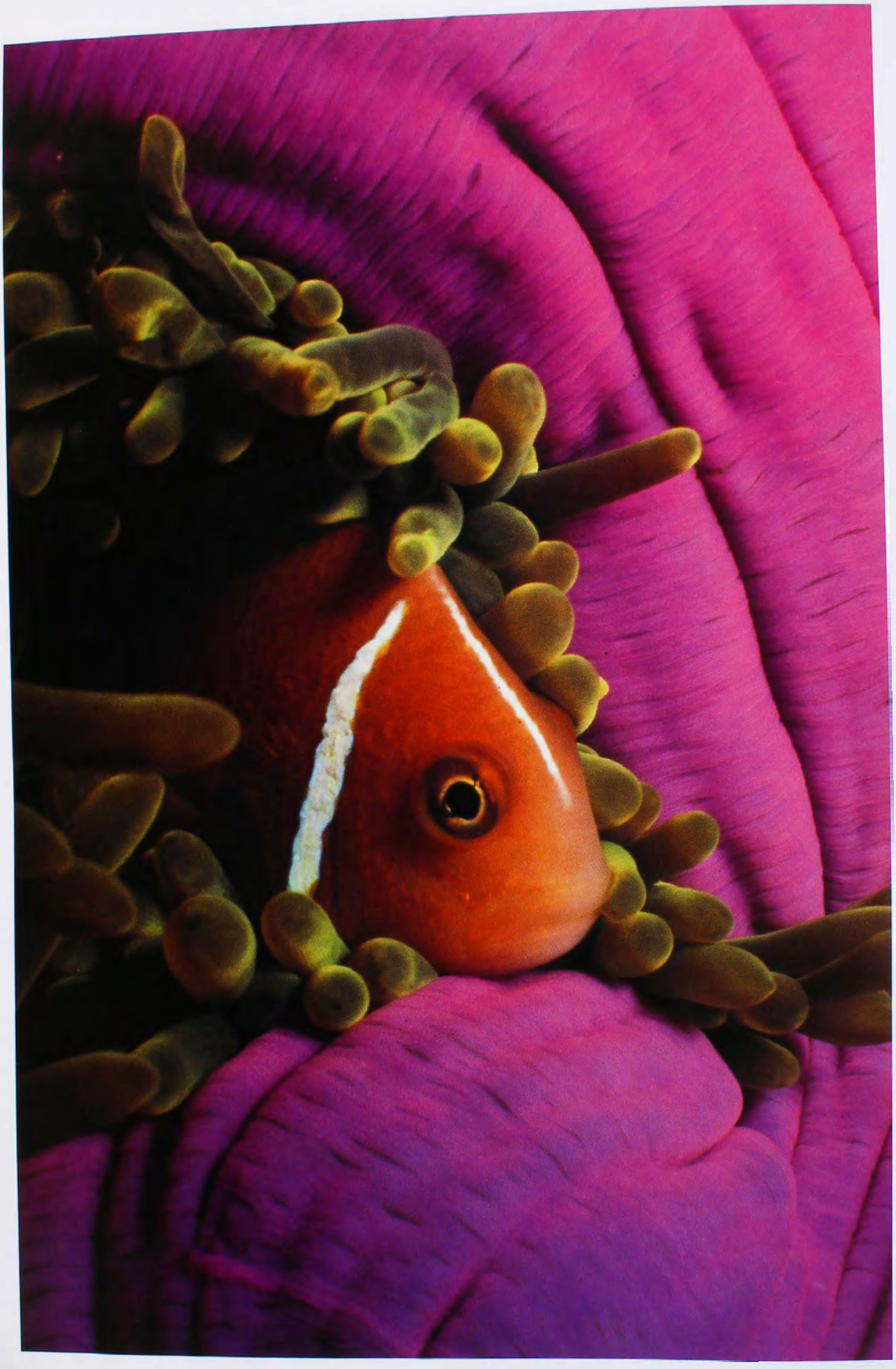
Bentrupperbäumer, J.M., 1997. Reciprocal ecosystem impact and behavioural interactions between cassowaries, *Casuarius casuarius*, and humans, *Homo sapiens. PhD thesis: James Cook University, Townsville.*

Crome, F.H.J. & Moore, L.A., 1990. Cassowaries in northeastern Queensland: report of a survey and a review and assessment of their status and conservation and management needs. Aust. Wildl. Res. *17: 369–385.*

*Kofron, C.P., 1999. Attacks to humans and domestic animals by the southern cassowary (*Casuarius casuarius johnsonii*) in Queensland,* Australia. J. Zool., Lond. *249: 375–381.*

