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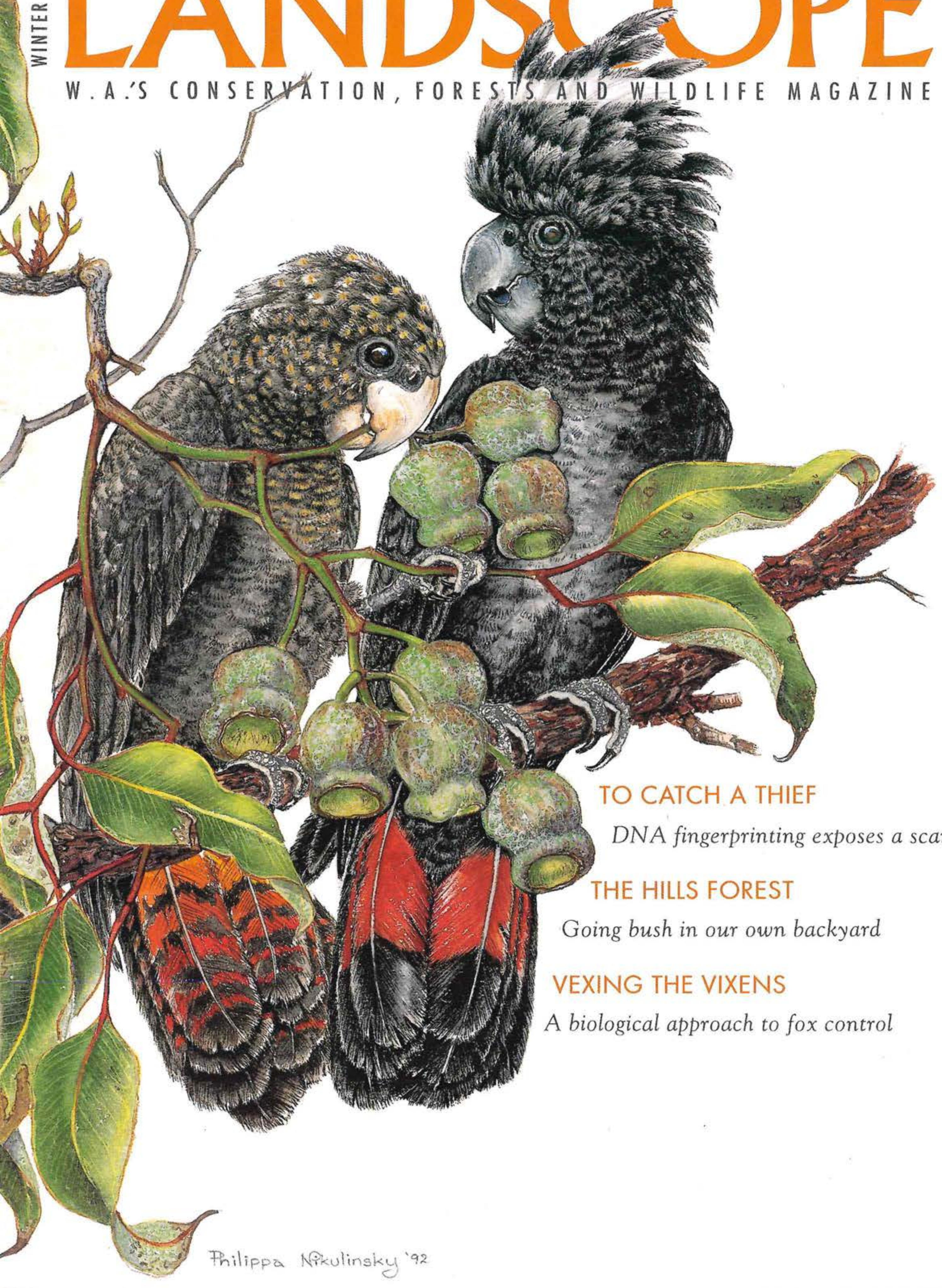
WINTER 1992

LANDSCOPE

W.A.'S CONSERVATION, FORESTS AND WILDLIFE MAGAZINE



TO CATCH A THIEF

DNA fingerprinting exposes a scam

THE HILLS FOREST

Going bush in our own backyard

VEXING THE VIXENS

A biological approach to fox control

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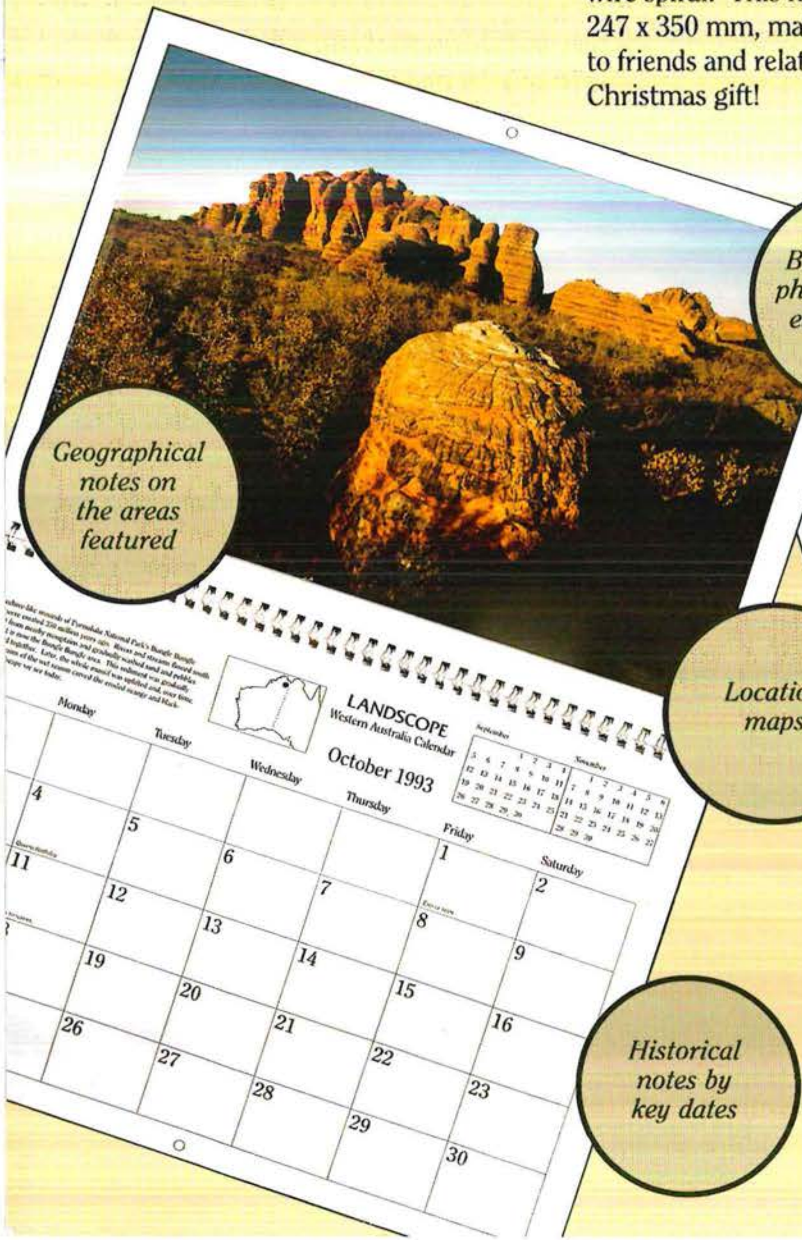

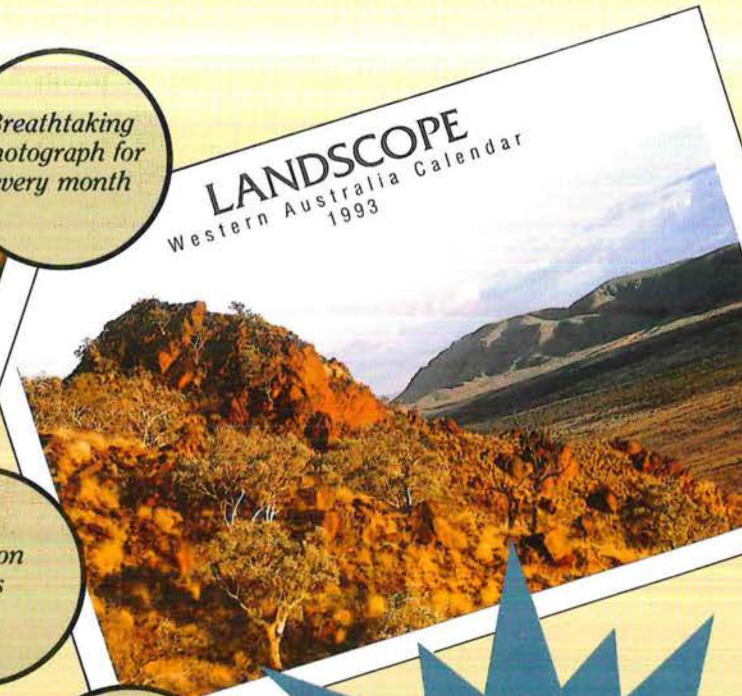

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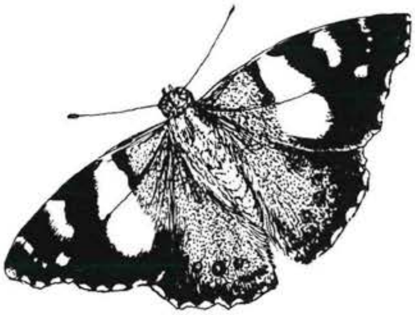
LANDSCOPE

VOLUME SEVEN NO. 4 WINTER ISSUE 1992

FEATURES

REGULARS

You don't have to go far from Perth to enjoy the peace and quiet of the bush. The forest is right on our doorstep. See page 10.



Painted ladies, northern admirals, southern admirals and Western Australian skippers - not the stuff of a sailor's dream, but all members of the butterfly family. See page 23.

Our native animals are prey to introduced species. While baiting gives them a fighting chance, scientists are looking for more long-term, humane solutions. See page 16.

The increase of births in captivity for cockatoos seemed promising, but was it related to the upsurge in 'birdnapping' in the wild? To Catch a Thief *explains how forensic experts unravelled the mystery. See page 28.*

The bilby has many names, including ninu and dalgyte. Ninu Magic *tells the story of this shy animal and its remarkable survival skills. See page 43.*

COVER

*The red-tailed black cockatoo (*Calyptorhynchus magnificus*) is one of several cockatoos native to Western Australia. These spectacular birds nest in tree hollows and can be found in the woodlands and grasslands of the south-west of Western Australia.*

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GROWTH & TECHNOLOGY

One of the underlying themes in the debate over the environment is the concern that as we develop and improve our standard of living, it will be at the expense of the Earth's ecosystem. Some members of the community suggest that we should adopt Rousseau's philosophy and return to the simple life. But while it's easy to be romantic and nostalgic about the simple life, it is very difficult to give up the benefits that we have derived from developing our economy.

One of the benefits of a developing economy is the level of technological innovation. Whereas physical and engineering sciences have been on a technological boom for decades, it is only recently that we have seen breakthroughs in technologies that are applicable to conservation, environment and land management. Some astonishing new technological tools are becoming available almost daily.

Two excellent examples of how modern technology can be used to deal with environmental problems are covered in this issue of LANDSCOPE. *'Vexing the Vixens' describes how scientists are investigating revolutionary ways to control the fox - the most important threat to our native animals. If successful, there is every prospect that native animals now threatened or nearly extinct throughout Western Australia will return to their previous levels of abundance.*

'To Catch a Thief' describes how DNA labelling can be used to identify birds. This technology has not only been applied to detect criminals, it has also been employed by volunteer aviculturists in collaboration with CALM to ensure that captive breeding of the naretha bluebonnet, a beautiful bird species from the Nullabor, can be carried out without risk of bird smuggling.

Syd Shea

The Publisher

LANDSCOPE GOLD

Everyone likes a friendly pat on the back from time to time, and those of us connected with *LANDSCOPE* are no exception. When the pat on the back is accompanied by a gold medal, it is all the better.

Your magazine, now in its seventh year, beat dozens of other Australian magazines and was awarded the only gold medal in its class at the 9th National Print Awards in Sydney, NSW. The award was given for excellence in design, pre-production and printing and means automatic entry for *LANDSCOPE* later this year in the Printing Industry of America international competition.

The gold medal is the second recent award for *LANDSCOPE*. In the past year, the magazine and CALM research scientist Jack Kinnear were awarded the Alex Harris Medal for excellence in science and environmental writing.

The real test, however, is whether the magazine not only informs but enriches and delights you. That is the test we aim to pass with every edition of *LANDSCOPE*. Let us know what you think about this edition of the magazine.

RON KAWALILAK
MANAGING EDITOR

PUTTING A BOMB UNDER POSTMAN PAT. . .

Whoops! Having sounded off about the non-delivery of *LANDSCOPE* here in this corner of the globe (see my letter sent two days ago) I now find the postman clattering his red post van up my somewhat pot-holed track in order to deliver the Autumn 1992 (Vol. 7 No. 3) issue of *LANDSCOPE*. So please ignore the recent letter! I can now set off in hot pursuit of the missing Summer issue via TNT Mailfast at Southall; it makes more sense for me to get on to them than have you expensively and laboriously chasing round the planet.

Congratulations, by the way, on yet another impressive copy of the magazine. The standards of photographs, maps, colour reproduction and writing are high and the contents very informative. From this distance the Department of Conservation and Land Management looks a pretty impressive outfit, staffed by people with eminently sound and hard-headed sets of values. It is little wonder that my pal Mr Fowler was keen to recommend the magazine; he rightly perceives that *LANDSCOPE* and the organisation behind it represent some of the best conservation and land management practices to be found anywhere. Many thanks.

R.L. COLE
VANGE, ESSEX, ENGLAND

We hope you have, by now, received your Summer 1991-92 issue of LANDSCOPE. *Your comments are appreciated by all concerned and we hope you will encourage others in your neck of the woods to subscribe to* LANDSCOPE.*- ED*

CREDIT WHERE CREDIT IS DUE

I wish to bring to your attention a small error observed in your Spring 1991 (Vol. 7 No. 1) issue of *LANDSCOPE*.

I refer you to the article entitled 'Wildflower Killers' and in particular the photo in the top left-hand corner of page 30, credited to B. L. Shearer, illustrating numerous *P. cinnamomi* sporangia (magnified under a microscope) releasing zoospores.

The photomicrograph in fact was taken by Les Harman in 1974, or possibly 1975. I was working for the then Forests Department on dieback research at Dwellingup at the time when Les was heavily involved in research photography, and we were building a collection of photomicrographs depicting the various life-cycle stages of *P. cinnamomi*.

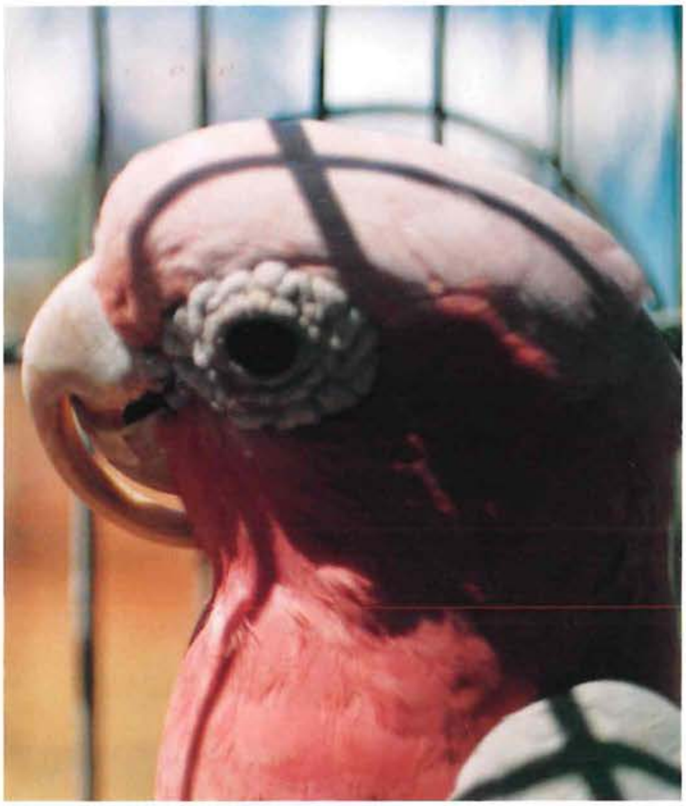
I clearly recall the subject photo: the method used to detect the presence of *P. cinnamomi* in soil was to place the test soil in a small container, cover with water and float several cotyledons of the highly susceptible *Eucalyptus sieberi* on the surface of the water. The cotyledons were microscopically examined for *P. cinnamomi* infection after several days. Infection was identified by the spore sacs (sporangia) growing from the cotyledon edge as illustrated in the subject photo. The subject was the most impressive I have seen of the many hundreds of cotyledons I had examined over the years. This was made even more impressive by using the dark field facility of the Dwellingup laboratory's high-powered microscope.

As Les was a dedicated photographer, it would be nice to think he could be credited for the work in question.

R. J. KITT
QUEENSLAND FOREST SERVICE

Thank you for pointing out that credit for the photograph was wrongly given to Bryan Shearer. Dr Shearer did not claim to have taken the photograph; that error was ours. Subsequent investigations have shown that the slide was one of several unidentified slides that have been kept at Dwellingup for many years. It is quite possible that the others in the collection were also taken by Mr Harman. - ED

CAPTAIN HOOK



This galah was spotted with a flock of wild galahs in an Exmouth backyard. It had an extremely overgrown beak and had trouble feeding. The bird was captured and is pictured before (left) and after (right) an operation performed by members of the wildlife rehabilitation group CARE. Photos - Les Harris

This galah was lucky enough to be spotted by CALM Volunteer Les Harris, also a member of the Conservation, Animal Rescue, Research and Education (CARE) group.

Les, who lives in Exmouth, noticed something odd about a bird in the usual flock of galahs that congregate in his backyard.

"It kept turning its head to one side to pick up the seed. Closer inspection revealed that it had an extremely overgrown beak," Les said.

He soon set about trapping the injured creature. He, together with CARE members Peter Vickridge and Chris Brooks, performed the "operation".

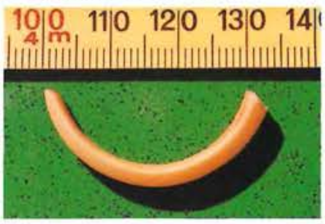
"I had on thick gloves and was holding the bird. Peter, also with thick gloves, held its head and beak, while Chris operated with clippers, trimmers and nailfile. All the while, the galah was protesting vocally.

"It didn't take long and the galah was soon back in his cage, looking like a normal bird, having had 40 mm cut off the top part of his beak."

They named the galah Captain Hook and kept him overnight for observation. In the morning, after Les was satisfied that he was feeding and drinking properly, the bird was released. He has since been seen every day.

The offcut beak and these photographs will be included in the CARE group's display of sick and injured animals it has treated.

The galah's offcut beak.



PARK PASS GETS FACE LIFT

National park annual passes released since May have a new look, featuring local wildflowers and the numbat on a Western Australian landscape.

The annual pass allows entry to national parks in Western Australia. Three types of passes can be purchased.

The Gold Star pass purchases entry to all national parks in the State as well as an annual subscription to *LANDSCOPE* for the price of $40. The annual pass provides entry to all national parks in the State for $25. The nominated park annual pass provides annual entry to one national park only, for $12. This is a new category of pass that will meet a need for people who wish to visit only one national park, or live in areas with only one national park in the locality.

Annual passes are becoming more valuable, as an increasing number of national parks charge for day use entry. An annual permit allows an unlimited number of park entries for an entire year. This can be compared to day use fees of $5 per day.

For the first time, the new passes will be validated by a duck stamp.

Purchasing an annual pass not only helps pay for the cost of managing national parks, but also directly contributes to wildlife conservation.

Annual passes can be obtained from CALM at 50 Hayman Rd, Como, phone 367 0333, or from CALM regional offices throughout the State. Some national parks also stock annual passes.

The Goldstar pass gives admission to national parks and a subscription to LANDSCOPE for only $40.

THE MYSTERIOUS SEA LION

Australian sea lionnumbers were greatly reduced by sealers in the eighteenth and nineteenth centuries. Now this fascinating species is just beginning to receive some serious scientific attention.

The Australian sea lion is the only pinniped (seal or sea lion) that is unique to Australian waters. The animals are one of our most attractive and interesting sea creatures.

Sea lions breed and rest on offshore islands from the Abrolhos near Geraldton to Pages Island, just east of Kangaroo Island in South Australia. The animal's range once extended east to Bass Strait before it was wiped out of this area by sealers.

The animals usually are fairly tolerant of people, but can be dangerous, especially during the mating season.

Marine mammal expert Nick Gales is studying sea lion biology. The project is jointly funded by the Department of Conservation and Land Management, the South Australian Parks and Wildlife Service, the Australian Research Council and the former Atlantis Marine Park.

"The Australian sea lion is the only sea lion in the world with an 18-month breeding cycle," said Nick. "Just as unusual is the fact that breeding and mating on each island throughout the sea lion's range takes place at different times of the year."

Nick set out to investigate the theory that there must be delayed implantation, by collecting blood samples to measure hormone levels during the reproductive cycle.

Collecting the blood is no easy task! First Nick must find a cow with a pup that has been researched, so that the date the mother gave birth (the end and beginning of her breeding cycle) is known. This often involves trudging up and down the beach in a fruitless search.

Once a suitable animal has been located, three assistants must immobilise it, while another fends off the surrounding animals, which often charge the researchers. Only then can Nick take blood from the female, quickly locating a vein in her lower back.

Nick has found evidence that the Australian sea lion has a six-month delayed implantation and 12-month placental phase.

"I will be able to pinpoint the exact time that implantation occurs, as there are major changes in the concentrations of hormones in the blood at this time."

The diet of the Australian sea lion has also been investigated by collecting hundreds of sea lion scats. Analysis has shown that crayfish, squid, cuttlefish, octopus, small shark and fish make up most of the animal's diet.

"The south-west and south coast of Western Australia are very low energy waters, with only a small amount of food available all year round. Sea lions have to be opportunistic and take whatever's around," Nick said.

"This situation probably influences sea lion reproduction. Animals need to have their young when the most food is available, but the

Don't be deceived by these snoozing sea lions. Though they are usually tolerant of people who keep their distance, they can quickly become aggressive and deliver nasty bites.