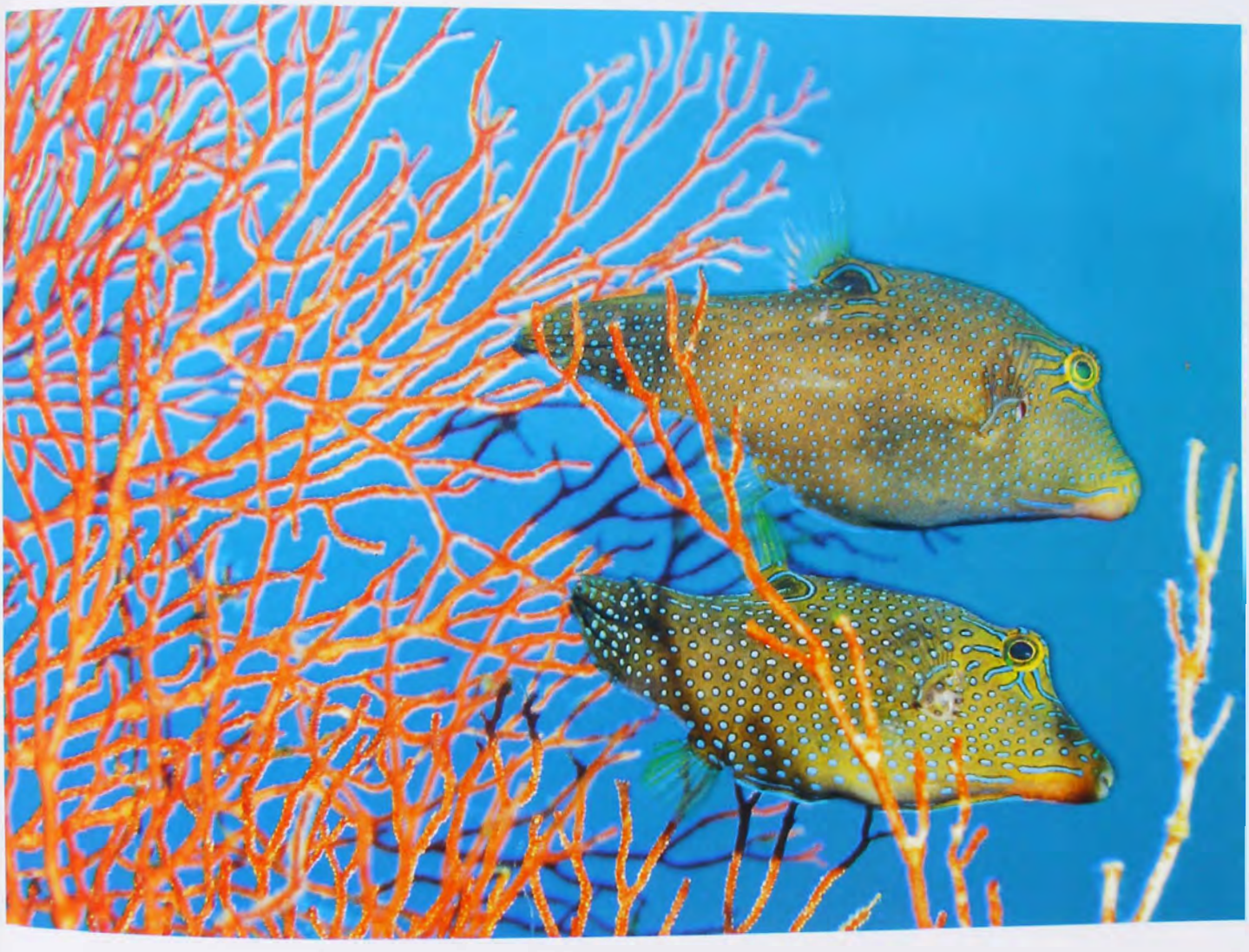
Westcott, D.A., 1999. Counting cassowaries: what does cassowary sign reveal about their abundance? Wildl. Res. *26: 61–67.*

DR FREDERIEKE KROON IS A RESEARCH SCIENTIST WITH NEW SOUTH WALES FISHERIES OFFICE OF CONSERVATION BASED AT PORT STEPHENS FISHERIES CENTRE.
DR DAVID WESTCOTT IS A RESEARCH SCIENTIST WITH CSIRO, DIVISION OF SUSTAINABLE ECOSYSTEMS, TROPICAL FOREST RESEARCH CENTRE, AND THE RAINFOREST COOPERATIVE RESEARCH CENTRE. THEY SPEND MOST OF THEIR FREE TIME OBSERVING ANIMALS IN THE BUSH OR UNDER WATER.



Pink Anemonefish (*Amphiprion perideraion*).

Coral (*Tubestrea* sp.).



Solander's Toby (*Canthigaster solandri*).