Australian sea lions "haul out" from their two-day fishing trips and breed in isolated coastal and island settings. While away fishing, mothers hide their pups under bush or behind a rock.
Photos - Carolyn Thomson

Australian sea lion inhabits waters where there is no appreciable difference between food availability in winter and summer.

"Instead, mothers feed their pups over a longer period of time, which is an advantage in an environment low in food sources. It takes a tremendous amount of energy to provide young with milk," he said.

Nick is the first researcher to systematically document how many sea lions there are and where they are found. Until recently, it was thought that the entire population of Australian sea lions was about 5 000. Nick has estimated that the population is actually between 10 000 and 15 000.

During the study, DNA sampling of sea lions was done for the first time. Seven or eight small populations have been sampled. It is believed that there is very little interaction between each population, so genetic fingerprinting will give researchers a rough idea of where the population boundaries are within the species' range.

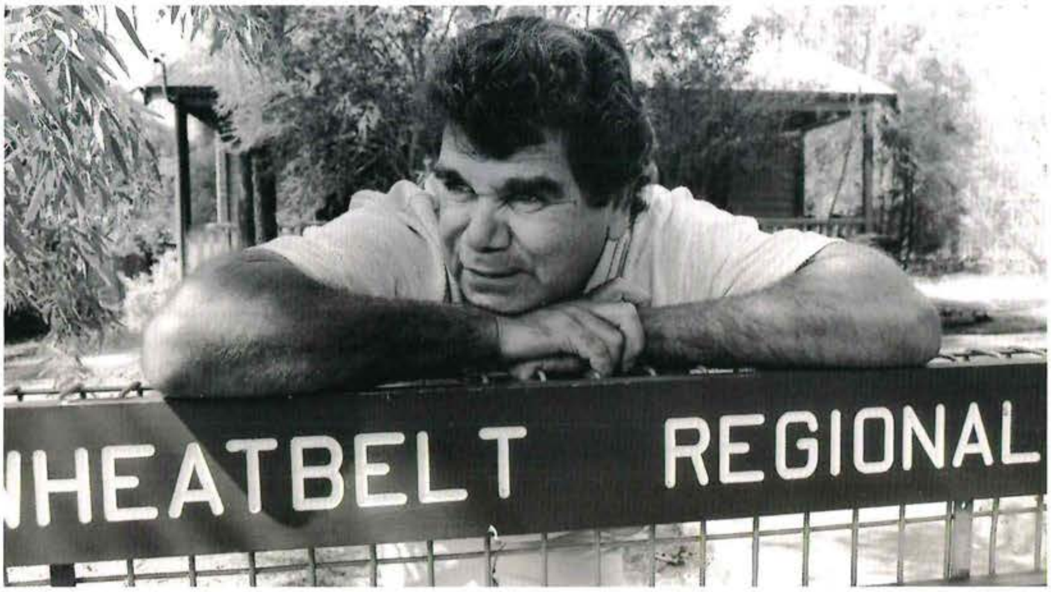
Eventually, Nick plans to visit every colony to find out where the exact population boundaries start and finish. The results should reveal precisely where the boundaries are and how much genetic exchange there is overall.

Nick Gales tries to sneak up on a female to test whether her pup has been tagged. If so, the mother is a prime target for blood sampling, as the beginning and end of her breeding cycle will be known.

The Australian sea lion is the only seal or sea lion in the world with an 18-month breeding cycle.

Four assistants hold down a female sea lion while Nick Gales extracts blood from a vein near her tail.
Photos - Carolyn Thomson

ABORIGINAL LIAISON OFFICER JOINS CALM



The new Aboriginal liaison officer for the Department of Conservation and Land Management, Noel Nannup. Photo - Tanyia Maxted

The Department of Conservation and Land Management (CALM) has appointed one of its Aboriginal employees to liaise with south-west Aboriginal people.

Noel Nannup has spent two and a half years studying cultural heritage management in Canberra.

Before this he worked for nine years as a ranger-in-charge, including seven years at Geikie Gorge National Park and two years at Millstream National Park.

The position will be based at Narrogin in CALM's Wheatbelt region, but Noel will also have responsibility for Aboriginal issues on CALM managed land in the Central Forest, Southern Forest, and South Coast regions.

A newly released CALM report, *Aboriginal Activities and Nature Conservation in the South-West of Western Australia*, has found that "a lot of work is needed to resolve issues of mutual interest to CALM and Nyungars".

For instance, the report found that Nyungar culture is still very much alive and that Nyungars still have an enormous amount of bush knowledge.

"Hunting, camping, gathering plants and taking kids to the bush to learn about Nyungar culture are still common, " Noel said. "Many of these activities take place on land managed by CALM and other Crown land."

Overall, the report recommended that CALM and south-west people should work closer together to improve nature conservation and give Aborigines greater access to some Crown land.

"We have to learn how CALM can meet Aboriginal needs in the bush and at the same time improve its management of nature conservation reserves," he said.

One possibility is that CALM and Nyungar people could jointly conduct education courses on wildlife and ecology. Another is that Nyungar people could help cull kangaroos from areas where farmers need to reduce kangaroo numbers; kangaroo meat is still an important part of the Nyungar people's diet.

The study recommends that CALM seeks to clarify laws relating to Aboriginal use, including hunting, of Crown and CALM-managed lands.

The Department will also investigate and try to develop employment opportunities for Nyungar people in conservation reserves and State forest.

During his first year, Noel will concentrate on describing and protecting Aboriginal sites, and liaising with Aboriginal groups.

Noel will undertake work in community (particularly school) education and liaison and he will also participate in a project aimed at recording oral history of Aboriginal culture and Dryandra.

PINK-FLOWERING JARRAH

This magnificent pink-flowering jarrah (*Eucalyptus marginata*) was first found in the Dale State forest 15 years ago by Mr Gordon Kealley, a commercial beekeeper from Maida Vale.

Photo - Lee Allan

Last summer the jarrah forest had the best general flowering throughout the State for about ten years and beekeepers produced substantial quantities of jarrah honey and pollen.

Mr Kealley found the tree flowering again this year while working his beehives in the Dale area. He was so impressed with the tree and its pink flowers that he contacted Mr Lee Allan, the Senior Apiculturalist with the Department of Agriculture, who took this photograph while the tree was in full bloom.

This pink-flowering form would make a beautiful addition to home gardens and parks if propagated by tissue culture techniques. Associate Professor Jen McComb, of Murdoch University, and Dr Ian Bennett, of Edith Cowan University, are enthusiastic about this prospect and have initiated research on the tissue culture of the plant.

The pink-flowering jarrah, like pink-flowering marri, is extremely uncommon, but not unique. Other pink-flowering jarrah trees have been reported at Forrestfield, before the area was developed for housing, and WA foresters have noted many other specimens in the forest over the years.

SAVING OUR SEAS

Earlier this year, CALM, along with Underwater World and Department of Marine and Harbours, was approached by the Marine Education Society of Australasia (MESA) to sponsor Seaweek '92. The theme for this year's eight-day festival was "Marine Parks - Saving Our Seas".

Seaweek is an annual event, held Australia-wide, with the festival in WA by far the biggest. A theme is chosen each year to highlight different aspects of the marine environment, and promote the wise use, enjoyment, understanding and protection of marine resources and environment. WA has five marine parks, as well as marine reserves, under the care of CALM.

Events were opened on May 3 at Fremantle Boat Harbour by Minister for the Environment Bob Pearce. Marquees were set up with displays from UWA, Fisheries, Marine and Harbours, CSIRO, Greenpeace, CALM, Naval Cadets and the model steam ship club. Demonstrations such as flare and life raft display, air sea rescue (with RAAF and Police Air Wing helicopters), and CALM whale stranding rescue equipment attracted much interest.

Free tasting of sardines, wine and cheese and musical entertainment contributed to a festival atmosphere. Boats from Customs, Marine and Harbours, the EPA, Police and CALM were on display.

During the week, there were shopping centre displays, guided tours of Shoalwater Islands Marine Park, museum displays and a series of evening lectures at Underwater World by CALM staff.

The final weekend was held at Hillarys Boat Harbour on May 9 and 10. HMAS Geraldton, a 42 metre patrol vessel, was berthed at Sorrento Quay and remained open for tours and displays, and Boat Torque Cruises ran free tours of Marmion Marine Park, guided by CALM staff and volunteers. On May 9, Underwater World held a "Seaweek Special" half price entry to Underwater World which was enthusiast-ically received by visitors. Each day, the Fisheries Department held talks on "Fishing for the Future". Events closed with a "fly-over" by four of the RAAF's PC9 planes, and with a Beach Ball held at Underwater World.

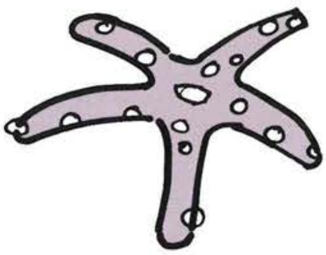
Seaweek '92 was a success largely because of the four major and over 60 minor sponsors and all the volunteers who were so generous with time, skills and resources.

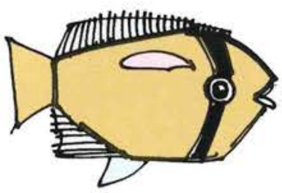
Top: Gorgonian coral.

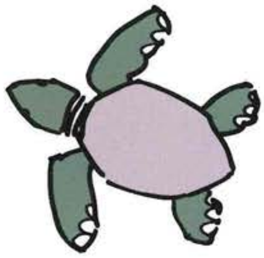
Above: Scorpion cod.

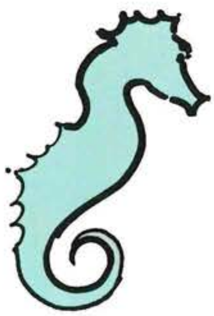
Left: Vermilion biscuit stars.

Photos - Duncan Dodd





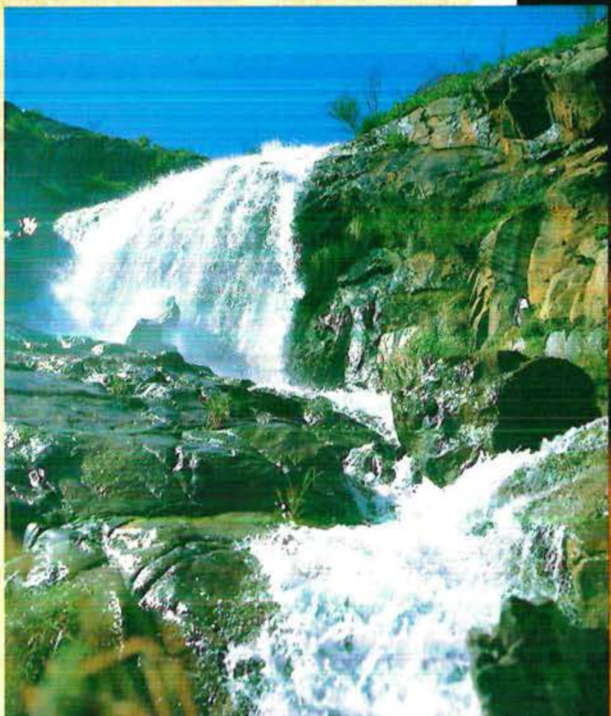




The Hills Forest

by Stev Slavin and Ray Bailey

Lakes, trees, valleys, hills ... Stev Slavin and Ray Bailey show us some of the sights of Perth's closest working forest, set among the hills of the Darling Range, east of the city.



Just a short swan's flight up river from the blue-green waters of the Indian Ocean, Perth is sitting pretty. Few capital cities can boast such pleasant surroundings, with a sweep of natural parkland immediately to the west, a beautiful river environment on its doorstep, and magnificent bushland on its eastern and south-eastern borders.

This bushland largely consists of jarrah forest. Jarrah (*Eucalyptus marginata*), one of the world's densest hardwoods, grows only in the forests that stretch from Lancelin to Wanneroo, Mundaring to Dwellingup, Waroona to Nannup, and Manjimup to Denmark. A good portion of that forest is preserved in national parks; the best-known near to Perth is probably John Forrest National Park east of Midland. Nearly all the rest is managed as State forest for many uses, including water catchment, timber, recreation, nature conservation and research.

To the east and south-east of Perth, an innovative project called The Hills Forest is being launched by the Department of Conservation and Land Management (CALM), incorporating in its 80 000 hectares an important part of this precious forest. Just 30 minutes from the heart of the city, The Hills Forest is very much the bush in Perth's back yard. It covers five national parks (including John Forrest National Park), scenic Mundaring Weir, a large area of State forest, and Mt Dale. The Hills Forest is served by the towns of Mundaring and Kalamunda, and runs almost as far south as Karragullen. Its location makes it ideal for day-trippers who want to get out of the city for a few hours, perhaps to take a quiet, leisurely bush lunch amidst the trees and wildflowers of the magnificent native forest. Indeed, the area attracts the highest number of visitors in Western Australia after Fremantle and Northbridge.

The land here is old and rich in natural features. Some of the massive king jarrah trees that tower over the scene are several hundred years old. The jarrah and marri woodland are intermixed with other eucalypts on the valley floors, and in areas such as the Helena River valley, wandoo grows side by side with flooded gums. Somewhat closer to ground level, the large boulders so prominent in the landscape are made of some of the most ancient granite and metamorphic rocks in the world; they date back almost to the time when the earth's crust cooled.

SEASONAL ACTIVITIES

The Hills Forest offers visitors an all-year-round natural environment. In winter, when the Helena and Bickley Reservoirs and Lake Leschenaultia are full, the creeks and waterfalls, such as Lesmurdie Falls, captivate the eye and ear, and cloudy skies accentuate the vivid yellows and golds of the wattles. In spring the wildflowers bloom, proliferating until early summer; this is the time for light breezes through the eucalyptus, and for sunset dinners off the beaten track. Autumn is for bushwalking and exploring, when the dusty green of the jarrah leaves turns amber in the late afternoon sunlight.

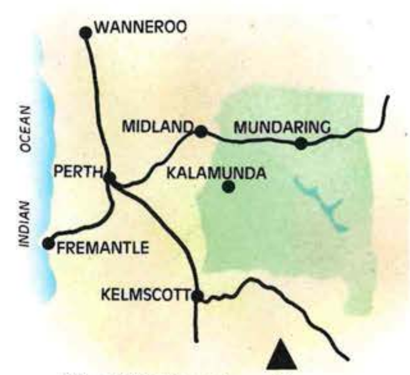
One of the most popular activities in The Hills Forest is the *Go Bush!*

Previous page:
Enjoying the light and companionable warmth of a campfire at the Little Oven campsite near the Bibbulmin Track.
Photo - Jiri Lochman

Inset: The Lesmurdie Falls cascading over the Darling Scarp.
Photo - M & I Morecombe

Above:
Golden rainbow (*Drosera microphylla*), part of the exquisite flora of the jarrah forest.
Photo - Babs and Bert Wells

Below:
Scene of abundant life: a brook near the Brookton Highway.
Photo - Babs and Bert Wells



The Hills Forest

Left:
The bull frog (*Litoria moorei*), a common resident of creeks and ponds in the Hills Forest.
Photo - Jiri Lochman

Below:
A grey shrike-thrush (*Colluricincla harmonica*) finds a meal in one of the hollows in a jarrah tree.
Photo - M & I Morecombe

recreational program currently offered by CALM during school holidays. Designed for the enjoyment of individuals, families and groups, *Go Bush!* operates at least 20 different activities out of The Hills Forest.

'Forest Under Canvas' is an activity where family groups walk into the bush to spend the night in a secluded spot around the campfire under the stars and later under canvas. In the morning, activity leaders give tips and advice to those who want to organise their own night out in the bush. In another program, 'Night Shift', CALM staff take small groups of people out into the forest after dark to discover the action as the nocturnal forest inhabitants begin their 'day'. Sometimes known as spotlighting tours, these popular excursions take people stealthily through the bush to observe animals, birds and insects - and no doubt to be stealthily observed themselves, by frogs, owls, bats, moths, and the occasional kangaroo, all of which can see much better at night than humans.

The jarrah forest provides habitat for a range of wildlife. It is the home of the grey kangaroo; the quenda makes its refuge amongst the thick creek-side scrub; the brush wallaby and even the endangered numbat and chuditch have been seen here in recent years. The brown-headed honeyeater and the grey shrike-thrush dart through the tree tops, while rufous tree-creepers cling to the trunks of the larger trees.

The Hills Forest has a wide range of attractive locations. There are small ones, such as South Ledge, Big Log, and The Dell; or, somewhat further from Perth, Mt Dale (70 km to the south-east near Brookton Highway) or Forsythe's Mill (40 km along the Great Eastern Highway). All these are splendid spots for picnics and bushwalking.

Then there are the bigger attractions. The Hills Forest is graced by five national parks: John Forrest, Gooseberry Hill, Greenmount, Kalamunda, and Lesmurdie Falls. In Mundaring Shire, Helena River Reservoir (known to most metropolitan residents as the Mundaring Weir) is a popular destination, with the Mundaring Weir Gardens overlooking the dam and the O'Connor Museum at the foot near the Water Authority's pumping station. Not far away is Lake Leschenaultia; originally designed to supply the eastern railway with water for steam locomotives, the lake is now a picturesque expanse of water set amongst

the tall jarrah and marri trees, and teeming with fish.

There are wonderful walk trails. Southell Track begins at Fred Jacoby Park, then wanders for seven kilometres through the lower Helena Valley past Mundaring Weir. The Mundaring stretch of the Kattamorda Heritage Trail carries signs describing some of the local history, with prints of old photographs that hint at the lifestyles of those who lived in the area during the past 150 years. The famous Bibbulmin Track begins in The Hills Forest and journeys 650 km to Walpole on the south coast of WA. There is an easy-to-walk 10 km section from Kalamunda town to Mt Gunjin, with two separate trails (the Kalamunda Circuit and the Little Oven Circuit) looping away and rejoining the track later.

Other walks explore gullies, granite outcrops, and the trees and plants of the hills. There are also trails for four legs instead of two; horse lovers particularly enjoy riding a beautiful track through the Lower Helena Valley, a gentle bridle trail through 40 km of bushland from Boya to Mundaring.

FOREST CUSTODIANS

The Hills Forest is the first of a series of recreation areas planned by CALM, each focusing on a particular ecological type - in this case, a forest. The wooded

The rare chuditch (*Dasyurus geoffroii*) on nocturnal prowl.
Photo - Jiri Lochman

Below:
A night-time observer: the tawny frogmouth (*Podargus strigoides*) caught away from its usual jarrah-bark camouflage.
Photo - Jiri Lochman

country will offer experiences for visitors to understand, value, and above all enjoy our unique natural environment. At the moment, people visit in high numbers, but they leave with memories of only a very small part of the area. Not many see its majestic waterfalls, the views it offers as far as Northam (some 65 km off to the north-east), or the old railway formations that carried trains on wooden rails.

This project, which will be developed during the next ten years, is beginning simply. As well as the creation of wide-ranging activities, recreation sites along Mundaring Weir Road will soon be improved. More trails for walkers, cyclists and horse riders are proposed. More picnic spots are being chosen, and will be designed to blend in with the bush. There are also plans for a bush campground, an environmental playground, interpretation trails, and even a 'demonstration' forest designed to show how a forest is managed. A further activity now being planned is a bushwalk, but one with a difference: it will be elevated, allowing visitors impressive views while taking a stroll through the very canopy of the forest.

CALM is encouraging other land managers in the area to join them in offering the biggest range of recreation opportunities possible. The area's other custodians include the Water Authority and the shires of Kalamunda, Mundaring, Swan and Gosnells. All have tried to plan and manage public areas independently, often with meagre resources. The Hills Forest concept allows a better use of resources, and it may well create a new sense of identity for businesses and residents of the area.

IMAGINATION IS THE LIMIT

The Hills Forest is not only the bush in Perth's back yard. It is an environmental opportunity for the future. The Hills Forest will promote the use of public land to develop nature-based recreation experiences, to encourage a greater awareness of the many values of Australian forests.

The Hills Forest will still be managed for its primary functions of water catchment, nature conservation, wildlife protection, and timber production. Indeed, it is the aim of the forest managers that visitors will become aware of these forest processes and how they are managed. Other traditional uses of the area, for example bushwalking, horse riding and picnicking, will be encouraged and diversified to offer a greater variety of bush experiences.

But Hills Forest management has plenty of other ideas. CALM staff will plan and construct a range of self-guided walks and guided interpretation trails. Diverse activity programs will be developed. The Forest Activities Centre is being constructed near the Mundaring Weir and will become the focus of the *Go Bush!* program. New sites will be developed and a wide variety of activities will be offered, from doing little and enjoying the sights to actively participating in a 'forest experience' group.

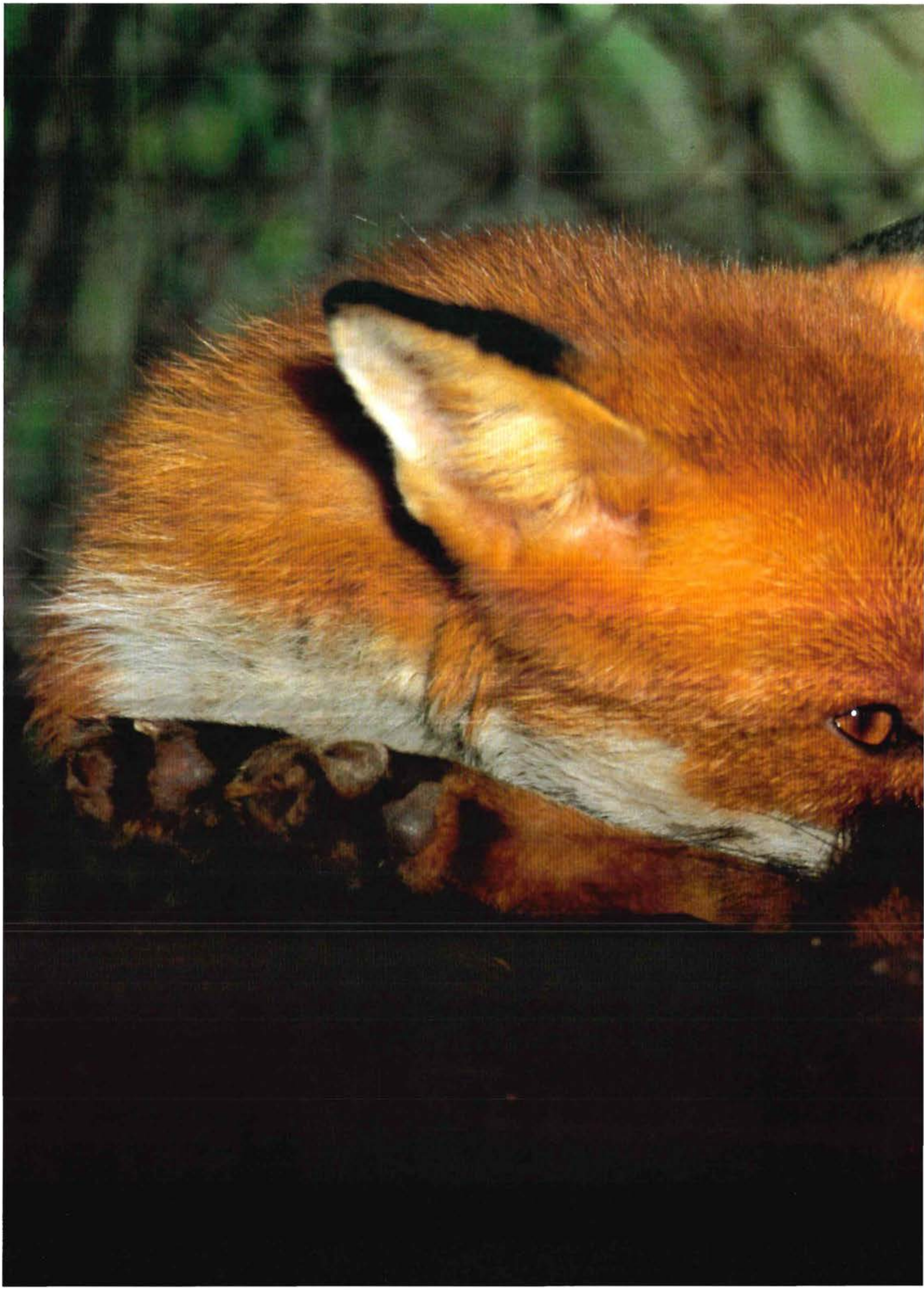
In The Hills Forest, imagination is the only limit!

Stev Slavin is the manager of The Hills Forest and can be contacted on (09) 295 3149. Ray Bailey is Senior Communications Coordinator at CALM and can be contacted on (09) 389 8644.

Above:
A western grey kangaroo (*Macropus fuliginosus*) on the alert for intruders. Its numbers are high within The Hills Forest.
Photo - M & I Morecombe

Above left:
Misty morning in the Darling Range jarrah forest.
Photo - Jiri Lochman

Left:
High in the saddle along the Helena bridle trail.
Photo - Jiri Lochman



Vexing the Vixens

Once or twice a week, in Dryandra State Forest near Narrogin, some old wildlife magic is being recreated - thanks to a radical new way of dealing with predators.

BY JACK KINNEAR

♂♀

As dusk falls, Joe and Ivy Van Den Elzen, minders of the tiny settlement at Dryandra, switch on a light and scatter some wheat at the back of their cottage. This ritual sets the scene for what is now an extraordinary wildlife spectacle - a gathering of woylies, a wildlife picnic.

When I last had the pleasure of witnessing this little spectacle, I counted up to 12 woylies busily foraging for the wheat. (The attendance record is 32.) These were noisy, tense little gatherings punctuated by hisses and grunts; but this is to be expected, for woylies are normally solitary animals with minimal social skills.

Now and then the tension is relieved as a dispute breaks out with much hissing and grunting; fur can fly and the little group may scatter into the darkness, only to reform almost immediately. The wheat is irresistible and tolerance reigns again, at least for a while.

I have seen similar evening picnics at a wildlife sanctuary in the Adelaide Hills in South Australia. There, I recognised some eastern States relatives of the woylie - the potoroo and the rufous rat-kangaroo. But emanating out of semi-darkness were also the unmistakable grunts of woylies, descendants of Western Australian woylies sent to South Australia many years ago.

None of these scenes would have been possible without one essential thing: the removal and the continued exclusion of introduced predators - the fox and the feral cat.

In the Adelaide hills predators have been excluded by constructing an electrified fence. In WA it is not practical to erect fences on the scale needed. Here, predators are excluded by an invisible fence - deadly fox baits containing of 1080 poison, periodically replenished by field officers from the Department of Conservation and Land Management (CALM).

This invisible 1080 fence works, for wherever we have done this, endangered mammals have increased. They become visible, part of the landscape once again. The strategy of erecting 1080 fences will lead to an increasing number of nature reserves and forest areas where fox numbers are reduced to a tolerable level. Within these, the predation-affected native fauna will increase.

However, fox control by baiting is only a short-lived solution; foxes are constantly ready to invade. So why bother trying? Why commit resources endlessly to a seemingly hopeless cause? There are two very good reasons. The first is that we know that when a mammal species drops out of sight, chances are it will disappear forever unless steps are taken to control introduced predators.

The second reason is that the future is not as hopeless as it would seem. Far removed from the bush, a new kind of high-tech biologist holds the key to our conservation problem. These biologists work with molecules instead of organisms; they are molecular biologists and gene engineers.

BIOLOGICAL CONTROL

Mention biological control and we think of a pest species in plague numbers. Numerically foxes do not exist at plague levels, yet they threaten Australia's unique wildlife, a national resource not yet fully appreciated.

Previous page:
What's for dinner tonight? Woylie, tammar, numbat?
Photo - R Knox

Left:
A rufous rat-kangaroo resting in its nest, which affords little protection from foxes.
Photo - Jiri Lochman

Below right:
The numbat is safe within its hollow log, but vulnerable when away from it.
Photo - Jiri Lochman

Below:
The woylie thrives when foxes are controlled.
Photo - Mogens Johansen

Right:
Forty per night; a reflection of fox abundance in Western Australia. Such numbers shot have little effect on the fox population.
Photo - Babs and Bert Wells

Below right:
When first released the myxoma virus killed 99% of the rabbit population. Rabbit numbers have been increasing since and currently myxoma virus is less than 50% effective.
Photo - Babs and Bert Wells

Biological control ('biocontrol' for brevity) traditionally involves releasing a species for the purpose of controlling another species. In biological terms, the objective is to release species capable of regulating (i.e. reducing) the population of the pest species.

In Australia, there have been some spectacular biocontrol successes. One example is the prickly pear cactus, which was imported into Australia. It quickly spread, creating an impenetrable cacti forest. Eventually, a moth from Argentina was released and it achieved control.

Spectacular and dramatic control of the rabbit in Australia was achieved by releasing the myxoma virus in 1951. Control was almost complete with the virus killing over 99 per cent of the rabbits.

Since then, however, the effectiveness of the virus as a controlling agent has declined, and rabbits are again a serious economic and ecological pest.

These dramatic results have tended to inflate the successes and to obscure the failures. The downside to biocontrol is that it is difficult to find and release, with safety, a species capable of regulating the numbers of another. Most attempts have failed.

This situation could well change as a result of advances in molecular biology and genetic engineering. Molecular biologists study processes within the cells of organisms. They are particularly interested in DNA molecules, which carry information. This provides a set of blueprints for cells to grow, to carry out some function, and to make copies of themselves.

Having learned how to read the blueprints, molecular biologists have also learned how to change the plans. They can remove genes and add them. Most importantly, they can transfer genes between different organisms, because the genetic code is universal. By adding, removing or transferring genes, we can make an organism do things to suit our purpose. Thus, molecular biologists can engineer an organism's genetic makeup.

Before we move on to apply this new kind of engineering to pest control, the only molecular biology we need to remember is that genes carry the instructions for making proteins. And further, if we put a gene into other organisms such as viruses or bacteria, they will make that protein when they divide and replicate.

REVOLUTIONARY SOLUTION

Ideally, we would like to exterminate the fox from Australia. But this is probably not possible at this stage. Failing that, we can thin out foxes to a level which permits the fauna to exist in reasonable numbers - that is, at population sizes which promote long-term survival. There are three ways to do this: increase the death rate, lower the birth rate (by making foxes infertile), or both.

The second option is best, because it is merciful as well as effective and practical. The objective is to prevent fertilisation in an unobtrusive, humane way. The method selected is ingenious: scientists propose to sterilise foxes by using a virus as a living vaccine.

Clearly, biocontrol through molecular biology is a new, revolutionary approach to the problem of a species out of control.

Fertilisation occurs when the genes carried in the sperm unite with the genes in the egg. The attachment sites consist of special proteins, chains of smaller molecules (amino acids) linked together.

Now, suppose we inject these proteins into a female fox. The immune system responds; it makes antibodies to the proteins and these antibodies bind to the proteins we injected. But in addition, and here is the trick, some antibodies detect identical proteins on the surface of the eggs in the fox's ovaries. These antibodies bind to those sites where sperm have to attach. Thus fertilisation is prevented, because the antibodies made by the fox's own immune system clog the sites.

A clever trick, but not quite clever enough. There is a flaw: we can't go about the countryside vaccinating female foxes, because they do not cooperate! What we need is a delivery system that achieves the same thing without human intervention.

Again the molecular biologists have the answer, because they can swap genes. All we have to do is find a virus which infects foxes and insert the gene with codes for the attachment site proteins into it. The engineered virus is released.

If all works well, many female foxes will not breed successfully. As time passes, we will find that the population consists mainly of adults and that the population has declined; with few cubs being born, dying adults are not being replaced. Control will have been achieved.

This new approach to biocontrol was conceived by Dr Hugh Tyndale-Biscoe, Chief Scientist with the CSIRO's Division of Wildlife and Ecology. Initially it was to be applied for the purpose of improving rabbit control, but as the impact of the fox became known from studies in WA, the fox was included. It may well be applied to other species, for example the house mouse, which periodically reaches plague numbers in eastern Australia, and the feral cat.

PROSPECTS OF SUCCESS

The task of implementing and coordinating this new approach to biocontrol is daunting. It requires scientists from many different disciplines and institutions. It also takes time and money. Initially, the only funds allocated to fox control and research in Australia

Right:
Tracking a predator: a fox fitted with a radio collar, is about to be released.
Photo - Tom Leftwich

Below:
Since the arrival of the cunning fox, the native mammal fauna have declined.
Photo - R Knox

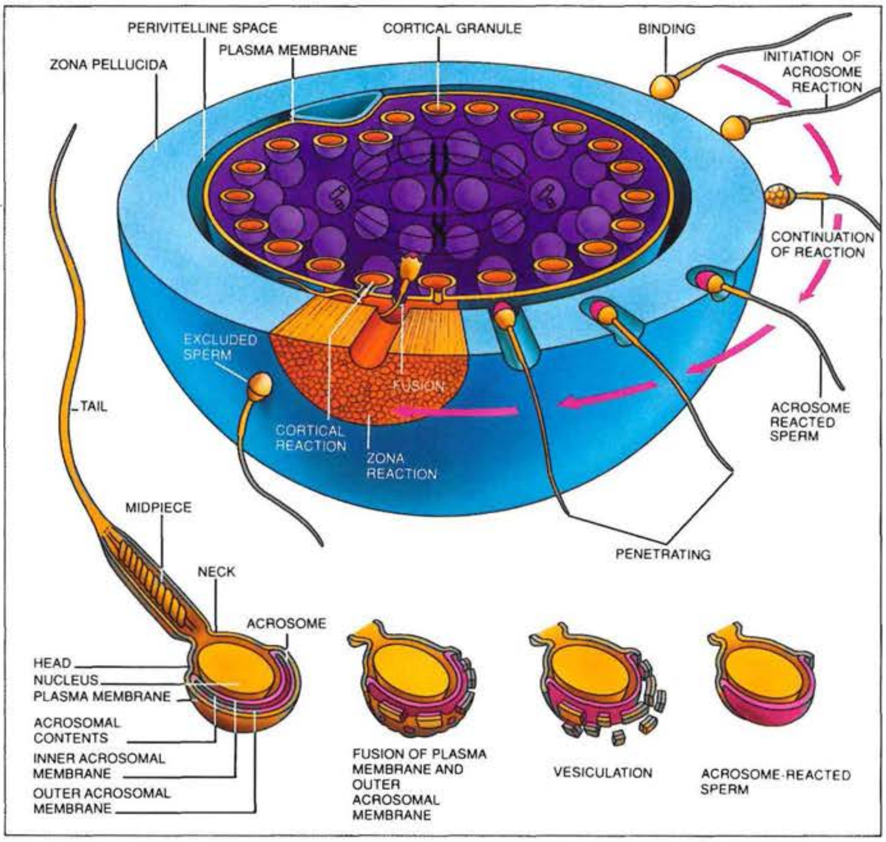
were provided by CALM and by the Endangered Species Program of the Australian National Parks and Wildlife Service (ANPWS). But because of the magnitude of the task, the Commonwealth Government announced in December 1991 that funds for a Cooperative Research Centre (CRC) had been granted for the specific purpose of developing and implementing the Tyndale-Biscoe approach to biocontrol.

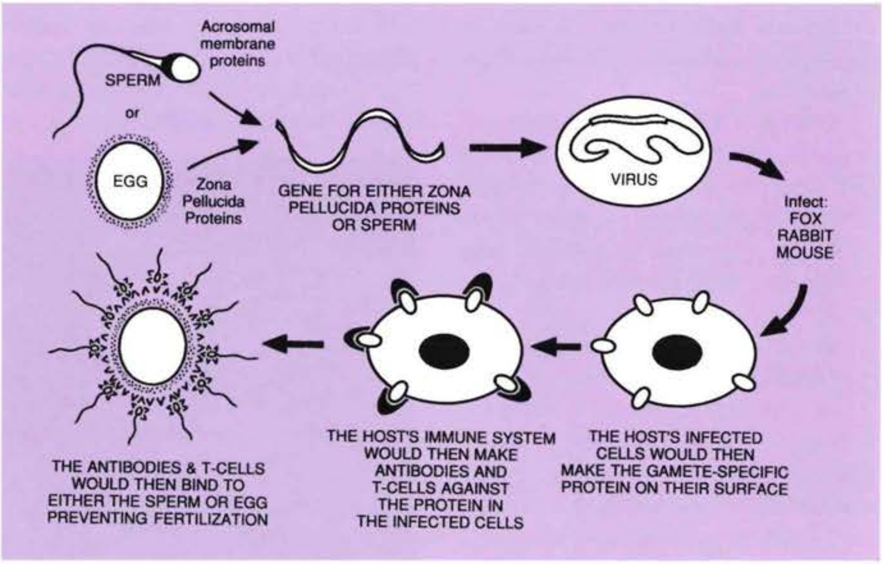
Scientists from four institutions are involved: the CSIRO Division of Wildlife and Ecology, CALM, the Australian National University, and the Agriculture Protection Board (APB). The CRC will grow as more scientific expertise is required. Special committees of experts have agreed to act in advisory roles. In addition, the CRC's educational component enables students to be trained and to carry out research for present and future benefits.

Eventually, the rabbit and fox will be brought under control. Nobody believes it will be easy. Immunologists see major problems in tricking the immune system. Given that a virus is engineered to carry the sperm attachment gene, the product of this gene (the protein to which sperm normally attach) may be ignored by the fox's immune system; that is, hardly any antibodies may be made. What we want to do is to provoke the immune system to make buckets of antibodies so that all of the sites where sperm can attach are completely coated by antibodies. It may be necessary also to engineer a 'panic gene' whose purpose is to stimulate antibody production, and insert that into the virus as well.

There are numerous other unknowns that have to be conquered. Nonetheless, there are already runs on the board. Work on the rabbit is off to a promising start, because the molecular biologists already have a virus which they can engineer - the myxoma virus that was released and produced the disease myxomatosis in rabbits. Dr Ron Jackson of the CSIRO has determined the particular DNA sequence of this virus. Moreover, he has engineered the virus, having found a site where it will be possible to insert a gene. The next step is to make and insert the gene that tricks the immune system.

Outside of the laboratory, ecologists are researching those aspects of rabbit





Top:
The sequence of events from the time a sperm binds to an egg through to fertilization. As soon as the sperm binds, the acrosomal reaction begins as it penetrates the egg. Antibodies to the protein on the zona pellucida (the outside of the egg) would block the "binding" sites of the sperm. Alternative approaches to immuno-contraception would include antibodies that attach to the acrosomal proteins (the outside of the sperm), which would also block binding, or antibodies that would attach to the tail of the sperm interfering with motility, thus preventing the sperm from swimming to the egg.

Two approaches to immuno-contraception, both working on the same principle. A gene for either the zona pellucida proteins (of the egg) or the acrosomal proteins (on the head of the sperm) is introduced into the virus. The virus infects the target, in this case a fox, which produces antibodies to the protein. These antibodies would bind to sperm or egg and prevent fertilization.

and fox biology which we need to understand to successfully engineer a controlling virus. Theoretical studies are in progress. CSIRO scientists Roger Pech and Graham Caughley have constructed models which predict the requirements and conditions that have to be met for effective biocontrol. Their models have highlighted the need to study the social system of rabbits and foxes.

HITTING THE TARGET

All genetically engineered organisms must satisfy stringent regulations and conditions before the release of such agents will be allowed. We need to establish that any engineered virus is safe and specific for the target species we seek to control, but we expect that all conditions will eventually be met.

One of the reasons for this belief is that molecular biologists have the ability to devise techniques that are highly species-specific. This ensures that only foxes are affected and not domestic dogs or dingoes. Undoubtedly, the task for meeting these requirements will be time-consuming.

CALM scientists in collaboration with research scientist Peter Thomson of the APB are committed to the fox control program. Pioneering studies on the fox by CALM, supported by ANPWS, have already laid the foundations for future work.

While the fox has been studied extensively in Europe and North America, it has been largely ignored in Australia. It is extraordinarily difficult to study, being a secretive, wary animal; anyone who works on them learns to appreciate the phrase 'as cunning as a fox'.

With so much to learn about foxes, it is easy to get side-tracked. Mathematical models based on epidemiology, which is about epidemics, are helping us focus on the important things. In releasing an engineered virus, we seek to cause an infertility epidemic among foxes.

We need to know how abundant foxes are. We need to know their life span, the size of their litters, how far the young move when they strike out on their own. Of importance is the number of times foxes meet, for this determines the likely spread of the virus through one infected fox infecting others.

When an engineered organism is released, CALM and the APB scientists will play a prominent role. If it were possible to release an engineered virus today, research carried out by CALM scientist Dr Dave Algar would provide the ways and means for assessing its effectiveness as a biocontrol agent.

BIOCONTROL BENEFITS

If we can control the rabbit and the fox, we can expect a number of benefits. There should be changes in the flora; the affected fauna would increase; re-introductions would be feasible; fauna management costs would be greatly reduced. Ecologists could address conservation problems without having to contend with the intruding species' confounding impact.

There would be tourism benefits. At present, except for kangaroos, koalas and a few other species, our unique mammals are a visual non-event because of introduced predators. Biocontrol would bring economic benefits by increasing the diversity of species available for display within their natural habitats.

But perhaps best of all, biocontrol would allow us to gather up our families and head for places like Dryandra Forest to observe a wildlife picnic, without uninvited guests. ▣

A CALM scientist fitting a radio collar to a fox caught in the Gibson Desert.
Photo - Ray Smith

Jack Kinnear is a Principal Research Scientist and head of the Introduced Predator Research and Control Unit at CALM's Wildlife Research Centre at Woodvale. He can be contacted on (09) 405 5100.

Australian ADMIRAL

By Robert Powell

The Australian admiral is our version of the stunning red admiral of the northern hemisphere. It can easily be reared from a caterpillar, making it ideal for study by schoolchildren. Naturalist Robert Powell describes the sometimes elusive lifestyle of this admirable admiral.

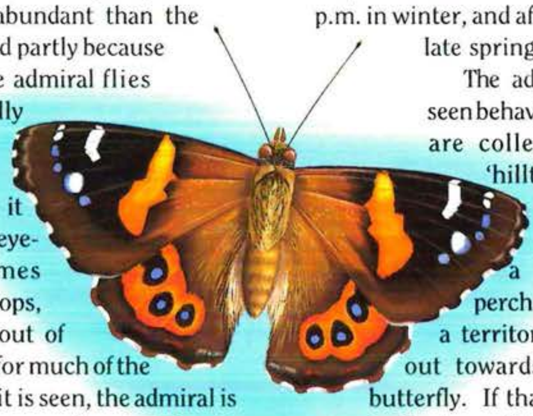
Although known best from eastern and southern Australia, the Australian admiral (*Vanessa itea*) apparently occurs throughout this continent. It has been collected as far inland as the MacDonnell Ranges, and specimens in the WA Museum were taken as far north as Koolan Island and Darwin. The admiral also occurs in New Zealand, Norfolk Island, Lord Howe Island, and east across other islands in the South Pacific to Rapa Island, about halfway between Australia and South America.

Such a wide range is not surprising, given that our admiral belongs to the genus *Vanessa*, many of whose species range very widely indeed. The most notable example is the painted lady (*Vanessa cardui*), one of the world's most widespread butterflies, which occurs through most of Europe, Asia, Africa and North America.

Butterflies of the genus *Vanessa* are of medium size and are brightly coloured, predominantly in reds and blacks. The sixteen species can be divided into three groups, the 'painted ladies', the 'northern admirals' and the 'southern admirals'. The painted ladies, which have rather chequered markings in pinkish-orange, black and white, include the species referred to above and eight further species, most of them in the Americas. The northern admirals are more boldly marked; the commonest one, the red admiral of Europe, Asia and North America, is a striking species that is one of the world's best-known butterflies. The other four species of northern admiral occur chiefly in Asia. There are only two southern admirals: the Australian admiral and the New Zealand red admiral. The Australian species, with large oval areas of pale yellow on its forewings, features a colour that is shared only with two uncommon, tropical species in the genus. In New Zealand it is called the 'yellow admiral'. In that country these two southern admirals have occasionally produced hybrids, demonstrating that they are indeed closely related.

In Australia the admiral's closest relatives are the Australian painted lady (*Vanessa kershawi*), a very common and widespread species in this country, and the 'European' painted lady, the almost cosmopolitan species referred to earlier. The latter has arrived in Australia in recent times, probably from South Africa, perhaps with the help of ships, and has become established around Bunbury.

Some butterflies are highly visible. The introduced cabbage white, apart from being very common, stands out because of its colouring and its relatively slow, floating flight. Many butterfly species, however, are more cryptically coloured, are rare or have elusive habits, or, like many Western Australian 'blues' and skippers, are very small; and they therefore go largely unnoticed by all except butterfly enthusiasts. The Australian admiral is one such. This is partly because it is much less abundant than the cabbage white, and partly because of its habits. The admiral flies fast, and we usually catch no more than a glimpse of it. Moreover, it often flies above eye-level, sometimes round the tree-tops, and is therefore out of our field of vision for much of the time. Even when it is seen, the admiral is not very conspicuous on the wing, despite its bright colouring. It tends to look like a dark blur, but a flicker of its yellow wing markings can often be seen; this enables it to be distinguished from the Australian painted lady and from another fast-flying butterfly, the meadow argus.