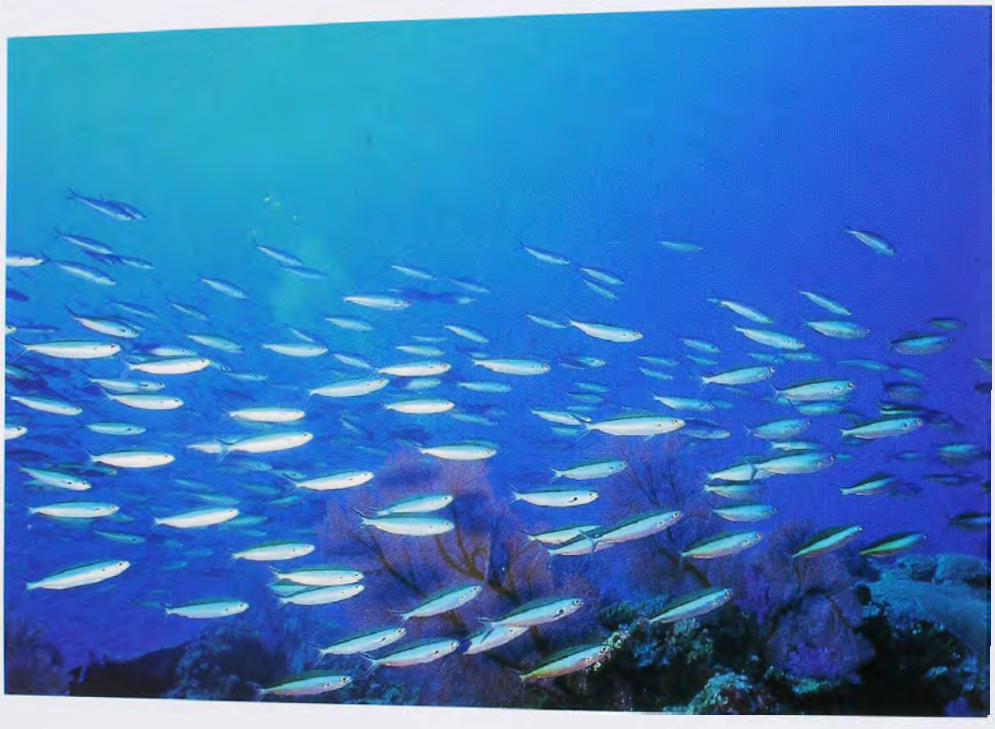
tropical waters

BY LIN SUTHERLAND

Crinoids, featherstars, sponges and seawhips.

Bluestriped Fangblenny (*Plagiotremus rhinorhynchos*).

Tropical snappers (*Pinjalo* sp.).

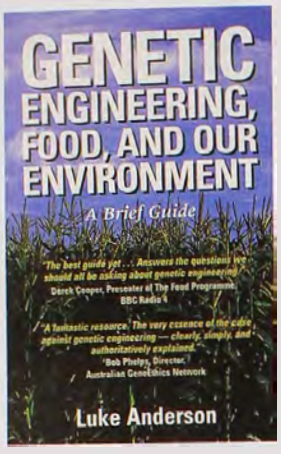


Neon Fusilier (*Pterocaesio tile*).

Soft coral crab on soft coral (***Dendronephthya***).

Gorgonian sea fern (***Melithaea*** sp.).

reviews



Genetic Engineering, Food, and Our Environment

By Luke Anderson. Scribe Publications, Vic., 2000, 191pp. $17.95rrp.

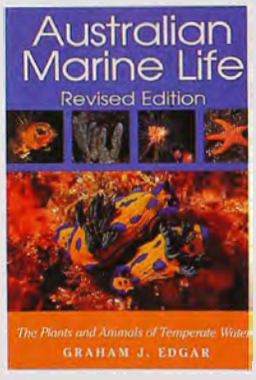
THIS BOOK IS A SUCCINCT AND WELL-REFERENCED OVERVIEW of the issues surrounding the debate on genetic engineering of food. It is particularly useful at a time when those urging a ban, or even a moratorium, on the release of genetically engineered organisms into the environment are marginalised as the lunatic fringe.

It presents a dispassionate case against the release of these organisms into the environment, where no studies have been carried out as to the long-term effects on the surrounding ecology or consumers.

The author effectively refutes the arguments most often presented in favour of the release of genetically engineered foodstuffs—that it's the only way we can 'feed the world'—pointing out that people in developing countries do not go hungry because they can't grow enough food, but because they no longer have access to land and resources.

I found the book somewhat distressing, as it shows how the political processes that regulate (or fail to regulate) the research and release of genetically modified organisms are seriously flawed in most cases, and completely corrupt in others. Still, an excellent book, recommended for those who would like to hear the other side of the GE debate.

—ALIX HYSLOP
AUSTRALIAN MUSEUM



Australian Marine Life: The Plants and Animals of Temperate Waters

By Graham J. Edgar. Reed New Holland, NSW, 2000, 544pp. $76.00rrp.

THIS REVISED EDITION OF *AUSTRALIAN MARINE LIFE* by Graham Edgar colourfully displays over 1,200 of the more common marine plants and animals of shallow (generally less than 40 metres depth), coastal, southern Australian waters. The strength of this book lies in the informative presentation of an array of interesting subjects. It covers all marine phyla to some extent, but is most useful for its content on fishes, molluscs, crustaceans, echinoderms (starfish, urchins etc.), algae and seaweeds. Each species is accompanied by a photograph and text, which contains information on the distribution, habitat, maximum size and distinguishing characteristics.

This publication is a useful guide for marine biologists, tertiary students, amateurs, or anyone interested in knowing more about the marine life of southern Australia (Sydney to Perth). There are few comparable guides to marine organisms of southern Australia that are as easy to digest as this fine work. Only minor changes have been made to the 1997 edition. These changes are regularly updated and are accessible via the World Wide Web at: www.zoo.utas.edu.au/AML.html

—JOHN POGONOSKI
AUSTRALIAN MUSEUM

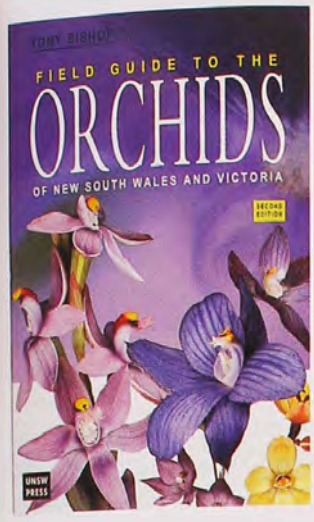
Australian Menagerie: A Challenging Game about Australia's Wildlife

Game by Wild Connections, NSW, 2000, approx. $25.00. Additional habitats available.

AUSTRALIAN MENAGERIE IS A RARE SPECIES INDEED—a fun and informative game about environmental issues. Players learn about wildlife, the habitats they live in, and the threats to their survival. The cards and boards around which the game is based are filled with detailed colour illustrations of well-known and not-so-well-known wildlife and the habitats in which they live. There are Malas, Koalas, bell frogs and Bilbies, even the Kosciuszko Grasshopper gets a guernsey. The game itself has three levels of play, catering for all family members and situations. Its aim is to accumulate wildlife cards in their habitats while fending off threats with management-strategy cards.

Instructions are detailed and informative, although a little heavy for under 10s. More reference information on the animals, habitats and threats would have added interest and information. Neatly packaged in a small box, it's perfect for after-dinner entertainment or family camping holidays, and as a gift for overseas friends. We recommend it highly for families with children aged 4 to 14.

—PAUL AND INGRID FLEMONS
AUSTRALIAN MUSEUM



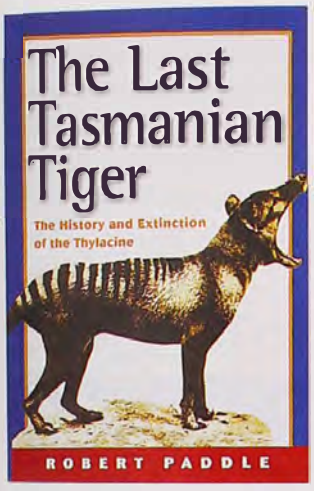
Field Guide to the Orchids of New South Wales and Victoria

By Tony Bishop, UNSW Press, NSW, 2000, 2nd ed., 256 pp. $37.95rrp.

THIS SECOND EDITION UPDATES THE TAXONOMY presented in the first, making it the most up-to-date reference on orchids of south-eastern Australia. David Banks (editor of *The Orchadian* and the *Australian Orchid Review*) and John Riley have contributed in this respect, adding their knowledge to that of the late Tony Bishop. It is primarily intended to be 'a true field guide', and is a must-have for orchid enthusiasts.

Like the first edition, this is divided into three sections—descriptions of taxa, photographs and keys—so that users can find what they're after quickly. Over 500 photos are presented in wonderful full-colour detail (most were taken in the field), and there is a plate for every species described. The language is quite technical, but there is a glossary, and there are several worthy recommendations in the further reading section. The keys are extremely useful and written to avoid the need for dissection. There is also a strong conservation message. So all you need to enjoy this rich orchid flora is your walking boots, hand lens and the Field Guide.

—GABBY TAAFFE
AUSTRALIAN MUSEUM



The Last Tasmanian Tiger: The History and Extinction of the Thylacine

By Robert Paddle. Cambridge University Press, Vic., 2000, 288pp. $49.95rrp.

THERE CAN BE LITTLE DOUBT THAT THIS WORK WILL QUICKLY BECOME the definitive text on the history and annihilation of the Thylacine, last of an ancient and once-diverse family of marsupial predators. Clearly the product of exhaustive and meticulous research, this book draws on a multitude of previously untapped 19th- and early 20th-century sources. The result is a graphic reconstruction of the Thylacine's behaviour and biology, as well as the tragic history of its extinction. Much in the way of myth and misconception is demolished in each instance. But Paddle presents more than a simple catalogue of facts and assertions; he deeply probes the history of human interpretation of the Thylacine and its demise.

This book could easily stand alone on its merits as a study of psychology in the context of human-induced extinction. The end product is a singular example of scholarship, a must read, not only for those interested in the Thylacine, but for anyone interested in the conservation of endangered species.