Left: Australian painted lady.
Top: New Zealand admiral.
Right: Australian admiral.
Illustrations - Ian Dickinson

Previous page
Main: Wing detail.
Photo - Jiri Lochman
Inset: Butterfly shortly after emerging, its wings still crumpled.
Photo - Matthew Williams

Illustration - Margaret Pieroni

The admiral does settle to feed at flowers. Then one may see it opening its wings in the sunshine: a splendid sight. It should be approached gingerly, as it will usually take off at the slightest disturbance. At other times, the admiral likes to rest head-downwards on tree-trunks. Here, by folding its wings above its body with its hind wings overlapping its forewings, it can conceal itself very successfully.

The best places to find admiral butterflies are hilltops. For quite a number of butterfly species, and also other insects - some dragonflies, for instance - hilltops are where the sexes meet. (We human beings have our own places - clubs, bars, etc. - that serve the same important purpose!) The more prominent the hill, the more chance of finding admirals; Buckland Hill (near the war memorial), Reabold Hill and Mt Flora are good ones on the coastal plain. Go there on a sunny day during the spring months, or in August if it is warm, in the late afternoon (after 3:30 p.m. in winter, and after 5:00 p.m. in late spring).

The admirals will be seen behaving in ways that are collectively called 'hilltopping'. The males establish a number of perching-sites within a territory, and will fly out towards any passing butterfly. If that butterfly is a male, the two will make dashes at one another. Or they will fly around each other in tight circles - which can be interpreted as an aerial combat, or merely a vigorous investigation of each other. Often the two will fly off together into the wind, one behind the other, or in parallel, sometimes rising far up into the air before separating and returning; the purpose of this is even less clear. If the butterfly encountered is a female, the two will fly more slowly, often one close behind the other in a bobbing flight. I have never yet seen mating take place; perhaps the pair go well away from the hill to mate.

Often Australian painted ladies will be hilltopping too. The behaviour of

On Rottnest Island, where pellitory and nettles grow in abundance, Bob Hay, of the Western Australian Insect Study Society, and children from Rottnest Primary School collect pellitory plants and admiral larvae for captive rearing.
Photo - Chas Hansen

the two species on hilltops is very similar. The admirals' territories tend to be concentrated nearer the summit of the hill than those of the painted ladies; and the admirals tend to perch on trees, shrubs or walls, whereas the painted ladies often perch on the ground.

The admiral appears to be comparatively long-lived. In southern parts of Australia butterflies that emerge in summer or autumn are known to hibernate through the winter, appearing again when warmer weather arrives.

MIGRATION

On sunny days in late winter and early spring I have often seen and recorded admirals flying rapidly south. These butterflies were probably migrating, a behaviour typical of the genus *Vanessa*.

Specimens of the admiral collected over its wide range exhibit no regional variation; this suggests that it migrates extensively. In eastern Australia it has been recorded as joining in migrations of the Australian painted lady, which each spring travels south from southern Queensland, as far as Tasmania. What is remarkable is that the admiral can also travel across large expanses of ocean between the South Pacific Islands from which it has been recorded.

Several Australian species of butterfly do occasionally make the eastward crossing from Australia to New Zealand. This often happens when strong westerly winds are blowing while the butterflies are migrating in eastern Australia; apparently some of them are blown off course and carried to New Zealand. Suitable winds could propel them across the 2 000 to 2 500 km distance in two to four days. What is not known is how the butterflies can survive for that length of time without feeding. In order not to fall into the ocean they must fly actively, and this uses up energy. They probably drift as much as possible, or make lazy wing movements. The opposite journey - from east to west - must be very uncommon, as the prevailing winds are westerly.

FOOD-PLANTS

'Food-plants' refers to the plant species on which a butterfly's eggs are laid and on which the larvae feed. (All adult butterflies, on the other hand, feed on fluids, such as nectar, by means of a roll-up tube called a proboscis.) Many species of butterfly are limited to a very narrow range of food-plants. The caterpillars of the Australian admiral feed only on plants in the nettle family. In eastern Australia they use both a native species of nettle (*Urtica incisa*) and the introduced common stinging nettle (*U. urens*). In Western Australia, where there are no native nettles, introduced nettles have been the only known food-plants.

Until recently, that is. A few local naturalists interested in butterflies believed that there must be a native food-plant for the admiral in Western Australia. The only likely candidate was pellitory (*Parietaria debilis*), a small annual plant that, whilst in a different genus from the nettles, belongs to the same family, and is the only member of the nettle family native to south-western Australia. On Rottnest Island, pellitory and stinging nettle grow in abundance, in some places side by side. On both of these plant species I observed caterpillars that looked like admiral larvae, some of them in shelters typical of those made by admiral larvae. Some of the larvae found on the Rottnest plants were subsequently reared in captivity on pellitory. The larvae grew, pupated and hatched into healthy admiral butterflies: pellitory as a food-plant was confirmed.

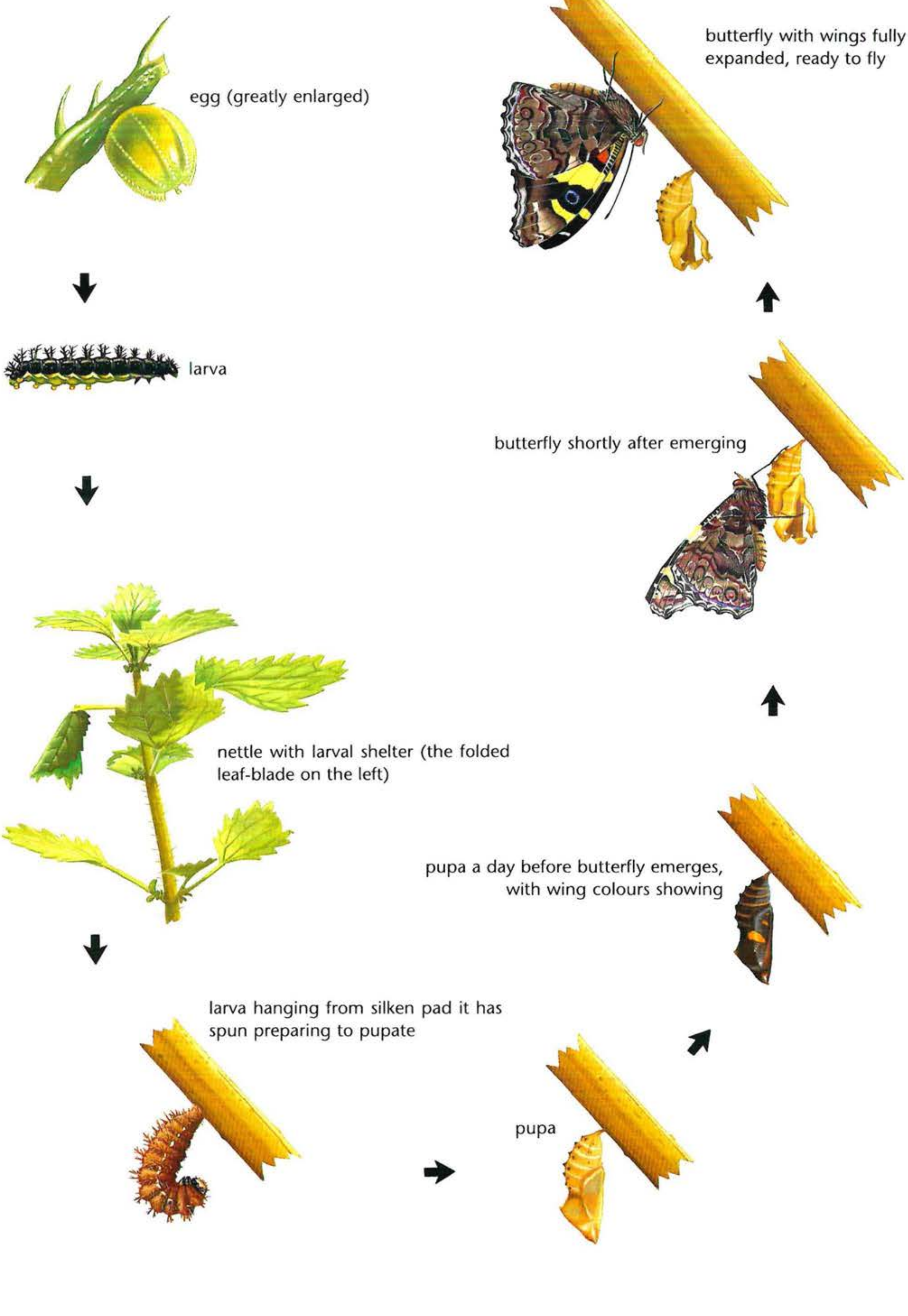
Since then, I have also examined another type of pellitory (*Parietaria judaica*), an introduced perennial species from western and southern Europe, which has become established in parts of Fremantle, and found empty admiral pupal-cases adjacent to these plants on limestone walls in laneways south-west of the Fremantle markets. As there were no other obvious food sources in the vicinity, it is reasonable to suggest that the admiral uses this plant too.

The native pellitory has declined in the South-West, as a result of agricultural clearing, urbanisation and competition from weeds. Where native plant species

Pellitory (*Parietaria debilis*), the Australian admiral's native food-plant in south-western Australia.
Illustration - Ian Dickinson

THE LIFE CYCLE OF THE ADMIRAL

Reference photographs by Matthew Williams.



decline, so do most of the insects and other animals that depend on them. The admiral butterfly, which continues to prosper, is an exception. By being able to transfer to introduced plants, it has survived the decline of its natural food source and has become, to some degree, domesticated.

REARING CATERPILLARS

An ideal way for schoolchildren and others to learn about the life-cycle of an insect is to rear insect larvae in captivity, and the admiral is one of the easiest Australian butterflies to rear.

First, find some nettles. A market-gardener, or even a home vegetable-grower, may have them, and be pleased to give some away! In late winter or early spring these plants, particularly if they are growing in abundance, are likely to be supporting admiral larvae. Look for the larvae, which may be very small, or may betray themselves by their shelters. Pot one or two plants that have larvae on them, and several more plants for further feed. Remove from them any spiders (which kill caterpillars) and preferably any slender green caterpillars, which will be the larvae of the silver-Y moth. Keep the plants with admiral larvae indoors, in a room that is not too dark. If possible, keep them in a transparent or translucent enclosure - such as an aquarium with a bit of cloth over the top, weighed down around the sides with pegs.

An enclosure serves two purposes. It prevents the older larvae, which often leave the food-plant during the day, from wandering too far. It also keeps out spiders - particularly important if, like me, you hate to discourage them from sharing your home with you.

The main maintenance thereafter is to water the nettles once every few days to keep them alive, and to provide further nettles once the existing plants have been eaten.

The larvae shed their skins four times during their development as caterpillars. To do so they may make a shelter and retreat into it for a day or so. The periods between the skin changes are called 'instars'. After a larva of the fifth, and final, instar has been eating and growing for five or six days, it will leave the food-plant and seek the underside of a horizontal surface, such as the top of the enclosure. It will attach its rear end to a small silken pad it has spun and will hang head-downwards, curled into the shape of an inverted comma. It will then form into a chrysalis. This stage (pupation) will last ten to eighteen days, depending on the temperature. A day or two before the butterfly emerges, wing colours begin to show through the chrysalis. The butterfly will emerge at a time of day when the temperature is rising, usually in the morning and often quite early.

ADMIRALS IN THE GARDEN

Another way to breed butterflies is to grow their food-plants in the garden. This requires a different approach to gardening - one that aims to benefit conservation by considering the garden as a place not only for plants, but also as habitat for insects and other animals. Australia could follow the example of other countries such as the United Kingdom, where this approach has received much attention. It is particularly appropriate in expanding urban regions such as Perth.

Those of us who enjoy the challenge of propagating new plants should try to establish native pellitory in our gardens. We may then find that we experience the satisfaction of having the Australian admiral breed there each year. ▣

ORIGIN OF NAMES

The Australian admiral is so named to identify it as a relative of the red admiral, a common summer immigrant to England. The *Oxford English Dictionary* (*OED*) quotes a book of 1720 on the natural history of English insects as an early use of the name admiral: 'A most beautiful Fly called the Admiral Butter-fly'. The meaning of the name is interesting. The *OED* considers that it may have had nothing to do with the navy, but may have been a contraction of 'admirable'; in another book on natural history, of 1798, the butterfly was referred to as the 'red admirable'. In those days 'admirable' meant 'surprising' and 'wonderful', rather than 'something of which one approves'.

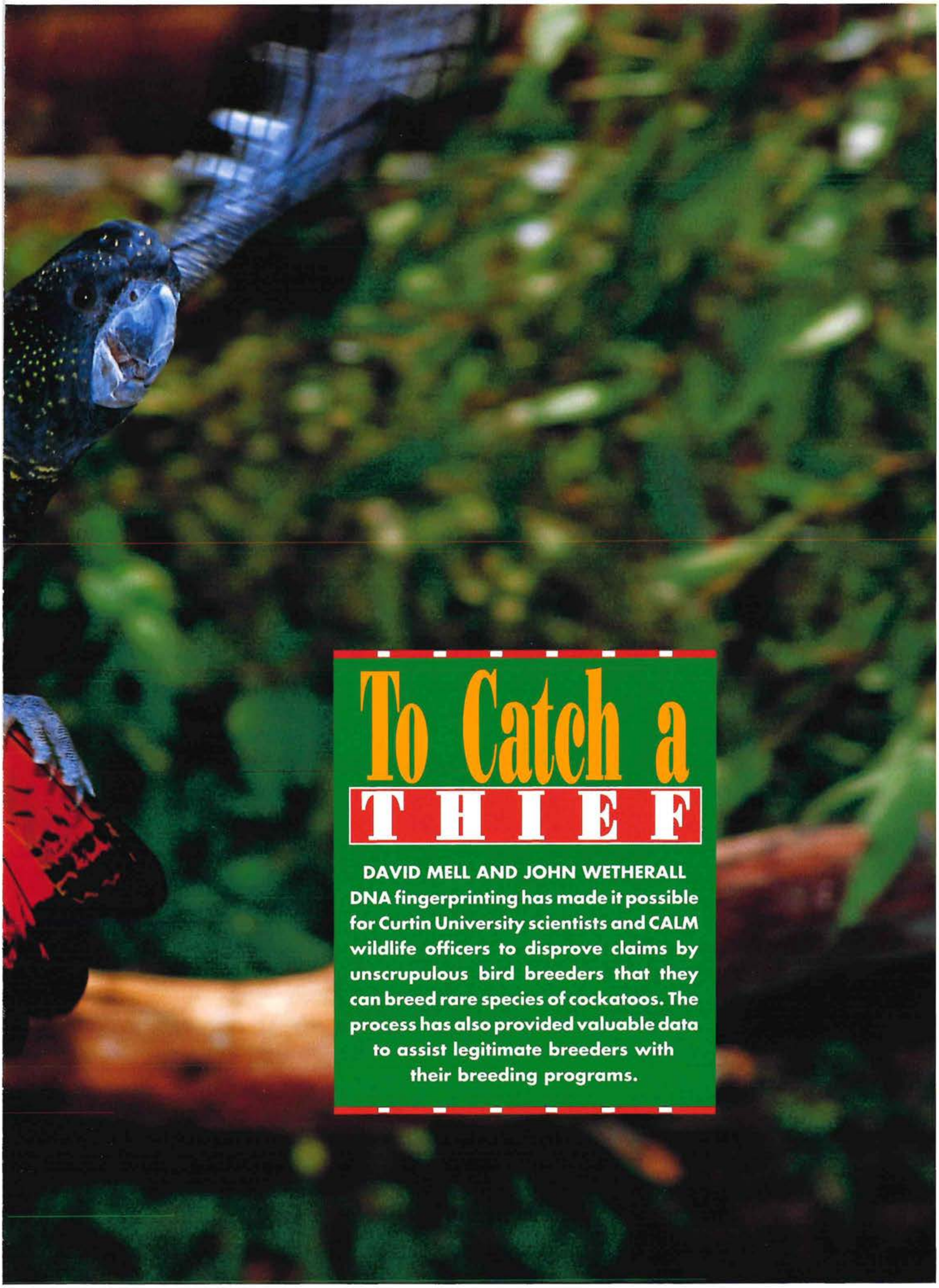
The Australian admiral's scientific name is *Vanessa itea*. 'Vanessa' is the 'wondrous maid' of Jonathan Swift's poem *Cadenus and Vanessa* (published 1726). The species name, 'itea', was published in 1775, but no explanation of its origin or meaning was given.

Spot formed by excretion of waste products after the butterfly emerges from its chrysalis. The colour varies depending on the food-plant and the butterfly species.

Caterpillar of the silver-Y moth, another species found on nettles. The cocoon is often parasitised, and many tiny wasps emerge instead of a moth.

Photos - Robert Powell

Robert Powell began observing butterflies in his childhood. He is a member of the Western Australian Insect Study Society, which can be contacted by ringing Terry Houston at the WA Museum, on (09) 328 4411.



To Catch a THIEF

DAVID MELL AND JOHN WETHERALL

DNA fingerprinting has made it possible for Curtin University scientists and CALM wildlife officers to disprove claims by unscrupulous bird breeders that they can breed rare species of cockatoos. The process has also provided valuable data to assist legitimate breeders with their breeding programs.

White-tailed and red-tailed black cockatoos are widely recognised as being difficult to acquire and breed. Before 1987 very few Western Australian aviculturists had successfully bred these highly valued birds. However, during 1987 and 1988 claims of breeding success increased dramatically.

Scarce and in demand, red-tailed black cockatoos (*Calyptorhynchus magnificus*) retail within Australia for $5 000 a pair, and Baudin's white-tailed black cockatoos (*Calyptorhynchus baudinii*) at $3 000 a pair. Smuggled overseas, these birds fetch far greater prices.

At about the same time as the increase in claims of breeding successes, wildlife officers from the Department of Conservation and Land Management (CALM) noted a disturbing rise in nest-robbing activities in various parts of the natural range of both species. They suspected that many young birds were being removed from nesting sites and were entering the WA aviculture trade as 'bred' birds. It became apparent that a laundering racket existed within the avicultural industry; for example, any licensed aviculturist with a pair of rare cockatoos could claim to have bred offspring from them in captivity. The wildlife officers were faced with the problem of determining the truth of breeding claims.

In Europe, a new scientific technique, referred to as 'genetic fingerprinting', had been applied to verify claims of captive breeding of hyacinth macaws (*Anodarhynchus hyacinthinus*), in a well publicised prosecution of two Dutch bird dealers. With this in mind, CALM wildlife officers David Mell and Kingsley Miller approached Associate Professor John Wetherall of Curtin University's School of Biomedical Science to see if the technique could be applied to cockatoos in Australia.

Professor Wetherall and David Groth are leading authorities on DNA fingerprinting in Australia. They had successfully applied the technique to many animal species and have used it in high value stock-breeding programs.

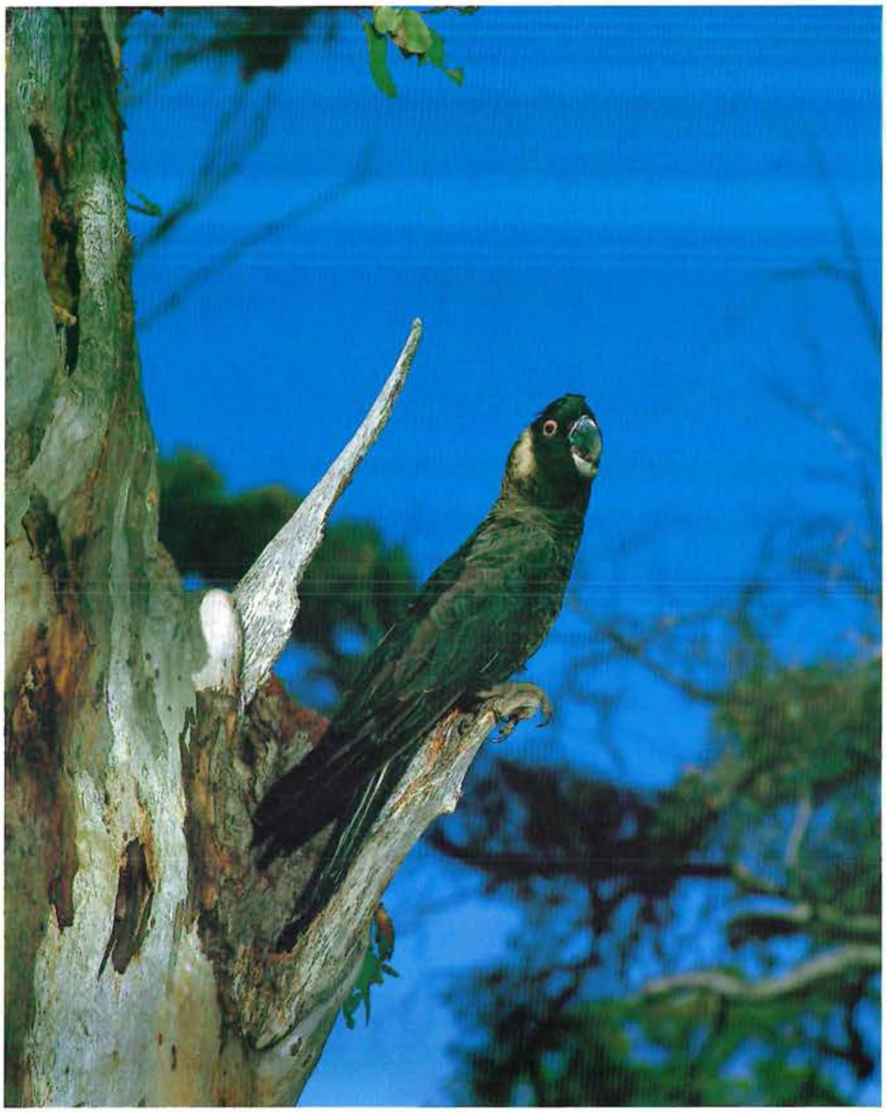
Genetic fingerprinting is the scientific analysis of DNA (deoxyribonucleic acid), the main constituent of the chromosomes of all organisms. The examination of DNA for a particular group of genes can determine the family relationship of individuals of that species. Genetic fingerprinting has been used successfully to convict serious criminals, such as rapists and murderers, and clear those falsely charged with such crimes.