—STEPHEN WROE
AUSTRALIAN MUSEUM

Gemstones and Minerals of Australia

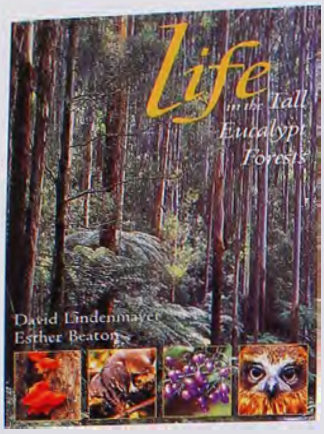
By Lin Sutherland and Gayle Webb. Reed New Holland, NSW, 2000, 128 pp. $25.00rrp.

I HAVE READ MANY GOOD GEMSTONE AND MINERAL GUIDES over the years but one of the most outstanding features of this one is its entirely Australian content. Such guides are normally very international in their scope (my own included!), but here Lin Sutherland and Gayle Webb show us that Australia's vast gemstone and mineral riches, alone, are enough to fill the pages of any such guide. There are six spectacular colour photographs per double page and many of the actual specimens can be seen in the Australian Museum's mineral gallery.

The book is divided into two parts. The first is a short introduction into what are gemstones and minerals, and the second deals with each major Australian gemstone or mineral group as an attractive, well-illustrated, two-page spread. The guide starts with precious and semi-precious gemstones (diamond, sapphire, ruby, opal, quartz, emerald, topaz, garnet, zircon etc.). Gold, platinum and silver, appropriately, form the bridge between the gems and the metal-bearing minerals (copper, lead, zinc, tin, iron, manganese, nickel, aluminium ores etc.), followed by the silicate minerals (feldspars, pyroxenes, amphiboles, micas etc.).

I have no hesitation in recommending this book, being well laid out with location maps and easy-to-read text. It is well finished with a glossary of terms, buyers' guide to gemstones, further reading, specimen details and index.

—ROBERT COENRAADS
GEMMOLOGICAL ASSOCIATION OF AUSTRALIA, SYDNEY



Life in the Tall Eucalypt Forest

By David Lindenmayer and Esther Beaton. Reed New Holland, NSW, 2000, 96pp. $29.95rrp.

THIS MAGAZINE-STYLE BOOK WAS COMPLETE *DÉJÀ VU* FOR ME. Not because anything like it has been published before, but because it so accurately encapsulates my 15-years-old memories of working in the tall forests of Victoria. The photographs are stunning and fully capture the flavour of Mountain Ash forests, and, perhaps surprisingly for the text of a top-class research scientist, the words fill your ears with the sounds and your nose with the smells of the forest. Particularly evocative for me were the smell of ants in summer around the boles of the giant eucalypts and the sound of the wing beats of virtually unseen spinebills as they chase each other through the mintbush in spring.

However, this book is much more than a collection of forest icons. It successfully integrates the components of the forest to portray the functioning, interconnected and dynamic elements that are the forest ecosystem. Arranged into chapters dedicated to the Canopy Trees, Bark, Rainforest, Understorey, Treeferns, Logs, Ground Cover and Forest Floor, the book tells the stories of the forest's inhabitants and how the plants, animals and fungi interact. Many of the photographs contain artistic side plots on top of the image that first meets the eye, and although it's hard not to discover something spiritual, the text is loaded with the knowledge that comes from a dedicated scientist. It contains none of the platitudinous crap that too often goes with beautiful picture books about nature.

Reflecting the specialty of the author, the text is particularly strong in its discussion of possums and their forest resources. Readers are bound to gain a new understanding of important possum concepts including time scales, tree hollows, sap flows, crown shyness, self-thinning and decomposition. If you have ever been confused by the conflicting accounts of conservationists and timber-harvesters on issues such as old-growth values and forest regeneration, this book will provide you with new insights based on fact, not rhetoric. With 96 pages including 130 full-colour photographs, descriptive captions and meaningful text, *Life in the tall eucalypt forest* represents an excellent collaboration between a photographer and a scientist. If you are the sort of person who enjoys *Nature Australia* magazine, you will find this book more than worth its weight in paper.

—RICHARD MAJOR
AUSTRALIAN MUSEUM

SOCIETY PAGE

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

ANIMAL WELFARE

Wildlife Welfare Organisation (SA) Inc.
PO Box 197
GOOLWA SA 5214
Web: http://wildlfe.mtx.net
Contact: Debbie Robinson

Membership: $15.00

WIRES
The NSW Wildlife Information & Rescue Service Inc.
PO Box 260
FORESTVILLE NSW 2087
Ph: (02) 8977 3333
Web: www.wires.webcentral.com.au
Contact: Anne Lloyd-Jones
Newsletter/journal

Membership: $33.00

WRIN
Wildlife Rescue & Information Network Inc.
30 Collins St
KANGAROO FLAT
Vic. 3555
Ph: (03) 5441 3211
Contact: Rob Schrieber