Wetherall and Groth told CALM they could assist with the DNA fingerprinting of cockatoos, but it would depend on establishing a database of DNA profiles of a small number of individuals and family groups of birds.

CALM successfully sought funding for the establishment of a DNA database from the Australian National Parks and Wildlife Service's (ANPWS) States Cooperative Assistance Program. John Ingram from CSIRO and Gary Martin from the Agricultural Protection Board provided valuable assistance with blood collection from wild, as well as captive, red-tailed and white-tailed black cockatoos.

A small sample of blood (1 millilitre or less) was required from each bird, and was extracted from the bird's wing veins. Every effort was made to minimise stress on the birds. During the entire operation more than 100 birds were tested and none developed any problems from the process.

Previous page:
Red-tailed black cockatoos are scarce in the wild, and prices for captive birds are high.
Photo - Robert Garvey



The white-tailed black cockatoo is confined to the south-west of Western Australia, and a valuable catch for unscrupulous bird breeders.
Photo - M&I Morcombe

As a result of their research, Curtin University scientists advised CALM they had extracted DNA and recorded DNA bands which identified parent-progeny relationships in cockatoos.

Wildlife officers subsequently called on aviculturists who had claimed to have bred young red-tailed and white-tailed cockatoos. Thirty-six birds - 30 white-tailed black cockatoos and six red-tailed black cockatoos - were taken from nine aviculturists. Of the nine aviculturists who had their birds DNA-tested, the technology proved that one breeder had been successful as claimed. In this case the aviculturist had cooperated with wildlife officers, volunteering his birds for testing. The other eight all claimed breeding success, but subsequently many admitted that most of the young cockatoos had been taken from the wild.

A number of other birds were also seized from aviculturists who readily admitted that their claims of breeding successes were untrue. Most of these birds had been acquired from the wild unlawfully.

Word quickly spread among aviculturists that DNA technology was being used and there was a sudden decline in red and white-tailed black cockatoo breeding claims. In addition to the use of DNA technology, the knowledge that the DNA technique was available had an immediate effect as a deterrent.

To date, four cases have been dealt with in court. In all cases the birds were forfeited to the Crown and the aviculturists heavily fined.

The use of DNA technology has resulted in a more accurate reflection of

Above left from top to bottom:
Wandoo woodland is ideal nesting country for white-tailed black cockatoos.

Wildlife officers cover holes cut by nest-robbers with sheets of tin so the nesting hollow can continue to be used by cockatoos.

Red-tailed black cockatoos usually lay only one egg in their salmon gum nest hollows.
Photos - Jon P. Green

Top right:
Blood samples from yellow-tailed black cockatoos in South Australia have been sent to WA for DNA fingerprinting to give the species greater protection.
Photo - Jiri Lochman

Right:
Chicks aged 8 - 11 weeks are most often stolen from the nests, although eggs and younger chicks are also taken.
Photo - Jiri Lochman

Far right:
Red-tailed black cockatoos are found in the south-west where they are scarce, and in the Kimberley.
Photo - Robert Garvey

breeding success claimed by aviculturists. The few who continue to claim breeding success have cooperated with wildlife officers and willingly offered birds for DNA testing.

DNA technology has also been applied to the management of naretha blue bonnets (*Northiella haematogaster narethae*). This sub-species is very rare in captivity and is consequently a target for poaching.

CALM approved the capture by a private aviculturist of 40 narethas in January 1991. This founder colony will be used to establish a captive breeding colony to make the birds available to the avicultural industry.

The birds were DNA fingerprinted and a database of the profiles was established. Comparison of the DNA profiles of new birds in the future with the database can determine if they were derived from the original stock.

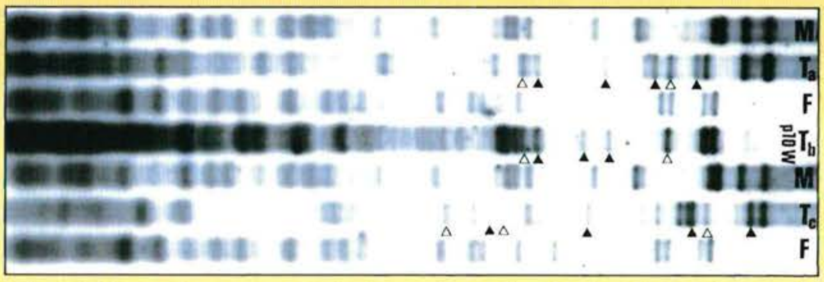
Parent-progeny relationships can also be substantiated. Entry of illegally captured narethas into the avicultural trade can be prevented, thereby protecting stocks in the wild from poaching.

It is hoped that CALM can continue to work closely with aviculturists to ensure that wild stocks are properly protected and do not enter the industry illegally. A benefit for aviculturists is that DNA technology allows them to verify a bird's legitimacy and can provide genetic information for breeding purposes, improved security for high-value birds and the potential to identify the sex of immature birds.

Other State wildlife authorities have noted the successful use of DNA fingerprinting in Western Australia. South Australian authorities have already sent blood samples to Curtin University from Major Mitchell and yellow-tailed black cockatoos, two species that are targeted by nest-robbers and found to be entering the avicultural industry in that State as 'bred' birds.

The establishment of databases for these and other species can ultimately assist all States in managing aviculture to ensure the protection of parrot and cockatoo populations in the wild.

The technique can also help to prevent the illegal introduction of exotic birds by proving whether birds have been bred in Australia or have been illegally imported.



DNA FINGERPRINTING AND BIRDS

DNA (deoxyribonucleic acid) is said to be the"stuff of life", as every living organism has DNA packaged into chromosomes. The chromosomes are in turn made up of genes which control the working of each cell in the body. It has been scientifically established that every human has unique DNA and half of a person's DNA comes from the father and half from the mother.

These principles are used in the process of DNA fingerprinting, which was first discovered by scientists in the United Kingdom in 1985.

THE METHOD

The technique of DNA fingerprinting, as used in forensic science, has been applied to bird blood samples, both overseas and now in Western Australia.

Firstly, a small blood sample (less than one millilitre) is taken from the wing vein. Then the membranes of the blood cells are ruptured (lysed) to release the DNA, which is separated from the impurities until a purified sample is collected.

The DNA is then cut by biological scissors, called restriction enzymes, into smaller fragments. The soup of fragments is loaded onto an agarose gel in an electrolyte solution. An electric current is then applied and the fragments move through the gel.

The smaller fragments move further than the large pieces, thus producing a gradient of fragments. The separated fragments are transferred onto a nylon membrane by a process called "Southern blotting".

The gel is then discarded. The membrane containing the DNA is dried and treated to irreversibly fix the DNA onto the membrane.

A solution of DNA probe containing radioactive phosphorus is prepared and added to a bottle containing the membrane. The probe binds to each fragment of DNA on the membrane which it recognises.

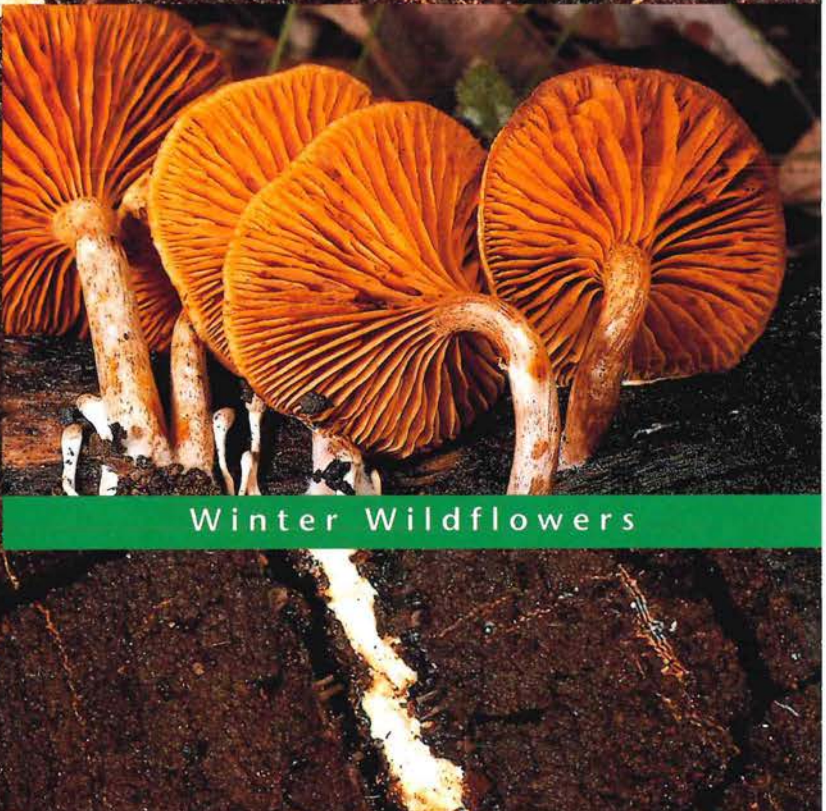
Excess probe is washed from the membrane, which is exposed to an X-ray film. The radiation emits small packages of light onto the X-ray film in the same position as the "hot" DNA on the membrane. The result is a series of dark bands on the developed film, much like a bar code.

David Mell is Chief Wildlife Officer with CALM and can be contacted on 367 0292.
John Wetherall is Associate Professor at the School of Biomedical Science, Curtin University and can be contacted on 351 7375.
The authors acknowledge the valuable assistance of Kingsley Miller, Special Investigations Officer with CALM, David Groth, Scientific Officer, and Graham Hall, Research Scientist with the School of Biomedical Science, Curtin University, in the preparation of this article and the work involved in this project.

Fungi

Text and photos by Gerhard Saueracker

Western Australia's springtime wildflower display is world-renowned, but its more subtle winter equivalent is relatively unknown.
Fungi have a beauty of form, if not of colour, that while not as widely appreciated as wildflowers, has a distinction all its own.



Winter Wildflowers

Many of us wait for spring, when the bush comes alive again with the colours of wildflowers, but the quiet winter months can display an equally wonderful, though far more subtle, array of beauty.

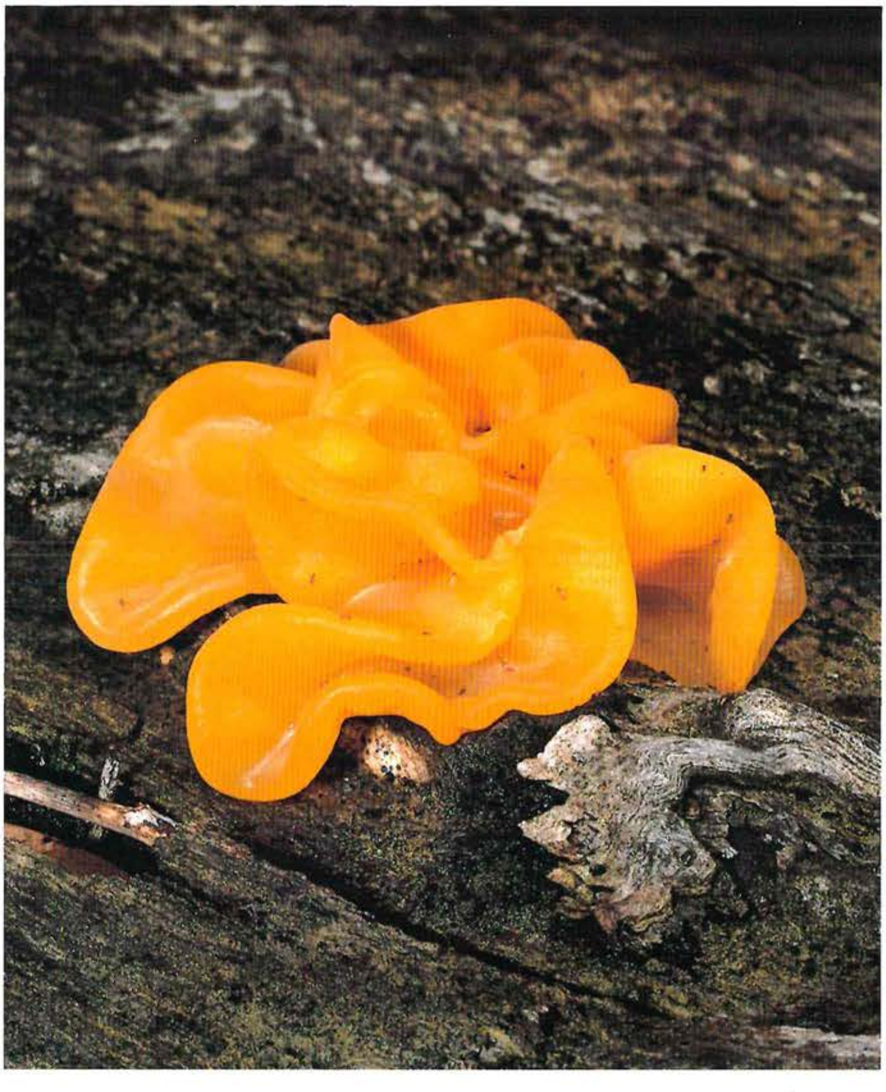
The features of the winter rain-washed forests are less obvious than those of the spring. Fungi, with their interesting shapes, textures and colours, are at their best when the weather is at its worst. However, even in the depths of winter there is an occasional clear, crisp day when feeble sunlight breaks through, and this is the time to pay an invigorating visit to the forests in search of the winter wildflowers.

A likely place to look for fungi is on fallen trees. Standing out like a beacon on the dark wood of a rotting eucalypt, the bright yellow to orange colours of the jelly fungus are a vivid exception to the usually pale fungi. This convoluted, gelatinous fungus is found not only on fallen timber; it may also sprout from the erect stems of dead saplings.

On a sapling, jelly fungus is likely to be the only fungus present. On a giant log there may be an entire community of fungi, many belonging to a group called agarics, more commonly known as mushrooms and toadstools.

The agarics of rotting wood are tiny structures with conical or rounded caps, often delicately fluted, perched on elegantly thin stems. They make quite a contrast to the ponderous logs from which they sprout.

Like the stouter field mushroom, which makes a brief appearance in the paddocks, the agarics of rotting wood are short-lived. Their transient nature is partly due to their makeshift construction: agarics maintain their shape by inflating their cells with water. Warm or dry weather speeds up the loss



Previous Page Main:
A sawn eucalypt log reveals the white mycelium of invading fungus.
Inset: Gymnopilus penetrans is frequently found on dead wood, particularly on fallen banksia. The loosely attached bark can be peeled away to reveal the fungal mycelium.

Left:
The brilliant hue of the jelly fungus makes it our most obvious fungus. It grows on dead wood, from standing saplings to massive fallen logs.

Top left:
The bright underside of the scarlet bracket fungus reveals the pores that characterise so many of the bracket fungi.

Top right:
This group of pretty grey bonnets was growing on a living tree, but the cleft in the bark indicates that they may be colonising dead wood in an old wound.

of water from such fungi and hastens their demise. The jelly fungus also shrivels in warm weather, but unlike the agarics it can resume its shape when rehydrated by rain.

Although we usually imagine the umbrella-shaped agarics sprouting straight up out of the ground, they may sprout from any surface of a log, even the underside. No matter what angle the fungus starts at, the stem curves around to the vertical and the cap on the end remains horizontal. This allows the spores found in the gills - the radiating vertical plates on the underside of the cap - to be released and to fall away under gravity without being trapped.

Also found on logs are the bracket fungi. Easily recognisable, they grow as horizontal semicircular plates. They are constructed of thick-walled fibres, or fibrils, reinforced by other branched fibrils which bind the structure together and give it a tough, leathery consistency. As they do not owe their shape to moisture-swollen cells, they are not dried out by warm weather, and their remains may be found throughout the year. However, they lack the delicate forms of the winter fungi.

The underside of most bracket fungi is covered with pores instead of gills, hence the alternative name 'polypores'. The pores serve the same function as gills: the release of spores.

Although the bracket fungus grows horizontally to release spores, it is possible to find it in a vertical position. This is because the fungus remains in place even after the tree it is growing on has toppled over. A bracket which was horizontal on a standing tree becomes vertical when the tree falls. Any new brackets and additional growth will be horizontal, allowing us to differentiate between the two types of bracket fungi: beneficial and parasitic.

The beneficial bracket fungi break down dead wood, so they are only likely to grow after a tree has fallen. They will be the horizontally growing fungi. On the other hand, the parasitic bracket fungi, which grow on living trees and contribute to their death, will become vertical when the tree has fallen over and will cease to grow.

FUNGAL FRUIT

The bracket and jelly fungi, mushrooms and toadstools all disperse spores. These spores are the equivalent of fruit which carries seed. But if they are the fruit, where is the tree? The business end of wood-attacking fungi is inside the log. Fine fibrils, each composed of a single strand of elongated fungal cells, grow through the wood, digesting it as they go. When conditions are right, a mass of cells grows to the surface, and there forms the familiar mushroom, toadstool or bracket. On banksia limbs, the loosely attached bark can be peeled away to reveal the furry white fungal mass running along inside the bark until it finds a gap and sprouts into the open. This fruiting body can broadcast spores a lot further afield than the fungus itself can grow.

Fungi are not only found on logs. The principal food of many is dead plant matter, which is distributed thinly over the forest floor. Logs are essentially large concentrations of such matter, inhabited by concentrations of fungi.

This leathery non-pored bracket fungus projects from decaying logs as a small ledge banded in shades of yellow, orange and brown. It has a hairy upper surface, a characteristic reflected in its scientific name - *hirsutum* - meaning hairy.

Soils of the bush also support fungi, but these fungi are more isolated than those of the logs, and finding them requires a more careful search.

The coral fungus, the most obvious of the forest floor fungi, is bright yellow, like the jelly fungus. It looks as if it would be more at home under water. Nevertheless it is quite common in the jarrah forests of the Darling Scarp.

Other fungi are less common or perhaps just less obvious. Brown fungi blend in well with the leaf litter of the forest floor. Particularly hard to see is one species with a rounded cap which mimics the gumnuts of the marri trees under which it grows.

These beautiful little cup fungi were well disguised amongst the orange gravel of the Darling Scarp.

MYCORRHIZA

Top:
This fungus in the 'split-gill' group was found growing on a dead eucalypt sapling. Though it has the gills of a mushroom, it has the shape of a bracket fungus, to which it is related.

Coincidentally camouflaged, the rounded cap of this toadstool makes it almost invisible amongst the gum nuts beneath a marri tree. Although it appears to have sprouted from the ground, this fungus has probably risen from some buried wood, as it belongs to a group known to grow on wood.

Fungi can be essential to the growth and survival of many trees and plants. This symbiotic relationship is known as mycorrhiza.

Fungi and roots form two basic types of mycorrhizal association. In one (known as vesicular-arbuscular mycorrhiza) the fungi extend from the soil right into the cells of the roots, but the fruiting bodies of such fungi are underground and microscopic. In the other (known as ectomycorrhiza) the fungi form sheaths around the outside of certain roots; fungi which do penetrate the root run between the host cells. These are found in eucalypts and form fruiting bodies above the ground where they may be seen by the amateur observer.

Such associations of fungi and roots are common, and certainly not confined to eucalypts. Indeed, they occurred before eucalypts - or even flowering plants - evolved, in such primitive plant groups as ferns and cycads (the zamia palm of the west, and the burrawang of eastern Australia) which now grow in the forest understorey shaded by the eucalypts.

Even before plants had roots, mycorrhizal fungi probably aided water and nutrient absorption, as their presence has been shown in the 400-million-year-old fossil stems of a delicate, rootless, leafless ancestral plant called *Rhynia*. But to the modern eucalypt, growing in the ancient, leached soils of Australia, any ploy to extract more nutrients is important, and all species of eucalypts whose roots have been examined show evidence of symbiosis with fungi.

Co-operation of plant and mycorrhizal fungi, however, is not sufficient to explain the growth of tall, productive eucalypt forests on soils which elsewhere in the world could barely support tree growth. After all, introduced pines have mycorrhiza, but grow poorly on soils which supported vigorous eucalypt forests.

The answer probably lies in the extensive root system and fine roots which enable eucalypts to fully use available nutrients and find sufficient water in an often dry land. This may also be a factor in the susceptibility of eucalypts to fungal diseases.

SYMBIOSIS IN THE FOREST

But fungi are more than winter decorations. Just as the wildflowers of spring herald a new generation, the fungi are signs of new growth. For even as they decompose logs and leaf litter, they recycle nutrients which plants of the forest need if they are to grow. Further around the cycle, when the plants are taking up these nutrients, fungi are involved again. Some fungi grow in and around plant roots where, together, the roots and fungi form a structure called a mycorrhiza. Mycorrhizal fungi facilitate the uptake of essential nutrients by plants, a vital role in our nutrient-poor soils (see 'In Search Of the Perfect Pine', *LANDSCOPE*, Autumn 1992). In the floors of Western Australian forests, these fungi are more important than those feeding on dead plant matter; indeed all eucalypts whose roots have been examined show evidence of mycorrhiza. In exchange for the nutrients, the trees provide the fungi with energy in the form of sugars, so both partners benefit. Some of these fungi grow up to the forest floor and form a fruit, most commonly of umbrella-like form.

Unlike the masses of springtime wildflowers, fungi are seldom visible from the window of a tourist coach. However, for the visitor who is willing to get out into the forest, they are an attraction whose delicate features rival the wildflowers' colours during a season when few plants are in bloom.

Gerhard Saueracker is a well-known photographer. His photographs have appeared in *LANDSCOPE* and diving magazines. Photographing the fungi of WA has led him to research them further. Gerhard works in medical research and can be contacted after hours on (09) 367 1194.

MANAGING THE MIDGE

BY ADRIAN PINDER, JENNY DAVIS AND JIM LANE

On a typical spring or summer evening, millions of small flies can be seen emerging from many of Perth's urban wetlands. They form dense swarms in swirling columns around the shores, and being attracted to lights, they are a nuisance in nearby residential areas. While they do not bite or sting, their sheer numbers prevent many outdoor activities such as jogging or entertaining. These flies, commonly known as non-biting midges and belonging to the insect family Chironomidae, are one of the more obvious environmental problems associated with urban wetlands in Perth.

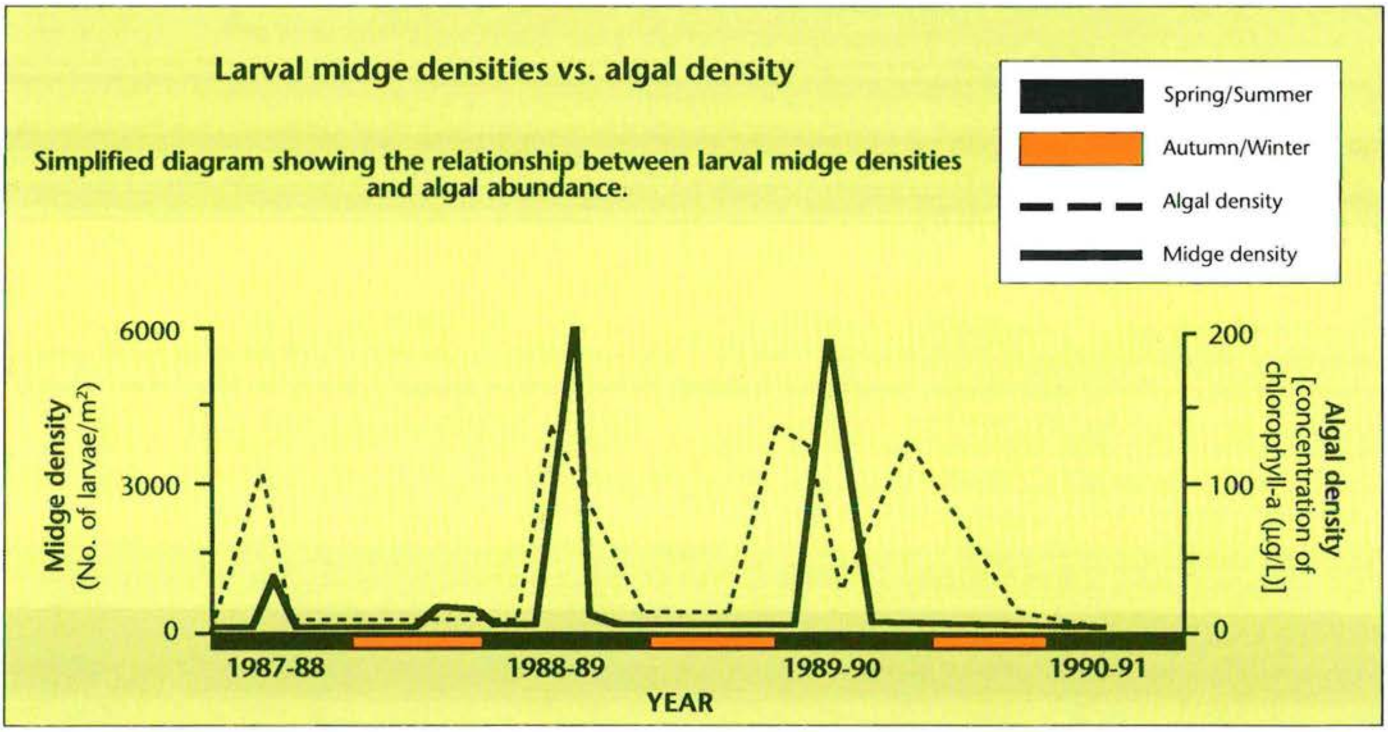
There are several types of difficulties caused by these midge swarms. As some species are small enough to pass through the holes in flyscreens, windows cannot be left open on hot summer nights. If windows are left open for ventilation, the lights must be turned off. Outdoor entertaining in the evenings becomes impossible. Dead midges are often found piled high on window sills and may also stain laundry hung out to dry. The huge number of midges provides nightly banquets for spiders, which cover patios and verandas with their webs. Walking, jogging or cycling around lakes becomes unbearable as midges get in eyes and mouths. Driving, too, may become hazardous as dead midges smear thickly on windscreens and roads.

Jackadder Lake - the original fringing vegetation has been replaced by steep banks and lawns, resulting in low densities of midge predators.
Photo - A. Pinder

Previous page
Inset: **An adult midge, *Kiefferulus intertinctus*. Large numbers can occur around Perth wetlands.**
Photo - K. Trayler
Main: **Food for midge larvae - an algal bloom at North Lake.**
Photo - S. Rolls

Adult chironomids, unlike mosquitoes, do not have biting or piercing mouthparts and so are not vectors of disease. However, there are some reports of people being allergic to the haemoglobin in the bodies of adult midges; this has been implicated in such complaints as asthma and conjunctivitis.

Until recently, the traditional remedy to these problems was to kill the aquatic midge larvae using the insecticide Abate® (temephos). However, midges appear to be building up a resistance to this insecticide. Partly in response to this, a research steering committee was established in Perth in 1987 to guide research into more effective, economic and environmentally acceptable methods of midge control - the aim is not to eliminate the midges, but to control them, as midge larvae are an essential part of aquatic ecosystems. Some of the wetlands where midge problems occur are nature reserves (for example, Forrestdale Lake) and so it is especially important that the food chains of these ecosystems are not overly disrupted by pesticides. After four years of research carried out by a Murdoch University study team, new methods of control are being proposed.



MIDGES AND WETLANDS ECOLOGY

Nutrient enrichment and the degradation of wetlands is believed to be a major factor in the high densities of midge larvae in lakes. Generally, the most nutrient-enriched lakes have the worst midge problems.

Undisturbed wetlands on the Swan Coastal Plain are characterised by complex food webs. The growth of algae is limited by low nutrient concentrations, grazing by zooplankton, and by naturally occurring coloured compounds (resulting from the decomposition of plant material, such as leaves from fringing vegetation) which limit the availability of light. The algae that is not eaten eventually sinks to the bottom of the wetland, where it contributes to the organic debris (known as detritus) and is consumed by a variety of microbes and invertebrates, including midge larvae. Those midges that feed on decaying plant and animal matter help to recycle such material and so help to keep the food chains flowing, effectively acting as nature's vacuum cleaners in wetlands. The zooplankton and the detritivores in turn either fall prey to the predatory invertebrates (such as dragonfly larvae and beetles) and vertebrates (such as tortoises and birds) or themselves add to the detritus. Nutrients, released from the detritus and from excretion by the animals, return to the water column to fuel algal growth, so continuing the cycle.

Disturbed wetlands are often excessively enriched with nutrients and have most of their natural fringing rushes and woodland removed. The high availability of nutrients encourages growth of a type of algae (blue-green) that is not readily digested by the zooplankton. These algae, fuelled by the excessive nutrients, form blooms that collapse and become the basis of a rich food source for midge larvae.

Many animals that would ordinarily prey on the midge larvae rely on catching their prey by sight. During a dense algal bloom they are no longer able to see their prey. This effect, combined with low oxygen concentrations caused by decaying algae, the effects of other pollutants and the reduced habitat diversity associated with the loss of aquatic vegetation, results in low densities of predators and favourable conditions for midges.

Nymphs of the dragonfly *Hemianax papuensis* which occur in the urban wetlands are natural predators of midge larvae.
Photo - S. Rolls

The larval midge *(Chironomus occidentalis)* can occur in very large numbers in Perth wetlands. The larvae inhabit the sediments where they feed, and pass through four stages (instars) before pupating.
Photo - S. Rolls

Decomposing algae at the edge of North Lake - an abundant source of food for larval midges.
Photo - S. Rolls

CONTROL BY CHEMICALS

Chemical control of midges was initiated in the 1950s when organochlorine pesticides were applied to wetlands to kill larvae. Use of these chemicals ceased in the late 1960s and the organophosphate insecticide Abate® was used instead. This chemical is still the only registered insecticide for midge control in WA.

In recent years Abate® has declined in effectiveness at some Perth lakes, most likely because of genetic resistance in midge populations and the increased abundance of algal blooms in the water. One aim of research at Murdoch University has been to find an alternative chemical for use in short-term control programs.

Several different pesticides have been assessed. However, most were considered unacceptable from an environmental viewpoint or were not effective in controlling midges.

One chemical, Sumilarv® (pyriproxyfen), was effective in field and laboratory tests. Sumilarv® is known as a juvenile hormone analogue - a synthetic chemical which mimics the effects of a naturally occurring insect growth hormone. When mature midge larvae are exposed to this artificial hormone their natural hormone balance is upset and they are unable to develop into pupae and adults. However, some adverse side effects, such as changes in invertebrate community structure, cannot be ruled out and these aspects are still under investigation.

Because resistance to this chemical is likely to develop with persistent use, Sumilarv® will only be useful as a short-term control option. It will not provide a permanent solution to Perth's midge problems.

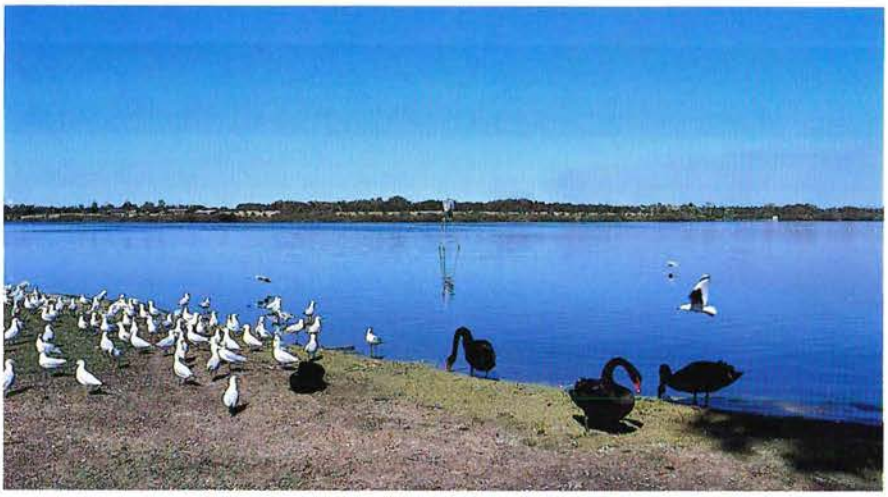
AN INTEGRATED APPROACH

Chemical control is only one of a variety of modern pest control techniques. Others include biological control (such as predation and parasitism), light traps, in-lake modifications (such as nutrient binding), public education, and improved environmental management and land-use planning.

Light traps exploit the natural attraction of midges to bright lights. These can be placed close to the lakes and away from residential areas to reduce the number of midges in the suburbs. Such light traps have been installed at Lake Monger by the City of Perth, with the dual purpose of midge control and footpath lighting, and preliminary studies indicate that these may form an effective component of an integrated approach.

Many attempts have been made overseas to control chironomids by using insect diseases, parasites or predators, i.e. by biological control. These attempts, however, have generally been unsuccessful or have had deleterious effects upon the environment. The dangers of introducing exotic species to control pest populations have been exemplified by the case of the infamous cane toad (*Bufo marinus*) of Queensland. The introduced mosquitofish (*Gambusia affinis*), which has been used (largely unsuccessfully) in attempts to control mosquitoes, is present in high numbers in many wetlands where midge problems occur. But it does not appear to feed on the sediment-dwelling midge larvae unless there is nothing more accessible to eat.

Preventing further nutrient enrichment of wetlands and rehabilitating those that are already degraded must form an integral part of midge control in the long term. In essence, this will involve improved management of wetland catchments, possibly with some in-lake work for the worst-affected sites.



Above left:
A light trap installed on the edge of Lake Monger to attract and collect adult midges.
Photo - A. Pinder

Above right:
Aerial photograph of Lake Monger and Herdsman Lake. The greeness of Lake Monger is a result of the presence of a large algal bloom.
Photo - from the Perth Road Guide Services

Below:
The lack of fringe vegetation at Bibra Lake means that swarms of midges move easily to nearby well-lit residential areas.
Photo - A. Pinder

MANAGEMENT

Sources of nutrients to wetlands include agricultural and urban runoff, leakage from septic tanks, and abandoned tip sites, which were often located in or near wetlands in the past. Nutrients from these sources enter wetlands either through the groundwater or via surface runoff, for example stormwater drains. Many of these sources can be reduced by appropriate land management practices.

In urban areas, much of the nutrient matter that enters wetlands is derived from fertilisers and detergents, which are either washed into drains or seep into the groundwater. Slow-release fertilisers or, even better, gardens that require minimum fertilisation, are ways to reduce this source. Phosphorus-free detergents are also preferable.

Sometimes it may be desirable to divert urban or agricultural drains away from wetlands. In other situations, nutrients can be chemically stripped from the drainage water before it enters the wetland. Where septic tank leachate is a source of nutrients, connection to deep sewage networks should be considered.

Fringing vegetation, such as rushes, sedges and paperbark woodlands, is important for natural wetland functioning. Its removal leads to loss of habitat diversity and thus a reduced diversity of invertebrate and vertebrate fauna. This type of vegetation can also absorb much of the nutrients entering a wetland via the groundwater and some of the nutrients from lake sediments.

A wide buffer zone of vegetation

hides the lights associated with residential areas that are so attractive to midge swarms and presents a physical barrier to the movement of swarms from the wetland. Large trees (for example, the swamp paperbark *Melaleuca rhaphiophylla*) growing at the edges of wetlands also shade the shallow littoral zone, resulting in lower water temperatures, and this helps to reduce the growth of both algae and midge larvae. In addition, the brown colouration caused by the tannins which leach from the resulting leaf litter can help reduce algal growth. Thus the replanting of native vegetation is an essential aspect of wetland restoration from a midge control perspective.

Biological manipulation has the potential to reduce the amount of algal growth in nutrient-enriched wetlands and may be achieved by altering the balance between various components of the biota, especially the fish, zooplankton and phytoplankton.

However, this is only likely to be successful if carried out with appropriate wetland restoration strategies. Such techniques have had some success overseas. Physical and chemical modifications - such as deepening of wetlands, the addition of tannins to darken lake water, or the addition of chemicals such as aluminium sulphate to bind nutrients - may also be considered.

WHICH WAY NOW?

Clearly, the use of chemical insecticides alone to control midges is only a stopgap measure aimed at the symptom and not the root causes of the problem. In the longer term, wetland restoration using the above strategies will be required. Such strategies have the potential to enhance other values associated with wetlands, including conservation, recreation and education.

In the past, inappropriate land use has led to conditions highly favourable to midges, and the huge numbers which emerge from lakes during summer cause significant nuisance problems for nearby residents. The use of chemical control agents is undesirable from certain perspectives, but with measures such as light traps it is currently the only effective means of controlling the number of midges which reach residential areas. Long-term midge control requires that the water quality of wetlands be considerably improved. Hopefully, this process will hopefully be accelerated by fundamental changes in our perceptions of the value of those wetlands and just how far we are prepared to go to preserve them. ◘

Fringing vegetation at the northern end of Loch McNess.
Photo - S. Rolls

Paperbarks at Star Swamp. Wetlands that are not excessively nutrient-enriched and still support fringing vegetation do not usually experience midge problems.
Photo - C. Pinder

Inset:
The dragonfly - a natural predator of midges.
Photo - K. Trayler

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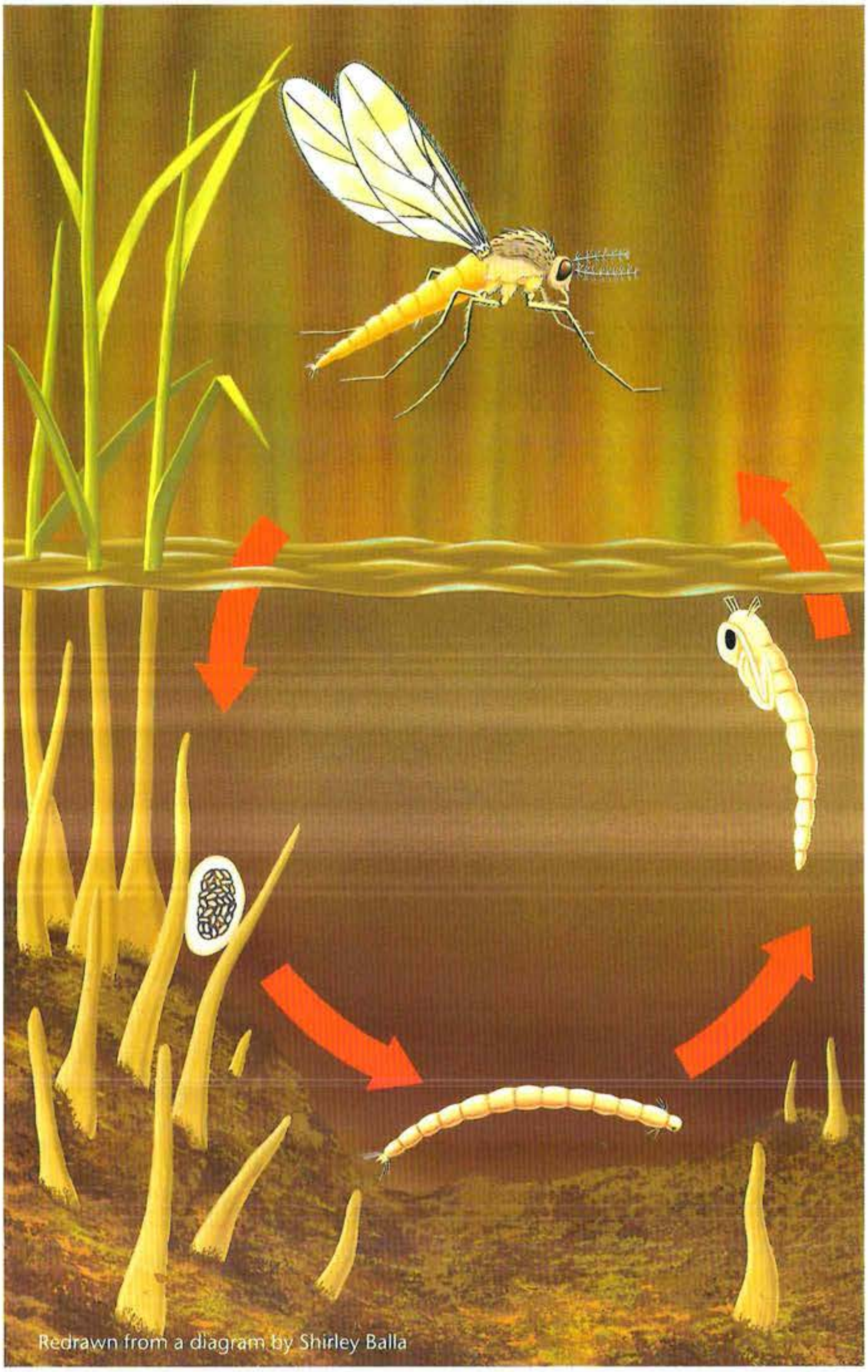
The valuable contributions to the project of Sue Harrington and Kerry Trayler, and the cooperation of local government authorities, are acknowledged by the authors.

THE LIFE OF MIDGES

Chironomids are a major component of the invertebrate community in many aquatic habitats. About 5 000 species worldwide and 461 species in the Oceania region, including Australia, have been described, and at least 35 of these have been recorded in or near wetlands in the Perth region.

Midges pass through several stages in their life cycles. The terrestrial adults lay eggs in such diverse aquatic habitats as water-filled tree holes, waterfalls, hot springs, lakes and streams. The aquatic larvae grow and eventually develop into pupae. At emergence, the pupae rise to the water surface and the adult breaks free from the pupal case. Millions of midges emerge nightly during summer and emergence rates of over 1 500 midges per square metre per night have been recorded in Perth wetlands. After emerging, the midges form mating swarms, commonly seen as the tall, swirling columns around local wetlands. The females leave the swarm after mating, each to lay one jelly-like egg mass containing thousands of eggs. These sink to the bottom of the wetland or become attached to plants and other submerged objects. The high number of eggs laid by each female means that the abundance of larvae can increase from low to very high densities in a matter of weeks under favourable conditions.

The length of the life cycle, and thus the rate of population growth, is highly dependent upon temperature and food availability. During warm summer months the entire life cycle can be completed in a few weeks. In colder climes, up to seven years are required to complete larval development.


Redrawn from a diagram by Shirley Balla

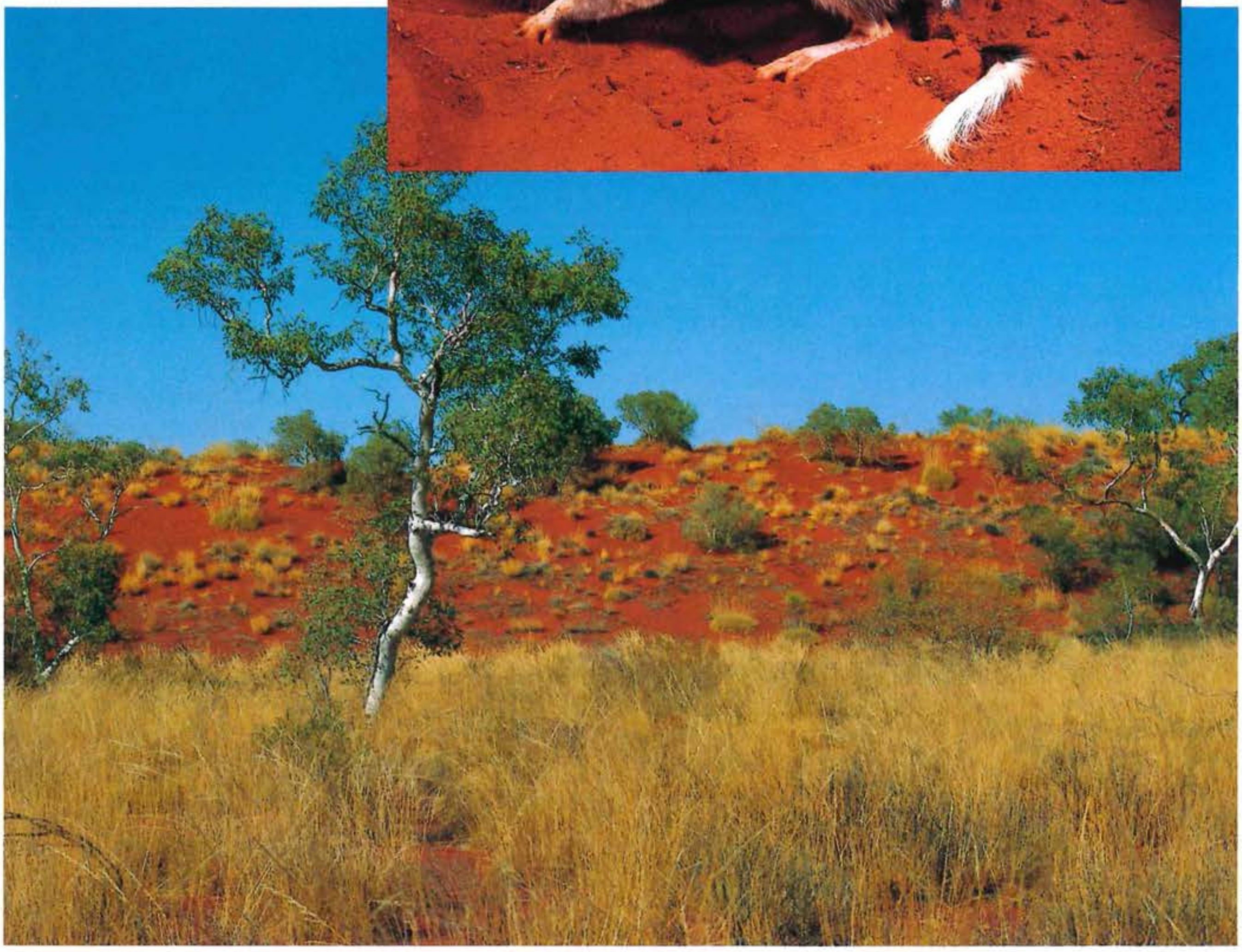
The larvae, also known as bloodworms, are usually red or brown and range from 0.5-3 cm in length when mature. Species that inhabit lakes are generally sediment dwellers. Some inhabit tubes, which they construct from fine particles. They are usually filter feeders, eating debris, bacteria and algae, which may be sucked into the tube by the rhythmic movements of the larvae. Other species are more mobile and are either grazers of algae or are predatory, feeding upon other animals. The larvae pass through four juvenile stages before pupating and emerging as adults. Up to 100 000 larvae per square metre of sediment have been found in Perth wetlands.