Membership: $15.00

BIRDS

South Australian Ornithological Association
c/- SA Museum
North Terrace
ADELAIDE SA 5000
Ph: (08) 8303 4498
Contact: John Hatch

Membership: $33.00
ordinary

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CONSERVATION

Australian Plants Society
PO Box 744
BLACKTOWN NSW 2148
Ph: (02) 9621 3437
Contact: Mary Lou Simons

Membership: $35.00 single, $28.00 concession, $40.00 joint, $32.00 joint concession

Malleefowl Preservation Group Inc.
PO Box 29
ONGERUP WA 6336
Ph: (08) 98282007
Contact: Susanne Dennings

Membership: $10.00 family

Society for Growing Australian Plants (Qld Region) Inc.
PO Box 586
FORTITUDE VALLEY
Qld 4006
Ph: (07) 5546 9494
Web: www.sgapqld.org.au
Contact: Mr Ian Waldron

Membership: $37.00 new, $32.00 renewing

Tasmanian Conservation Trust
102 Bathurst St
HOBART Tas. 7000
Ph: (03) 6234 3552
Web: www.tct.org.au
Contact: Alistair Graham

Membership: $25.00 single, $15.00 concession

EDUCATION

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

Membership: $27.10

Gould League of NSW Inc.
PO Box 16
GLADESVILLE NSW 2111
Ph: (02) 9817 5621
Contact: Cath Hitchcock

Membership: $40.00

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

Membership: $90.00 primary, $100.00 secondary

ENVIRONMENTAL

Trees for Life
5 Fitzgerald Rd
PASADENA SA 5042
Ph: (08) 8372 0150
Web: www.treesforlife.org.au
Contact: Danielle O'Neill

Membership: $33.00 / $16.50

MICROSCOPY

The Postal Microscopical Club
PO Box A1017
SYDNEY SOUTH PO
NSW 1235
Web: www.pnc.com.au/~dingley
Contact: Michael Dingley

Membership: $20.00-$40.00

MUSEUM

TAMS - The Australian Museum Society
6 College St
SYDNEY NSW 2000
Ph: (02) 9320 6225
Web: www.austmus.gov.au/tams/
Contact: Michelle Ball

Membership: $66.00 single, $83.60 family, $49.50 student

The Waterhouse Club SA Museum
North Terrace
ADELAIDE SA 5000
Ph: (08) 8203 9802
Web: www.waterhouseclub.org.au/whc
Contact: Mary Lou Simpson

Membership: $70.00 single, $90.00 family

NATURAL HISTORY

Launceston Field Naturalists Club Inc.
PO Box 1072
LAUNCESTON Tas. 7250
Ph: (03) 6344 1076
Web:www.tased.au/tasonline/ltnfdnat/linkhtm
Contact: Dr A. Pegler

Membership: $15.00 single, $20.00 family, $2.50 junior

REPTILES

SA Herpetology Group
c/- SA Museum
North Terrace
ADELAIDE SA 5000
Ph: (08) 8204 8772
Contact: Helen Owens

Membership: $28.00 standard, $24.00 concession, $32.00 family

Tablelands Frog Club Inc.
Mail Bag 71
YUNGABURRA
Qld 4872
Ph: (07) 4096 6556
Contact: Beryl Davidson

Membership: $10.00 adult, $5.00 student, $15.00 family

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q&a

Winter Spiders

Q: *Can you explain where golden orb-weaving spiders go each year after festooning our gardens with their splendid webs over summer?*

—Gail Ferrier
Cottlesbridge, Vic.

A: Orb-weaving spiders, like most spiders, have a relatively short life span. Their life cycles are closely attuned to the seasons. During winter when their food (flying insects) is scarce, the spiders are usually in either the egg stage or early juvenile stage. In contrast, in spring and summer when flying insects are most abundant, the larger juveniles and adults are encountered. The adults do not hibernate but an occasional individual may hang on well into the winter under favourable circumstances.

—Graham Milledge
Australian Museum

Harmless Moths?

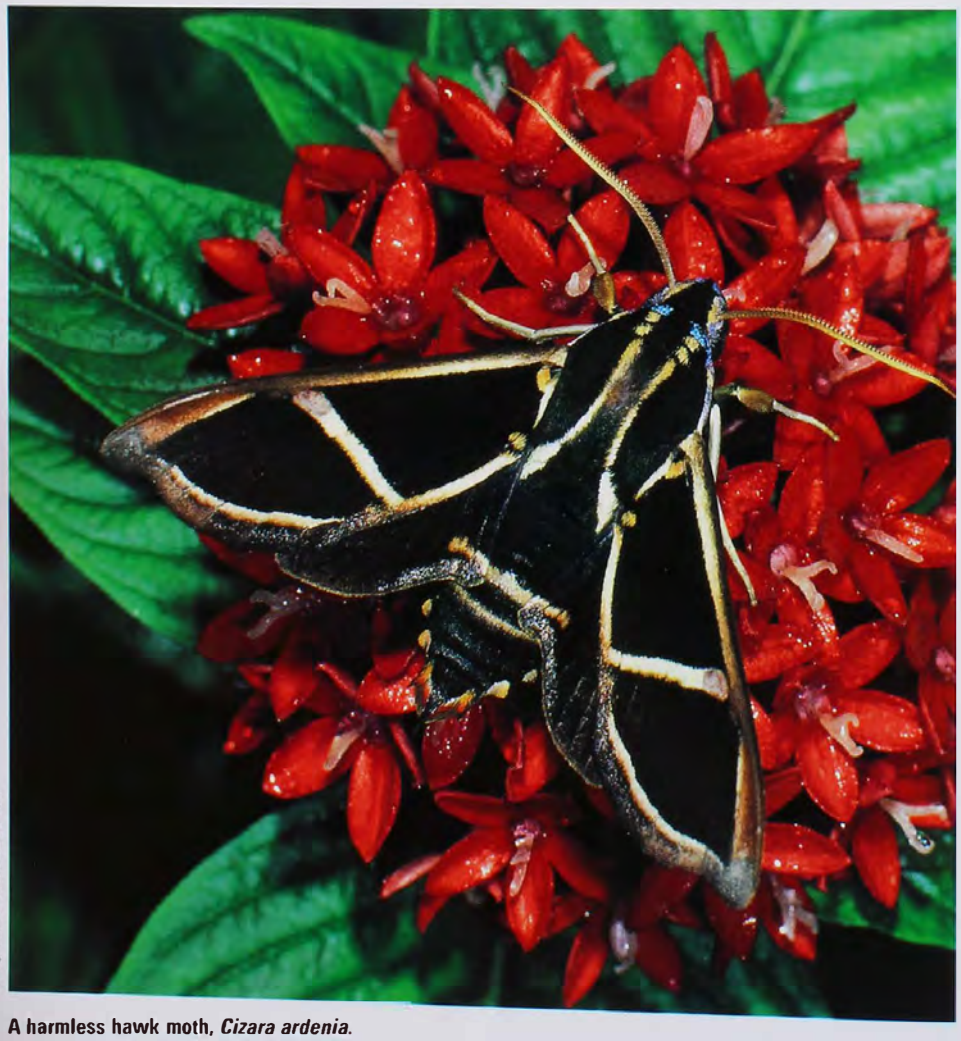
Q: *I've noticed that some people are afraid of moths. My daughter went through a phase of being scared of moths fluttering around her bedroom at night. But I told her that all moths are harmless and not to worry. Is this true?*

—Elizabeth Noti
Bellevue Hill, NSW

A: Moths are harmless, they have no sting at all, they don't bite and their hair-like scales are not hard or prickly. There are a few species that can be quite nasty to eat but, given that there are 10,000 species or more in Australia alone, no-one has actually done a definitive culinary study of all of them. The arctiid moths are toxic when eaten by their normal predators (other insects, spiders, bats, birds) and it is assumed that predators come to recognise their distinctive colouration as a warning. The toxin derives from the poisonous plants upon which the arctiid caterpillars feed. One arctiid moth has glands on its thorax that can pump out a hissing froth, which apparently repels predators.

Moth caterpillars are a different kettle of fish. Larvae of several moth families have irritating hairs that can cause an allergy or be mildly toxic and sting. The long hard hairs of some species are sometimes used by the caterpillars to arm their cocoons, offering further defence while they lie dormant as pupae within.

—Shane McEvey
Australian Museum



H. & J. Beste/Nature Focus

A harmless hawk moth, *Cizara ardenia*.

Death Indoors

Q: *At a recent stay in Ourimbah, New South Wales, we would wake up every morning to find what seemed like hundreds of small dead insects on the floor. We would sweep them up and the next morning there would be more. Can you please tell me what these things are (sample enclosed) and why they chose to die on our floor?*

—Lea Eldridge
Annandale, NSW

Answers to Quiz in Nature Strips (page 17)

1. *La Niña*
2. *South Africa*
3. *Lake Mungo (Willandra Lakes, NSW)*
4. *Northern and southern lights*
5. *Eastern Rosella (*Platycercus eximius*)*
6. *Rachel Carson*
7. *Bioluminescence*
8. *Lucas Heights, Sydney*
9. *Eyrie*
10. *Wanderer Butterfly*

These amphipods died of dehydration after invading a holiday home in Ourimbah.

A: What you have are terrestrial amphipods invading your holiday home. These particular amphipods are *Talitroides topitotum* and they are probably an introduced species. Amphipods are a type of crustacean and, like prawns or crabs, go red when they are dead or cooked. These amphipods are a shiny brown colour when they are alive. They get around by walking or hopping, and are sometimes called landhoppers. They eat detritus, dead insects, old newspapers etc. They normally live in damp leaf litter or soil and probably come inside under the door. If you have a front door mat and you lift it up, you will probably find live ones. Once they come inside, however, they die of dehydration. As to why they come inside, there could be many reasons. Too much rain, someone spraying insecticide outside, or a house that sits in a geological depression, may all help drive amphipods indoors.