The larval chironomids are important food sources for a variety of animals, including invertebrates, birds and tortoises. This is recognised by managers of waterfowl breeding habitats. In some areas of North America, wetland managers actively encourage high numbers of midges to provide a food source for waterfowl.

NINU *Magic*

by Per Christensen and Graeme Liddelow

The ninu, better known as the dalgyte or bilby, is one of the few medium-sized mammals still found in WA's remote desert regions. Per Christensen and Graeme Liddelow came face-to-face with these hardy survivors.



Most Australian desert mammals weighing between 35 and 5 500 grams have disappeared. One exception is the animal the Aboriginal peoples of the western desert call the ninu, otherwise known as the dalgyte, bilby or rabbit-eared bandicoot (*Macrotis lagotis*). The ninu weighs between 1 and 2 kg, putting it fairly and squarely into the vulnerable group.

The ninu is one of our most attractive and endearing animals. Like the numbat, it is totally passive and doesn't attempt to scratch or bite when caught or held. It is comparatively slow-moving, has little stamina over any distance, and lives in very open country with little cover which also supports low numbers of foxes and feral cats. How does such an unlikely animal survive where others of its size class have failed?

SURVIVAL KIT

We first located and caught a ninu in the Gibson Desert in 1988 while working on the *Desert Dreaming* project (see *LANDSCOPE*, Autumn 1990), organised by the Department of Conservation and Land Management (CALM). The animal, named Lee-Anne (after Lee-Anne Martin, our radio contact in Kalgoorlie), was fitted with a radio collar and tracked every night for a week. On the first night of tracking she introduced us to some of the features that make up her impressive survival kit. First among these were her very large ears and superb hearing. Having tracked many different animals in the south-west forests over the years, we had a good feeling for how far behind an animal you needed to be to avoid disturbing it while it went about its business. Normally about 200 metres would be sufficient if you were quiet. But with this animal, if we were closer than 300 to 400 metres she heard us and bolted down one of her numerous burrows.

This introduced us to another survival aid. The ninu has strong claws and is a very efficient burrower. In sandy soil it can disappear from sight in less than three minutes. Not bad for an animal the size of a large domestic cat! Ninu burrows go down in a steep spiral to a depth of some two metres. The steep descent and depth make it very difficult for any predator to unearth a ninu. If you attempt to dig one out it buries itself even deeper - just ask the four CALM researchers who spent an afternoon of unsuccessful digging! Of the hundreds of burrows we have found we never once saw one that a fox had attempted to dig out. The Aboriginal people were apparently more adept at digging than us or the fox: ninu was one of their favourite foods.

The ninu digs burrows wherever it goes, and may use as many as two dozen at any one time. It always feeds close to a burrow, mostly within 100 metres or so. It may visit several burrows each night before choosing one in which to spend the daylight hours. This behaviour is confusing for anyone trying to locate a ninu, as many burrows have signs (including smell) of being occupied. We have spent many hours locating burrows to trap animals for radio-tracking research. Traps were set at the entrances of those burrows that appeared to be occupied, only to find the next morning that we had missed a burrow or that the ninu had come out of one which we had not trapped.

Previous Page Inset:
The ninu or dalgyte (*Macrotis lagotis*).
Photo - Babs and Bert Wells
Main: Sand dune country, ninu's home in times of drought in the Gibson.
Photo - Graeme Liddelow

Top:
The long soft fur and delicate features of the ninu seem out of character with the harsh deserts it occupies.
Photo - Wade Huges/Lochman Transperancies

Below:
The individual known as Alex with CALM scientists Per Christensen and Neil Burrows.
Photo - Ray Smith

The ninu is also very patient, prepared to wait until danger has passed. On several occasions, having made no captures after two nights, we gave up and moved the traps from the burrow entrances, thinking we had been mistaken in believing there was an animal below. The following morning we would see signs of an animal having come out to feed after lying low for 48 hours.

Many burrow systems also have 'bolt holes' that come up some little distance away from the main entrance. These escape hatches are usually hidden in spinifex. We lost at least one animal before becoming aware of this little trick. No doubt predators such as foxes and feral cats, which are also common in the desert, experience similar troubles with the ninu's cunning use of its burrows. The magic of evolution!

Other aspects of the animal's biology also contribute to its success in minimising predation by foxes and cats. Ninus are largely solitary, widely dispersed and occur in low numbers, often in some of the most inhospitable parts of the desert. For example, a favourite habitat in the Gibson Desert is the lower slopes of the Young Range, and similar sites. These have very open country with shallow soils peppered with loose stones about the size and shape of small potatoes - real ankle-twisting country! Narrow strips of deeper soils, supporting mulga and spinifex, allow the ninu to dig its burrows in this barren land. Few other animals live in this country, so foxes find it difficult to make a living and occur only in very low numbers.

FOOD AND FIRE

Ninus' eating habits help to explain why they live a largely solitary lifestyle and are very thin on the ground. Their main food items are bulbs and insects such as termites, witchetty grubs and honeypot ants. Witchetty grubs, the larvae of some large Cossid moths, burrow in the roots of several acacia species, notably the minniritchi (*A. grasbyi*) in the Gibson Desert. The ninu digs them out, locating them by smell; or perhaps its sensitive and accurate hearing detects the chewing larvae. When the larvae are plentiful the characteristic diggings of ninu may be seen beneath acacia bushes.

The grubs are nutritious, and were once an important part of the diet of desert Aborigines. The time of the year when the pupae rise to the surface in their burrows was important to the Aborigines, since large numbers could be gathered just before they emerged without the labour of digging deeply for them.

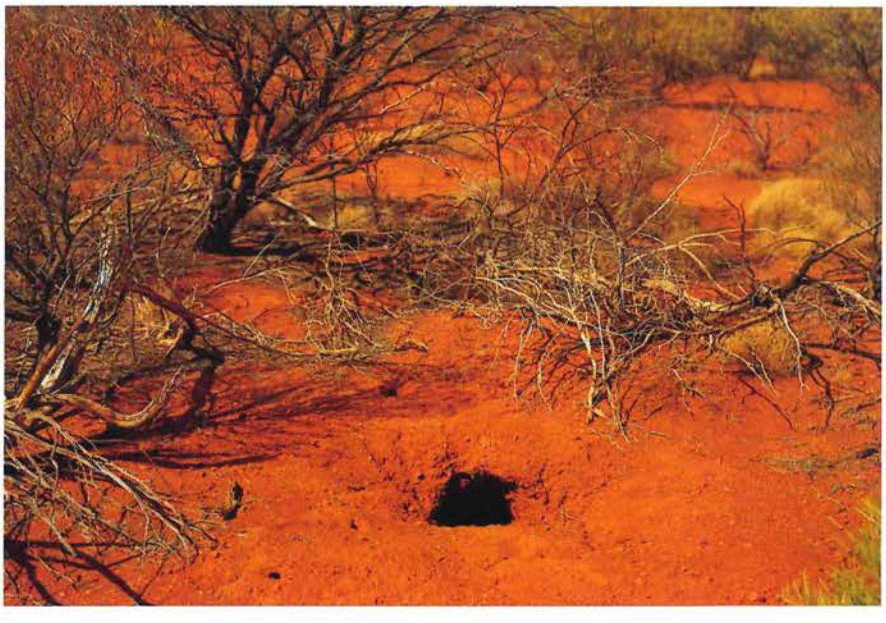
The well-known anthropologist, Norman Tindale, who worked in the desert in the 1920s, recorded that the Pitjantjatjara people sang a song at the end of summer about this anticipated event, *Wardaruka miring tjarei,* which literally translates as 'Acacia trees pupae are carrying'.

Top:
The ninu, called Lee-Anne, after being radio-collared and released.
Photo - Graeme Liddelow

Below:
Witchetty grubs are a favourite food of the ninu.
Photo - Graeme Liddelow

Below left:
Digging out a burrow - a good way to keep fit, but a fool's way to catch a ninu!
Photo - Carolyn Thomson

Below right:
A ninu burrow. They are typically better concealed in spinifex.
Photo - Ray Smith



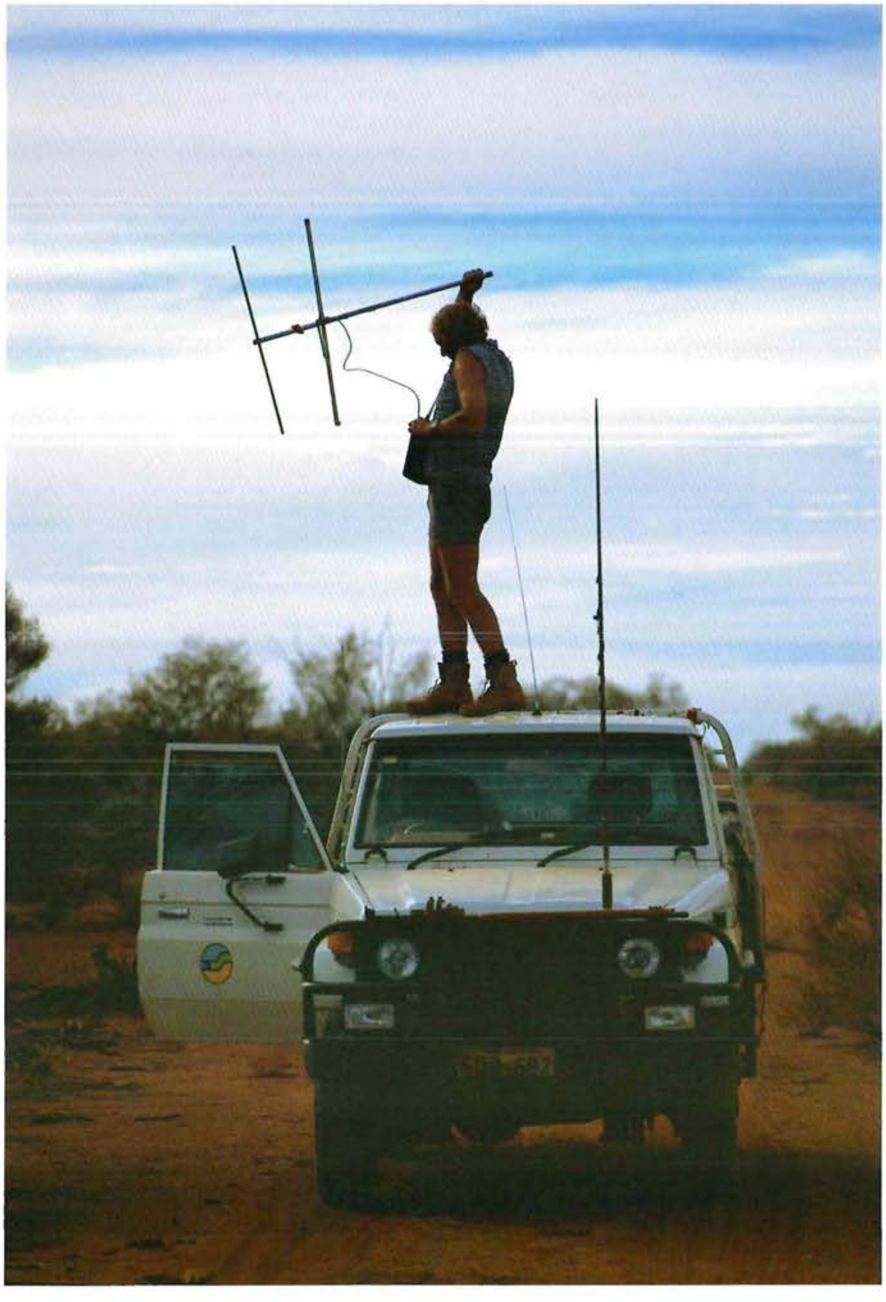
Bulbs of certain plant species, for example desert onion (*Cyperus bulbosus*) and desert Nancy *(Wurmbea deserticola)*, are major food items. These occur mostly on sites with deep sandy soils such as sand dunes, another favourite habitat of ninu in the Gibson Desert. Termites also form a considerable part of the ninu's diet, and are more readily available after rain. Such a diet forces the ninu to adopt a pattern of shifting use of its habitat, similar to that practised by the Aborigines.

When we first started working on the ninu in May 1988, the signs of animals, their characteristic diggings and burrows, were common along the lower slopes of the Young Range and other ranges in the area. Diggings at this time were particularly prolific under the minniritchi. In 1989 the pattern was similar. Then a three-year drought really set in and, in 1990 and 1991, numbers declined, as indicated by our monitoring plots over an area of some 600 kilometres. The remaining ninus now seem to be concentrated in the plains on the deeper sands, where they appear primarily to be eating bulbs.

We are finding that each animal uses an extensive area, but occupies only a portion of that area at any one time. The very low numbers of ninu, often in habitat carrying low numbers of other animals and hence few foxes, work in the ninu's favour. Foxes, nevertheless, do restrict ninu numbers, though to what extent is not known. Our first ninu, Lee-Anne, was eventually taken by a fox. We located her remains on our second trip some months after we first caught her. Microscopic examination of fox scats from the Gibson Desert has also shown up ninu fur.

Let's hope that the animal's biggest problem is the periodic droughts that are very characteristic of the deserts. The ninu has long since learned to cope with natural disasters, and with its high breeding rate - it breeds throughout the year in good times - the species should be able to expand quickly to fill the empty spaces.

Fire appears not to pose any great problems to the ninu. A significant part of the animal's habitat will not burn at all, except perhaps after exceptional seasons when plant growth is especially prolific. In the plains near the sand dunes we recorded ninu diggings, and four months after burning we caught a young male (whom we named Fred) living on the bare sand at the base of one of the dunes. In May 1991 we caught yet another ninu on the burnt area, an old male we called Alex. This animal showed us yet another trick. After tracking it for several hours for eight to ten kilometres in a huge circle across the burnt sand, we found it had buried itself in the sand for the day by digging a hole and filling it in behind itself! Whether this extraordinary behaviour is unusual we do not know,



Locating a radio-collared animal using a directional aerial. The extra height gives better reception.
Photo - Ray Smith

Right:
Ninu country is harsh terrain.
Photo - Graeme Liddelow

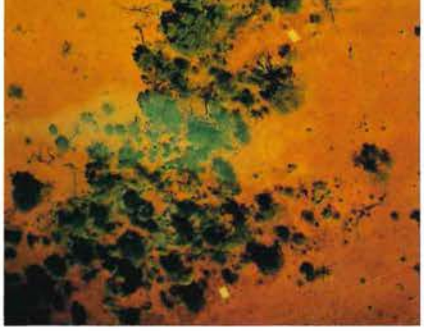
nor do we know what the animal was doing travelling such a distance through burnt country. Perhaps it was an exploratory journey, as it only dug up and ate about a dozen bulbs on the trip.

LAST OUTPOST

What is to become of the ninu? Is it really the survivor it appears to be? Or has it just been able to hang on longer than the other desert mammals on a steady decline towards extinction? Will the ninu once again bounce back after drought as it has done very many times in the past, or will the fox beat it? Our judgement is that the animal's solitary ways and low numbers on the ground, its exceptionally acute hearing, its burrowing habits, together with a shifting use of its habitat and clever use of its burrow system, will win the day for the ninu. Though the animal was once widespread across much of southern Australia, its last outpost, the northern deserts, is marginal habitat for the fox. This introduced predator is on the very edge of its range in these deserts, and if the ninu is going to make a last stand it will be here, in the harsh climate to which it is so well adjusted. Adaptability, patience, and cunning - these make the ninu a truly magical mammal. ◘

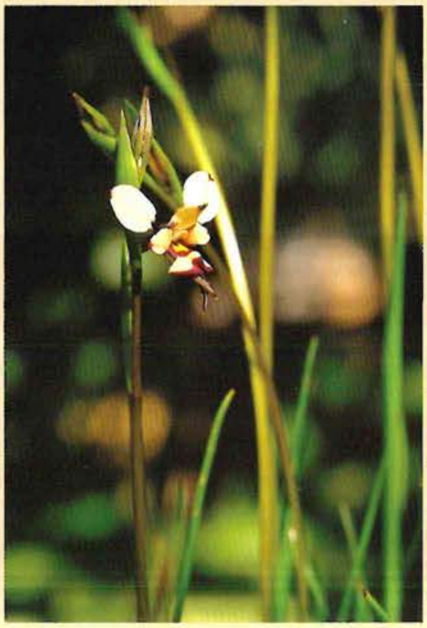
Ninu burrows go down in a steep spiral to a depth of some two metres.
Photo - Ray Smith

The two yellow markers are the location of ninu burrows, which were mapped by CALM scientists.
Photo - Steve Dutton



Per Christensen is a Senior Principal Scientist and Graeme Liddelow is a Senior Technical Officer with CALM.

ENDANGERED!



THE DWARF BEE ORCHID (*DIURIS MICRANTHA*)

The dwarf bee orchid is one of Western Australia's rarest plants. This donkey orchid is so rare, and its habitat so restricted, that it remained undiscovered until 1974 when Andrew Brown and Warren Stoutemire found it in a single winter wet swamp in the Perth metropolitan area. Since then the dwarf bee orchid has been thoroughly surveyed. Western Australian Native Orchid Society members have also conducted several dwarf bee orchid forays, but no new populations have been found. Consequently, it was declared as rare flora in 1989, and in 1991 David Jones of the National Botanic Gardens named the species *Diuris micrantha*.

Seen above right with its nearest relative, the common bee orchid, *Diuris micrantha* is distinguished by its small, pale yellow flowers, and shorter labellum midlobe. It is a clump-forming species, and in early September produces up to a dozen inflorescences in a cluster.

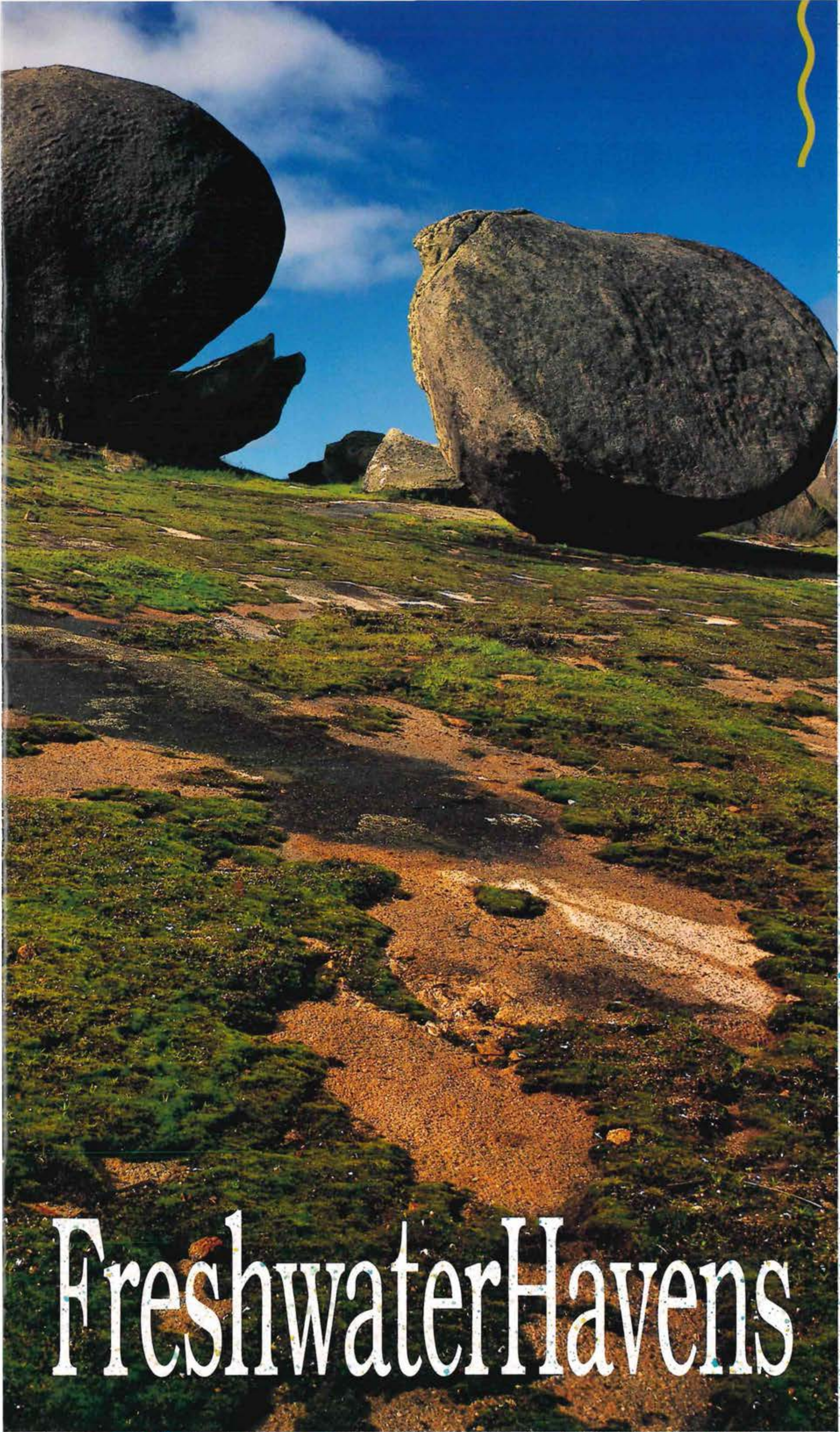
Donkey orchids abound in winter wet areas throughout the south-west, and not surprisingly 27 species have evolved in Western Australia. But as four are rare, *Diuris micrantha* was selected to represent the genus in a joint Department of Conservation and Land Management (CALM) and Australian National Parks and Wildlife Service "Rare Orchid" project. Other species included in this project were the underground orchid (*Rhizanthella gardneri*), the glossy-leafed hammer orchid (*Drakaea elastica*), the elegant spider orchid (*Caladenia elegans*) and the Cape spider orchid (*Caladenia caesaria* subsp. *maritima*).