—J.S.

Pic Teaser

Do you recognise this? If you think you know what it is, then send your answer to Pic Teaser, *Nature Australia* Magazine. Please don't forget to include your name and address. The first correct entry will win a copy of *The atlas of the prehistoric world* from the Australian Museum Shop. Summer's Pic Teaser was the pupal case of a cossid moth.

PHIL GERMAN/NATURE FOCUS

Not so easy being green

The best protection for wildlife species is to give them zero legal value by letting no-one own or exploit them.

BY DAVID HORTON

THE HEADLINE IN *THE BULLETIN* read, "It's easy being green". It was a review of a book suggesting that environmental protection will come via capitalism with profits to be made. In Australia there are increasing demands for conservation to be turned over to capitalism—wildlife exploited and national parks privatised. The idea is that, if a dollar value is put on the environment, there will be incentive to protect it. But for me the idea is wrong, and would quickly complete the devastation of the Australian environment begun in 1788.

There are endless examples of the fallacy of 'privatise it, value it, therefore protect it' theory—rhinos, elephants, Tibetan Antelope, Murray Cod, rare cockatoo species, whales and orchids. As soon as wildlife is exploited, either directly through private ownership or indirectly through licensing, its value increases—not just in terms of money but also for employment, cultural-heritage and other less-tangible reasons. As the exploitation develops and numbers decrease, the value of the remaining wildlife continues to increase, as does the commercial imperative to exploit it further. The best protection for wildlife species is to give them zero legal value by letting no-one own or exploit them.

The British colonists who arrived in 1788 came from a countryside that was almost completely managed and manicured; one in which everything had a value (animals were either domesticated or hunted), but where there was little diversity. In Australia they found a whole continent of wilderness, which to them was a sign of lack of care or of failure. So they set about putting it in order. Kangaroos were replaced by Sheep and Cattle; valueless eucalypts were cleared to make way for oaks and willows, grass and wheat; the only large carnivore (Thylacine) was hunted to extinction; and wasteful rivers that ran to the sea were dammed. So what appears to be a new idea about only keeping things that have human value, is actually an old one that goes back to the economic rationalists aboard the First Fleet. The problem with Australian conservation is not that the idea hasn't been tried, but that we are looking at the end result of 210 years of application of the idea!

Once you start harvesting a species, whether black-cockatoos or kangaroos, or maintaining captive-breeding populations of, say, Giant Pandas or Sumatran Tigers, you're on the inevitable path to domestication. Subtle effects of selection begin to bite—favouring individuals that are easily handled and less susceptible to disease, that thrive on zoo diets, produce more young in captivity, or have more attractive plumage or whatever. Having Domestic Sheep isn't a way of preserving wild sheep; in fact, Domestic Sheep are what you get when you enhance the dollar value of wild sheep.

By the same token, privatised 'national parks' making money out of visitors will constantly strive to increase visitor numbers and facilities and visitor access to wildlife, in order to increase income. In Antarctica, even with its low level of tourists, effects have been found on penguin breeding populations—subtle and impossible to prevent, but possibly spelling doom for the species that are supposedly being protected.

The imperatives of commerce demand a continual increase in efficiency. If, say, kangaroos are being farmed as a means of preserving them, it would quickly become evident that one or two species were more profitable—faster growing, better behaved, better meat producers, faster breeders etc. Those farmers with the less profitable species would be forced to shift from them. Commercial imperatives don't encourage diversity of breeds. Nor do they encourage diversity within breeds. Inevitable selection and crossbreeding result in the loss of the original form and genetics of those breeds. Finally would come embryo transfer techniques, genetic engineering and cloning. Some cattle breeds show seriously reduced genetic diversity and may reach the point where every herd member is the clone of a single individual. The process is also well under way in plants, including the new plague of genetically modified foods. Genetic variety is a curse of efficiency. We are approaching the point of factory farming, and the potato blight that hit Ireland in the 1840s, which wiped out the potatoes and almost the people, shows the outcome that can result.

As well as its warning against the dangers of monoculture, the 19th century carries warnings against returning to a culture where the only motive is profit, and every aspect of life is there to be exploited. Public ownership developed to make sure that the interests of the public are protected. As conservationists we should resist the idea that being green is easy and a dollar is there to be made, and return to the idea that the environment is a community concern. Profit for a few will mean damage to many. Trying to conserve wildlife by exploiting and privatising it is like trying to quench a fire by dousing it with petrol.

DR DAVID HORTON IS A BIOLOGIST AND ARCHAEOLOGIST WHOSE MOST RECENT BOOK IS *THE PURE STATE OF NATURE* (ALLEN & UNWIN, 2000).

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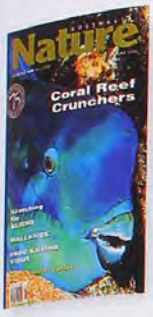

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