The rare orchids are being studied at the Western Australian Herbarium, and results show that the number of *Diuris micrantha* has decreased since its discovery. In 1987 a wildfire devastated 10 per cent of the orchid site, killing many plants, and by 1990 a further 26 per cent of the site had been destroyed by recreational motor-cyclists. In response, CALM implemented management strategies to reduce the risk of fire, and motor-cycle traffic has since been diverted from the orchid site.

Genetic studies indicate that if the present population size is maintained, *Diuris micrantha* could perpetuate itself without the need for human intervention.

Steps are being taken to make the *Diuris micrantha* site a nature reserve, but ultimately the survival of this species probably depends on land use in its immediate vicinity. If for any reason the water table drops, by only a few centimetres, *Diuris micrantha* might soon become extinct.

STEPHEN A. CARSTAIRS AND ANDREW BROWN



FreshwaterHavens

In the south-west of Western Australia there are small, shallow, temporary pools teeming with micro-fauna and flora that are perched on top of ancient granite rocks. Ian Bayly, Reader in Zoology at Monash University, investigates these rocks and pools and argues that a balance should be struck between their use as water harvesters and their conservation values.

by
Ian Bayly

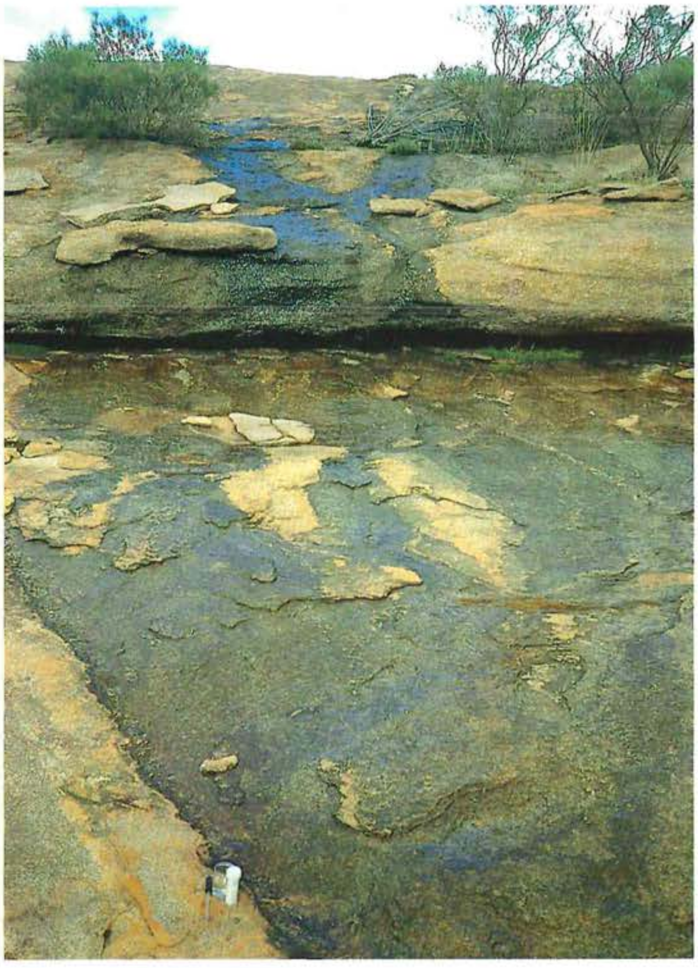
Much of Western Australia's South West consists of very ancient igneous rocks. Outcrops of resistant, elevated granites dot the landscape and are often the main features that add diversity and interest to an otherwise monotonous countryside. To many people living in the vicinity of these granite rocks, their main if not sole value is as impermeable surfaces and water harvesters - and on a continent as arid as Australia this is perfectly understandable. Harvesting is achieved by the construction of extensive, low walls to divert runoff into reservoirs. This is a common practice that represents one value of a granite outcrop, and the thoughtful and selective use of some rocks as water harvesters is unobjectionable. Another, often poorly appreciated, value of granite outcrops is as habitats for a wide range of freshwater flora and fauna.

My biological exploration of these granite inselbergs (literally 'island mountains'; hills that rise abruptly from the plains like islands from the sea) began in the winter of 1977, and they made a deep impression on me. Using a hut in Pemberton as a base, repeated visits were made to Mt Chudalup and Muirillup Rock, near Northcliffe, to sample the micro-fauna living in the temporary rock pools. Outstanding features were the lushness and extent of the moss beds on Muirillup Rock and the capacity of several small animals to flourish in the very small and shallow pools near the summit of Mt Chudalup. In these there occurred in great abundance a beetle-mite that had abandoned the terrestrial habits of nearly all its relatives and had opted for an aquatic mode of life. It was later described under the name *Chudalupia meridionalis*. (The nearest relatives of this animal occur in similar habitats in South Africa.) That winter a total of 19 pools, distributed between nine different granite outcrops, were sampled.

THIRTEEN YEARS ON

In the winter of 1990 I returned to Western Australia for a more extensive study of granite rock pools, including some of the most eastern examples. Travelling in from the east I turned south at Balladonia and headed towards Mt Ragged. With a sense of excitement I spotted Coragina Rock and pulled off the track. Walking to the low summit I saw what appeared to be a fine pool. Then to my dismay I realised that the level of the natural pool had been raised about 18 cm (the maximum depth was only 25 cm) - someone had cemented together some exfoliated pieces of granite to form a low dam.

After travelling almost 3 000 km it was disappointing and surprising to find that this apparently remote rock had suffered human modification. It was also difficult to understand, because there was a major dam at the base of the rock whose capacity was at least 1000 times greater than that of the shallow summit pool. What stood before me was not the pristine habitat I had travelled so far to study. Natural granite rock pools are always acidic, but the pH of this pool was 8.7 (the mean pH of 10 unmodified pools studied in 1977 was 5.3, while the mean for 32 such pools in 1990 was 6.1). The alkalinity was due to basic materials



Previous page:
Massive granite boulders atop Boulder Rock, in the jarrah forest on Albany Highway.
Photo - M and I Morcombe

Temporary stream on Yorkrakine Rock, north of Kellerberrin.
Photo - D.H. Edward

Northcliffe kennedya (*Kennedya glabrata*) is a declared endangered plant. Many rare plants and animals seek haven on granite outcrops throughout the State.
Photo - S.D. Hopper

Granite rocks are a major source of fresh water throughout the south-west. Frequently, exfoliated slabs are found cemented together to form low walls to direct runoff into dams and tanks, as seen here at Pingaring Rock.
Photo - S.D. Hopper

The shallow soils and mossfields on granite rocks are prone to erosion. Here a walkway has been built to avoid degradation of communities on Mt Chudalup.
Photo - S.D. Hopper

having been leached out of the cement mortar.

In the more populated wheatbelt regions of Western Australia some form of human modification of the hydrology and ecology of granite outcrops is more the rule than the exception. An extreme example of stone walling is to be found on Beringbooding Rock, to the north-east of Mukinbudin. Here, apart from the usual walling of the lower flanks of the rock, most of the patches of vegetation growing on the rock are completely encircled by cemented stones - in the manner of a formal garden on a suburban block! This work was done to assist water supplies for early settlers and steam locomotives. Such extensive works are today unnecessary; they contribute only very marginally, if at all, to the efficiency of water harvesting. Not surprisingly, the largest pool on Beringbooding Rock (outside of the main reservoir) was markedly alkaline with a pH of 8.8.

A large part of the natural inland aquatic environment in Western Australia is saline. Even before the advent of Europeans this was almost certainly the case. In the late Pleistocene, about 18 000 years ago, Australia suffered an intense period of aridity. Freshwater habitats were severely restricted and there was a great expansion of inland saline waters (mainly temporary). Despite some subsequent improvement, salt lakes still dominated much of Western Australia, especially in the vast arheic or riverless region that includes Salinaland around Kalgoorlie, at the time the Europeans arrived. Although the amount of fresh water in artificial impoundments has increased significantly during the past 100 years or so, land clearing for agriculture has resulted in a great increase in the salination of the natural aquatic environment (see 'The Last Lake', *LANDSCOPE*, Winter 1988). It is a commonplace that many Western Australian rivers that were formerly fresh are now saline. There are even rivers in which the salinity increases as you go upstream!

INSELBERGS: FRESHWATER HAVENS

The exceptions to this general trend are the granite inselbergs, which demonstrate an important value of granite outcrops: they provide refuge for strictly freshwater organisms within an otherwise highly saline area, and they are sometimes the only home for some very ancient and primitive organisms.

Being domed rather than funnel-shaped, these granite inselbergs are almost perfect exorheic systems (shedding rainwater and dissolved salts to the surrounding lowlands). In fact, they are like rock islands in a salty sea. For many organisms adapted to temporary fresh waters and with an intolerance of salt, granite rock pools must now represent one of their few habitats not under major threat.

An extremely primitive fly (Diptera) was discovered in Western Australia in 1967. It belonged to the family Chironomidae, which had always been regarded as lacking functional toothed mandibles (jawlike biting appendages) and which were commonly referred to as the non-biting midges. A very closely related family (the sandflies) which possessed functional toothed mandibles were distinguished as the biting midges (these insects are common near estuaries where they often inflict much misery on humans). The newly discovered Western Australian insect confounded this neat distinction; it was essentially a chironomid but it had functional jaws like its sandfly cousins. It was subsequently discovered that the larval stage of this fly (*Archaeochlus brundini*) occurred in freshwater seepages flowing from clumps of moss growing on granite hills. This species has been subject to intensive study by Dr Don Edward of the University of Western Australia, who recently discovered a second species in the same genus inhabiting the same habitat. This second species awaits description.

The granites of south-western Western Australia are ancient. Many of the habitats associated with them have had a continuous (even if seasonal) existence throughout vast periods of geological time. This is doubtless a key factor allowing *Archaeochlus* to persist to the present day; it is believed that the

Pre-Cambrian granites on which *Archaeochlus brundini* occurs have not been invaded by the sea since before the Triassic (that is, this type of habitat has been in existence for at least 240 million years). As with *Chudalupia*, the closest relatives to the Australian species of *Archaeochlus* occur in similar habitats in southern Africa. The explanation for this doubtless lies in the fact that 150 million years ago Australia and Africa were combined together as parts of one land mass - the supercontinent Gondwana.

Granite outcrops have figured prominently in the history of biological explorations in Western Australia. Yorkrakine Rock, north of Tammin, is the 'tor' in Main's (1967) book entitled *Between Wodjil and Tor* which is an elegant plea for the recognition of the high conservation values associated with remaining natural areas in the Wheatbelt. This rock and others have played a major role as field sites for ecological studies conducted over many years by biologists from the University of Western Australia. Yorkrakine Rock is the type locality for the frog *Crinia pseudinsignifera* Main, and for the mygalomorph spider *Kwonkan eboracum* Main. Professor Don Bradshaw of the University of Western Australia has made an extensive study of the ecology and physiology of the ornate dragon, *Amphibolurus ornatus*, on granite habitats.

The conspicuous fairy shrimp (*Branchinella longirostris*), the bright red calanoid copepod (*Boeckella opaqua*), and the black 'water flea' (cladoceran) *Daphnia jollyi* are not only characteristic inhabitants of pools on Western Australian granites, but all three species are known only from these habitats. Plants commonly found growing in silt on the floor of these rockpools include quillworts (*Isoetes* spp.), mudmats (*Glossostigma* spp.), crassulas (*Crassula* spp.), mudworts (*Limosella australis*) and the waterwort (*Elatine gratioloides*).

INSENSITIVITY - AND VANDALISM

Many of the rocks have strong aesthetic appeal. Some are positively awe-inspiring. In what is often a monotonous landscape one would think that the rocks might be revered for these qualities alone. Unhappily, insensitive placement of artificial structures effectively destroys or greatly impairs the beauty of many rocks. For example, a large and unsightly tank sits right on top of Nunegin Hill at Bruce Rock.

I had heard much about the famous Wave Rock at Hyden. But when I arrived there I found that even this wondrous formation had not escaped walling. Here was a masterpiece of nature surmounted by an artificial eyesore! Presumably the wall was built before tourism became important. Surely part at least of the potential catchment for the Hyden dam could now be foregone and the wall discreetly rerouted so that visitors, many of whom come from interstate and overseas, could stand at the base of the rock and have an untrammelled view of the masterpiece. More deliberate vandalism and impairment of aesthetic qualities is not uncommon. The gorge region of Yorkrakine Rock is plastered with graffiti.

On returning to Muirillip Rock in early July 1990, I was pleased to find that the Department of Conservation and

Right:
Archaeochlus brundini larva from temporary streams on granite outcrops.
Photo - D.H. Edward

Far right:
Sundews (*Drosera*) are tuberous plants found in the mossfields of granite rocks.
Photo - S.D. Hopper

Below:
Yorkrakine Rock, north of Kellerberrin.
Photo - Ian Bayly

Below right:
This ephemeral rock pool belies the searing summer heat waves that killed the shrubs left standing as grey skeletons.
Photo - Ashley de Prazier

Land Management (CALM) had now designated the area a conservation park. However, I was dismayed to find strips of moss torn away from the granite by trail-bikes and four-wheel-drive vehicles. Even the beautiful little moss-covered pool that had been first studied in 1977 had not been spared. Several weeks later I was as much amazed as annoyed to see a clear tyre imprint running right across the bottom sediments of a shallow pool that was within 15 metres of the summit cairn of Yorkrakine Rock. So much for the official designation of this rock as a 'limited access area'!

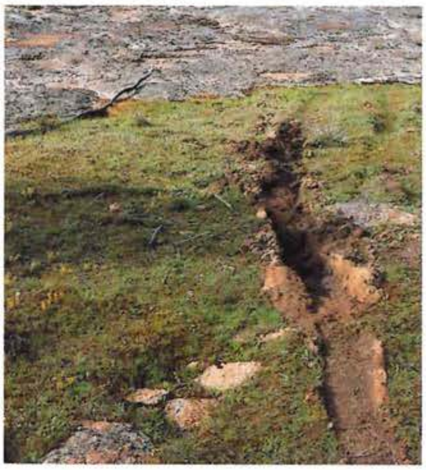
UNDERSTANDING THE VALUES

Although vandalism is all too prevalent, even at rocks officially designated as reserves, it is unreasonable to expect that officers of CALM should be the main agency in curtailing this. They can't be present at every rock, every day. In the long haul, a general heightening of community consciousness concerning the values of granite outcrops is required. The schools are the obvious place to start. There is enormous scope for capitalizing on the unique biological and geological features of the ancient granites in field studies associated with science education at both primary and secondary school levels. CALM is to be strongly commended for recently publishing an excellent booklet entitled *Exploring Granite Outcrops*. There is another useful CALM publication relating specifically to the Sanford [Sandford in the publication] Rocks north of Westonia. These are just some of the resources available to teachers keen to take up the challenge.

I have often walked past the ornamental pool alongside Winthrop Hall on the University of Western Australia campus and pondered over the inscription it bears: 'Verily by beauty it is that we come at wisdom'. This is an interesting proposition. I firmly believe that it is an appreciation of beauty in one or other of its diverse forms that is the primary driving force behind many human endeavours and achievements with which it may not be immediately associated. It was not the devotion of many years of my life to the scientific study of inland waters that awakened me to the aesthetic qualities of lakes, ponds and pools. Rather, I believe it was an acute sensitivity during adolescence to the beauty emanating from a landscape containing bodies of water that caused me to embark on the scientific study of inland waters. It has certainly been a personally rewarding preoccupation. It might even have imbued me with some wisdom, but that is not for me to judge.

My plea is for us all to acknowledge that the Western Australian archipelago of granite hills has values other than water harvesting (and trail-bike riding!). We should open our eyes to the way in which it beautifies and diversifies the landscape. The rest, the wise conservation of a goodly number of rocks, should follow naturally.

Ian A.E. Bayly is a Reader in Zoology at the Department of Ecology & Evolutionary Biology, Monash University. He is a joint author (with W.D. Williams) of the book *Inland Waters and their Ecology*, first published in 1973 and reprinted five times.



Far left:
A trailbike has caused erosion scars that will take decades to repair.

Left:
Use of ephemeral rock pools by cattle causes major damage to native animal and plant communities, and opens the way for weed invasion.

Below left:
The spider *Rebilus* hides in tiny spaces beneath slabs of exfoliated rock.

Below right:
Bold Rock Creek, Fitzgerald River National Park.
Photos - S.D. Hopper

URBAN ANTICS!

A Spare Bit of Bush

A cold weekend morning - crisp, cool but clear - a typical Perth winter day... beautiful.

The urge to retreat under your blankets is great, then you remember ...*that special place*.

As a kid it was always your secret domain, your 'Alamo', your school of nature, an inner sanctum where close friends made pacts of impossible dreams. To others, it was simply... a spare bit of bush.

Most of us still have our special spots, be they childhood haunts, new-found parks, or well-vegetated backyards. There we can divorce our minds from the hustle, bustle, bricks and cement of urbanisation, and be at one with nature.

Imagine you've just arrived at one such secluded spot. The old tuart tree thrusts its enormous branches to the sky like a welcoming giant. High above, Port Lincoln parrots silently nip the flowering fruit and shower you with white blossom. Still higher, a black-shouldered kite, its striking white plumage emblazoned against the clear blue sky, stares into eternity through blood-red eyes.

Take a leaf from the tuart, hold it to the sun and observe the amazing textures and patterns of its cells and veins. Better still, crush the leaf in your hands and smell the unique aroma of eucalyptus oil. It's enough to conjure up a vision of cool green cubby houses and long-gone pals.

Wrap your arms around the tree trunk, press your face against its rough, soft, grey powdery bark. Feel its size, feel its strength, feel its majesty.

Time to step away now. The sounds of this living place are starting to take your attention.

A seemingly drunken fat honey bee cruises past your ear like a B52 bomber; a bush cricket, excited by a ray of energy-giving sun, tests its calling apparatus and another answers from the depths of a nearby shrub.

Suddenly a cool puff of wind caresses your cheek and creates musical tones in the sheoak and pricklebush behind you.

By now you're mesmerised and slowly sink to sit upon an old grey banksia log. Against the shadows of the undergrowth you can see and smell the steaming dank remnants of night moisture rising from decaying wood.

Your attention strays toward the grey sandy quartz at your feet. Here the glistening silica comprises myriads of granules, chips, chunks and flakes, together with thousands of tiny twigs, leaves and assorted vegetable matter.

Ants come and go from beneath the log and unashamedly swarm over your boots. Nearby, a flat bush cockroach labours to pull a leaf into the seclusion of its burrow.

All of a sudden you realise you've been consumed into this other world, a world of ancient textures and repeated patterns. Everything is in balance but nothing at rest - prey and predator, move and stop, ebb and flow, like the energy of the sun as it moves in the silent flames of grass and then through the bodies of grazing caterpillars.

Your final realisation: we are just another part of being, inextricably enmeshed in the web of life on Earth.

JOHN HUNTER

DID YOU KNOW?

- *If the Earth was reduced to the size of a tennis ball, the precious air surrounding it would be no more than the thickness of a human hair.*
- *If you counted the number of living bacteria at the rate of one every second, in a teaspoonful of soil from a cultivated field, it would take you 30 years.*
- *In one hectare of cropland, living and dead bacteria in the topsoil make up a mass of organic matter exceeding two tonnes.*

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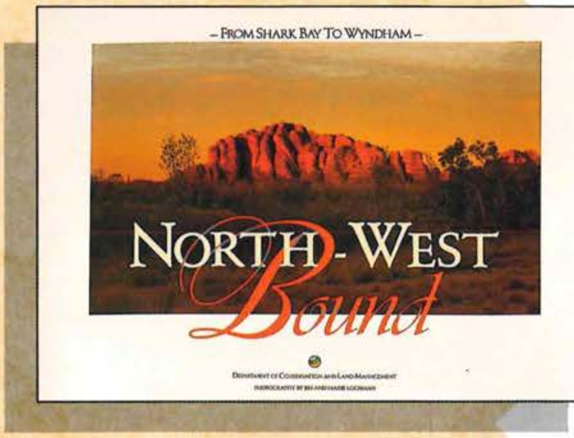

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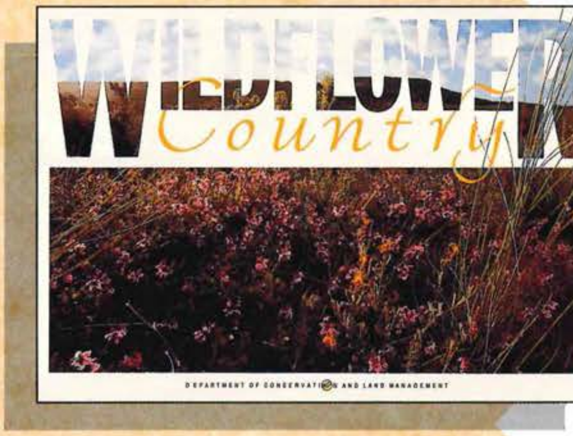

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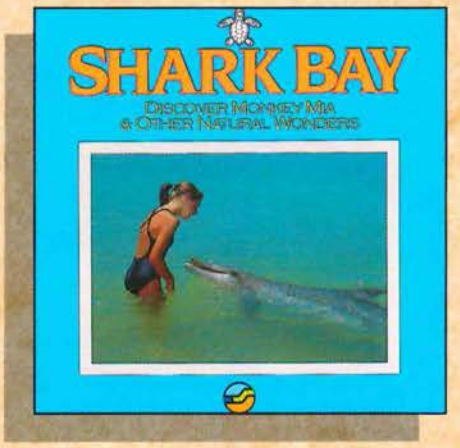

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